DEGREE PROJECT IN MEDIA TECHNOLOGY,
SECOND CYCLE, 30 CREDITS
STOCKHOLM, SWEDEN 2021

Persuasive Design in Digital Pediatric Asthma Self-Management: Physician Perspectives

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ABSTRACT

This work explores the acceptability of various persuasive design principles for pediatric users of a digital, asthma self-management solution. While persuasive design methods have been shown to motivate adherence to digital self-management, effective persuasion is highly context-dependent. The gap in research on persuasive design for younger users of asthma self-management applications raises the question of which persuasive principles are acceptable for this group's unique context. This question is explored through the Persuasive Systems Design model. Based on interviews and workshop feedback from physicians, six persuasive principles were chosen for a redesign of an existing asthma self-management solution. The prototype was evaluated for potential acceptability by user proxies. The Personalization and Simulation persuasive principles were perceived as most acceptable for pediatric, digital asthma self-management.

Övertygande design i ett pediatrisk självhanteringssystem för astma - Läkarperspektiv

SAMMANFATTNING

Detta arbete undersöker hur pediatriska användare upplever acceptansen av övertygande designprinciper av ett digitalt självhanteringsstystem för astma. Även om övertygande designmetoder har visat sig motivera att man följer digital självhantering, är effektiv övertalning mycket kontextberoende. Den vetenskapliga kunskapsluckan rörande övertygande design för yngre användare väcker frågan om vilka designprinciper som anses vara acceptabla för denna grupps unika sammanhang. Denna fråga utforskas i detta arbete genom modellen för övertygande systemdesign. Baserat på intervjuer och workshops med läkare valdes sex övertygande designprinciper ut för att designas om för ett befintligt självhanteringssystem för astma. Designprototypen utvärderades med avseende på potentiell acceptans av användarproxys. Resultatet av undersökningen visade att personifierings- och simuleringsövertygande designprinciper uppfattades som mest acceptabla för pediatrisk, digital självhantering för astma.

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2021-10-25

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Author Keywords
Persuasive systems design; mHealth; Behavioral change support systems; Pediatric care; Asthma.

CSS CONCEPTS
• Human-centered computing~Human computer interaction (HCI)~HCI theory, concepts and models • Applied computing~Life and medical sciences~Health care information systems

INTRODUCTION
Asthma is the most common chronic disease among children worldwide, affecting approximately ten percent of school-age children in Sweden alone [39]. Even in patients with mild conditions, symptoms and lung function often vary in intensity depending on exposure to triggers like exercise, allergens, and weather changes. Due to this variability, asthma management requires continuous assessment of patient symptoms and lung function to identify necessary treatment adjustments. Self-management interventions, in which the patient is provided with the tools and education required to manage their condition, are recommended for effective, long-term asthma control [14].

Self-management of chronic diseases is increasingly facilitated through mobile health applications (mHealth). The ease of use and accessibility afforded by mHealth makes it an attractive alternative to other self-management interventions like diaries or school-based aid for children. However, its effectiveness in promoting medication and asthma testing adherence (both major factors in positive health outcomes) in patients of all ages is inconsistent [16,18,26]; moreover, few publicly available mHealth apps are explicitly designed for children [17,28]. As the reviews identifying these trends are dated between 2012 and 2016, more work may have been done since then on improving adherence to pediatric mHealth; however, exploring this context may reveal alternative avenues to motivating self-management.

Improving adherence means designing systems that shape patients' habits, and ultimately attitudes, towards self-management. Persuasive design is an approach that integrates behavioral change theory into the design of user experiences [11]; it is commonly used in mHealth to motivate a range of healthy behaviors, including asthma self-management [16-18,26]. For this persuasion to be effective, understanding user context must be an integral part of the design process; factors such as lifestyle, personality, and age can all influence how a user responds to persuasion [29].

Oinas-Kukkonen and colleagues' Persuasive Systems Design (PSD) model [29] is an influential, context-dependent approach to designing and evaluating persuasive technology. PSD offers 28 principles to use as motivators in the persuasive system; however, selecting which of these will be effective for the intended users and target behavior is based on the *use-*, *user-*, and *technology context*. PSD has been used to integrate persuasive principles into a variety of health-based persuasive systems [1, 35]; however, this does not include digital, self-management solutions for pediatric asthma (as far as the author is aware). Limited work on evaluating persuasive design for pediatric self-management perpetuates the issue of lacking research into children and mHealth, and consequently poorer adherence rates for treatment.

Therefore, this research evaluates the potential acceptability of various persuasive design principles for 10-12 year old users of digital asthma self-management solutions. The intention is to explore which persuasive principles may be suited for improving treatment adherence in pediatric asthma patients, based on their unique context. More than half of children in Europe aged 9-16 own smartphones [25], meaning that the apps they use should be designed for them, not their guardians. Context definition and selection of

persuasive principles were done together with pediatric asthma care specialists and followed the process outlined in the PSD model [29]. Then, the selected principles were integrated into an existing asthma control assessment design in the AsthmaTuner mobile app. Finally, the potential acceptability of the principles in the redesigned prototype was evaluated by asthma care specialists.

AsthmaTuner

This work was done in collaboration with the digital health startup AsthmaTuner [23]. The AsthmaTuner mobile app and companion digital spirometer help asthmatics manage their condition together with their physician. The primary self-management tool in the app is the Treatment Check: an asthma control assessment that results in a tailored medication recommendation. As the Treatment Check tool should be used regularly by patients, it is a good candidate for a persuasive redesign aimed at motivating this target behavior. This work allows AsthmaTuner to explore methods for better engaging their younger users.

Delimitations

The design approach of this work is user-centered and collaborative, however pediatric asthma care specialists were involved instead of 10-12 year old asthmatics. This was primarily due to the ethical challenges of interviewing a vulnerable group about sensitive health information. Substituting end users with expert proxies is not ideal, but is necessary when the target group is difficult to involve [3]. While this may mean a less accurate representation of user experiences and contexts, pediatric asthma specialists have also observed a wider range of patient types than may have been available for this work.

