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Abstract:

Mobile health (mHealth) systems hold great potential for supporting users in self-managing disease and engaging in a healthier life. However, given the mobile context and the multiple factors that affect a person's health, designing mHealth systems involves much complexity and a range of pitfalls. To overcome these pitfalls, scholars have called on system designers to employ a co-design approach; that is, to involve stakeholders in all phases of the design process. However, the literature on how, when, and why designers use co-design in mHealth remains scant. To address this gap, we systematically reviewed 61 studies that co-designed mHealth systems. Our results show that co-designing mHealth systems constitutes a fragmented and rapidly evolving research field with only limited overlaps and a strong focus on the early design phases (i.e., pre-design, generative). Thereby, the co-designed artifacts cover various application contexts in disease management (e.g., heart disease, diabetes) and health promotion (e.g., physical activity, nutrition) and a diverse group of involved users, healthcare professionals, and system designers. Finally, guided by Sanders and Stappers' (2014) co-design framework, we provide a concise overview of the most widely used methods in the different co-design phases.

Keywords: Co-design, Literature Review, mHealth.

E. Vance Wilson was the accepting senior editor for this paper.

1 Introduction

Mobile user devices' ubiquity and increasing capabilities have created new opportunities for delivering health services. We define mobile health (mHealth) as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" (World Health Organization, 2011, p. 6). mHealth systems can support users in 1) disease management (i.e., helping users better self-manage a disease, such as diabetes, stroke) and 2) health promotion (i.e., helping users engage in healthier lifestyle habits that reduce their individual risk of disease (e.g., increased fruit and vegetable intake, smoking cessation). However and notwithstanding the opportunities, when designing an mHealth system, one often faces much complexity and various pitfalls such as limited stakeholder involvement (Burke et al., 2015), lack of mHealth artifact interaction with the other health systems (Winters, Oliver, & Langer, 2017), and low use of empirically supported behavior-change strategies (Burke et al., 2015; Noorbergen, Adam, Attia, Cornforth, & Minichiello, 2019).

In order to overcome these pitfalls, scholars have suggested applying the co-design approach to mHealth systems (e.g., Burke et al., 2015; Eyles et al., 2016; Slater, Campbell, Stinson, Burley, & Briggs, 2017; Winters et al., 2017). Co-design, which researchers sometimes also refer to as participatory design (Kensing, 2003; Kensing, Simonsen, & Bodker, 1998), refers to the "creativity of designers and people not trained in design working together in the design development process" (Sanders & Stappers, 2008, p. 6). Researchers believe that using co-design in developing mHealth systems could support system designers in better involving stakeholders in the design and, thereby, contribute to improved mHealth applications (Burke et al., 2015). However, despite repeated calls from researchers to use co-design in mHealth studies, there is a dearth of coherent understanding on the scope of empirical mHealth studies that have actually used co-design in terms of 1) the targeted disease management and/or health promotion context, 2) the involved stakeholder groups, and 3) the methods they used in the different co-design phases. In this paper, we help close that gap by addressing the following overarching research question:

RQ: What is the current state of research on co-designing mHealth systems for disease management and health promotion?

To address this question, we conducted a systematic literature review spanning multiple disciplines¹ to identify empirical studies that employed co-design methods in developing mHealth artifacts for disease management and/or health promotion. While extensive research has examined general frameworks and methods used in co-design, research on how co-design has been applied in the context of mHealth is sparse and highly fragmented. Hence, we provide an overview of empirical studies that have used co-design for developing mHealth systems and map the co-design activities carried out in these studies to a well-established co-design framework. Specifically, we build on Sanders and Stappers' (2014) framework, which breaks down the co-design process into four interconnected phases (pre-design, generative, evaluative, and post-design) and has emerged as one of the most widely recognized resources in the co-design literature.

We make four contributions with this study. First, we comprehensively overview the current state of research on how researchers and practitioners have used co-design in mHealth for disease management and health promotion. While Eyles et al. (2016) overviewed nine mHealth studies that were published between 2009 and 2015, our results show that the field has rapidly evolved with a marked increase in studies since 2015 (77% of the studies in our review appeared after 2015). Second, based on a bibliometric co-citation analysis, we uncover the current body of literature's fragmented nature. In this way, we demonstrate the need to better integrate the literature to help develop common standards and best practices for co-designing mHealth systems. To support this need, we also identify six publications that emerged as the most influential ones based on how frequently the reviewed studies cited them. Third, by directly mapping the reported co-design activities to Sanders and Stappers' (2014) established framework, we concisely overview the methods involved in different phases of co-designing mHealth artifacts. By building on the framework's structure, researchers and practitioners (such as human-computer interaction and health promotion scholars) can use this overview as a shared frame of reference when planning and executing their co-design activities. Finally, we identify gaps in the literature that warrant further investigation.

This paper proceeds as follows: in Section 2, we provide theoretical background on the foundations of co-design, the four co-design phases in Sanders and Stappers' (2014) framework, and co-design applications

¹ The studies we identified in the review come from the computer science, design, information systems, and public health research areas.

in mHealth. In Section 3, we outline our research methodology. In Section 4, we present the results of our literature review with a specific focus on the different phases in the co-design process and the stakeholders and methods involved. In Section 5, we discuss future research avenues and practical implications of this research before concluding the paper.

2 Theoretical Background

2.1 Foundations of Co-design

Since the 1970s, researchers and practitioners have gradually shifted from designing systems *for users* to designing systems *with users* (Sanders & Stappers, 2008). In particular, the user-centered design paradigm acknowledges that one needs to design systems around their users' characteristics and needs. However, scholars have raised concerns that the design process rarely involves actual users but instead relies on domain experts' opinions and experiences (Sanders & Stappers, 2008). Against the backdrop of increased system complexity and issues related to poor user interface design, researchers and practitioners have recognized the critical role of user experience in successful technology adoption (Pralhad & Ramaswamy, 2004). Hence, following the notion that users represent experts in their own experiences, research has called on researchers and practitioners to actively involve users in the design process (Sanders & Stappers, 2008).

Co-design—as Sanders and Stappers (2008, p. 6) describe it—refers to “the creativity of designers and people not trained in design working together in the design development process”. It has its origins in the social-democratic workplace relations of 1970s Scandinavia where practices of participatory design were developed to mitigate the threat of deskilling workers with the advent of computerized systems (Ehn, 1993). Ehn (1993, p. 41) elaborates that participatory design had a political nature because it raised “questions of democracy, power, and control at the workplace” by involving workers directly in decisions that impacted them. Yet, the original practices in Scandinavia also focused on design because, as Bødker, Ehn, Sjögren, and Sundblad (2000, p. 22) state, it gave “the end users a voice in design and development of computer support in work places, thus enhancing the quality of the resulting system”.

By directly involving users in the design process, co-design can contribute to capturing users' tacit knowledge and latent needs. Thereby, Trischler, Pervan, Kelly, and Scott (2018) show that co-design can help system designers create artifacts that yield high user benefit and novelty but not necessarily feasibility. Similarly, Steen, Manschot, and de Koning (2011) note that co-design can facilitate a better fit between system design and users' needs and, thus, result in better user experience and satisfaction. In contrast to non-participatory forms of user-centered design (where one usually conducts user testing *after* the design phase), co-design involves defining and solving complex design problems *with* users (Lindström & Ståhl, 2015; Visser, Stappers, van der Lugt, & Sanders, 2005). Thereby, co-design includes various methods that allow stakeholders to express themselves as experts of their own experiences (e.g., cultural probes, paper prototyping, storytelling) (Sanders & Stappers, 2008).

Sanders and Stappers (2008) argue that co-design and conventional user-centered design differ in that conventional user-centered design constitutes a designer-centric (or controlled) process as its focus on end users intends to create a better solution for, but not with, them. Co-design, on the other hand, values users' expertise and recognizes them as partners through “the active and direct involvement of all product stakeholders in and throughout the design process” (Sanders, 1992, p. 53). Co-design views users as experts in how they use the emerging artifacts and acknowledges that they may use them in ways that designers never imagined let alone intended. Following this paradigm, collaboration with users allows system designers to discover users' motivations, understand the contexts of artifact use, generate ideas, and understand users' wishes that go beyond what one can achieve from observations (in the present or past) (Keller, Pasma, & Stappers, 2006).

2.2 Co-design Frameworks

To help researchers and practitioners use co-design in systems development, researchers have proposed various methodological frameworks (e.g., Sanders & Stappers, 2008, 2014; Visser et al. 2005). By creating a conceptual structure of the co-design process, these frameworks provide important guidance as a shared frame of reference for researchers and practitioners. As Sanders and Stappers (2014) note, the increasing number of methods also drove researchers to develop these frameworks: “So many methods, tools and techniques have been introduced that it has become useful to provide frameworks for organizing them” (p. 7). For instance, Visser et al.’s (2005) framework structures the co-design process into five phases: preparation, sensitization, sessions, analysis, and communication. In a different conceptualization, Brandt, Binder, and Sanders (2012) describe an iterative making, telling, and enacting cycle.

Building on these earlier conceptualizations, Sanders and Stappers’ (2014) framework has emerged as one of the most widely recognized resources in the co-design literature (as of May, 2021, it has 581 citations in Google Scholar and 188 in the Web of Science). As Figure 1 shows, the framework breaks down the timeline of the co-design process (shown in blue) into four inter-connected phases: the pre-design phase, the generative phase, the evaluative phase, and the post-design phase. First, the pre-design phase focuses on understanding the surrounding context and people’s experiences, establishing goals for future experiences, and sensitizing participants to the problem space². Following an approach that “values uncertainty”, this phase captures an “open world” notion whereby one sets out to explore tacit knowledge in the actual user context (Gaver, Boucher, Pennington, & Walker, 2004, p. 53). Second, the generative phase focuses on the future and on producing ideas, insights, and concepts that explore the “design space”. Users take an active role in making conceptual artifacts via co-creation (e.g., journey maps, paper prototyping, storyboards) that embody and express ideas about how participants wish to live their future lives. Although the final artifact’s vision remains fuzzy at this point, system designers use these methods to test, transform, and refine “ideas, insights, and concepts that may then be designed and developed” in order to explore their technical and social feasibility (Sanders & Stappers, 2014, p. 10).

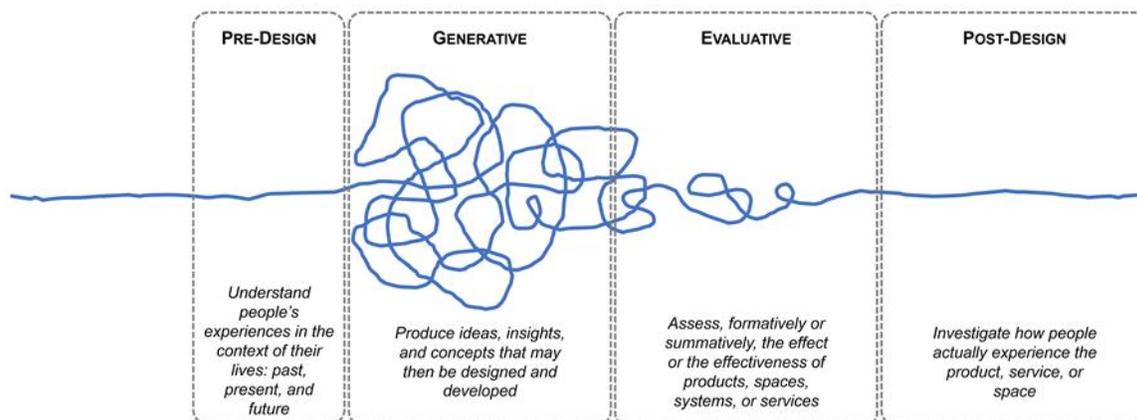


Figure 1. Sanders and Stappers' Co-design Framework (Adapted from Sanders & Stappers, 2014)

Third, the evaluative phase allows users to assess the effects and effectiveness of the devised concepts. Here, the final artifact’s vision becomes more tangible through the evaluation of prototypes that allow for users “to experience a situation that did not exist before” (Sanders & Stappers, 2014, p. 7). Finally, the post-design phase refers to the notion that, once users inhabit a system and it becomes a part of their lived experiences, the system needs to evolve along with their needs, habits, and use patterns. As such, “the tail end of the post-design phase [leads] to the front end of another design process” (Sanders & Stappers, 2014, p. 10). This link between the post-design phase to the front end of another co-design process captures the notion that no designed system is ever complete. Furthermore, note that, while the framework follows an intuitive sequence from left to right, co-design projects can start in any phase (e.g., with an existing prototype

² Note that the pre-design phase also commonly appears outside co-design. In conventional user-centered design, this phase often uses “methods of observation to look for patterns of activity, and general user concern” (Druin, 2002, p. 7). Similarly, the system development lifecycle contains a dedicated problem-identification phase (Kendall & Kendall, 2013). However and in contrast to co-design, during these activities, system designers seek little to no feedback from users about their experience of using objects and technology (Sanders & Stappers, 2014).

that leads to further contextual and generative research similar to the process model functions that Peffers, Tuunanen, Rothenberger, and Chatterjee (2007) describe). In Section 2.3, we build on Sanders and Stappers' (2014) framework to organize the results of our systematic literature review.

