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Thematic Review on Mobile Health Applications in Design Perspective Publications from 2018-2023: Analysis of Trends for Future Studies

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Abstract: *As 5G technology expands, many people use mobile health apps (mHealth apps) to manage their health, including chronic disease health management, maternal health information inquiry, mental illness problem consultation, and personal health management. Applications for mobile health that are poorly designed make it difficult for users to access health information. Despite the rise in publications on the subject, few evaluations look at the design of mHealth apps and their potential futures. Accordingly, the specific objective of the study is to report the results of a thematic review analysis that examined the research on mHealth apps development from the perspective of design, addressing the knowledge and methods required to build design-based mHealth apps. Thematic review analysis of 49 articles from 2018 to 2023 was used to collect data for this study, and the results of the ATLAS.ti 23 code-to-document review show the trends that researchers should look for. Four major themes can be seen from the analysis: 1) mHealth Apps applied Theory; 2) mHealth Apps Functionality Features; 3) mHealth apps design strategy; 4) mHealth Apps Design Elements. The findings imply that in order for users to adhere to mHealth apps as intended, future research trends in their design practice should integrate design strategy with transdisciplinary research. This endeavor will produce new understanding of new standards for research trends in mHealth app development.*

Keywords: thematic review; mHealth apps development; ATLAS.ti 23; design strategy; user preference

1. Introduction

A standalone piece of software known as a "mHealth app" can supply services linked to health via portable devices like smartphone. Global sales of mHealth apps are projected to reach $ 43.5 billion in 2022, and from 2023 to 2030, they are expected to grow at a CAGR of 11.6 percent (*Global mHealth Apps Market Size & Trends Report, 2030*, 2022). The advancement of high-quality healthcare delivery is greatly anticipated by mHealth technologies(Wu et al., 2019). Many people use mHealth apps to manage their health, including chronic disease health

management, maternal health information inquiry, mental illness problem consultation, and personal health management (Hill et al., 2022; Scott et al., 2022; Tran et al., 2022; Zhang et al., 2022).

Over the past decades, extensive research has been dedicated to enhancing the functionalities of mHealth applications. Examples include the development of apps for managing chronic diseases (Koumpouros, 2022), monitoring fetal health in pregnant women (Pinnarong et al., 2021), and promoting physical well-being in the general population (Mathur et al., 2021). McCurdie et al., 2012) argue that the prevalence of mobile phone and their frequent usage make mHealth a suitable platform for disseminating health information, thereby rendering mobile health technology a viable tool for engaging patients in their healthcare journey. Moreover, mHealth apps have the potential to provide persons with chronic health issues with individualized self-management support. Furthermore, Xu et al., (2020) emphasized the role of smartphone app features in encouraging patients to adopt behaviors recommended by guidelines, offering evidence-based information, and providing advice. This viewpoint is reinforced by Rathnayake et al., (2021), who underlined that time efficiency, user-friendly design, real-time feedback, personalized aspects, complete information, and engagement of healthcare professionals have all increased the effectiveness of mHealth applications. However, despite the widespread availability of health apps, most lack of basis in scientific evidence (Amann et al., 2020). This idea is supported by study by Vlahu-Gjorgievska et al., (2023), which shows that although long-term user adherence to these programmes is still low, mHealth apps have the potential to increase engagement in health initiatives.

Several researchers have addressed the deign concerns associated with mHealth apps Rathnayake et al., (2021), indicated that poorly crafted mHealth apps present obstacles for users with limited health literacy when attempting to access health-related information. However, a noteworthy number of electronic health and mHealth interventions are structured around established healthcare system frameworks, potentially lacking the effectiveness of those that engage end users during the design phase (McCurdie, 2012). This viewpoint is supported by Tran's findings (2022), which contend that an evidence-based co-design process should be used, incorporating patients from the early design phases, in order to effectively combat medication adherence through gamified and incentivized mobile apps. Additionally, Xu (2022) proposes that collaborating with stakeholders during the design process can significantly enhance the progress of app development.

Mobile health apps are useful health solutions based on mobile communication and network technology that allow end users to monitor their own physical health, remain in touch with clinical physicians, and prevent and control illnesses(Yu et al., 2023). User involvement in design and evidence-based information in mHealth applications are concerns. Lack of detailed literature outlining design requirements and lack of defined research methodologies in design. Designing mHealth applications requires professional requirements and design skills. Despite extensive app development, there are few review articles on mHealth app design themes. Thus, this study examines mHealth app design literature from 2018 to 2023 for trends and patterns. The purpose is to promote future research and determine the theoretical and practical direction of mHealth app design.

Thus, the objective of this endeavour is to address the concerns that have been deliberated in publications regarding the design of mHealth apps from 2018 to 2023. This will be achieved by formulating the subsequent research inquiry:

From the standpoint of design, what theories and trends in mHealth apps have been published in the literature between 2018 and 2023?

2. Materials and Methods

SCOPUS and Web of Science served as the primary data sources. This research used a theme review strategy, with ATLAS.ti 23 serving as the primary analytical software. Zairul's (2020) suggestion of using a theme analysis technique within the framework of a literature review was chosen as the appropriate methodology for this investigation (see Table 1).