Additionally, the specialists involved in the interviews and workshop are all either employed by AsthmaTuner or have a stake in the company. Participants in the final evaluation were not directly involved with AsthmaTuner, but do treat patients with the app. However, there is no glaring conflict of interest.

Finally, this study does not evaluate whether adherence improved as a result of the redesign. This would have required ethical approval and several weeks of testing, which was not possible within the scope and timeline of this thesis.

RELATED WORK

Persuasive Health Technology

Persuasive technology, a term coined by behavioral change researcher B.J. Fogg, is any computer system intended to *"change behavior or attitudes or both (without coercion or deception)"* [11] (the absence of coercion or deception is a critical part of designing for persuasion and is discussed further in the Ethical Considerations). Persuasive design plays an important role in m- and eHealth for chronic disease management, where maintaining user adherence continues to be a barrier to effective treatment [16]. In order to motivate users to perform target behaviors, systems employ methods called persuasive principles: *Tailoring* (information is tailored to user characteristics), *Reduction* (complex tasks are reduced into simple steps), and *Reminders* (users receive reminders to perform the target behavior) are principles commonly used in persuasive health technology [38].

While not all persuasive m- and eHealth follow frameworks during design, doing so standardizes the process and allows for easier evaluation of their effectiveness [38]. One example is Fogg's influential behavioral model (FBM) [10], which suggests that effective persuasive systems boost users' *ability* and *motivation* to perform a task and must include an appropriate *trigger* for the intended action. Sittig and colleagues [36] incorporated *trigger messages* based on this theory into the diabetes management app capABILITY; however, to facilitate the development of capABILITY, the study also involved the relatively unused persuasive design framework GuideView [19]. While FBM offers a foundation of behavior change theory in which to base the persuasive design, it is more of a conceptual model than a standalone framework to guide the design process.

Oinas-Kukkonen's popular PSD model [29] offers a practical approach to persuasive system design that remains rooted in behavioral change theory and defining user context. Senette and colleagues [35] followed PSD to design an app aimed at improving the lifestyle habits of menopausal women. Combined with participatory design, the authors could identify persuasive principles to employ that were considered acceptable during user evaluation of the app. Similarly, Bartlett and colleagues [1] evaluated the acceptability of different persuasive principles for an app aimed at motivating COPD patients to physical activity; the authors designed three prototypes for evaluation, using the PSD model to guide the process. As far as the author is aware, there are no studies explicitly evaluating the acceptability of persuasive principles in engaging preteen asthmatics to self-management. However, PSD's focus on defining user context provides a framework within which to explore the experiences of this demographic and how they influence treatment adherence.

Digital Asthma Care for Children

While pediatric asthmatics generally respond well to mHealth self-management solutions, treatment adherence rates remain poor. Research into the attitudes of patients, parents, and physicians towards asthma self-management reveals several common influences on treatment adherence: physician-patient relationships, parental and family attitudes towards treatment, and patient asthma education [9,30]. Digital solutions that employ behavioral change strategies like reminders, education, and consistent physician-patient contact have been found to improve adherence [30].

Tae-Jung Yun and colleagues [41] designed a system to facilitate asthma self-management through SMS communication between physicians and their younger patients (10 years and older); while not referenced as such in the study, this is an example of the *Reminder* persuasive principle. The authors found that receiving self-management

related questions *and* true/false asthma knowledge questions via SMS led to improved health outcomes and patient understanding of the condition. Kenyon and colleagues [21] used reminders as well as a financial incentive (the *Reward* persuasive principle, again not referenced as such) in a mobile app to motivate asthma self-management in 5-11 year old patients from poorer backgrounds; the study found significant improvements in adherence and health outcomes. Similarly, Mosnaim and colleagues [27] improved asthma treatment adherence in adolescents from minority backgrounds by tailoring physicians' feedback and education to a population with low health literacy. While [21] and [27] focused primarily on the users' socioeconomic background, the results are an example of the importance of considering context when choosing persuasive principles.

A few strategies like SMS and in-app reminders have been found effective at improving adherence in multiple studies [20,21,27,41]; however, there remains an unexplored gap for the acceptability of other persuasive principles in the context of pediatric self-management. [21] and [27] indicate that there are more opportunities for improving adherence through persuasion by exploring user context.

DEFINING THE PERSUASION CONTEXT

Designing for persuasion begins with understanding a user's context when interacting with the system. The PSD defines context through three dimensions: *Intent*, *Event*, and *Strategy*.

Intent

The intended behavioral outcome of this design is weekly use of the Treatment Check tool by asthmatic children aged 10-12 years old, who have been prescribed AsthmaTuner by a physician; this frequency of use is defined by asthma care specialists involved with AsthmaTuner.

Event

The event involves the *use context*, *user context*, and *technology context* [29]. The *use context* is relevant when the user is interacting with the persuasive system (i.e. testing their asthma control level); in this case, mood, physical location, privacy, and features of the task involved are all factors that affect persuasiveness. Conversely, the *user context* is independent of the task of self-management, but includes user-dependent factors that may affect system persuasiveness, such as social influences, goals and motivations, and lifestyle. Finally, the *technology context* is the medium through which the persuasive message is relayed, meaning the device, application, system implementation, etc. and any technical challenges involved [15]. In this paper, the use and user contexts are defined through the interview results, and the technology context is considered in the design process.

Strategy

The persuasive message relies on users feeling that regular self-management offers greater benefits (health, social, etc.) than disregarding it; this is also defined by asthma care specialists at AsthmaTuner. The strategy involves both direct and indirect routes of persuasion [29] (for example, explaining the effect of treatment on asthma versus allowing users to personalize the interface, respectively).