2.3 Co-design in mHealth Systems Development

Based on mobile user devices' increasing capabilities and ubiquity, mHealth systems hold great potential for novel ways to deliver health services. Rather than limiting the delivery of health services to specific physical locations (e.g., offices of medical practitioners, specialist clinics), mobile user devices enable immediate access to health services in everyday situations (Nahum-Shani et al., 2018). In addition to the ability to communicate health advice through the user interface, these devices can also enable one to cost-effectively collect and process data that provide insight into the users' everyday activities (e.g., eating habits, physical activity) and health status (e.g., insulin, stress level) using various data-collection methods (e.g., biosensors, cameras, questionnaires; Noorbergen et al., 2019). Based on that data, mHealth systems can respond to users' unique circumstances to support disease management (e.g., diabetes, heart disease) and health promotion (e.g., healthy eating habits, smoking cessation) in a targeted way (Burke et al., 2015; Direito, Carraça, Rawstorn, Whittaker, & Maddison, 2017).

Notwithstanding the opportunities associated with mobile user devices, one needs to recognize that mHealth systems also entail new challenges for system designers. Given the mobile context, the mHealth systems need to smoothly "integrate into users' daily lives" (Bock, Heron, Jennings, Magee, & Morrow, 2013, p. 157). To design such systems, system designers need to profoundly understand users' environment and daily routines that the mHealth systems operate in. The many factors that affect and support a person's health compound this complex environment; as such, these factors require careful consultation with domain-specific stakeholders. Depending on the application context (e.g., diabetes self-management, promotion of healthy eating habits), such stakeholders include domain-specific healthcare professionals with expertise on specific health conditions and physiological mechanisms (e.g., dietitians, endocrinologists) and end users from potentially vulnerable populations (e.g., stroke survivors). Furthermore, mHealth systems' effectiveness commonly relies on a change in users' behavior both for disease management (e.g., adhering to medication regime (Vilarinho, Floch, & Stav, 2017), performing rehabilitation exercises (Davis et al., 2018)) and health promotion (e.g., reducing alcohol consumption (Gustafson et al., 2014), forming healthy eating habits (Dol, Kulyk, Velthuisen, Van Gemert-Pijnen, & Van Strien, 2016)). Hence, when designing mHealth systems, designers need to ensure they clarify the targeted behavior and the strategy that the system follows to facilitate behavioral change (Burke et al., 2015; O'Reilly & Spruijt-Metz, 2013).

Against the backdrop of these challenges, scholars have suggested applying the co-design approach and directly involving stakeholders in designing mHealth systems (e.g., Burke et al., 2015; Eyles et al., 2016; Slater et al., 2017; Winters et al., 2017). However, despite a growing number of studies that have applied co-design approaches in mHealth systems design, the literature lacks reviews on studies that have used co-design for mHealth systems development. In 2016, Eyles et al. (2016) reviewed nine studies published between 2009 and 2015. However, the field has rapidly evolved with a marked increase in the number of studies since 2015 (77% of the studies in our review appeared after 2015). More recent reviews, such as the one that Moore, Wilding, Gray, and Castle (2019) conducted, have focused specifically on disease management and not considered health promotion or the mHealth context specifically. However, as we state above in this section, the mHealth systems context introduces new challenges that require system designers to profoundly understand users' environment and daily routines. As such, to the best of our knowledge, no review has 1) considered both disease management and health promotion, 2) provided an up-to-date mapping between methods (e.g., cultural probes, storytelling) to particular co-design phases in this context, or 3) overviewed the mHealth stakeholders involved in the co-design process.

3 Research Method

In order to establish the current state of research on co-designing mHealth systems, we conducted a systematic literature review following Kitchenham and Charters' (2007) and Webster and Watson's (2002) guidelines and recommendations. As such, we subdivided the review into three stages: plan, conduct, and report (see Figure 2).

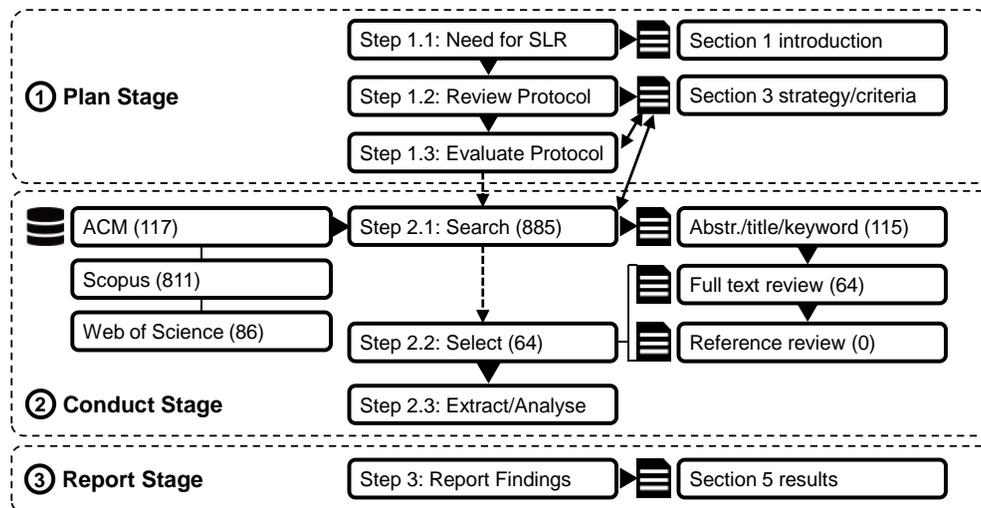


Figure 2. Stages of the Systematic Literature Review Based on Kitchenham and Charters' (2007) Guidelines

3.1 Selection Criteria

In line with our overarching research question, we included only studies that used co-design to directly involve stakeholders (e.g., users, healthcare professionals, system designers) in developing an actual mHealth system for disease management and/or health promotion. Hence, we excluded purely conceptual studies or studies that used co-design to develop a system outside the mHealth context. Also, we included only peer-reviewed book chapters, journal papers, and full-text conference papers in English.

3.2 Search Strategy

In order to develop our search string, we first conducted an initial search on Google Scholar using the search query: ("co-design" OR "participatory design") AND ("mHealth" OR "m-Health"). After reviewing the results, we identified 12 studies that matched the study selection criteria. After reviewing these studies in full, we refined the search string as follows: ("mHealth" OR "m-health" OR "mobile health") AND ("co-design" OR "codesign" OR "participatory design" OR "design game*" OR "storyboard*" OR "cultural probe*" OR "informational probe*" OR "technology probe*" OR "empathy probe*" OR "journey map*").

Given the subject matter's interdisciplinary nature, we decided to conduct the search in three separate databases to cover a broad range of publications (ACM, Scopus, Web of Science). The search covered research published up until the end of 2019. As Figure 2 shows, the main search yielded 885 studies from three databases (after removing duplicates). We then screened the publications based on their title, abstract, and keywords, which narrowed down the set to 115 publications. After screening the remaining papers in full, we identified 61 studies to include in the review.

3.3 Data Extraction

In order to analyze how the studies applied co-design to mHealth systems development, we extracted information on the targeted disease management (e.g., asthma, diabetes) and/or health promotion (e.g., nutrition, physical activity) context and the stakeholders and methods involved in the different phases in the co-design process. To extract this information, we carefully perused each paper with a particular focus on the information reported in the respective method section. Thereby, we extracted the exact wording for the stakeholders and methods and then mapped this information to the four co-design phases in Sanders and Stappers' (2014) framework. The mapping to the four phases was based on our own reading of the paper

using the information reported in the papers and the original descriptions of the phases by Sanders and Stappers (2014). For instance, we mapped research activities as part of “contextual”, “problem identification”, and “requirement elicitation” research to the pre-design phase. Conversely, we mapped activities reported as part of “concept generation” and “generative workshops” to the generative phase. Further, we mapped activities to develop and/or evaluate a “software prototype” to the evaluative phase. Lastly, we mapped activities that mentioned the term “post-design” (e.g., “post-design interviews”; Ahmad et al., 2008) to the post-design phase.

3.4 Bibliographic Analysis

In addition to the information extracted from the papers, we also wanted to examine the level of fragmentation of the literature on co-designing mHealth artifacts and the publications that this field of literature builds on. To do so, we conducted a co-citation analysis to provide insight into the structure of the reviewed publications based on which literature they cite. Specifically, we drew on co-reference coupling, a variation of co-citation coupling, to establish a normalized measure of how “connected” any two papers are based on the overlap in the references they draw on (Osareh, 1996). By doing so, we could also identify the most influential papers that this stream of literature has built on.

4 Results

In our analysis, we first present the number of studies that examined the disease management and/or health promotion contexts. Second, we overview the stakeholders that participated in the co-design process. Third, we overview the co-design methods that the studies employed and map them to the four phases in Sanders and Stappers’ (2014) framework. Finally, we report the results from our bibliometric co-citation analysis to assess the degree to which publications in the field conceptually overlap and display cohesion.

4.1 Application Contexts

As Figure 3 shows, the number of studies that have used co-design methods to design mHealth systems has significantly increased over time (61 papers in our review compared to nine papers in Eyles et al. (2016)). In fact, most studies appeared after 2015 (47). Thereby, we can observe that most studies focused exclusively on either the disease management context (38 studies or 62.3%) or the health promotion context (22 studies or 36.1%). Only one early study from 2010 focused on both contexts.

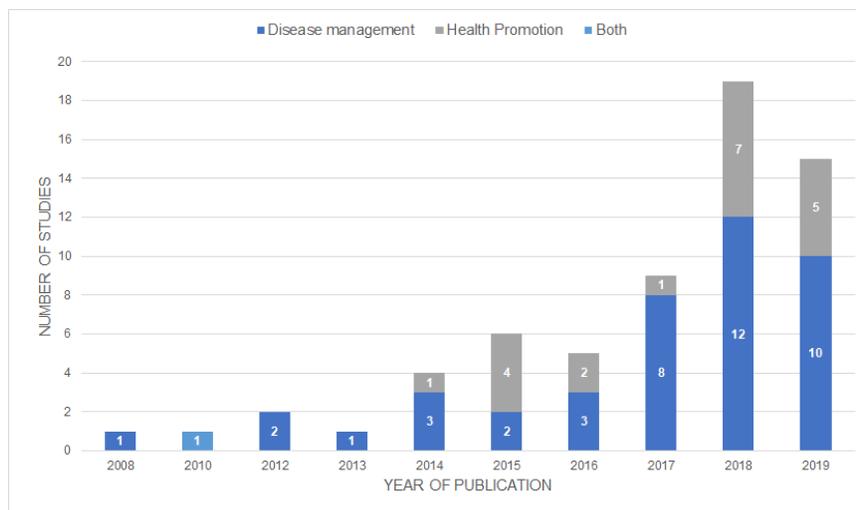


Figure 3. Empirical mHealth Papers that Use Co-design Over Time

Table 1 shows the specific areas in disease management and health promotion that the studies addressed. The studies in disease management primarily focused on heart disease (8), diabetes (5), asthma (3), home-based healthcare (3), and bipolar disorder (3). Conversely, the studies in health promotion focused on physical activity (6), mental health (6), nutrition (5), and smoking cessation (2).