Table 1: Search strings from SCOPUS and WOS

SCOPUS	TITLE-ABS-KEY (“mobile health application” AND design) AND PUBYEAR > 2017 AND (LIMIT-TO (DOCTYPE, “ar")) AND (LIMIT TO (LANGUAGE , "English"))	141 articles
WOS	Results for "mobile health application" (Topic) AND design (Topic) and Preprint Citation Index (Exclude – Database) and Article (Document Types) and English (Languages) Timespan: 2018-01-01 to 2023-01-01 (Publication Data) Editions = A&HCI, BKCI-SSH, BKCIS, CCR-EXPANDED, ESCI, IC, CPCI-SSH, CPCI-S, SCI-EXPANDED, SSCI.	205 articles

In-depth investigation of a topic in order to draw out commonalities and develop overarching themes, as described by Clarke et al. (2013). The next step requires reviewing the practice and developing unique categories in order to evaluate the published trajectory of mHealth app development. Our project's ultimate purpose is to analyze and evaluate the data and advise mHealth app development research. The following criteria were used to choose review articles: 1) they had to be published between 2018 and 2023; 2) they had to contain the most important keywords related to mobile health applications; 3) they had to focus on design-related challenges in mobile health; 4) they had to be written in English; and 5) they had to be journal articles or conference papers that could be accessed through Web of Science or Scopus. Table 1 shows the Web of Science and SCOPUS search phrases used to find related publications.

The exploration for the term "mobile health application" was carried out during the literature search. In the initial phase of investigation, a total of 346 articles were located across the two databases. The search strings employed, which included "mobile health application" AND LANGUAGE(English) AND PUBYEAR > 2017 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")), yielded 141 outcomes in SCOPUS. Similarly, in the Web of Science database, the query involving the term "mobile health application" (Topic) AND design (Topic), while excluding Preprint Citation Index (Database) and encompassing Article (Document Types) and English (Languages), resulted in 205 relevant articles. The timeframe for the search encompassed January 1, 2018, to January 1, 2023 (Publication Data), and the articles were restricted to various editions, including A&HCI, BKCI-SSH, BKCIS, CCR-EXPANDED, ESCI, IC, CPCI-SSH, CPCI-S, SCI-EXPANDED, and SSCI.

The exploration of literature was conducted within the realm of mobile health applications and design. The initial inquiry yielded 205 articles from the SCOPUS database and 141 articles from the WOS database.

Out of the total articles, 297 documents were excluded due to reasons such as reliance on anecdotes, preliminary outcomes, or absence of discussion on the topic of mHealth apps design. Moreover, certain papers were identified as incomplete, inaccessible, duplicated, had fragmented links, or exhibited incomplete metadata. Thus, 49 papers were assessed (as depicted in Figure 1). These papers were uploaded as primary files into ATLAS.ti 23, then categorised by authorship, journal source, publisher, issue and volume numbers, and year of publication. English-only articles were selected. ATLAS.ti 23 analysed the remaining 49 papers (as illustrated in Figure 1).

The purpose of this research is to analyze and interpret the results as thoroughly as possible, and to provide suggestions for the improvement of mHealth applications in the future by way of grounded theory. The articles were selected because they met the following criteria: (1) they were published between 2018 and 2023; (2) they used the phrase "mHealth applications;" and (3) they linked mHealth apps to a design stance. The research topic was developed first, then data sources were selected, retrieved, and pre-processed, and finally data extraction, analysis, and synthesis of themes were performed. In the end, the findings will be presented graphically, analyzed, and discussed.

In the qualitative portion, an inductive thematic analysis strategy is used to move information from particulars to broad generalizations, which aids in the creation of hypotheses that suitably connect the themes to the information(Patton, 1990). Coding, categorizing, and identifying patterns or themes that might show at several levels are all part of this technique (Braun & Clarke, 2006).

The results presented in this article are based on both qualitative and quantitative research approaches. The quantitative part provides numerical data, while the qualitative parts extract themes from carefully chosen articles and provide a theoretical foundation for the design-focused creation of mHealth applications.

The research shows that there has been little attention paid to the usability of mHealth applications in real-world settings, and that the field is still in its infancy when seen from a design viewpoint. Some research procedures lack empirical evidence, while some research approaches lack paradigmatic consistency. The practical and case study approach of current research on mHealth design is very advantageous. Improvements are needed in evaluating data collection techniques, units of analysis, and theoretical frameworks. The literature's research focus over the past five years underscores prevailing trends and patterns within the discipline (see Figure1).