Methodology

Interviews

To define the user and use contexts of 10-12 year old asthmatics, semi-structured interviews were conducted with three pediatric asthma care specialists; the specialists served as proxies to the intended end users. Interviews are a standard and commonly used data collection method in user-centered design; the semi-structured format produces richer qualitative results by allowing for follow-up questions about participant answers [6]. Access to physicians was very limited due to Covid-19 vaccine rollout; therefore, the decision was made to interview a smaller sample of participants who were available for longer interview and workshop sessions. Each participant agreed to be interviewed for 45 minutes.

Interview questions were based on insights from a review of previous work on pediatric patient, parent, and physician attitudes towards asthma self-management. According to research, the major predictors of treatment adherence in children and adolescents are consistent physician-patient relationships, parental and family attitudes towards treatment, and patients' comprehension of their condition [9,30]. Several interview questions explored these themes, while others were more open-ended to allow for participants to offer any alternative perspectives on adherence and self-management. The purpose of the interviews was to collect data with which to define the use and user contexts; therefore, the questions also indirectly referenced the factors involved in both contexts. Interviewees were briefed on the study background and told to share their experiences and insights on 10-12 year old patients.

All data was transcribed and context themes were identified through the KJ method [33]. Participants are referred to as P1, P2, and P3.

Use Context

The following are *use context* factors discussed by the interviewees. These factors are situational and describe the user's self-management experience when interacting with the AsthmaTuner system.

Emotional reactions to system use

All interviewees noted that patients are excited and curious when they first receive AsthmaTuner and the companion spirometer. This appears to be due to a combination of several factors: the tool is novel compared to traditional solutions; patients are allowed to use an app on their phone, an activity which otherwise might be limited by their parents; and having a tool intended for their own personal use gives patients independence in their self-management. As mentioned by P1, "*In the beginning they think it's really cool to have an app, and their own device, and they can actually do something themselves.*"

However, the interviewees have noticed that after about a week the initial interest begins to wane. From that point on, engagement appears to be less rooted in entertainment value and more in recognizing the effect of successful treatment. P2 explained how patients who were followed up with eight weeks after starting AsthmaTuner were especially happy with their progress because they had started seeing a positive effect on their asthma and their life; for example, one patient was excited that they could now meet their friend's cat without its fur triggering a flare-up. By this point patients also tend to become more inquisitive about their asthma:

> When you have a meeting with them kinda soon [after starting AsthmaTuner] then they have some questions like 'What do you mean with that symptom question? Why doesn't it change if I have this percentage of lung function? I have a cold now but it says-' They have so many then and they're actually starting to get it.

Unfortunately, self-management outside of a study usually involves yearly check-ups with the doctor, meaning that many of the early milestones are forgotten by the time of the appointment.

Parental involvement

Parental influence on children's engagement in self-management is well-documented [9,30], and responses from the interviewees reflect previous findings. In the interviewees' experiences, parents (or guardians) are still significantly involved in self-management of 10-12 year olds. Self-management is a collaborative effort, with patients often relying on their parents to remind them to test and take their medication. Parents even get involved during testing by explaining complicated language or urging their children to read carefully.

Education

Asthma education that promotes awareness and comprehension in patients has been found to improve treatment adherence [30]. While the interviewees echoed this from their own experiences, they stressed that education is truly effective when explaining *why* regular treatment is important. Without this context, the theory tends to be lost on patients, as explained by P1:

> You have your asthma, these are the symptoms, these are the meds that help, that's it...I think it's hard to motivate a 10 or 12 year old by talking about theoretical concepts like airway inflammation. In very general terms, yes.

P2 stressed the importance of using the medical realities to provide meaning to patients' self-management and in turn motivate why they should adhere to it. They also noted that physicians can forget that patients do not all have the same level of 'general knowledge;' some may feel like they have seen it all before, while others are left confused about what an asthma diagnosis and treatment means for them.

Task-related factors

All the interviewees referenced aspects of the self-management task that influence patients' adherence. On the one hand, the process of assessing asthma control involves a straightforward series of steps. P1 and P3 agreed that this was beneficial for younger patients because they wanted to skip instructions and instead learn hands-on.

On the other hand, there is a certain level of regulation when using a standard method for asthma control assessment that is not entirely suited for younger patients. P2 noted that patients tend to have the most trouble when recording their symptoms because the questions set by international guidelines [14] use language that is too advanced. This can be especially disarming when patients are used to more accessible language from their physician and the rest of the app:

> When you're talking to the kid, in the clinic, you're talking to them in a certain way, and then when you get the symptom questions from here, you want to change them, just so they understand what they're asking.

User Context

The following are *user context* factors discussed by the interviewees. These factors are independent of AsthmaTuner and instead focus on users' overarching experiences as young asthmatics.

Lifestyle

The level of activity in a patient's lifestyle is considered a significant influence on treatment adherence by all interviewees. From their experience, patients with active lifestyles are easier to motivate because they trigger their asthma more regularly during exercise and therefore directly see the benefits of reducing their symptoms through treatment; the feeling of being triggered also affirms to them that they have asthma. Meanwhile, patients who are sedentary do not necessarily face performance challenges due to their asthma and consequently have fewer opportunities to see the practical benefits of self-management, as described by P1:

> Some kids aren't motivated, they just want to sit in front of their computer and they're going to as few...sports or PE lessons as possible at school and trying to avoid any type of physical activity, and then you can't - it's really difficult to motivate, because they don't trigger their asthma that often, that much, either.

Without a payoff, these patients may not understand the purpose of treatment or believe they need it.

Attitude and skepticism

Patients tend to have varying attitudes towards their asthma, based on previous treatment experience and the attitudes of authority figures around them. P2 and P3 described how patients with severe asthma are more likely to be bored or fatigued by their condition than milder cases; this stems from the chore of daily management as well as the stress of regular

doctor's visits and new treatments. An apathetic approach can mean these patients are less receptive to introducing new tasks into their treatment routine and less open to discussing their asthma.