Table 1. Specific mHealth Areas that the Reviewed Studies Investigated

Context and area (# of studies / % of total)	References
Disease management (39 / 63.9%)	
Heart disease (8 / 13.1%)	Andersen et al. (2017), Woods, Cummings, Duff, & Walker (2017a, 2017b, 2018a, 2018b), Woods, Duff, Roehrer, Walker, & Cummings (2019a), Woods, Roehrer, Duff, Walker, & Cummings (2019b), Woods et al. (2019c)
Diabetes (5 / 8.2%)	Castensøe-Seidenfaden et al. (2017, 2018), Kanstrup (2014), Ledderer, Møller, & Fage-Butler (2019), Shin & Holtz (2019)
Asthma (3 / 4.9%)	Davis et al. (2018, 2019), Peters et al. (2017)
Home-based healthcare (3 / 4.9%)	De La Harpe (2012, 2014), De La Harpe, Lotriet, Pottas, & Korpela (2013)
Bipolar disorder (3 / 4.9%)	Bauer et al. (2017), Matthews et al. (2015, 2016)
Osteoarthritis (3 / 4.9%)	Danbjørg, Villadsen, Gill, Rothmann, & Clemensen (2018), Jakobsen, Hermann, Søndergaard, Wiil, & Clemensen (2018b, 2018a)
Cancer (2 / 3.3%)	Lipson-Smith et al. (2019), Veale, Dogan, & Murphy (2019)
Depression (2 / 3.3%)	Bauer et al. (2017), Løventoft, Nørregaard, & Frøkjær (2012)
HIV (2 / 3.3%)	Marent, Henwood, & Darking (2018a), Marent, Henwood, Darking, & EmERGE Consortium (2018b)
Schizophrenia (2 / 3.3%)	Terp, Jørgensen, Laursen, Mainz, & Bjørnes (2018), Terp, Laursen, Jørgensen, Mainz, & Bjørnes (2016)
Stroke (2 / 3.3%)	Aljaroodi, Adam, Chiong, Cornforth, & Minichiello (2017), Balatsoukas et al. (2019)
Other (6 / 9.8%)	Ahmad, Komninos, & Baillie (2008), Arslan et al. (2010), Bauer et al. (2017), Das, Bøthun, Reitan, & Dahl (2015), Grosjean, Bonnenville, & Redpath (2019), Vilarinho et al. (2017)
Health promotion (23 / 37.7%)	
Physical activity (6 / 9.8%)	Capel, Schnittert, Snow, & Vyas (2015), Dol et al. (2016), Ni Mhurchu et al. (2019), Partridge et al. (2019), Te Morenga et al. (2018), Van Velsen et al. (2019)
Mental health (6 / 9.8%)	Arslan et al. (2010), Christie et al. (2019), Deady et al. (2018), Halje et al. (2016), Peters, Deady, Glozier, Harvey, & Calvo (2018), VanHeerwaarden et al. (2018)
Nutrition (5 / 8.2%)	Dol et al. (2016), Ni Mhurchu et al. (2019), Partridge et al. (2019), Te Morenga et al. (2018), Verbiest et al. (2019)
Smoking cessation (2 / 3.3%)	Ni Mhurchu et al. (2019), Paay et al. (2017), Paay, Kjeldskov, Skov, Lichon, & Rasmussen (2015)
Menopause self-care (2 / 3.3%)	Trujillo & Buzzi (2016), Trujillo, Senette, & Buzzi (2018)
Positive psychology (2 / 3.3%)	Jessen, Mirkovic, & Ruland (2018a), Jessen, Mirkovic, & Westeng (2018b)
STI and drugs (2 / 3.3%)	Birrell et al. (2018), Cordova et al. (2015)
Other (3 / 4.9%)	Arslan et al. (2010), Danbjørg, Wagner, & Clemensen (2014), Ni Mhurchu et al. (2019), Wechsler (2015)
The table lists specific areas in the disease management and health promotion contexts that at least two studies targeted. We include all areas that only one study mentioned in "other". For disease management, such areas include chronic obstructive pulmonary disease (COPD), cystic fibrosis, presbyopia self-diagnosis, post-myocardial infarction, and PTSD. For health promotion, such areas include improving overall wellbeing, lowering alcohol consumption, lowering CVD risk, and postnatal care. Totals do not always match summed subtotals as one study focused on both disease management and health promotion (Arslan et al., 2010).	

Note that different health contexts connect in important ways. For instance, individuals with mental health conditions have a higher likelihood to smoke and to consume alcohol. However, despite these important connections, the literature commonly refers to mental health, reduction in alcohol consumption, and smoking cessation as separate fields in the literature (Noble, Paul, Turon, & Oldmeadow, 2015).

4.2 Stakeholders

Overall, 57 studies (93.4%) involved users in the design process. As Table 2 shows, the most frequent user groups included patients (39 / 64%), general population (13 / 21.3%), family members (11 / 18.0%), and caregivers (9 / 14.8%).

Table 2. Users Involved in the Reviewed Studies

Group (# of studies / % of total)	Disease management (% of 39 studies)	Health promotion (% of 23 studies)
Patients (39 / 64%)	Ahmad et al. (2008), Aljaroodi et al. (2017), Andersen et al. (2017), Arslan et al. (2010), Balatsoukas et al. (2019), Bauer et al. (2017), Castensøe-Seidenfaden et al. (2017, 2018), Danbjørg et al. (2018), Das et al. (2015), Davis et al. (2018, 2019), De La Harpe et al. (2013), Grosjean et al. (2019), Jakobsen et al. (2018b), Jessen et al. (2018a, 2018b), Kanstrup (2014), Ledderer et al. (2019), Lipson-Smith et al. (2019), Løventoft et al. (2012), Marent et al. (2018a, 2018b), Matthews et al. (2015, 2016), Peters et al. (2017), Shin & Holtz (2019), Terp et al. (2018, 2016), Veale et al. (2019), Vilarinho et al. (2017), Woods et al. (2017a, 2017b, 2018a), Woods et al. (2019a, 2019b, 2019c) (37 / 94.9%)	Arslan et al. (2010), Dol et al. (2016), Trujillo et al. (2018) (3 / 13.0%)
General population (13 / 21.3%)	Arslan et al. (2010), Bauer et al. (2017) (2 / 5.1%)	Arslan et al. (2010), Birrell et al. (2018), Capel et al. (2015), Deady et al. (2018), Dol et al. (2016), Ni Mhurchu et al. (2019), Paay et al. (2017, 2015), Te Morenga et al. (2018), VanHeerwaarden et al. (2018), Verbiest et al. (2019), Wechsler (2015) (12 / 52.2%)
Family members (11 / 18.0%)	Andersen et al. (2017), Castensøe-Seidenfaden et al. (2017, 2018), Kanstrup (2014), Ledderer et al. (2019), Shin & Holtz (2019), Vilarinho et al. (2017), Woods et al. (2017b, 2018a) (9 / 23.1%)	Birrell et al. (2018), Danbjørg et al. (2014) (2 / 8.7%)
Caregivers (9 / 14.8%)	Aljaroodi et al. (2017), Balatsoukas et al. (2019), De La Harpe (2012, 2014), De La Harpe et al. (2013), Shin & Holtz (2019), Woods et al. (2017a, 2019a, 2019b) (9 / 23.1%)	
(Pre)adolescents (4 / 6.6%)	Arslan et al. (2010) (1 / 2.6%)	Arslan et al. (2010), Christie et al. (2019), Cordova et al. (2015), Partridge et al. (2019) (4 / 17.4%)
Elderly (2 / 3.3%)	Arslan et al. (2010) (1 / 2.6%)	Arslan et al. (2010), Van Velsen et al. (2019) (2 / 8.7%)
Other (2 / 3.3%)		Te Morenga et al. (2018), Trujillo & Buzzi (2016) (2 / 8.7%)
The table lists all user groups that participated in at least two studies. We include all user groups that participated in only one study in "other" (e.g., communities and pregnant women). Totals do not always match summed subtotals as one study focused on both disease management and health promotion (Arslan et al., 2010).		

Focusing on mHealth systems' inherent health component, we now look into the studies that included health professionals. Overall, 37 studies (60.7%) involved healthcare professionals, which rendered this group the second most involved after users (see Table 3). We found that studies in the disease management context (28 / 71.8%) tended to involve more healthcare professionals than studies in the health promotion context (9 / 39.1%).

Table 3. Healthcare Professionals Involved in the Reviewed Studies

Group (# of studies / % of total)	Disease management (% of 39 studies)	Health promotion (% of 23 studies)
General clinicians (18 / 29.5%)	Ahmad et al. (2008), Aljaroodi et al. (2017), Castensøe-Seidenfaden et al. (2018), Davis et al. (2018), De La Harpe et al. (2013), Ledderer et al. (2019), Lipson-Smith et al. (2019), Løventoft et al. (2012), Marent et al. (2018a, 2019b), Matthews et al. (2015, 2016), Peters et al. (2017), Terp et al. (2016), Veale et al. (2019) (15 / 39.5%)	Christie et al. (2019), Halje et al. (2016), Partridge et al. (2019) (3 / 13.0%)
Nurses (15 / 24.6%)	Andersen et al. (2017), Castensøe-Seidenfaden et al. (2017, 2018), Grosjean et al. (2019), Ledderer et al. (2019), Marent et al. (2018b), Terp et al. (2016), Vilarinho et al. (2017), Woods et al. (2017b, 2017a, 2018a, 2018b), Woods et al. (2019a, 2019b) (13 / 34.2%)	Danbjørg et al. (2014), Wechsler (2015) (2 / 8.7%)
Dietitians (14 / 23%)	Castensøe-Seidenfaden et al. (2017, 2018), Grosjean et al. (2019), Marent et al. (2018b), Veale et al. (2019), Vilarinho et al. (2017), Woods et al. (2017a, 2017b, 2018a, 2018b), Woods et al. (2019a, 2019b) (12 / 31.6%)	Dol et al. (2016), Partridge et al. (2019) (2 / 8.7%)
Health behavior Scientists (11 / 18%)	Aljaroodi et al. (2017), Castensøe-Seidenfaden et al. (2017), Davis et al. (2018), Marent, Henwood, & Darking (2018), Matthews et al. (2015), Peters et al. (2017), Terp et al. (2016) (7 / 18.4%)	Deady et al. (2018), Dol et al. (2016), Halje et al. (2016), Partridge et al. (2019) (4 / 17.4%)
Pharmacists (8 / 13.1%)	Davis et al. (2018), Marent et al. (2018b), Woods et al. (2017a, 2017b, 2018a, 2018b, 2019a, 2019b) (8 / 21.0%)	
Physiotherapists (8 / 13.1%)	Danbjørg et al. (2018), Woods et al. (2017a, 2017b, 2018a, 2018b, 2019a, 2019b) (7 / 18.4%)	Dol et al. (2016) (1 / 4.4%)
Specialist doctors (7 / 11.5%)	Ahmad et al. (2008), Andersen et al. (2017), Veale et al. (2019), Vilarinho et al. (2017), Woods et al. (2017a, 2018b), Woods et al. (2019a, 2019b) (7 / 18.4%)	
Social workers (2 / 3.3%)	Castensøe-Seidenfaden et al. (2017), Marent et al. (2018b) (2 / 5.3%)	
Other (9 / 14.8%)	Ahmad et al. (2008), Balatsoukas et al. (2019), Bauer et al. (2017), Davis et al. (2018), Lipson-Smith et al. (2019), Marent et al. (2018b), Terp et al. (2016) (7 / 18.4%)	Birrell et al. (2018), Peters et al. (2018) (2 / 8.7%)

The table lists all user groups that participated in at least two studies. We include all user groups that participated in only one study mentioned in "other" (e.g., care managers, occupational therapists, and sexologists). Specialist doctors included cardiologists, oncologists, opticians, pediatricians, pulmonologists, and respiratory specialists. Totals do not always match summed subtotals as one study focused on both disease management and health promotion (Arslan et al., 2010).

Focusing on mHealth systems' inherent system design component, we now look into the studies that included system designers. In total, 32 studies (52.5%) involved system designers. As Table 4 shows, these individuals included software production professionals (27 / 44.3%), user experience designers (8 / 13.1%), design researchers (5 / 8.2%), graphics designers (5 / 8.2%), and IT researchers (4 / 6.6%).

In addition to users, healthcare professionals, and system designers, some studies also included other types of stakeholders (6 / 9.8%). For example, three studies included anthropologists (De La Harpe, 2012, 2014; Ledderer et al., 2019), three studies included facilitators (Balatsoukas et al., 2019; Grosjean et al., 2019; Terp et al., 2016), and two studies included advisory groups (Bauer et al., 2017; Birrell et al., 2018).