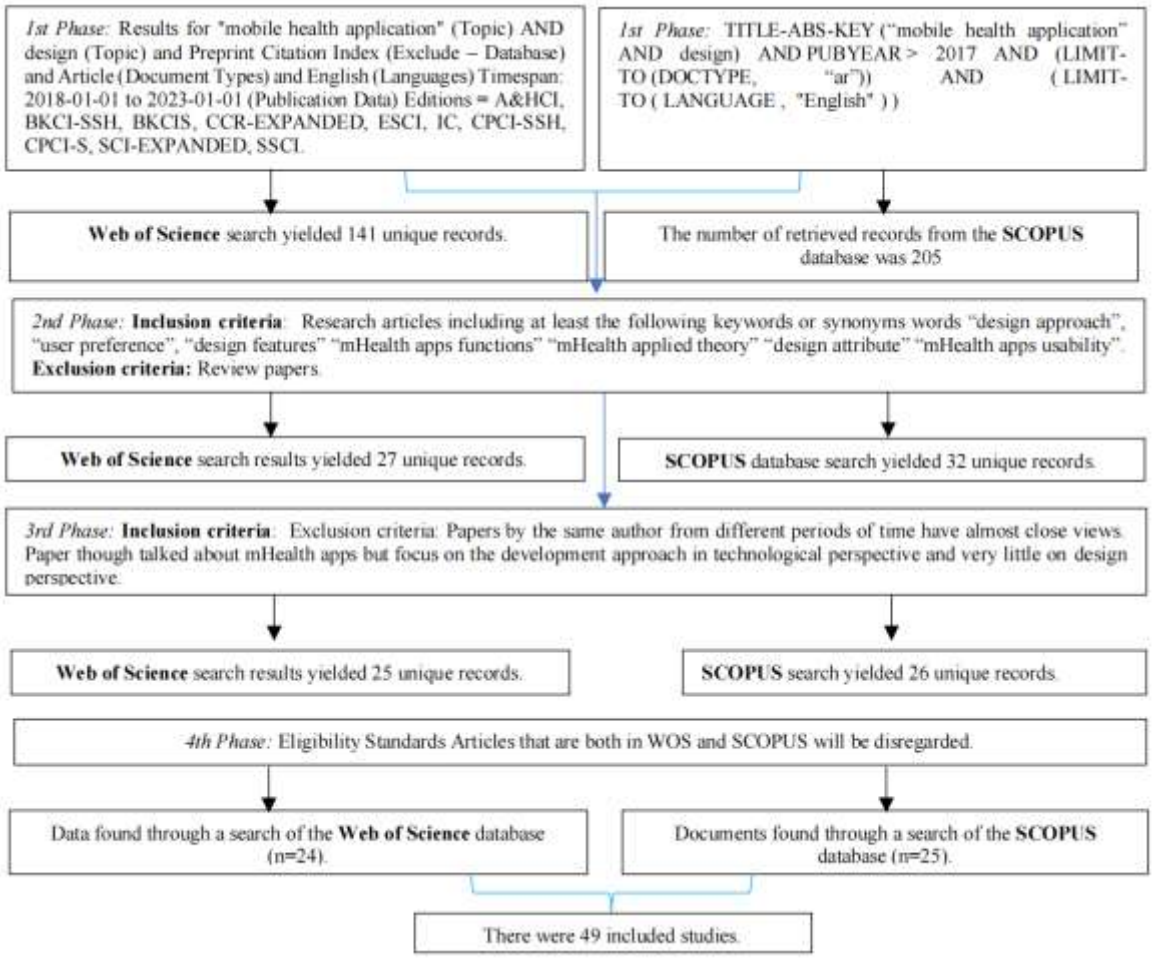

Figure 1: Inclusion/exclusion criteria used to choose papers for theme analysis review

3. Results and Discussion

This section will summarise the theme analysis's key findings. This study examines quantitative and qualitative trends and patterns in mHealth application design literature and studies. A quantitative word cloud analysis of the first 49 sentences is shown in Table 2. A quantitative word cloud analysis of the first 49 sentences is shown. The distribution of these publications by country, number of articles published, and publishing status by year are examined next.

This section summarises theme review's key results. This research examines how prior studies and papers have approached mHealth application development. The outcomes are quantitative and qualitative. The quantitative component begins with a word cloud from the 49 primary texts. The frequency of articles in different journals, geographic distribution by publishing country, and yearly distribution are next examined.

Table 2: Thematic review of mHealth apps from 2018-2023

	2018	2019	2020	2021	2022	2023	TOTAL
Applied Theory	2	1	3	5	2	1	14
Functionality Features	12	8	18	18	12	12	80
Design Strategy	4	17	23	27	21	22	114
Design Elements	15	14	47	27	13	10	126
TOTAL	33	40	91	77	48	45	334

During the subsequent qualitative analysis, a total of 19 initial codes were generated to review the 49 articles, capturing various trends and patterns. Through iterative rounds of re-coding and merging of codes within ATLAS.ti 23, four distinct and noteworthy themes were ultimately identified and summarized from the observed trends and patterns (as indicated in Table 2).
The fundamental objective of this study is to learn about the process used to create mHealth app design strategies, as stated before. Despite the amount of research on mHealth app development, there are few review studies on design approach opinions and multidisciplinary crossovers. From designing the study through assessing the data, the research plan is well-organized and based on earlier studies.

3.1 Quantitive Results

The most prominent words shown in the word cloud during the preliminary analysis reflect their frequency of recurrence in the texts. Notably, in Figure 2, the words that stand out from the 49 papers are "design," "mobile health app," and "user." These high-frequency words captured from the 49 papers encompass "app" (appearing 3461 times), "health" (mentioned 2979 times), "user" (mentioned 2378 times), "design" (mentioned 1979 times), and "mHealth" (mentioned 1674 times), respectively.

Figure 2: 49 articles used to create this word clouds

Figure 3 depicts the results of one of our analyses that shows the different publications that mHealth app development researchers selected to publish in. According to the report, "*International Journal of Environment Research and Public Health*" is the most popular with "*Digital Health*" and "*JMIR MHEALTH AND UHEALTH*". As started earlier, if "mobile health application" was the only key words used in the search, there would be ten thousand of articles. However, the results are much narrowed and targeted when the search is limited to "mobile health application" AND "design," indicating that there is still much to learn about this emerging field.

Figure 3: Number of articles per periodicals

The geographical dispersion study demonstrates that mHealth applications are growing in popularity in the United States (see Figure 4 and Figure 5). the most publications in the last five years. Many of these publications talk about how applied theory may be utilized to create mHealth apps. This can be seen in Eaves et al., (2023) and Brewer et al., (2022), integrating user centered design strategy into mHealth apps development process to improve the evidence-based contents and iterative it to enhance users' self-efficiency towards improving end-users satisfaction and support from society(Arevian et al., 2020; Brewer et al., 2022; Connor et al., 2018; Joshi et al., 2019; Sonney et al., 2019; Tsangaris et al., 2022). Additionally, another argument is that the human-centered design strategy could engage users' preference into the development of mHealth apps to make the visualization data towards improve mHealth apps usability(Bonet Olivencia et al., 2022; Greer & Abel, 2022, 2022; O'Brien & Rosenthal, 2020). However, the viewpoints from Erguera et al., 2019; Gunter et al., 2018; Mehta et al., 2021; Saberi et al., 2020 stated that integrating health change behavior theory into the development of mHealth apps can change users' health behavior and improve their adherence. Jordan was next contributing 4 papers. In Alsswey et al., (2020) through implanting the relevant cultural aspects while developing mHealth applications could enhance the adherence of elderly users with mHealth apps. He emphasized in a subsequent study he conducted in 2021 that a system's usability can be improved by catering to the tastes, differences, and needs of the target audience. All the research refers to user satisfaction on UI design(A. Alsswey & Al-Samarraie, 2021).