Another attitudinal challenge to adherence is patient skepticism about whether they even have asthma. Often this is actually due to a successful treatment plan which reduces symptoms and leads to patients assuming they are 'cured' and do not need medication. Moreover, if a patient ever received an inconclusive asthma diagnosis (whereby further treatment is required to 'wait and see'), then, according to P2:

> These kids, they remember this, even like twenty years later they're gonna like, 'Oh well the doctor wasn't sure if I even have asthma, so I'm not sure if I should take this medication...but I do when I have symptoms, because then I think it helps. But they don't even know if I have asthma'...It's not like a blood test that says 'Yes, you got it,' then they're like 'Oh ok.'

While patients are sensitive to clinicians' skepticism, they are particularly influenced by parental attitudes towards asthma treatment. Most 10-12 year old patients will echo their parents' sentiments, suggesting that patients with parents who question the diagnosis or are wary of giving their child medication have poorer treatment adherence.

CHOOSING PERSUASIVE PRINCIPLES

The second phase of PSD involves selecting the persuasive principles that will be used in the system. Persuasive principles are methods by which the system motivates the user to perform the intended behavior; for example, the *Reward* principle is employed when an incentive is offered to the user. The PSD lists 28 principles, however not all are suitable for the system. The Event definition (Intent, Contexts, and Strategy) should motivate the selection of acceptable principles [4].

Methodology

Interviewees P2 and P3 were also involved in selecting the principles through a workshop. In order for the participants to offer informed insights into which principles may be acceptable for 10-12 year old AsthmaTuner users, the results of the interviews were synthesized into three personas and introduced at the beginning of a workshop; this also allowed the participants to confirm that the themes identified in the qualitative data were an accurate representation of their responses. During the workshop, participants discussed which personas would benefit from nine pre-selected principles.

Personas

Personas are a common method for representing qualitative data wherein mock users are built from data insights. The traditional reasoning for data-driven personas is that they help motivate design decisions by allowing designers to consider the impact on different types of real users [6]. While the method's success in this purpose has been debated, personas have alternatively been found effective in "[activating] the pre-understanding" of other users [2]. In this work, the personas acted as a common thread throughout the rest of the study, by which workshop and final evaluation participants could reflect on their own understanding of the target group.

The use- and user context factors served as the basis for three personas:

- Nadine (12), who never received a conclusive diagnosis and is skeptical that she has asthma (see Figure 1);
- Oskar (10), who is treating his asthma because his doctor said it would improve his football performance;
- Lisa (11), who has severe asthma and adheres to self-management because her parents tell her to

The personas were presented to workshop participants as digital cards and included information about the personas' home life, their likes, their reason for using AsthmaTuner, and the regularity of their self-management habits. After reviewing the personas, the participants agreed that they were reflective of their observations of 10-12 year old patients.

Figure 1. "Nadine" persona used in workshop to represent patients who are skeptical about their asthma. Photo: Julia M Cameron on Pexels.

Workshop

The purpose of the 1.5 hour workshop was to co-evaluate the potential acceptability of persuasive principles for 10-12 year old AsthmaTuner patients. Ultimately, insights from the discussion between participants drove the selection of principles to incorporate into the app design. Out of the 28 principles listed in PSD, 9 were pre-selected for discussion during the workshop (see Table 1). The other principles were filtered out because they were either already implemented as an AsthmaTuner feature or considered irrelevant to the intent and context.

Principle	PSD definition [29]
Tailoring	System presents information that

	reflects users' needs, wants, etc.
Personalization	System content and services can be personalized
Simulation	System simulates to users positive effect of target behavior
Authority	System takes on a role of authority or references authority figures
Social role	System takes on a social role
Social comparison	System allows users to compare their performance to others'
Competition	System allows users to compete
Praise	System uses positive, affirming language
Similarity	System reminds users of themselves

Table 1. Persuasive principles discussed in workshop

The two workshop participants were first briefed on persuasive design and persuasive principles to give context to the discussion. Before the workshop, they also received a deck of digital cards that included a definition of each pre-selected principle, an example from an app or website, and a quote from the interviews that had motivated the inclusion of that principle in the 9 pre-selected (see Figure 2). The use of cards was inspired by previous work showcasing the method's effectiveness in persuasive co-design and co-evaluation workshops [8,31].

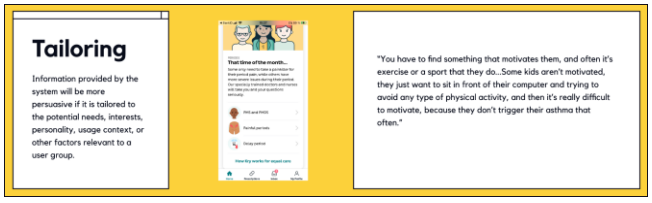

Figure 2. Tailoring persuasive principle card with definition from [29], example, and related quote from interview. Screenshot: Kry mobile app.

Due to Covid-19 restrictions, the workshop was remote and held through video call. All resources were available to participants in a collaborative digital whiteboard. During the workshop, participants took time to individually move 'stickers' representing each persona to the persuasive principle cards they felt were acceptable for them. The workshop concluded with the participants explaining why they had placed the stickers on those principles; this typically developed into a discussion if there was inconsistency between participants' choices.

Results

There was unanimous agreement that the Praise and Similarity principles would be persuasive for all 3 personas. The participants believed Praise to be an effective motivator for patients of all ages. Similarity was considered useful in the context of 10-12 year old patients in order to address issues of uncertainty around medical jargon, as explained by P2:

> They would feel more like 'oh this is an app for *me* that I can use and that I understand' instead of being a bit scared of the app, not sure that they're using it right. They don't even know if they're supposed to trust the treatment plan because they don't know if they actually understood the symptom questions.