Table 4. System Designers Involved in the Reviewed Studies

Group (# of studies / % of total)	Disease management (% of 39 studies)	Health promotion (% of 23 studies)
Software production professionals (27 / 44.3%)	Ahmad et al. (2008), Aljaroodi et al. (2017), Andersen et al. (2017), Bauer et al. (2017), Birrell et al. (2018), Castensøe-Seidenfaden et al. (2017), Danbjørg et al. (2018), Davis et al. (2018), De La Harpe (2012, 2014), De La Harpe et al. (2013), Grosjean et al. (2019), Jessen et al. (2018a), Ledderer et al. (2019), Lipson-Smith et al. (2019), Marent et al. (2018a, 2018b), Terp et al. (2016), Veale et al. (2019), Woods et al. (2017a, 2018a, 2019a) (22 / 56.4%)	Christie et al. (2019), Danbjørg et al. (2014), Deady et al. (2018), Te Morenga et al. (2018), Verbiest et al. (2019) (5 / 21.7%)
User experience designers (8 / 13.1%)	Ahmad et al. (2008), Aljaroodi et al. (2017), Andersen et al. (2017), Arslan et al. (2010), Peters et al. (2017) (5 / 12.8%)	Arslan et al. (2010), Deady et al. (2018), Dol et al. (2016), Peters et al. (2018) (4 / 17.4%)
Design researchers (5 / 8.2%)	Aljaroodi et al. (2017), Das et al. (2015), De La Harpe (2012, 2014), De La Harpe et al. (2013) (5 / 12.8%)	
Graphics designers (5 / 8.2%)	Andersen et al. (2017), Terp et al. (2016) (2 / 5.1%)	Christie et al. (2019), Deady et al. (2018), Te Morenga et al. (2018), Verbiest et al. (2019) (4 / 17.4%)
IT researchers (4 / 6.6%)	Aljaroodi et al. (2017), De La Harpe (2012, 2014), De La Harpe et al. (2013) (4 / 10.3%)	
Other (3 / 4.9%)	Aljaroodi et al. (2017), Arslan et al. (2010) (2 / 5.1%)	Arslan et al. (2010), Christie et al. (2019) (2 / 8.7%)
The table lists all user groups that participated in at least two studies. We include all user groups that participated in only one study mentioned in "other" (e.g., bioengineers, health informatics researchers, and narrative designers). Totals do not always match summed subtotals as one study focused on both disease management and health promotion (Arslan et al., 2010). We did not include system designers inside the research team.		

4.3 Employed Methods

In this section, we summarize the methods that the reviewed studies used and map them to the four co-design phases (i.e., pre-design, generative, evaluative, post-design) in Sanders and Stappers' (2014) framework. In particular, we focus on the diversity of methods in individual phases and how it differs between health promotion and disease management. Further, we use the analysis to discern the methods that studies have most frequently used in co-designing mHealth artifacts.

4.3.1 Pre-design Phase

Over half of the studies we reviewed (35 / 57.4%) involved stakeholders in the pre-design phase in creating an mHealth system. Table 5 summarizes the methods that studies used in the pre-design phase. In the disease management context, studies most frequently used interviews (41.0%), personas (17.9%), and focus groups (10.3%). In the health promotion context, studies most frequently used interviews (30.4%), personas (21.7%), focus groups (17.4%), and questionnaires (17.4%).

Scholars reported several benefits from incorporating co-design methods in the pre-design phase. First, co-design methods help scholars better understand participants' latent needs and experiences as well as the data they collected from more general methods (e.g., interviews, observation). For example, Capel et al. (2015) used cultural probes to more deeply understand findings from interviews, while Te Morenga et al. (2018, p. 93) stated that these methods provide "deeper insight into the lives and aspirations of our participants than captured by traditional ethnographic methods, such as in-depth interviews and observations". Second, scholars also used co-design methods in the pre-design phase to sensitize participants to different aspects of the problem space so they were familiar with it before moving into the generative phase (Das et al., 2015).

Table 5. Methods that the Studies Used in the Pre-design Phase

Method (# of studies / % of total)	Disease management (% of 39 studies)	Health promotion (% of 23 studies)
Interviews (22 / 36.1%)	Ahmad et al. (2008), Aljaroodi et al. (2017), Andersen et al. (2017), Arslan et al. (2010), Balatsoukas et al. (2019), Castensøe-Seidenfaden et al. (2017), De La Harpe (2012), Grosjean et al. (2019), Jakobsen et al. (2018a), Kanstrup (2014), Ledderer et al. (2019), Løventoft et al. (2012), Matthews et al. (2015), Vilarinho et al. (2017), Woods et al. (2017b, 2017a) (16 / 41.0%)	Arslan et al. (2010), Capel et al. (2015), Christie et al. (2019), Cordova et al. (2015), Halje et al. (2016), Paay et al. (2017), VanHeerwaarden et al. (2018) (7 / 30.4%)
Personas (11 / 18.0%)	Arslan et al. (2010), De La Harpe (2012), Jessen et al. (2018a), Woods et al. (2017a, 2017b, 2018a), Woods et al. (2019a) (7 / 17.9%)	Arslan et al. (2010), Dol et al. (2016), Trujillo et al. (2018), VanHeerwaarden et al. (2018), Wechsler (2015) (5 / 21.7%)
Focus groups (8 / 13.1%)	Balatsoukas et al. (2019), Bauer et al. (2017), Danbjørg et al. (2018), De La Harpe (2012) (4 / 10.3%)	Christie et al. (2019), Deady et al. (2018), Paay et al. (2017, 2015) (4 / 17.4%)
Probes (6 / 9.8%)	Danbjørg et al. (2018), Kanstrup (2014), Løventoft et al. (2012) (3 / 7.7%)	Capel et al. (2015), Paay et al. (2017), Wechsler (2015) (3 / 13.0%)
Questionnaires (5 / 8.2%)	Arslan et al. (2010), Løventoft et al. (2012) (2 / 5.1%)	Arslan et al. (2010), Deady et al. (2018), Trujillo et al. (2018), VanHeerwaarden et al. (2018) (4 / 17.4%)
Storytelling (5 / 8.2%)	Aljaroodi et al. (2017), Das et al. (2015) (2 / 5.1%)	Cordova et al. (2015), Te Morenga et al. (2018), Verbiest et al. (2019) (3 / 13.0%)
Observation (4 / 6.6%)	Andersen et al. (2017), Arslan et al. (2010), Ledderer et al. (2019), Løventoft et al. (2012) (4 / 10.3%)	Arslan et al. (2010) (1 / 4.3%)
Other (2 / 3.3%)	Jakobsen et al. (2018a), Woods et al. (2019a) (2 / 5.1%)	

We sort the methods based on their usage in the reviewed studies (from highest to lowest). We include all methods that only one paper mentioned in "other". This includes field studies, journey maps, and stakeholder maps. Totals do not always match summed subtotals as one study focused on both disease management and health promotion (Arslan et al., 2010).

4.3.2 Generative Phase

As in the pre-design phase, more than half of the studies we reviewed (33 / 54.1%) involved users in the generative phase in creating an mHealth system. As Table 6 shows, in the disease management context, studies most frequently used sketching (23.1%), storyboards (23.1%), mock-ups (23.1%), and paper prototyping (20.5%). In the health promotion context, studies most frequently used paper prototyping (13%) and wireframes (13%).

Scholars reported several benefits from involving users in the generative phase when designing mHealth systems. First, the generative phase aided 1) idea generation, 2) discussion between participants, and 3) sensitizing participants to the problem space. For example, Løventoft et al. (2012) used storyboards and sketching to facilitate idea generation and discussion among participants. Second, the generative phase allowed for scholars to refine early ideas in an inexpensive and flexible way as participants viewed, interacted with, and modified low-fidelity mHealth system representations (Ahmad et al., 2008; De La Harpe, 2012; e.g., mock-ups, wireframes, paper prototypes).

Table 6. Methods that the Studies Used in the Generate Phase

Method (# of studies / % of total)	Disease management (% of 39 studies)	Health promotion (% of 23 studies)
Paper prototyping (11 / 18.0%)	Ahmad et al. (2008), Castensøe-Seidenfaden et al. (2017), Danbjørg et al. (2018), De La Harpe (2012), De La Harpe et al. (2013), Grosjean et al. (2019), Løventoft et al. (2012), Terp et al. (2016) (8 / 20.5%)	Peters et al. (2018), Van Velsen et al. (2019), Wechsler (2015) (3 / 13.0%)
Wireframes (11 / 18.0%)	Andersen et al. (2017), De La Harpe et al. (2013), Grosjean et al. (2019), Jakobsen et al. (2018a), Matthews et al. (2015), Veale et al. (2019), Woods et al. (2017a, 2018a) (8 / 20.5%)	Christie et al. (2019), Verbiest et al. (2019), Wechsler (2015) (3 / 13.0%)
Sketching (10 / 16.4%)	Balatsoukas et al. (2019), De La Harpe (2012), Grosjean et al. (2019), Jakobsen et al. (2018a), Kanstrup (2014), Terp et al. (2016), Vilarinho et al. (2017), Woods et al. (2017a, 2018a) (9 / 23.1%)	Paay et al. (2015) (1 / 4.3%)
Storyboards (10 / 16.4%)	Arslan et al. (2010), Bauer et al. (2017), De La Harpe (2012), Løventoft et al. (2012), Terp et al. (2016), Woods et al. (2017a, 2017b, 2018a), Woods et al. (2019a) (9 / 23.1%)	Arslan et al. (2010), Trujillo et al. (2018) (2 / 8.7%)
Mock-ups (9 / 14.8%)	Balatsoukas et al. (2019), Castensøe-Seidenfaden et al. (2017), Danbjørg et al. (2018), De La Harpe (2014), De La Harpe et al. (2013), Jakobsen et al. (2018a), Løventoft et al. (2012), Matthews et al. (2015), Terp et al. (2016) (9 / 23.1%)	
Journey maps (4 / 6.6%)	De La Harpe (2012), Woods et al. (2017a) (2 / 5.1%)	VanHeerwaarden et al. (2018), Wechsler (2015) (2 / 8.7%)
Interviews (3 / 4.9%)	Marent et al. (2018a, 2018b), Veale et al. (2019) (3 / 7.7%)	
Scenarios (3 / 4.9%)	Arslan et al. (2010), Das et al. (2015), De La Harpe (2012) (3 / 7.7%)	Arslan et al. (2010) (1 / 4.3%)
Brainstorming (2 / 3.3%)	Løventoft et al. (2012), Woods et al. (2018a) (2 / 5.1%)	
Card sorting (2 / 3.3%)	Grosjean et al. (2019), Terp et al. (2016) (2 / 5.1%)	
Design games (2 / 3.3%)	Jakobsen et al. (2018a), Kanstrup (2014) (2 / 5.1%)	
Focus groups (2 / 3.3%)	Balatsoukas et al. (2019), Bauer et al. (2017) (2 / 5.1%)	
Idea matrix (2 / 3.3%)	Woods et al. (2017a, 2017b) (2 / 5.1%)	
Other (6 / 9.8%)	De La Harpe (2012), Kanstrup (2014), Veale et al. (2019), Woods et al. (2017a) (4 / 10.3%)	Peters et al. (2018), VanHeerwaarden et al. (2018) (2 / 8.7%)

We sort methods based on their usage in the reviewed studies (from highest to lowest). We include all methods that only one paper mentioned in "other" (e.g., collaborative ideation, conversation cards, feature mapping, impact/effort matrix, questionnaires, reflection, "rose, thorn, bud", signposting, stakeholder maps, Venn diagrams, visual votes, and world café). Totals do not always match summed subtotals as one study focused on both disease management and health promotion (Arslan et al., 2010).

4.3.3 Evaluative Phase

Almost half of the studies we reviewed (30 / 49.2%) engaged in the evaluative phase and built a software prototype. As Table 7 shows, in the disease management context, studies most frequently used high-fidelity prototyping (33.3%) and interviews (20.5%). In the health promotion context, studies most frequently used high-fidelity prototyping (21.7%) and questionnaires (21.7%).

Scholars reported that the main benefit from involving users in the evaluative phase concerned their ability to test and gain feedback about high-fidelity prototypes before they moved on to the post-design phase. For

instance, Kanstrup (2014) found that developing high-fidelity prototypes in a co-design environment helped them test an mHealth system's usability in a playful, co-operative, and engaging way. Further elaborating on this notion, Kanstrup (2014, p. 56) stated: "Legitimacy is obtained via participation. One cannot perform wrongly—the consequences of actions are only simulated and breaking the rules can even be fun". Ahmad et al. (2008) and Castensøe-Seidenfaden et al. (2017) engaged with users in the evaluative phase to accomplish testing and feedback using usability testing (e.g., think-aloud technique).

The studies we reviewed commonly report one important challenge to consider in the evaluative phase: understanding the distinction between designers' and developers' roles and the implications that this distinction has on stakeholder involvement. For instance, De La Harpe (2014, p. 27) noted that she excluded end users and designers at certain points during development as "the translations required by the development process were just too technical to them". Based on the papers we reviewed, in the evaluative phase, users should focus on testing high-fidelity prototypes and providing feedback to ensure that system designers and developers can adequately translate the mHealth system that they identified in the previous phases (De La Harpe, 2012, 2014).