The academic literature on mHealth app design reveals significant themes. The original code generated 19 traits but merging and renaming left four themes. Four subjects are design strategy, functionality features, applied theory, and design components. Topics will be fully discussed in the upcoming qualitative section.

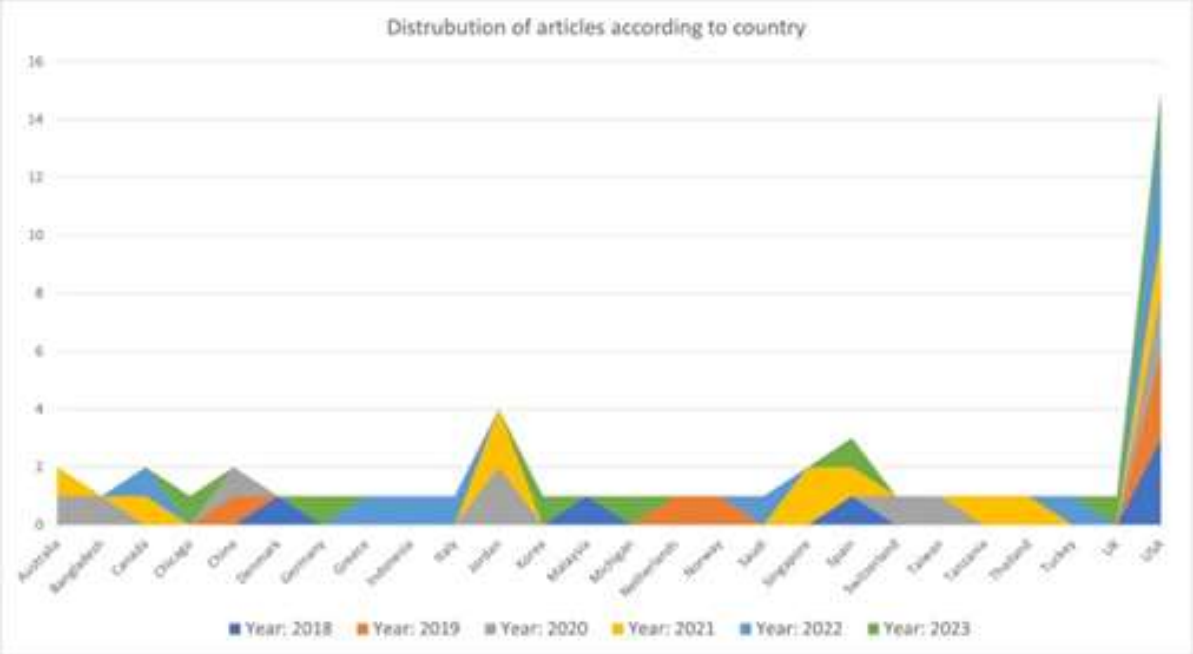

Figure 4: Distribution of papers based on the nation of publication

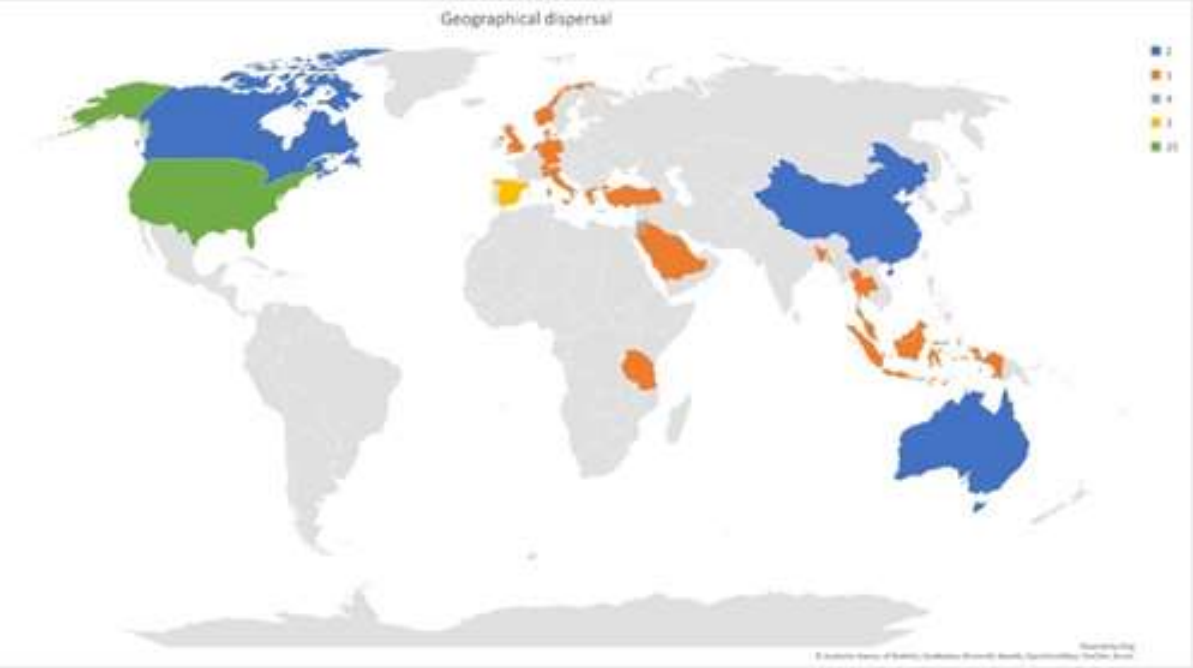

Figure 5: Articles sorted by publishing nation.