The Social Comparison and Competition principles were initially recommended for all 3 personas by P2 and only for the "Oskar" persona by P3; the latter felt that Oskar's predisposition to sports lent itself better to gamification-based persuasion. However, after discussion the participants agreed that the true benefit to these principles is rooted in allowing patients to connect with their peers, as described by P2:

> To see that other kids have asthma and how they are feeling and what they are doing. I think they would be motivated to see that they're not by themselves.

Furthermore, the risk of introducing competitiveness into self-management was called into question. The participants felt that Competition would have to be independent of personal health outcomes to avoid the danger of comparing treatment progress.

P2 chose the Authority principle for Nadine and Lisa because these personas were not internally motivated, and thus could benefit from a better understanding of why treatment is important to *them*. Leveraging Authority could reference back to the important asthma information the doctor had given these types of patients, to remind them what might happen to their condition if they do not adhere to treatment. P3 was skeptical of Authority, and felt that the Social Role principle was a lighter option for integrating the physician-patient relationship into the app:

> I think authority is a really fine balance...maybe it's a better approach as I understand the social role, maybe the app could have a role more like the doctor and reminding in a fun way.

Both participants agreed that Tailoring and Personalization were suited to one persona each (Oskar and Lisa, respectively). They believed Tailoring to be more effective for Oskar because he had a clearer personal motivation for self-management (i.e. his interest in sports); however, adapting for different interests could help illustrate to patients that asthma affects more than just physical

performance. Personalization seemed better suited for Lisa as a patient who is tired of being reminded that she has asthma, because it would allow her to focus on more fun aspects of self-management and in time "*befriend her asthma*," as described by P2.

The Simulation principle drew concern from the participants about the likelihood of false promises for treatment outcomes. As explained by P3:

> If you make sure they understand that this is a potential, that potentially they could be like this or the effect could be like this, but there are no guarantees. You never make the child disappointed.

They felt that the principle could be persuasive for the Oskar persona, who has a practical treatment goal (i.e. improving in football), and the Nadine persona, who lacks a reference for how treatment could benefit her. However, simulating too great of a positive outcome would only disappoint patients and create another barrier to adherence.

REDESIGNING THE PERSUASIVE SYSTEM

The next stage involved integrating the persuasive principles into the system by redesigning the existing AsthmaTuner Treatment Check flow.

Technology Context

According to the PSD, the third contextual influence on persuasion is the technical medium [29]. However, software implementation of the redesign is not within the scope of this study; therefore, besides designing for a mobile interface common among AsthmaTuner users, technical challenges were not considered. AsthmaTuner is used on mobile iPhone or Android devices, so the prototype is designed for an iPhone X interface.

Methodology

The selection of principles to include in the new design was based on the workshop feedback and the scope of the Treatment Check flow. While all 9 principles could undergo further evaluation, ultimately Authority, Personalization, Social Role, Simulation, Praise, and Similarity were chosen for the redesign. As for the remaining three: Tailoring is already commonly used in mHealth and shown to be effective in improving adherence, while Social Comparison and Competition would have required adding features outside of the Treatment Check.

The design process followed the commonly used double diamond model [4], however due to time pressure only one iteration was performed. The double diamond method is cyclical: a deliverable is meant to go through several iterations of ideation, design, and evaluation. However, the resulting prototype in this study is still a work in progress and the design should be revisited based on the results of the evaluation (this is expanded on in the Discussion).

The ideation stage aimed to identify opportunities for integrating the persuasive principles in the existing flow. Based on existing examples of persuasive features in other apps and suggestions offered during the workshop, several concepts were sketched for each of the principles. Figure 3 shows an alternative design for the Social Role principle, where a virtual doctor character walks the patient through the Treatment Check. Ultimately this seemed too obtrusive and text-heavy, so in order to avoid worsening cognitive acceptability this feature was not included.

Figure 3. Alternative design concept for Social Role principle.

The final stage of hi-fi prototyping involved an iteration of designing, building, and a simple think-aloud usability test with P2, who participated in the interviews and workshop, to evaluate that the integrated principles still allowed for a smooth user experience and aligned with the postulates.

Result

The result of the first redesign is a hi-fi prototype of the AsthmaTuner Treatment Check with the following persuasive principles: Authority, Personalization, Social Role, Simulation, Praise, and Similarity. The Treatment Check follows the standard asthma control assessment process: firstly, the patient measures their lung function by breathing into their companion spirometer; secondly, they record any asthma symptoms from the past week; finally, they receive a tailored medication recommendation based on their inputs [14]. The prototype maintains these steps. Additionally, the visual design observes the company design system.[1]

[1] Character designs courtesy of AsthmaTuner's lead designer, Isabella Smolarski.

The following are features that integrate the persuasive principles into the redesign:

- *Personalization* is the first principle to appear in the flow as theme and character customization. The user can choose between a light or dark theme and the design of an 'asthma avatar.'
- *Simulation* is conveyed through a storyline between assessment steps: the asthma avatar appears in a series of animations that illustrate how triggers can lead to poorer lung function and more symptoms, which are ultimately remedied with regular treatment (see the final animation in the series in Figure 4).
- *Social role* is also dispersed through the flow as subtle messages to the user from the system. For example, when the user records their asthma triggers, "Got it!" and "Tell me more…" texts appear at the top of the screen, as if the system were responding.
- *Similarity* is limited to the symptom questions, where the jargoned text is lightened by dividing the four questions into individual, swipeable cards that include simpler summaries alongside the phrasing set by international guidelines.
- *Authority* appears towards the end, when the doctor's role in the medication recommendation is emphasized. The recommendation appears as a message from the doctor, complete with their actual name (see Figure 4).
- *Praise* is already present at certain points in the current implementation Treatment Check, however this evaluation focuses on praising the user for having controlled asthma (i.e. a positive assessment result) (see Figure 4).