Table 7. Methods that the Studies Used in the Evaluative Phase

Method (# of studies / % of total)	Disease management (% of 39 studies)	Health promotion (% of 23 studies)
High-fidelity prototyping (18 / 29.5%)	Ahmad et al. (2008), Andersen et al. (2017), Bauer et al. (2017), De La Harpe (2012, 2014), Jakobsen et al. (2018a), Kanstrup (2014), Ledderer et al. (2019), Løventoft et al. (2012), Matthews et al. (2015), Woods et al. (2017a, 2018a), Woods et al. (2019a) (13 / 33.3%)	Birrell et al. (2018), Christie et al. (2019), Danbjørg et al. (2014), Paay et al. (2017), Partridge et al. (2019) (5 / 21.7%)
Interviews (9 / 14.8%)	Jakobsen et al. (2018a, 2018b), Ledderer et al. (2019), Shin & Holtz (2019), Terp et al. (2018), Woods et al. (2019a, 2019b, 2019c) (8 / 20.5%)	Danbjørg et al. (2014) (1 / 4.3%)
Questionnaires (7 / 11.5%)	Castensøe-Seidenfaden et al. (2018), Davis et al. (2019) (2 / 5.1%)	Birrell et al. (2018), Deady et al. (2018), Ni Mhurchu et al. (2019), Partridge et al. (2019), Trujillo & Buzzi (2016) (5 / 21.7%)
Pilot testing (6 / 9.8%)	Davis et al. (2019), Jakobsen et al. (2018b), Woods et al. (2019c) (3 / 7.7%)	Birrell et al. (2018), Danbjørg et al. (2014), Deady et al. (2018) (3 / 13.0%)
Usability testing (6 / 9.8%)	Ahmad et al. (2008), Bauer et al. (2017), Castensøe-Seidenfaden et al. (2017), Veale et al. (2019) (4 / 10.3%)	Christie et al. (2019), Partridge et al. (2019) (2 / 8.7%)
Randomized control trials (2 / 3.3%)	Castensøe-Seidenfaden et al. (2018) (1 / 2.6%)	Ni Mhurchu et al. (2019) (1 / 4.3%)
Other (6 / 9.8%)	Castensøe-Seidenfaden et al. (2018), Jakobsen et al. (2018a), Veale et al. (2019), Woods et al. (2019b) (4 / 10.3%)	Danbjørg et al. (2014), Trujillo & Buzzi (2016) (2 / 8.7%)

We sort methods based on their usage in the reviewed studies (from highest to lowest). We include all methods that only one paper mentioned in "other" (e.g., cognitive walkthrough, field studies, focus groups, laboratory testing, observation, roleplaying, "rose, thorn, bud", and storyboards). Totals do not always match summed subtotals as one study focused on both disease management and health promotion (Arslan et al., 2010).

4.3.4 Post-design Phase

Few studies engaged in the post-design phase (3 / 4.9%) (see Table 8). This finding represents a profound research gap as several scholars have highlighted the importance of post-design (Sanders & Stappers, 2014) and secondary design (Germonprez, Hovorka, & Gal, 2011). Interestingly, all studies that engaged in the post-design phase did so in the disease management context (i.e., no study in the health promotion context engaged in the post-design phase). The disease management studies that engaged in the post-design phase used methods such as post-design interviews, questionnaires, or focus groups to follow up with users and to evaluate the effectiveness of the mHealth system after its deployment (Ahmad et al., 2008; Davis et al., 2018; Løventoft et al., 2012).

Scholars reported the primary benefit of involving users in the post-design phase was that the mHealth system could be evaluated on how well it has achieved its intended goals (Davis et al., 2018). For instance, Davis et al. (2018) evaluated users' satisfaction with an mHealth system through focus groups, interviews, and questionnaires. Similarly, Løventoft et al. (2012) used a questionnaire, interviews, and data logging to measure compliance.

Table 8. Methods that the Studies Used in the Post-design phase

Method (# of studies / % of total)	Disease management (% of 39 studies)	Health promotion (% of 23 studies)
Interviews (2 / 3.3%)	Davis et al. (2018), Løventoft et al. (2012) (2 / 5.2%)	
Questionnaires (2 / 3.3%)	Ahmad et al. (2008), Davis et al. (2018) (2 / 5.2%)	
Focus groups (1 / 1.6%)	Davis et al. (2018) (1 / 2.6%)	

We sort methods based on their usage in the reviewed studies (from highest to lowest). Totals do not always match summed subtotals as one study focused on both disease management and health promotion (Arslan et al., 2010).

4.4 Co-citation Analysis

Finally, we look at the structure of the reviewed publications based on the literature they cite, which provides insight into 1) the overall body of knowledge these publications draw on and 2) the field's fragmentation/cohesion. Figures 4, 5, and 6 show three co-citation graphs of the reviewed papers (black) and the literature they refer to (grey, blue, and red). In particular, Figure 4 displays the co-citation graph for all 61 studies, while Figures 5 and 6 display the graphs for only disease management and health promotion, respectively.

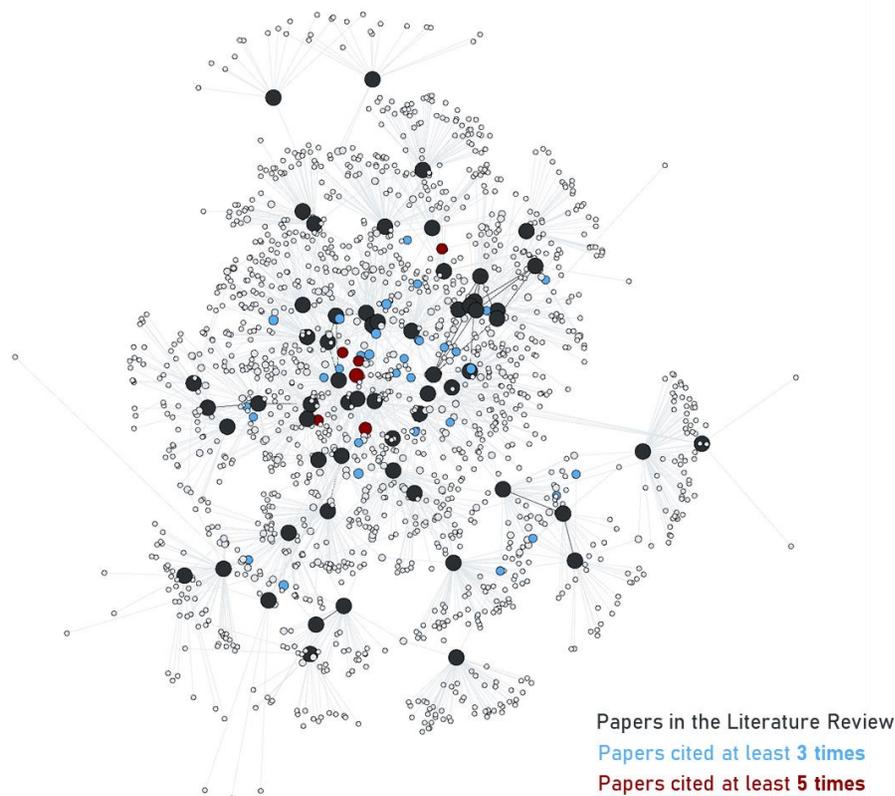


Figure 4. All 61 Studies



Figure 5. Disease Management Studies

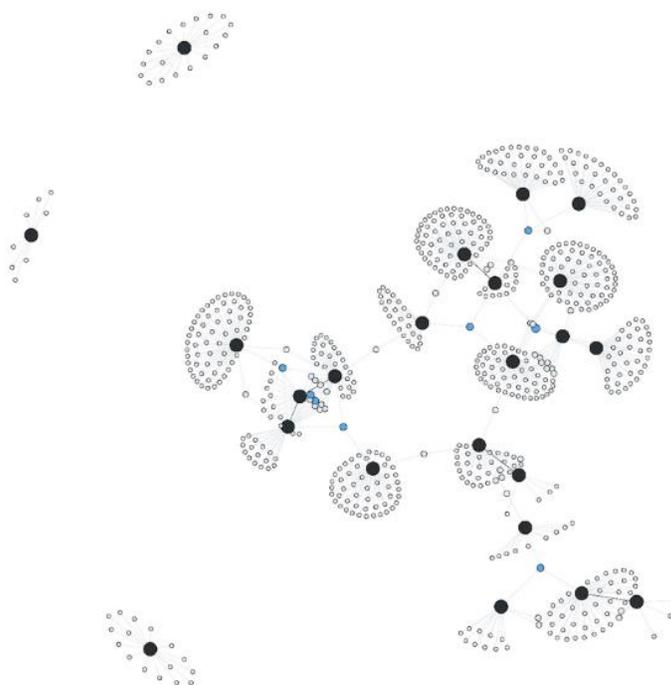


Figure 6. Health Promotion Studies

We can make two observations from these graphs. First, the reviewed studies rarely cite one another. In fact, only 28 (out of 1,881) citations actually link these papers. However, publication lag may partly explain this finding due to the fact that more than half of the papers appeared only in 2018 or 2019 (33 studies, 54.1%). Furthermore, the studies cover many different areas in the disease management and health promotion contexts that each have their own body of literature. Second, the studies in our sample (particularly in the health promotion context) cite few common publications overall (see Figure 5). Only 30 papers (colored blue in Figure 4) received three or more citations from the papers we reviewed, and only six papers received five or more citations (colored red)³.

Taken together, this evidence suggests the literature is fragmented—an unsurprising result given that the field that emerged in 2009 and has exhibited rapid growth (see Figure 2). However, the field requires integrative work such as the present review to help scholars form common standards, best practices, and terminology. To support such goals, we list the six most influential papers in the field based on how often they were cited by the reviewed studies (Table 9). Note that this list also contains studies that were not part of our initial set of reviewed studies. From this list, we can see a strong focus on co-design method sources (Kensing, 2003; Muller, 2008; Sanders & Stappers, 2008; Simonsen & Robertson, 2013). Notably, the list includes an important precursor to the Sanders and Stappers (2014) framework (i.e., Sanders & Stappers, 2008). Further, the list includes a widely established resource on thematic analysis (Braun & Clarke, 2006). At this stage, only one study specifically referred to the health context (Clemensen, Larsen, Kyng, & Kirkevold, 2007).

Table 9. Top Six Most Central Publications that Influenced Studies in the Review Corpus

Publication	Citations	
	Review corpus	Google scholar
Clemensen, J., Larsen, S. B., Kyng, M., & Kirkevold, M. (2007). Participatory design in health sciences: Using cooperative experimental methods in developing health services and computer technology. <i>Qualitative Health Research</i> , 17(1), 122-130.	9	198
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. <i>Qualitative Research in Psychology</i> , 3(2), 77-101.	7	89,127
Kensing, F. (2003). <i>Methods and practices in participatory design</i> . Copenhagen, DK: ITU Press.	5	134
Muller, M. J. (2008). Participatory design: The third space in HCI. In A. Sears & J. Jacko (Eds.), <i>Human-computer interaction handbook</i> (pp. 1061-1081). Mahwah, NJ: Lawrence Erlbaum.	5	150
Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. <i>CoDesign</i> , 4(1), 5-18.	5	3,981
Simonsen, J., & Robertson, T. (2013). <i>Routledge international handbook of participatory design</i> . New York, NY: Routledge.	5	881

Note: at least five studies in the review corpus cited the listed publications. Citations from Google Scholar as of December, 2020. We aggregate citation numbers for Muller (2008) on Google Scholar based on the individual records.

5 Discussion and Conclusions

In this paper, we conduct a systematic review to examine empirical studies that have employed co-design in mHealth systems development. In doing so, we comprehensively overview the current state of research on how researchers and practitioners have used co-design in mHealth for disease management and health promotion and the stakeholders involved in the co-design activities. Further, building on Sanders and Stappers' (2014) framework, we map the methods that studies have used in co-designing mHealth systems to the four phases in the co-design process. In this section, we discuss the knowledge gaps we identified and our study's practical implications.

³ To illustrate this further, consider the following example of a pairwise comparison. If Paper A (30 references) and Paper B (40 references) share 12 references we observe an overlap of 20.7% (12 out of unique 58 references). Across all pairwise comparisons in our case, we find an average overlap of 0.37%. In fact, in 87.6% of all pairwise comparisons, there does not occur one single common reference. Unsurprisingly, the highest degree of overlap was found by two articles with the same first author (Woods et al., 2018b, 2019b).

5.1 Knowledge Gaps

Even though the literature has repeatedly emphasized the post-design phase's importance (Germonprez et al., 2011; Sanders & Stappers, 2014), most studies in our review (95.1%) did not engage in it. However, engaging with users in post-design is important for system designers because "people engage systems in ways that were not planned by the designers" (Germonprez et al., 2011, p. 663); therefore, information required to refine the design of an mHealth system cannot be acquired until the artifact has been deployed in the real world and inhabited by users. This is reflected in the fact that the design process often has some degree of circularity, starting off from a minimum viable product and adding features incrementally.

Many mHealth systems also focus on facilitating health behavior change, such as by providing relevant information that assists people in increasing their capability to manage heart disease (Woods et al., 2017a) or improve their nutrition (Verbiest et al., 2019). Therefore, it is important that the design process does not end after the evaluation phase but that it continues and factors in user needs over time in an incremental way. This can only be accomplished by making active use of the post-design phase for the development and refinement of mHealth systems.