3.2 Qualitative Results

This section will discuss the four main topics from the qualitative analysis to answer the research question. As noted, thematic analysis of various publications and frequency distributions revealed these four themes. It is striking that these five topics overlap across the articles in this evaluation. Many works mix topics, and vice versa. Each issue will be extensively covered individually to directly answer the research question. Figure 6 shows a high-level perspective of the mHealth application design challenge.

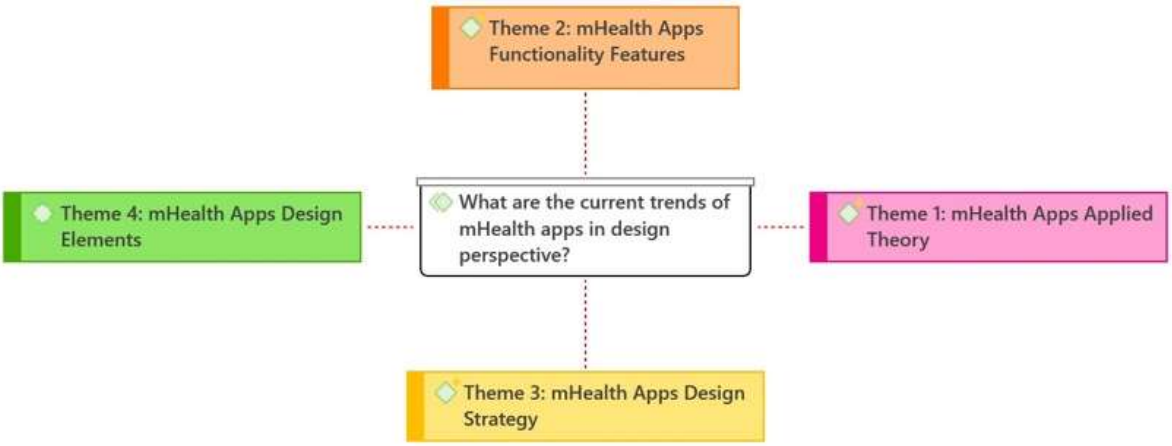

Figure 6: overall network for mHealth apps development in design perspective

3.2.1 mHealth Apps Applied Theory

As is shown in Figure 8, the recent studies from 2018-2023, mHealth Apps applied three kinds of theories to guide users' behaviors, they are self-efficacy theory (Connor et al., 2018; Meedya et al., 2021; Mehta et al., 2021), user acceptance theory (A. Alsswey et al., 2018; Dunn Lopez et al., 2021; Fernández-Gutiérrez et al., 2023; Islam et al., 2020; O'Brien & Rosenthal, 2020), and health behavior change theory (Brewer et al., 2022; Erguera et al., 2019; Krmpotic et al., 2022; Rathnayake et al., 2021; Saparamadu et al., 2021; Surendran et al., 2021) .

i. Self-efficacy theory

A person's perceptions of their ability to organize and carry out the processes required to accomplish certain kinds of performance are referred to as self-efficacy(Bandura, 1986). Computer use is simpler and less resistant with more self-efficacy. A mobile health app may easily substitute the PC in this situation, as was done in this study to obtain information on how people perceive they can use mHealth applications(Balapour et al., 2019).

According to recent 5 years studies, some of the studies applied the theory into mobile health apps to engage end users' use intention. In Meedya (2020) and Connor (2018) research, they both use the same theory of self-efficacy to affect user's attitudes towards enhancing user's intention and actual behaviors. However, according to Mehta (2021), the self-determination theory could be used in supporting users' autonomy and then to improve adolescent medication adherence. All the points that discussed above are to enhance end users' adherence and useful attitude. In somehow, the self-determination theory will enhance the self-efficacy. In this level, our research was agreed with Mehta(2021) research because it can furtherly explain patients' intentions to adopt mHealth apps(Carter et al., 2020).

ii. User acceptance Model

Among the various theories, the Technology Acceptance Model (TAM) stands out as the most influential and frequently utilized framework to elucidate an individual's willingness to adopt information systems (Lee et al., 2003)

In this content, user acceptance model is a general concept of the technology acceptance model (TAM) (see Figure 10), Theory of Acceptance and Use (UTAUT) model. In mobile health apps development research areas, many studies applied this theory to predict users' behavioral intention and then improve the usability of mHealth apps, such as O'Brien (2020), Dunn Lopez (2021), and ALsswey (2018). However, using UTAUT, Islam et al. (2020) established a theoretical model that predicts the behavioral intention of senior adults in Bangladesh to

embrace mHealth applications. All the three authors' research objective are to increase the perceived ease of user for mHealth apps through TAM. Our study provided support for their work because user approval is a crucial component of the adoption of mHealth-based interventions Fernández (2023).

iii. Behavior Change Theory

Using mHealth apps for public health and medical treatment has changed human lives in recent years. To improve lifestyle habits and chronic disease treatment, reminders, counselling, encouragement, and education have been utilized to increase application adherence. The aforementioned procedures are often referred to as behavior change techniques (BCTs) according to Aguiar et al. (2022).