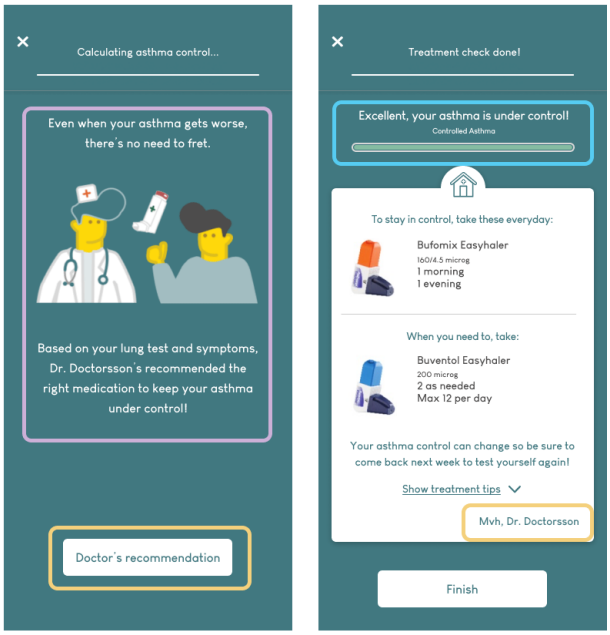

Figure 4. Examples of Authority (yellow), Simulation (pink), and Praise (blue) persuasive principles in redesign. The other elements are part of the original Treatment Check design.

EVALUATING POTENTIAL ACCEPTABILITY

To evaluate the potential acceptability of the persuasive principles in the context of the asthma control assessment, pediatric asthma specialists, who were not involved in the interviews or workshop, tested the prototype as expert proxies for the earlier personas. Due to extremely limited availability of physicians with relevant experience, only two participated in the evaluation.

Methodology

Acceptability is commonly used in healthcare as a metric for how a medical intervention addresses the needs and abilities of a target group [34]. However, the definition tends to be inconsistent between studies, with many lacking any explicit definition or theorization. Based on a review of such studies, Sekhon and colleagues [34] concluded that acceptability is *"a multi-faceted construct that reflects the extent to which people delivering or receiving a healthcare intervention consider it to be appropriate, based on anticipated or experienced cognitive and emotional responses to the intervention;"* the authors go on to identify seven components of acceptability, though this evaluation is based on the overarching proposed definition.

To gauge patients' *"anticipated...cognitive and emotional responses"* to the design, two asthma specialists performed think-aloud walkthroughs of the prototype and answered semi-structured interview questions. A think-aloud requires the participant to verbalize their thoughts as they interact with a system; [40] found the method suitable for evaluating both overall acceptability and that of specific elements in an intervention.

One challenge involved how to support the asthma specialists to act as expert proxies for 10-12 year old asthmatics. Therefore, the three personas were used once again to a) define the end user that the participant had in mind and b) provide them with concrete user needs on which to evaluate acceptability. Each participant chose the persona that they felt best reflected their patient experiences. While the use of personas in evaluating mHealth has not been reviewed, the method has been effective in the design of acceptable interventions [22,37]. Additionally, in a review of personas in heuristic evaluation, [12] found similar results between participants who used personas compared to those who did not.

Each 25 minute session began with a short introduction to the project. The participants then selected their persona and performed a think-aloud of the prototype. This was followed up by the semi-structured interview questions. The participants are referred to as P4 and P5.

Results

Both participants felt that the prototype would be generally acceptable for their chosen persona, in terms of cognitive and

emotional reaction. P4, who chose Oskar, thought he would be *"excited"* to use it and would find it *"really easy to follow the steps, and...easy to understand what to do."* Similarly, P5, who chose Lisa, said it is acceptable for her because it is *"so easy to understand."* The current design of the AsthmaTuner Treatment Check has already been found to be acceptable, so the overall perception is likely based on existing elements from the original design. However, the positive response suggests that the persuasive design changes did not affect the overall acceptability.

The participants' insights on specific principles reveal the perceived acceptability of the redesigned elements. The Simulation principle design involved placing the trigger tracking feature towards the beginning of the flow, instead of at the end. Both P4 and P5 praised this in its potential to improve patients' understanding of their asthma; for example, P5 suggested that it would be easier for patients to recognize *"that it's not only pollen that makes [your asthma] worse."*

The participants also appreciated the avatar selection (Personalization principle), although P4 simply felt that this would appeal to children, without further insight. P5 explained the appeal as *"it's like you have a friend in the app"*; this description suggests that the Personalization design element also fulfills the Social Role principle.

While P5 thought the multi-step design of the symptom questions was cognitively acceptable, P4 raised concerns about the increased number of steps in the Treatment Check flow, explaining that, *"sometimes they just want to make the lung function test and then it's so many steps they have to go through before they come there."* PSD has eight postulates for persuasive design, one of which states that *"Persuasive systems should aim at unobtrusiveness"* [29]; P4's comments suggest the design's shortcoming in this aim.

Finally, P5 drew attention to another opportunity for employing the Similarity principle when they noted that children and parents tend to refer to asthma medication by its packaging color rather than the name; however, they warned that that type of language is not professional for a medical app.

DISCUSSION

The aim of this work was to evaluate the perceived acceptability of certain persuasive design principles for 10-12 year old users of digital asthma self-management solutions. While these principles were evaluated in the context of an asthma control assessment design, they were chosen based on a broader definition of user and use context. Therefore, the question of which persuasive principles may be acceptable for the target group is answered through a discussion of results from all phases of this study.

Perceived Acceptability of Persuasive Principles

Tailoring, Reminders, Rewards, and Reduction are persuasive principles that have already been employed in digital, pediatric, asthma care [20,21,27,41], including AsthmaTuner [23]. By defining the specific context of 10-12 year olds who self-manage their asthma, this work explored further persuasive options for this target group.