Methodologically, the dearth of co-design studies on post-design calls for 1) research into how existing methods commonly used in earlier phases can be applied to the post-design phase and 2) the development of new methods that aid system designers in involving users in post-design. For instance, methods such as cultural probes (Sanders & Stappers, 2014) and storytelling (Visser et al., 2005) may also uncover unexpected insights. Sanders and Stappers (2014) noted that research in the contextual (pre-design) phase focuses on the larger context in which users' lived experiences occurs. Similarly, research in post-design focuses on how users "actually experience the product, service, or space" (Sanders & Stappers, 2014, p. 10). Hence, both design phases refer to users' experiences that occur in the real world. For that reason, Sanders and Stappers (2014) argued that the methods that designers use for the pre-design phase also suit post-design research. Further, scholars may devise new methods that allow a better involvement of users to champion artifacts in post-design and to bring to light potential improvements of mHealth systems in post-design. In this vein, secondary design (Germonprez et al., 2011) could potentially play an important role in facilitating feedback from stakeholders in the post-design phase to further refine mHealth systems.

In this regard, mHealth systems have the potential to capture data that pertain to how users interact with their different components (e.g., objectively measuring user engagement with behavior-change interventions) (Moller et al., 2017). At this stage, no study we reviewed elaborated on whether and, if so, how designers used the data they collected in the post-design phase, in subsequent design cycles, or ongoing developments. However, since most studies we reviewed emerged only in 2018 and 2019, further studies may emerge that report on subsequent refinements to initial designs.

As for facilitating behavior change, only 11 (Aljaroodi et al., 2017; Castensøe-Seidenfaden et al., 2017; Davis et al., 2018; Deady et al., 2018; Dol et al., 2016; Halje et al., 2016; Marent, Henwood, & Darking, 2018; Matthews et al., 2015; Partridge et al., 2019; Peters et al., 2017; Terp et al., 2016) studies involved health behavior scientists as stakeholders in the co-design process, and only five studies linked the design of their mHealth system to an established behavior change framework. Specifically, these five studies referred to the theory of planned behavior (Lipson-Smith et al., 2019), the trans-theoretical model of health behavior change (Paay et al., 2015), the theoretical domains framework (Ni Mhurchu et al., 2019; Verbiest et al., 2019), and Michie's behavior change technique taxonomy (Ni Mhurchu et al., 2019; Partridge et al., 2019; Verbiest et al., 2019). This lack of integration with the behavior-change literature also became evident in our co-citation analysis. However, mHealth systems' goals often implicitly involve behavior change with respect to a person's health (e.g., helping people form healthy eating habits). Further, previous reviews have shown that mHealth systems' effectiveness is positively associated with the number of behavior-change techniques that they implement (Noorbergen et al., 2019). Hence, building on existing behavior-change frameworks and involving health behavior scientists in the design process will provide a strong foundation to facilitate behavior change.

Finally, the studies we reviewed used diverse co-design methods in the different design phases. While some methods were used more often than others (e.g., 33 interview studies and 18 high-fidelity prototyping studies), no one method emerged as a de facto standard in the field. The complex and ever-changing circumstances in the mHealth context might explain this finding. For example, different stakeholder groups vary with regard to confidence in their creative ability and, therefore, require different methods to suit them (Sanders & Stappers, 2008). Moreover, different contexts entail different considerations about timeframes and require different methods (Sanders & Stappers, 2014). Also, researchers' backgrounds, individual

preferences, and familiarity with particular co-design methods represent relevant factors for selecting and developing methods (Sanders & Stappers, 2008, 2014). Future research may explore the usefulness of particular methods under specific boundary conditions. For instance, the inherent focus on a person's health often involves interaction with vulnerable cohorts and issues related to power distance between stakeholder groups (e.g., joint workshops with patients, nurses, and specialist doctors).

5.2 Practical Implications

With this paper, we make several practical contributions. First, we overview the methods and stakeholders that researchers and practitioners have used to co-design existing mHealth artifacts in different disease management and health promotion contexts. Thus, system designers can use our results to identify existing work on a particular mHealth topic and closely related research. Further, our study constitutes a starting point for work that identifies stakeholder categories typically involved in the design process and suitable methods to facilitate involvement in different stages of the process. In Table 10, we overview the most frequently used methods in the studies we reviewed, briefly describe them, and provide a methodological reference for them.

Table 10. Methods that Studies Frequently used for Co-designing mHealth Systems

Method (# of studies) and brief description	PRE	GEN	EVAL	POST
Interviews (33): a conversation in which an interviewer asks questions to interviewees to discover their views, experiences, beliefs and/or motivations about specific matters. Such conversations can be structured, semi-structured, or unstructured (Gill, Stewart, Treasure, & Chadwick, 2008; Kendall & Kendall, 2013).	22	3	9	2
High-fidelity prototyping (18): a prototype that one makes to closely represent the final design in appearance and functionality (Walker, Takayama, & Landay, 2002).	-	-	18	-
Questionnaires (13): any written instruments (e.g., surveys, inventories) that present participants with questions or statements that they can respond to by writing out an answer or selecting from among existing answers (Dörnyei & Taguchi, 2009; Kendall & Kendall, 2013).	5	1	7	2
Focus groups (12): a form of group interview where research participants communicate with one another in order to generate data (Kendall & Kendall, 2013; Kitzinger, 1995).	8	2	1	1
Paper prototyping (11): a type of usability testing where the design's intended users perform realistic tasks by interacting with a paper version of the interface. Lower fidelity than mock-ups (Snyder, 2003).	-	11	-	-
Personas (11): creating condensed user profiles and usage situations in order to model users, communicate with stakeholders, and speculate on future user needs (Vestergaard, Hauge, & Hansen, 2016).	11	-	-	-
Wireframes (11): one or multiple images that displays a design's functional elements. Typically used to plan a design's structure or functionality. Higher fidelity than sketching (Morson, 2014).	-	11	-	-
Sketching (10): (often freehand) drawings that one uses as a quick and simple way to explore initial ideas for designs. Lower fidelity than paper prototyping (Buxton, 2010).	-	10	-	-
Storyboarding (10): a type of visualization (often pictures or drawings) to represent use cases that allows one to experience, test, transform, develop, and complete early ideas (Sanders & Stappers, 2014).	-	10	-	-
Mock-ups (9): representing design in an initial and rough way. Usually comprises a scale or full-size model that one builds to study, test, or display. Fidelity level can vary greatly but often higher fidelity than paper prototyping (Ulrich & Eppinger, 2012).	-	9	-	-
Probes (6): materials designed to elicit a response. Users reflect on and verbalize their experiences, feelings, and attitudes and visualize their actions and contexts in order to provide inspiration to designers. Probe types include cultural, empathy, informational, and technology (Sanders & Stappers, 2014).	6	-	-	-
Usability testing (6): systematically collecting data (e.g., think-aloud, behavioral) and analyzing how users engage with a system with a particular focus on ease of use and usefulness (Dumas & Redish, 1999).	-	-	7	-

Table 10. Methods that Studies Frequently used for Co-designing mHealth Systems

Pilot testing (6): a small scale preliminary study that one conducts to evaluate feasibility, duration, cost, adverse events, and improve on a study design prior to implementing a system (Herman, D’Luzansky, & Ippolito, 1992).	-	-	6	-
Storytelling (5): a natural vehicle for capturing and sharing experiences through communicating stories in order to increase sensitivity to the problem space (Visser et al., 2005).	5	-	-	-
Note: PRE: pre-design, GEN: generative, EVAL: evaluative, POST: post-design. At least five studies cited the methods in the table in any co-design phase. We order the methods based on how often the review corpus used them (from most frequently to least frequently).				

Second, by building on Sanders and Stappers’ (2014) co-design framework, we map the employed methods to the four interconnected co-design phases (pre-design, generative, evaluative, post-design). The framework has emerged as one of the most widely used resources in the co-design field. By mapping the methods in the reviewed studies to this framework, we contribute to the knowledge base of mHealth systems designers and scholars who want to extend the methodological toolbox in this area. This mapping (see Figure 7) may provide researchers and practitioners with a shared frame of reference of the different activities involved in co-designing mHealth systems along the four interconnected co-design phases. This frame of reference may support design teams in planning activities and setting goals.

Finally, we identify knowledge gaps in research that has applied co-design to mHealth systems development (e.g., limited research in post-design). These knowledge gaps may provide a starting ground for researchers who intend to extend the methodological toolbox in this area (e.g., by devising methods to support user involvement in the post-design phase).

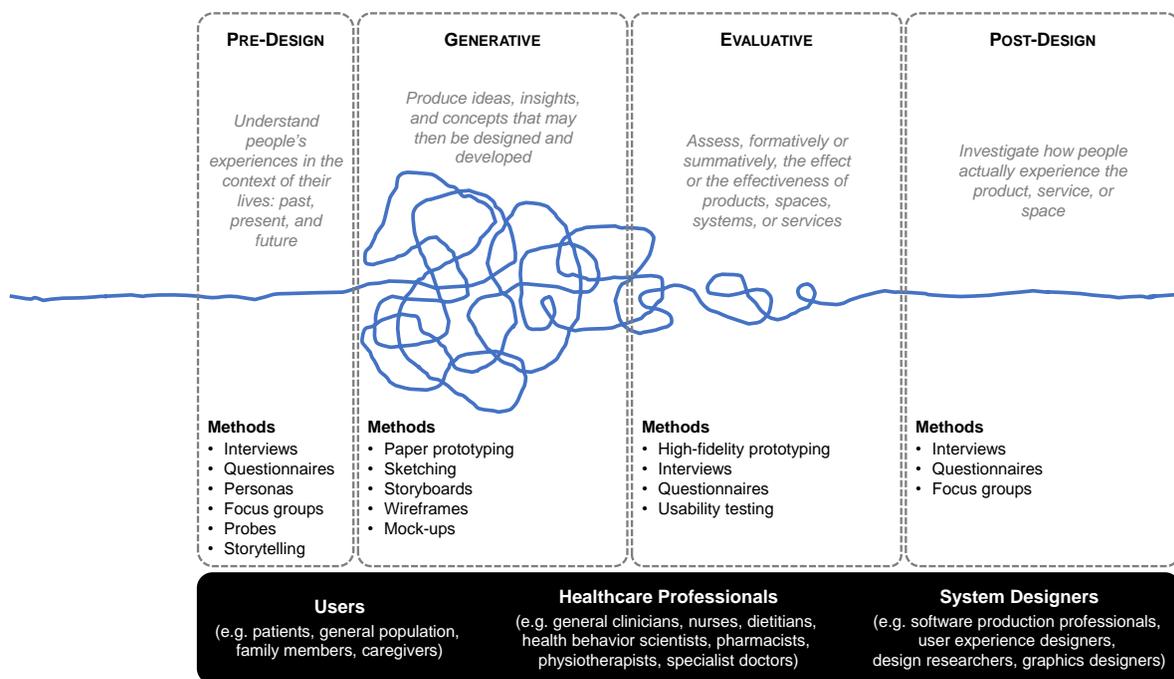


Figure 7. Mapping Methods and Stakeholders Reported in the Review Corpus to Sanders and Stappers’ (2014) Co-design Framework

5.3 Limitations

Our study has several limitations that readers should consider. First, while we carefully crafted our search string and inclusion criteria to identify papers that followed a co-design approach to directly involve stakeholders in mHealth systems development, we cannot rule out that we missed studies that followed a closely related approach but used different terminology to refer to a similar paradigm. Second, applying co-design to mHealth systems design remains a nascent research field; indeed, half of the studies we reviewed appeared only in 2018 and 2019. Hence, note that our results provide a snapshot of a rapidly evolving field.

Still, the fragmentation we discovered via co-citation analysis corroborates the need for studies that contribute to consolidating the field and help researchers and practitioners to form standards, best practices, and common terminology.

6 Conclusion

Taken as a whole, our study provides a comprehensive overview of the contexts, stakeholders, and methods involved in co-designing mHealth systems. We hope this study can serve researchers and practitioners as a reference guide for how one can conduct co-design in an mHealth context and to what advantage. Further, we identify a gap in the literature concerning the post-design phase. This gap makes it evident that more research is needed on how system designers can better use the post-design phase when developing mHealth systems and, thereby, develop systems that evolve over time with the changing needs of users.