Popular ideas like behavioral change theory are utilized to modify end users' health behaviors. Rathnayake (2021) suggests using adult learning theory into mHealth app development to engage adult learners like dementia careers. Saparamadu et al. (2021) also suggested using a mental model to modify healthcare behavior, which Surendran et al. (2021) found to be effective in motivating pregnant women to change their behavior by recognizing their health risks. As a particular group, pregnant women are attentive to their bodily and fetal health, supporting Surendran (2021) research. The second study by Brewer et al. (2022) used social incentives in the app to encourage healthy behavior. Daily fruit and vegetable consumption. Erguera et al. (2019) developed mHealth applications for AIDs patients using behavioral skills model to engage users and enhance adherence. Krmpotic et al. (2022) utilized behavioral economics to design mHealth applications for adolescents with type 1 diabetes that incorporated process-driven incentives. However, Spohrer et al. (2021) noted that mechanisms from one hypothesis may restrict the effectiveness of mechanisms from another. Thus, mHealth solution developers should be cautious while combining behavior modification methods.

Finally, these three mobile health app design concepts overlap. Information system acceptability is described by technology acceptance model. Self-efficacy will increase if someone quickly adopts mobile health app technologies, such as information structure, language, culture, etc. A positive experience might motivate people to change their health habits.

3.2.2 mHealth Apps Functionality Features

mHealth applications benefit chronic illness management, human health management, and wearable health devices. Many scholars have studied mHealth app health management capabilities in the last five years. However, few researched group persons. This conversation will highlight issues from the perspectives of adults, children, and the elderly.

i. Adults Group

Because of the large percent group among mHealth apps adults group users more research appeared in this target group. According to recent studies, the functionality of mHealth apps for adults are chronic disease management, such as Kidney Transplant Recipients (O'Brien, 2020), heart failure (Fernández, 2023), Seizure Management (Lazaro, 2023), health management, and even the health information for special people groups pregnant female, such as breastfeeding support (Meedya, 2020), Gestational Diabetes Mellitus(Surendran, 2021), cardiovascular mHealth intervention(Brewer, 2022), Perinatal Health Information(Connor, 2018), other target people like for health professional (Saparamadu, 2021), and family caregivers (Rathnayake, 2021).

Over the last five years, design research has focused increasingly on pregnant women and health management. It may be deduced that women are the most likely target demographic to seek health information and management via mobile health, and there is need to learn more about pregnant women's user preferences and experience in designing mobile health applications.

ii. Children and adolescents' Group

Erguera et al. (2019) initiated a pilot study procedure to design a mobile health app that increases medication adherence and HIV care involvement in young people. He stated the WYZ behavioural intervention strategy would promote teenagers' medication adherence self-efficacy and reduce medical professional contact barriers. Expanding his study, Mehta (2021). In his transdisciplinary research, Mehta (2021) developed mHealth applications to improve adolescent medication adherence. He found that the Med Venture, which includes patient and healthcare professional input, may improve mHealth applications like a game-based app to assist teenagers plan and adhere. However, the first author stated that healthcare professionals prefer mHealth applications that engage adolescent groups to create good health habits rather than creating user-provider connection, which would need more labour. Krmpotic (2022) advised implementing process-driven incentives in mHealth applications for type 1 diabetic adolescents to encourage self-monitoring.

iii. Elderly Group

In the recent half-decade, there has been minimal mention of mobile health apps catering to the elderly from a design perspective. A. Alsswey et al., (2018) conducted research exploring the acceptance of culturally tailored user interface design for mobile health applications among Arab elderly users. He emphasized that perceived ease of use and users' attitudes toward using the interface significantly influenced their intention to engage with the mobile health application. However, the study did not account for age-related variables. A. Alsswey et al. (2022) expanded on this theoretical premise by doing further study on the adoption of mHealth user interface design among older users, taking into account cultural influences and the moderating effect of age. In the succeeding research, he emphasized the important influence of age on the link between the interface's utility, usability, and propensity to use it.

3.2.3 mHealth Apps Design Strategy

According to Ludden et al., (2008) design strategy is a design process to make customers or end-users satisfied with the product user experience. Thus, through the recent 5 years study, design strategy can be divided into five kinds, they are user- centered design, participatory design, Co-design, and multidisciplinary. Among them, user-centered design is the most popular applied design strategy in mHealth apps area.

i. Co-design Strategy

Co-design, which allows the development of solutions that suit the real requirements and preferences of the relevant stakeholder groups, is a viable method for solving some of these challenge (Amann et al., 2020; Ramli et al., 2018).The recent five years studies presented offer insights into the use of co-design processes for developing mobile health applications, particularly in the context of breastfeeding support, dementia care, HIV testing, and spinal cord injury prevention.

The breastfeeding support study's co-design methodology includes various phases and the project team's knowledge and experiences. Although this technique may have led to a complete application, it is unknown how well it meets real-world breastfeeding demands and health

consequences. In a dementia caregiver mHealth app, Rathnayake (2021) demonstrated the advantages of co-design. End-user and stakeholder experiences ensured a complete prototype. The requirements assessment phase produced excellent insights, however the research did not show how these insights enhanced caregiver functionality and practical advantages. Saberi et al. (2020) examined mHealth apps for House Ball and Gay Family groups. Co-creation underlined the need of knowing end-users' technology engagement and interaction to adapt solutions. The dearth of knowledge about continuous upgrades and enhancements implies difficulties responding to shifting technology and societal contexts. The research above highlight co-ability design's to satisfy real-world requirements and preferences, increase trust, and improve intervention effectiveness. They also emphasise the necessity for thorough clinical studies to determine how these apps affect health outcomes and behaviour change. Future studies must fill this gap.