Acceptable principles

The Simulation principle was perceived as acceptable for the target group when employed for patient education, but its acceptability for goal-setting requires further exploration. The importance of both approaches was emphasized during the interviews and workshop: asthma education has been found to improve adherence [30] and this was echoed by the participants, while setting lifestyle goals was suggested to combat apathy among patients who do not recognize the purpose of treatment. During the workshop, the Simulation principle was discussed as a method for showing patients the link between asthma treatment and lifestyle improvements; however, the participants warned about false promises and the emotional unacceptability of disappointing patients. Consequently, the prototype design instead featured the Simulation principle in the context of educating about asthma flare-ups and responding with correct treatment. The purpose of integrating this into the asthma control assessment flow was to help patients recognize the role of each task in a positive health outcome. The participants' affirmation of the cognitive acceptability of the design in helping patients to understand their asthma suggests that the Simulation principle may be effective in this regard. However, the possibilities for Simulation (or alternative principles) in goal-setting should not be disregarded. In a study on personal informatics, Rooksby and colleagues [32] found that behavior change, such as increased exercise, did not occur as a result of using personal trackers, but rather because the trackers supported longer-term goals; in other words, personal tracking is *prospective*. Indeed, interviewee P2's anecdote about the patient who was satisfied with their treatment because it allowed them to visit their friend without a flare up from their cat contributes to the notion that tracking habits are built on emotional engagement in personal milestones.

The use of the Personalization principle in the asthma control assessment was perceived as emotionally acceptable for the target group, especially those with more severe asthma. According to interviewees P2 and P3, these types of patients tend to be fatigued by their condition and treatment, due to the chore of daily management as well as the stress of regular doctor's visits. During the workshop, the participants agreed that Personalization is better suited for the Lisa persona because it may let her engage in self-management without placing too much focus on her condition; as P2 put it, she could "*befriend her asthma*." In the prototype evaluation, both participants felt the Personalization design would appeal to their personas, but P5, who chose Lisa, explained that choosing an avatar was like having *"a friend in the app."* While this language may be more reminiscent of the Social Role principle, the level of engagement implied by 'making friends' with one's asthma suggests emotional acceptability of the Personalization principle; this is especially important

for Lisa-type patients, who, according to the observations of the participants, are disillusioned by asthma's presence in their life. However, the option to change the theme colors in the prototype was not referenced during the evaluation, which suggests that Personalization should be paired with the Social Role principle in order to trigger this type of friendly engagement; this can be explored further in future work.

Principles for further investigation and design

The Praise, Authority, Social Role, and Similarity principles were either not directly acknowledged during prototype evaluation or were not perceived as acceptable by at least one participant. Praise and Authority were not acknowledged; however, this does not necessarily mean that they are unacceptable. The designs may have been too subtle, so perhaps a comparative study between the current AsthmaTuner app and the prototype would draw more attention to smaller changes. The emphasis on these principles as powerful motivators by workshop participants suggests that they are good candidates for further investigation. Social Role was also not directly referenced, but as mentioned in the previous section, the language around 'making friends with one's asthma' through the Personalization avatar selection may mean an effective pairing between these two principles. Finally, while the Similarity principle has potential for making clinical jargon more accessible and recognizable to pediatric patients, as noted by workshop and prototype evaluation participants, its acceptability in this context also relies on adhering to clinical guidelines [14] and postulates of persuasive design [4].

In further iterations of the double diamond design process, alternative concepts should draw on feedback from physician participants; however, it would also be valuable to explore persuasive design implementations in other systems designed for children, such as educational apps [24]. Furthermore, despite the intentionally narrow context definition of 10-12 year olds with asthma, previous research on designing for children [5,13] may prove valuable in better meeting persuasive design postulates like *ease of use* and *cognitive consistency* [29].

Ethical Considerations

Designing for persuasion raises questions about the ethicality of motivating behavior and attitude change [7], especially in a group as vulnerable as pediatric patients. Granted, the intent of this system is to motivate behavior that leads to improved health outcomes; although, *how* that behavior is motivated must be determined with sensitivity and ethical considerations. During the workshop, the participants warned against the risks involved with certain principles, such as unrealistic expectations of treatment outcomes through Simulation or unhealthy comparison through Competition. These concerns were considered in the process of selecting principles for prototype design; however, next time a more rigorous approach, such as Value-Sensitive Design [7], should be used.

Physician Perspectives

Due to ethical limitations, this study was not done directly with end users. Instead, asthma care specialists acted as user proxies, offering their insights on context and acceptability based on extensive experience with pediatric patients. On the one hand, the physicians may have had insights on a wider range of patients, including those that would have otherwise been difficult to involve in a study (for example, Nadine-type patients who are skeptical of their asthma diagnosis). On the other hand, physicians do not have access to the patients' daily lives, when much of the habit-building of self-management occurs; therefore, they could only speak from their observations and patient accounts during clinic visits. For a more complete definition of user context, daily self-management by pediatric patients should be observed.

Furthermore, it should be noted that although the evaluation participants were able to identify at least one persona that represented patients they had treated, P5 noted that it was *"not so easy"* to assess the prototype as a proxy for a younger user. Involving more physicians in the entire design process, from interviews to evaluation, may have given participants more time to reflect on their experiences with pediatric patients and resulted in a more informed assessment of the redesign. Unfortunately, full schedules and limited availability made it unfeasible to include all five physicians in the entire design process.

Despite the challenges, physician perspectives are necessary in the development of acceptable mHealth. Within asthma self-management, the physician-patient relationship plays an important role in treatment adherence [9,30]; therefore, it is valuable to involve physicians in the development process to leverage their influence. Additionally, they can guide on clinical regulations that may influence design.