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References

- Ahmad, D., Komninos, A., & Baillie, L. (2008). Future mobile health systems: Designing personal mobile applications to assist self diagnosis. In *Proceedings of the 22nd Annual Conference of Interaction*.
- Aljaroodi, H. M., Adam, M. T. P., Chiong, R., Cornforth, D. J., & Minichiello, M. (2017). Empathic avatars in stroke rehabilitation: A co-designed mHealth artifact for stroke survivors. In *Proceedings of the International Conference on Design Science Research in Information System and Technology* (pp. 73-89).
- Andersen, T. O., Bansler, J. P., Kensing, F., & Moll, J. (2017). From prototype to product: Making participatory design of mHealth commercially viable. *Studies in Health Technology and Informatics*, 233, 95-112.
- Arslan, P., Nam, H., Romero, M., Perego, P., Costa, F., Andreoni, G., & Muschiato, S. (2010). MOHE: Mobile health for moms, kids, adults and elderly. In *Proceedings of the 1st International Conference on Design Creativity*.
- Balatsoukas, P., Porat, T., Sassoon, I., Essers, K., Kokciyan, N., Chapman, M., Drake, A., Modgil, S., Ashworth, M., Sklar, E., Parsons, S., & Curcin, V. (2019). User involvement in the design of a data-driven self-management decision support tool for stroke survivors. In *Proceedings of the 18th International Conference on Smart Technologies*.
- Bauer, A. M., Hodsdon, S., Hunter, S., Choi, Y., Bechtel, J., & Fortney, J. C. (2017). Lessons from the deployment of the SPRINT app to support collaborative care for rural patients with complex psychiatric conditions. In *Proceedings of the ACM International Conference on Ubiquitous Computing*.
- Birrell, L., Deen, H., Champion, K. E., Newton, N. C., Stapinski, L. A., Kay-Lambkin, F., Teesson, M., & Chapman, C. (2018). A mobile app to provide evidence-based information about crystal methamphetamine (ice) to the community (cracks in the ice): Co-design and beta testing. *JMIR mHealth uHealth*, 6(12), 1-14.
- Bock, B. C., Heron, K. E., Jennings, E. G., Magee, J. C., & Morrow, K. M. (2013). User preferences for a text message-based smoking cessation intervention. *Heal. Educ. Behav.*, 40(2), 152-159.
- Bødker, S., Ehn, P., Sjögren, D., & Sundblad, Y. (2000). Co-operative design—perspectives on 20 years with “the Scandinavian IT design model”. In *Proceedings of the First Nordic Conference on Human-Computer Interaction*.
- Brandt, E., Binder, T., & Sanders, E. B. N. (2012). Tools and techniques: Ways to engage telling, making and enacting. In J. Simonsen & T. Robertson (Eds.), *Routledge international handbook of participatory design* (pp. 145-181). New York, NY: Routledge.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Burke, L. E., Ma, J., Azar, K. M. J., Bennett, G. G., Peterson, E. D., Zheng, Y., Riley, W., Stephens, J., Shah, S. H., Suffoletto, B., Turan, T. N., Spring, B., Steinberger, J., & Quinn, C. C. (2015). Current science on consumer use of mobile health for cardiovascular disease prevention: A scientific statement from the American Heart Association. *Circulation*, 132(12), 1157-1213.
- Buxton, B. (2010). *Sketching user experiences: Getting the design right and the right design*. San Francisco, CA: Morgan Kaufmann.
- Capel, T., Schnittert, J. F., Snow, S., & Vyas, D. (2015). Exploring motivations of young adults to participate in physical activities. In *Proceedings of the 33rd Annual Conference on Human Factors in Computing Systems*.
- Castensø-Seidenfaden, P., Husted, G. R., Jensen, A. K., Hommel, E., Olsen, B., Pedersen-Bjergaard, U., Kensing, F., & Teilmann, G. (2018). Testing a smartphone app (young with diabetes) to improve self-management of diabetes over 12 months: Randomized controlled trial. *JMIR mHealth uHealth*, 6(6), 1-14.

- Castensø-Seidenfaden, P., Reventlov Husted, G., Teilmann, G., Hommel, E., Olsen, B. S., & Kensing, F. (2017). Designing a self-management app for young people with type 1 diabetes: Methodological challenges, experiences, and recommendations. *JMIR mHealth uHealth*, 5(10), 1-14.
- Christie, G., Shepherd, M., Merry, S. N., Hopkins, S., Knightly, S., & Stasiak, K. (2019). Gamifying CBT to deliver emotional health treatment to young people on smartphones. *Internet Interventions*, 18.
- Clemensen, J., Larsen, S. B., Kyng, M., & Kirkeveld, M. (2007). Participatory design in health sciences: Using cooperative experimental methods in developing health services and computer technology. *Qualitative Health Research*, 17(1), 122-130.
- Cordova, D., Bauermeister, J. A., Fessler, K., Delva, J., Nelson, A., Nurenberg, R., Lua, F. M., Alers-Rojas, F., & Salas-Wright, C. P. (2015). A community-engaged approach to developing an mHealth HIV/STI and drug abuse preventive intervention for primary care: A qualitative study. *JMIR mHealth uHealth*, 3(4), 1-19.
- Danbjørg, D. B., Villadsen, A., Gill, E., Rothmann, M. J., & Clemensen, J. (2018). Usage of an exercise app in the care for people with osteoarthritis: User-driven exploratory study. *JMIR Mhealth Uhealth*, 6(1), 1-13.
- Danbjørg, D. B., Wagner, L., & Clemensen, J. (2014). Designing, developing, and testing an app for parents being discharged early postnatally. *The Journal for Nurse Practitioners*, 10(10), 794-802.
- Das, A., Bøthun, S., Reitan, J., & Dahl, Y. (2015). The use of generative techniques in co-design of mHealth technology and healthcare services for COPD patients. In A. Marcus (Eds.), *Design, user experience, and usability: interactive experience design* (LNCS vol. 9188). Berlin: Springer.
- Davis, S. R., Peters, D., Calvo, R. A., Sawyer, S. M., Foster, J. M., & Smith, L. (2018). "Kiss myAsthma": Using a participatory design approach to develop a self-management app with young people with asthma. *The Journal of Asthma*, 55(9), 1018-1027.
- Davis, S. R., Peters, D., Calvo, R. A., Sawyer, S. M., Foster, J. M., & Smith, L. D. (2019). A consumer designed smartphone app for young people with asthma: Pilot of engagement and acceptability. *The Journal of Asthma*, 58(2), 253-261.
- De La Harpe, R. (2012). Lessons learnt from the participatory design of a mobile care data application in a resource-restricted context. In *Proceedings of the 12th Participatory Design Conference*.
- De La Harpe, R. (2014). The level of participation during the development of a mobile application for home-based healthcare data in a developing context: An actor-network theory perspective. *South African Computing Journal*, 54(2), 20-33.
- De La Harpe, R., Lotriet, H., Pottas, D., & Korpela, M. (2013). Socio-technical approach to community health: designing and developing a mobile care data application for home-based healthcare in South Africa. *Journal of Community Informatics*, 9(2), 1-14.
- Deady, M., Johnston, D., Milne, D., Glozier, N., Peters, D., Calvo, R., & Harvey, S. (2018). Preliminary effectiveness of a smartphone app to reduce depressive symptoms in the workplace: Feasibility and acceptability study. *JMIR mHealth uHealth*, 6(12), 1-14.
- Direito, A., Carraça, E., Rawstorn, J., Whittaker, R., & Maddison, R. (2017). mHealth technologies to influence physical activity and sedentary behaviors: Behavior change techniques, systematic review and meta-analysis of randomized controlled trials. *Annals of Behavioral Medicine*, 51(2), 226-239.
- Dol, A., Kulyk, O., Velthuisen, H., Van Gemert-Pijnen, L., & Van Strien, T. (2016). Developing a personalised virtual coach "denk je zèlf!" for emotional eaters through the design of emotion-enriched personas. *International Journal on Advances in Life Sciences*, 8(3-4), 233-242.
- Dörnyei, Z., & Taguchi, T. (2009). *Questionnaires in second language research: Construction, administration, and processing* (2nd ed.). London, UK: Routledge.
- Druin, A. (2002). The role of children in the design of new technology. *Behavior and Information Technology*, 21(1), 1-25.
- Dumas, J. S., & Redish, J. C. (1999). *A practical guide to usability testing*. Exeter, UK: Intellect Books.

- Ehn, P. (1993). Scandinavian design: On participation and skill. In D. Schuler & A. Namioka (Eds.), *Participatory design* (pp. 41-77). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Eyles, H., Jull, A., Dobson, R., Firestone, R., Whittaker, R., Te Morenga, L., Goodwin, D., & Mhurchu, C. N. (2016). Co-design of mHealth delivered interventions: A systematic review to assess key methods and processes. *Current Nutrition Reports*, 5(3), 160-167.
- Gaver, W. W., Boucher, A., Pennington, S., & Walker, B. (2004). Cultural probes and the value of uncertainty. *Interactions*, 11(5), 53-56.
- Germonprez, M., Hovorka, D., & Gal, U. (2011). Secondary design: A case of behavioral design science research. *Journal of the Association for Information Systems*, 12(10), 662–683.
- Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal*, 204(6), 291-295.
- Grosjean, S., Bonneville, L., & Redpath, C. (2019). The design process of an mHealth technology: The communicative constitution of patient engagement through a participatory design workshop. *Journal for Communication Studies*, 12(1), 5-26.
- Gustafson, D. H., McTavish, F. M., Chih, M.-Y., Atwood, A. K., Johnson, R. A., Boyle, M. G., Levi, M. S., Driscoll, H., Chisholm, S. M., Dillenburg, L., Isham, A., & Shah, D. (2014). A smartphone application to support recovery from alcoholism: A randomized clinical trial. *JAMA Psychiatry*, 71(5), 566-572.
- Halje, K., Timpka, T., Ekberg, J., Bång, M., Fröberg, A., & Eriksson, H. (2016). Towards mHealth systems for support of psychotherapeutic practice: A qualitative study of researcher-clinician collaboration in system design and evaluation. *International Journal of Telemedicine and Applications*.
- Herman, R. M., D’Luzansky, S. C., & Ippolito, R. (1992). Intrathecal baclofen suppresses central pain in patients with spinal lesions: A pilot study. *The Clinical Journal of Pain*, 8(4), 338-345.
- Jakobsen, P. R., Hermann, A. P., Søndergaard, J., Wiil, U. K., & Clemensen, J. (2018a). Development of an mHealth application for women newly diagnosed with osteoporosis without preceding fractures: A participatory design approach. *International Journal of Environmental Research and Public Health*, 15(2), 330-346.
- Jakobsen, P. R., Hermann, A. P., Søndergaard, J., Wiil, U. K., & Clemensen, J. (2018b). Help at hand: Women’s experiences of using a mobile health application upon diagnosis of asymptomatic osteoporosis. *SAGE Open Medicine*, 6.
- Jessen, S., Mirkovic, J., & Ruland, C. M. (2018a). Creating gameful design in mHealth: A participatory co-design approach. *JMIR mHealth uHealth*, 6(12), 1-18.
- Jessen, S., Mirkovic, J., & Westeng, M. (2018b). Game experience preferences of people with chronic illnesses. In *Proceedings of the 10th Nordic Conference On Human-Computer Interaction*.
- Kanstrup, A. M. (2014). Design concepts for digital diabetes practice: design to explore, share, and camouflage chronic illness. *International Journal of Design*, 8(3), 49-60.
- Keller, A. I., Pasman, G. J., & Stappers, P. J. (2006). Collections designers keep: Collecting visual material for inspiration and reference. *CoDesign*, 2(1), 17-33.
- Kendall, K., & Kendall, J. (2013). *Systems analysis and design* (9th ed.). New York, NY: Pearson.
- Kensing, F. (2003). *Methods and practices in participatory design*. Copenhagen, DK: ITU Press.
- Kensing, F., Simonsen, J., & Bodker, K. (1998). MUST: A method for participatory design. *Human-Computer Interaction*, 13(2), 167-198.
- Kitchenham, B., & Charters, S. (2007). *Guidelines for performing systematic literature reviews in software engineering*. Retrieved from https://www.elsevier.com/__data/promis_misc/525444systematicreviewsguide.pdf
- Kitzinger, J. (1995). Qualitative research: Introducing focus groups. *BMJ*, 311(7000), 299-302.
- Ledderer, L., Møller, A., & Fage-Butler, A. (2019). Adolescents’ participation in their healthcare: A sociomaterial investigation of a diabetes app. *Digital Health*, 5.