In conclusion, co-design is a viable method for mobile health app development that engages users and provides appropriate solutions. However, comprehensive clinical studies are needed to prove its health benefits. Researchers and developers should consider these crucial factors to guarantee the success of future mHealth co-design efforts.

ii. **User-centered Design Strategy**

User-centered design (UCD) or Human-centered design (HCD) is the primary design methodology used in the creation of mHealth applications, according to recent five-year study. User-centered design once be integrated with participatory design to applied into developing mHealth apps for health professionals (Saparamadu, 2021). "User-Centered Design" (UCD) is an approach to design where people have an influence on how a design evolves (Abras et al., 2004). The reason why user centered design strategy applied so widely in developing mHealth apps is that it can provide so many advantages, such as enhance users' engagement(Hantgan & Jariwala, 2023; Tang et al., 2019), broke ice-berg among teams(Pinnarong et al., 2021), transform the way to deliver care(Erguera et al., 2019; Tsangaris et al., 2022), provide key and professional contents(Renati et al., 2022), and optimize the usability of mHealth apps(Hantgan_Jariwala, 2023; Renati et al., 2022). The most general advantage is to meet users preference and needs（Pinnarong, 2021; Eaves, 2023; Hantgan_Jariwala, 2023; Sonney, 2019; Mathur et al., 2021; Joshi et al., 2019) (see Figure 17). However, few of the studies mentioned the validation in real context of the mHealth apps. Futher studies need to fill this gap.

iii. Participatory Design Strategy

Participatory design (PD) methods involve ongoing user interaction and a thorough grasp of the healthcare situation(Ravn Jakobsen et al., 2018)**.** The cornerstone of participatory design, which blends action research with qualitative research methods to enhance practice, is action research (KUSHNIRUK, 2016). Research on women's experiences with mobile health apps was carried out by Ravn Jakobsen et al., (2018) after getting a diagnosis of subclinical osteoporosis. He highlighted how the participatory design approach allows women to freely express their ideas and how easily self-management is supported by mHealth apps. Despite the fact that the research provides user feedback on the mHealth app user experience, it only tests a limited sample size. Similar research was done by Arevian et al., (2020) to improve community resilience using participatory technology development. He emphasized that participatory design was used to establish a culture of co-leadership, and that the development of mHealth apps involves all relevant parties. In order to create a mHealth apps for east African urban at-risk populations to prevent HIV, Mauka et al., (2021), performed research utilizing a participatory design technique. He emphasized that the participatory design method is helpful in developing and testing functional aspects that are specific to populations, improving

usability, and assuring long-term health impacts. It was not, however, tested in a real-world setting.

In conclusion, participatory design seems to be a potential strategy for developing more efficient and user-friendly mobile health apps that meet the specific requirements of various communities. Future research should focus on expanding the scope and scale of these studies to drive meaningful and sustainable health improvements in different contexts.

iv. Multidisciplinary and Transdisciplinary Design

A way of problem-solving and innovation that transcends conventional discipline boundaries is the transdisciplinary design (TD) approach. It entails assembling specialists from a range of disciplines, including design, engineering, social sciences, the arts, technology, and more, to work cooperatively on challenging problems. In mHealth app development area, multidisciplinary design approach means that all stakeholders participate into the design process, such as healthcare providers, end-users, mHealth developers, and even designers. In this way, all the stakeholders can contribute their knowledge and professional experience into the design process. Mehta (2021) used a multidisciplinary design (MD) approach and academic-industrial partnership to undertake research for a mobile health application to improve adolescent medication adherence. He highlighted that the multidisciplinary design approach can facilitate the youth group to the medication adherence. In a similar vein, Mayoral et al. (2021) did study on using smartphone apps to monitor asthma in children and adolescents. He highlighted that the multidisciplinary design approach can improve the usability of mHealth apps. However, both researches only focusses on the multidisciplinary design process of mHealth apps, and also only focus on the youth and adolescents' group. Thus, further research must fill this gap.

Transdisciplinary design involves professionals working together, similar to multidisciplinary design. Teamwork aims to break down boundaries and co-create the same design language for success. According to Fernández-Gutiérrez et al., (2023), like multidisciplinary design, transdisciplinary design involves cross-disciplinary professionals working together. The goal of collaboration is to break down boundaries and co-create the same design language for success. Multidisciplinary and transdisciplinary mHealth app development may engage users' adherence. These tactics prioritise end-user demands, building sophisticated, valuable, and user-friendly programmes. Developers, healthcare professionals, and app users co-create to diversify design. User-centered design focuses user needs through exploring and iterating feedback. Participatory design involves clients in app development decisions. Finally, interdisciplinary app design uses subject expertise. To improve user experience and address real-world healthcare issues, mHealth applications require these tactics. Balance user preferences with technical capabilities and scalability for maximum effect and acceptance.

3.2.4 mHealth Design Elements

Mobile health design components are the fundamental ideas and concerns for creating mobile health apps and solutions. These features are essential for user-friendly, effective, and interesting mHealth. According to recent 5-year research, mHealth design aspects include reliability, simplicity of use, personalization, usefulness, interactivity, gamification, and evidence-based information.

i. Reliability

Reliable in mHealth apps can be applied in terms of the content, functionality, and the private information data. According to Pinnarong et al., (2021), he emphasized that accurate

information from dependable sources and the proper posture for physical activity were the crucial factors to take into account based on a study of the information provided by the pregnant women. For pregnant women, the reliable information or content source means the correct and validate directions to guide their health care behaviors. Thus, it plays vital role for them and for someone who need this kind of mHealth apps. Additionally, according to Saberi et al. (2020), the co-creation process may provide important insight into how end users engage with and interact with technology, which can lead to timely and applicable solutions to clinical issues and perhaps enhance clinical outcomes.

However, Connor (2018) argued that while co-design or participatory methods that involve all stakeholders in the design process are reasonable, providers should continue their discussions with women about app information, recommend reputable mHealth apps from reputable sources, and periodically check the app content for accuracy.

ii. Ease of Use

Wildenbos et al., (2019) identified 'usability' as the key determinant influencing the acceptance of technology among older individuals, specifically referring to the ease of using the user interface. This finding finds corroboration in the study by Meedya (2020), where a well-designed, structured, interactive, and user-friendly mobile health application was deemed to effectively serve the needs of breastfeeding women. On the other hand, O'Brien and Rosenthal (2020) stressed that the notion of perceived ease of use relates to the degree of trust that users place in the technology's seamless operation.

iii. **Personalization**

Joshi et al., (2019) conducted a study focusing on a human-centered methodology for creating a dietary application tailored for patients with metabolic syndrome. Their findings emphasized that the process of personalizing the app should encompass details related to medical considerations, individual characteristics, personal preferences, and weight tracking. Furthermore, enhancing the personal significance of mobile health solutions through customization is seen as a potentially effective strategy for encouraging adoption.

iv. Usefulness

According to Alsswey's study from 2021, usefulness is the degree to which Arab senior consumers find using mHealth app user interfaces to be beneficial or helpful. In research using mixed methods, Surendran et al. (2021) investigated how women used mobile health applications for treating gestational diabetes mellitus and how beneficial they thought they were. Their findings highlighted that the inclusion of weight tracking in these apps could rapidly induce a sense of self-awareness in dietary choices and incentivize desired behavior, rendering them user-friendly for women. Nevertheless, it should be noted that the real-world applicability might still be lacking.

v. Interaction

Users' ability to browse mHealth apps is crucial to their success. This depends on the app's functionality and user interface. Alsswey (2018) confirmed that users intuitively employ culturally relevant technology and interfaces. Mauka (2021) created an HIV prevention software for vulnerable East African towns via participatory design.

The research found that an innovative interactive mHealth software might improve health information and services for these areas. Mauka (2021) stressed the positive influence of interface design on mobile health platforms offering evidence-based health information.

Therefore, evidence-based mHealth applications are incorporating interactive design into their primary functions.

vi. Gamification

The use of gamification was intended to stop app abandonment and increase user engagement. In Mehta (2021) study, he shows that the players can unlock new features, complete challenges, and earn points, it shows the adherence of users using mHealth apps. Further, in Fernández (2023) emphasized that a learn-while-you-play gamification technique might improve users' information and expertise obtained via mHealth applications.

vii. Evidence-based information

By combining evidence-based healthcare with evidence-based technology, evidence-based information can create trustworthy sources of information for mHealth apps for users (Istepanian & AlAnzi, 2020). This was supported by Meedya, et al. (2021), which followed the states' co-design creation process and could give clinical experience-confirming information like clinical suggestions. They stressed the need of leveraging evidence-based resources to produce the application's evidence-based content. Tang (2019) did a pilot research with ambulatory surgical patients to determine their mobile health app preferences and requirements. He noted that patient preferences may help create evidence-based mHealth applications for ambulatory surgical patients.

viii. User Interface (UI)

ALsswey (2018) argues that the success of mobile apps, technologies, and goods depends on their user-friendly interfaces. Thus, user interface is very important because it can be the direct impact on the users' experience. It can be seen from the UI that colors, icons, and structure.

ix. Colour

Blue, white, pink, light blue, and green were the most common hues used in the user interface of mHealth apps, accounting for a total of 70%. Other app interfaces, however, were a kaleidoscope of hues that distracted users from the app's basic function (Pinnarong, 2021).

x. Icon

Icon or button icons is the symptom of the mHealth apps functionality, it acts as the gate or entrance role of the mHealth apps. Generally, people all over the world has same reorganization on the symbol of graphic, such as the traffic safety signs. The significance of icons and symbols in UI design was, however, highlighted by A. Alsswey and Al-Samarraie (2021). (UI). It's common practise to utilise icons to communicate the capabilities of a system without resorting to text.

xi. Structure

The usefulness of mobile health applications will be affected by the design of their user interfaces (Pinnarong, 2021). Touch and slide options provide a similar experience, allowing users to easily get to the content they need by touching or swiping the menu, sub-menu, icons, or links (Rathnayake, 2021).

xii. **Usability**

Usability is one of the most important elements in determining whether mobile technologies, and particularly mobile health applications, are adopted. A useable programmed will be simpler for people to use and understand, and their interaction with it will be improved (Cruz Zapata et al., 2018).

In this collection of mHealth app usability studies, evidence-based information and user-centered design are recognised, although numerous crucial issues are unexplored or underemphasized. Meedya's research reveals that persuasive system design models provide evidence-based information for mHealth applications, but long-term usability is a worry. O'Brien's kidney transplant recipient study has highlighted usability qualities that require improvement, but it needs real-world testing. The Renati study shows promise in usability, efficacy, and caregivers' overall satisfaction as they manage with their loved ones' addiction. Without actual-context testing, its application in real life is uncertain. Wildenbos's geriatric usability testing also highlights motivational and cognitive barriers.A user-centered design technique with evidence-based content and social science ideas to improve user adherence is stressed in the paper. In approaching years, these mHealth app development trends will be prevalent. This opens up study on mHealth app design strategy for future academics.

4. Conclusion and Future Study

This report reviews 49 papers on mHealth app design from 2018 to 2023 using two methods. The data analysis results answer the study question on mHealth apps development publishing patterns and trends over time. The quantitative technique uses ATLAS.ti 23 visual data. Despite increased attention to the topic, there are no design-oriented review publications on mHealth app design methodologies. Qualitative analysis shows two tendencies. The first trend is designing mHealth applications to improve user preference and usability. The second trend is to apply behavior change theories to improve mHealth app user adherence. The studies revealed disconnected conceptualizations, a lack of theoretical foundations and research methodologies, and a preference for research-based approaches over practice-based ones. These considerations make mHealth app design techniques unclear. The paper emphasizes the need of user-centered design, evidence-based information, and social science ideas to increase user adherence. These directions will dominate mHealth app development in the future. This opens the door for future researchers to study mHealth app design strategy.

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