- Lindström, K., & Ståhl, Å. (2015). Figurations of spatiality and temporality in participatory design and after—networks, meshworks and patchworking. *CoDesign*, 11(3-4), 222-235.
- Lipson-Smith, R., White, F., White, A., Serong, L., Cooper, G., Price-Bell, G., & Hyatt, A. (2019). Co-design of a consultation audio-recording mobile app for people with cancer: The SecondEars app. *JMIR Formative Research*, 3(1), 1-12.
- Løventoft, P. K., Nørregaard, L. B., & Frøkjær, E. (2012). Designing Daybuilder: An experimental app to support people with depression. In *Proceedings of the Participatory Design Conference*.
- Marent, B., Henwood, F., & Darking, M. (2018a). Ambivalence in digital health: Co-designing an mHealth platform for HIV care. *Social Science & Medicine*, 215, 133-141.
- Marent, B., Henwood, F., Darking, M., & EmERGE Consortium. (2018b). Development of an mHealth platform for HIV care: Gathering user perspectives through co-design workshops and interviews. *JMIR mHealth uHealth*, 6(10), e184.
- Matthews, M., Abdullah, S., Murnane, E., Voids, S., Choudhury, T., Gay, G., & Frank, E. (2016). Development and evaluation of a smartphone-based measure of social rhythms for bipolar disorder. *Assessment*, 23(4), 472-483.
- Matthews, M., Voids, S., Abdullah, S., Doherty, G., Choudhury, T., Im, S., & Gay, G. (2015). In situ design for mental illness: Considering the pathology of bipolar disorder in mHealth design. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*.
- Moller, A. C., Merchant, G., Conroy, D. E., West, R., Hekler, E., Kugler, K. C., & Michie, S. (2017). Applying and advancing behavior change theories and techniques in the context of a digital health revolution: Proposals for more effectively realizing untapped potential. *Journal of Behavioral Medicine*, 40(1), 85-98.
- Moore, G., Wilding, H., Gray, K., & Castle, D. (2019). Participatory methods to engage health service users in the development of electronic health resources: Systematic review. *Journal of Participatory Medicine*, 11(1), 1-31.
- Morson, S. (2014). Using wireframes to design your app. In S. Morson (Ed.), *Learn design for iOS development* (pp. 69-84). Berkeley, CA: Apress.
- Muller, M. J. (2008). Participatory design: The third space in HCI. In A. Sears & J. Jacko (Eds.), *Human-computer interaction handbook* (pp. 1061-1081). Mahwah, NJ: Lawrence Erlbaum.
- Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2018). Just-in-time adaptive interventions (JITAs) in mobile health: Key components and design principles for ongoing health behavior support. *Annals of Behavioral Medicine*, 52(6), 446-462.
- Ni Mhurchu, C., Te Morenga, L., Tupai-Firestone, R., Grey, J., Jiang, Y., Jull, A., Whittaker, R., Dobson, R., Dalhousie, S., Funaki, T., Hughes, E., Henry, A., Lyndon-Tonga, L., Pekepo, C., Penetito-Hemara, D., Tunks, M., Verbiest, M., Humphrey, G., Schumacher, J., & Goodwin, D. (2019). A co-designed mHealth programme to support healthy lifestyles in Māori and Pasifika peoples in New Zealand (OL@-OR@): A cluster-randomised controlled trial. *The Lancet Digital Health*, 1(6), 298-307.
- Noble, N., Paul, C., Turon, H., & Oldmeadow, C. (2015). Which modifiable health risk behaviours are related? A systematic review of the clustering of smoking, nutrition, alcohol and physical activity ("SNAP") health risk factors. *Preventive Medicine*, 81, 16-41.
- Noorbergen, T. J., Adam, M. T. P., Attia, J. R., Cornforth, D. J., & Minichiello, M. (2019). Exploring the design of mHealth systems for health behavior change using mobile biosensors. *Communications of the Association for Information Systems*, 44, 944-981.
- O'Reilly, G. A., & Spruijt-Metz, D. (2013). Current mHealth technologies for physical activity assessment and promotion. *American Journal of Preventive Medicine*, 45(4), 501-507.
- Osareh, F. (1996). Bibliometrics, citation analysis and co-citation analysis: A review of literature I. *Libri*, 46(3), 149-158.

- Paay, J., Kjeldskov, J., Brinthaparan, U., Lichon, L., Rasmussen, S., & Srikandaraja, N. (2017). QuittyLink: Involving smokers in the design of technology that supports individuals in quitting. In *Proceedings of the Fourth International Conference on Design4Health*.
- Paay, J., Kjeldskov, J., Skov, M. B., Lichon, L., & Rasmussen, S. (2015). Understanding individual differences for tailored smoking cessation apps. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*.
- Partridge, S. R., Raeside, R., Latham, Z., Singleton, A. C., Hyun, K., Grunseit, A., Steinbeck, K., & Redfern, J. (2019). "Not to be harsh but try less to relate to 'the teens' and you'll relate to them more": Co-designing obesity prevention text messages with adolescents. *International Journal of Environmental Research and Public Health*, 16(24).
- Peppers, K. E. N., Tuunanen, T., Rothenberger, M. A. M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, 24(3), 45-77.
- Peters, D., Davis, S., Calvo, R. A., Sawyer, S. M., Smith, L., & Foster, J. M. (2017). Young people's preferences for an asthma self-management app highlight psychological needs: A participatory study. *Journal of Medical Internet Research*, 19(4), 1-13.
- Peters, D., Deady, M., Glozier, N., Harvey, S., & Calvo, R. A. (2018). Worker preferences for a mental health app within male-dominated industries: Participatory study. *Journal of Medical Internet Research*, 20(4), 1-11.
- Prahalad, C. K., & Ramaswamy, V. (2004). Co-creation experiences: The next practice in value creation. *Journal of Interactive Marketing*, 18(3), 5-14.
- Sanders, E. B.-N. (1992). Converging perspectives: product development research for the 1990s. *Design Management Journal*, 3(4), 49-54.
- Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign*, 4(1), 5-18.
- Sanders, E. B.-N., & Stappers, P. J. (2014). Probes, toolkits and prototypes: three approaches to making in codesigning. *CoDesign*, 10(1), 5-14.
- Shin, J. Y., & Holtz, B. E. (2019). Towards better transitions for children with diabetes: User experiences on a mobile health app. In *Proceedings of the 18th ACM International Conference on Interaction Design and Children*.
- Simonsen, J., & Robertson, T. (2013). *Routledge international handbook of participatory design*. New York, NY: Routledge.
- Slater, H., Campbell, J. M., Stinson, J. N., Burley, M. M., & Briggs, A. M. (2017). End user and implementer experiences of mhealth technologies for noncommunicable chronic disease management in young adults: Systematic review. *Journal of Medical Internet Research*, 19(12), 1-26.
- Snyder, C. (2003). *Paper prototyping: The fast and easy way to design and refine user interfaces*. San Francisco, CA: Morgan Kaufmann.
- Steen, M., Manschot, M., & de Koning, N. (2011). Benefits of co-design in service design projects. *International Journal of Design*, 5(2), 53-60.
- Te Morenga, L., Pekepo, C., Corrigan, C., Matoe, L., Mules, R., Goodwin, D., Dymus, J., Tunks, M., Grey, J., Humphrey, G., Jull, A., Whittaker, R., Verbiest, M., Firestone, R., & Ni Mhurchu, C. (2018). Co-designing an mHealth tool in the New Zealand Māori community with a "Kaupapa Māori" approach. *AlterNative*, 14(1), 90-99.
- Terp, M., Jørgensen, R., Laursen, B. S., Mainz, J., & Bjørnes, C. D. (2018). A smartphone app to foster power in the everyday management of living with schizophrenia: Qualitative analysis of young adults' perspectives. *Journal of Medical Internet Research* 20(10), 1-14.
- Terp, M., Laursen, B. S., Jørgensen, R., Mainz, J., & Bjørnes, C. D. (2016). A room for design: Through participatory design young adults with schizophrenia become strong collaborators. *International Journal of Mental Health Nursing*, 25(6), 496-506.

- Trischler, J., Pervan, S. J., Kelly, S. J., & Scott, D. R. (2018). The value of codesign: The effect of customer involvement in service design teams. *Journal of Service Research*, 21(1), 75-100.
- Trujillo, A., & Buzzi, M. C. (2016). Participatory user requirements elicitation for personal menopause app. In *Proceedings of the Nordic Conference on Human-Computer Interaction*.
- Trujillo, A., Senette, C., & Buzzi, M. C. (2018). Persona design for just-in-time adaptive and persuasive interfaces in menopause self-care. In *Proceedings of the International Conference of Design, User Experience, and Usability*.
- Ulrich, K. T., & Eppinger, S. D. (2012). *Product and design development* (5th ed.). New York, NY: McGraw-Hill/Irwin.
- Van Velsen, L., Van Weering, M. D., Luub, F., Kemperman, A., Ruis, M., Urlings, J., Grabher, A., Mayr, M., Kiers, M., Bellemans, T., & Neven, A. (2019). Travelling with my soulmate: Participatory design of an mHealth travel companion for older adults. In *Proceedings of the 5th International Conference on Information and Communication Technologies for Ageing Well and e-Health*.
- VanHeerwaarden, N., Ferguson, G., Abi-Jaoude, A., Johnson, A., Hollenberg, E., Chaim, G., Cleverley, K., Eysenbach, G., Henderson, J., Levinson, A., Robb, J., Sharpe, S., Voineskos, A., & Wiljer, D. (2018). The optimization of an eHealth solution (Thought Spot) with transition-aged youth in postsecondary settings: Participatory design research. *Journal of Medical Internet Researcch*, 20(3), 1-11.
- Veale, G., Dogan, H., & Murphy, J. (2019). Development and usability evaluation of a nutrition and lifestyle guidance application for people living with and beyond cancer. In *Proceedings of the 8th International Conference on Design, User Experience and Usability*.
- Verbiest, M., Corrigan, C., Dalhousie, S., Firestone, R., Funaki, T., Goodwin, D., Grey, J., Henry, A., Humphrey, G., Jull, A., Vano, M., Pekepo, C., Te Morenga, L., Whittaker, R., & Mhurchu, C. N. (2019). Using codesign to develop a culturally tailored, behavior change mHealth intervention for indigenous and other priority communities: A case study in New Zealand. *Translational Behavioral Medicine*, 9(4), 720-736.
- Vestergaard, L., Hauge, B., & Hansen, C. T. (2016). Almost like being there; the power of personas when designing for foreign cultures. *CoDesign*, 12(4), 257-274.
- Vilarinho, T., Floch, J., & Stav, E. (2017). Co-designing a mHealth application for self-management of cystic fibrosis. In *Proceedings of the 16th IFIP Conference on Human-Computer Interaction*.
- Visser, F. S., Stappers, P. J., van der Lugt, R., & Sanders, E. B.-N. (2005). Contextmapping: Experiences from practice. *CoDesign*, 1(2), 119-149.
- Walker, M., Takayama, L., & Landay, J. A. (2002). High-fidelity or low-fidelity, paper or computer? Choosing attributes when testing Web prototypes. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*.
- Webster, J., & Watson, R. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly*, 26(2), xiii-xxiii.
- Wechsler, J. (2015). HCD mobile health project: Post collaboration reflection of researcher and designer. In *Proceedings of the Asia Pacific HCI and UX Design Symposium*.
- Winters, N., Oliver, M., & Langer, L. (2017). Can mobile health training meet the challenge of “measuring better”? *Comparative Education*, 53(1), 115-131.
- Woods, L., Cummings, E., Duff, J., & Walker, K. (2017a). Design thinking for mHealth application co-design to support heart failure self-management. *Studies in Health Technology and Informatics*, 241, 97-102.
- Woods, L., Cummings, E., Duff, J., & Walker, K. (2017b). The development and use of personas in a user-centred mHealth design project. In *Proceedings of the 29th Australian Conference on Computer-Human Interaction*.
- Woods, L., Cummings, E., Duff, J., & Walker, K. (2018a). Conceptual design and iterative development of a mHealth app by clinicians, patients and their families. *Studies in Health Technology and Informatics*, 252, 170-175.

- Woods, L., Cummings, E., Duff, J., & Walker, K. (2018b). Partnering in digital health design: Engaging the multidisciplinary team in a needs analysis. *Studies in Health Technology and Informatics*, 252, 176-181.
- Woods, L., Duff, J., Roehrer, E., Walker, K., & Cummings, E. (2019a). Design of a consumer mobile health app for heart failure: Findings from the nurse-led co-design of CARE4MyHeart. *JMIR Nursing*, 2(1), e14633.
- Woods, L., Roehrer, E., Duff, J., Walker, K., & Cummings, E. (2019b). Co-design of a mobile health app for heart failure: Perspectives from the team. *Studies in Health Technology and Informatics*, 266, 183-188.
- Woods, L., Duff, J., Roehrer, E., Walker, K., & Cummings, E. (2019c). Patients' experiences of using a consumer mhealth app for self-management of heart failure: Mixed-methods study. *Journal of Medical Internet Research*, 21(5), 1-15.
- World Health Organization. (2011). *mHealth: New horizons for health through mobile technologies*. Retrieved from http://www.who.int/goe/publications/goe_mhealth_web.pdf

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