CONCLUSION AND FUTURE WORK

In conclusion, out of the evaluated principles, Personalization and Simulation were perceived as most acceptable for 10-12 year old users of a digital, asthma self-management solution. More specifically, Personalization may improve emotional acceptability by promoting engagement without focusing on condition, especially when combined with the Social Role principle. Simulation may be cognitively acceptable in educating patients on cause and effect of the asthma control assessment. To confirm this, an acceptability study must be performed with the target group. Furthermore, the Praise, Authority, Social Role, and Similarity principles should be explored further, either in more targeted evaluations of the respective redesigned elements or alternative prototype designs. Finally, an overlooked aspect of the user context was the role of family in pediatric self-management; future work could focus on the acceptability of using parental influence in persuasive design.

ACKNOWLEDGEMENTS

I am grateful to all the physicians who participated in this study and offered their valuable insights. A big thank you

goes to my supervisor Madeline Balaam, who provided excellent guidance and reassurance from start to finish. Last but certainly not least, a special thank you goes to AsthmaTuner, who not only trusted me to drive this project but also were a consistent support in organizing participants (thank you Anna Carleborg and Isabella Smolarski!).

REFERENCES

1. Bartlett, Y., Webb, T. and Hawley, M. Using Persuasive Technology to Increase Physical Activity in People With Chronic Obstructive Pulmonary Disease by Encouraging Regular Walking: A Mixed-Methods Study Exploring Opinions and Preferences. *Journal of Medical Internet Research 19*, 4 (2017), e124.
2. Bødker, S., Christiansen, E., Nyvang, T. and Zander, P. Personas, people and participation. *Proceedings of the 12th Participatory Design Conference on Research Papers: Volume 1 - PDC '12*, (2012).
3. Boyd-Graber, J., Nikolova, S. and Moffatt, K. et al. Participatory design with proxies. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, (2006).
4. British Design Council. *Eleven lessons: managing design in eleven global brands*. London, 2007.
5. Chen, X., Nayak, M., Wong, T., Kawas, S. and Kientz, J. Interaction design & children toolkit. *Proceedings of the 2020 ACM Interaction Design and Children Conference: Extended Abstracts*, (2020).
6. Cooper, A., Reimann, R., Cronin, D. and Noessel, C. *About Face: The Essentials of Interaction Design*. John Wiley & Sons, Inc., Indianapolis, 2014.
7. Davis, J. Design methods for ethical persuasive computing. *Proceedings of the 4th International Conference on Persuasive Technology - Persuasive '09*, (2009).
8. Davis, J. Generating Directions for Persuasive Technology Design with the Inspiration Card Workshop. *Persuasive Technology*, (2010), 262-273.
9. Drotar, D. and Bonner, M. Influences on Adherence to Pediatric Asthma Treatment: A Review of Correlates and Predictors. *Journal of Developmental & Behavioral Pediatrics 30*, 6 (2009), 574-582.
10. Fogg, B. A behavior model for persuasive design. *Proceedings of the 4th International Conference on Persuasive Technology - Persuasive '09*, (2009).
11. Fogg, B. *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann, San Francisco, 2002.
12. Friess, E. Personas in Heuristic Evaluation: An Exploratory Study. *IEEE Transactions on Professional Communication 58*, 2 (2015), 176-191.
13. Gelderblom, H. and Kotzé, P. Ten design lessons from the literature on child development and children's use of technology. *Proceedings of the 8th International Conference on Interaction Design and Children - IDC '09*, (2009).
14. Global Initiative for Asthma. *Global Strategy for Asthma Management and Prevention*. 2021. https://ginasthma.org/
15. Halttu, K., Oduor, M., Tikka, P., and Oinas-Kukkonen, H. About the persuasion context for BCSSs: Analyzing the contextual factors. *CEUR Workshop Proceedings 1369*, (2015), 43–50.
16. Hamine, S., Gerth-Guyette, E., Faulx, D., Green, B. and Ginsburg, A. Impact of mHealth Chronic Disease Management on Treatment Adherence and Patient Outcomes: A Systematic Review. *Journal of Medical Internet Research 17*, 2 (2015), e52.
17. Huckvale, K., Car, M., Morrison, C. and Car, J. Apps for asthma self-management: a systematic assessment of content and tools. *BMC Medicine 10*, 1 (2012).
18. Hui, C., Walton, R., McKinstry, B., Jackson, T., Parker, R. and Pinnock, H. The use of mobile applications to support self-management for people with asthma: a systematic review of controlled studies to identify features associated with clinical effectiveness and adherence. *Journal of the American Medical Informatics Association 24*, 3 (2016), 619-632.
19. Iyengar, M., Florez-Arango, J. and Garcia, C. GuideView. *Proceedings of the 4th International Conference on Persuasive Technology - Persuasive '09*, (2009).
20. Johnson, K., Patterson, B. and Ho, Y. et al. The feasibility of text reminders to improve medication adherence in adolescents with asthma. *Journal of the American Medical Informatics Association 23*, 3 (2015), 449-455.
21. Kenyon, C., Sundar, K. and Gruschow, S. et al. Tailored medication adherence incentives for high-risk children with asthma: a pilot study. *Journal of Asthma 57*, 12 (2019), 1372-1378.
22. LeRouge, C., Ma, J., Sneha, S. and Tolle, K. User profiles and personas in the design and development of consumer health technologies. *International Journal of Medical Informatics 82*, 11 (2013), e251-e268.
23. Ljungberg, H., Carleborg, A. and Gerber, H. et al. Clinical effect on uncontrolled asthma using a novel digital automated self-management solution: a physician-blinded randomised controlled crossover trial. *European Respiratory Journal 54*, 5 (2019), 1900983.
24. Lucero, A., Zuloaga, R., Mota, S. and Muñoz, F. Persuasive Technologies in Education: Improving Motivation to Read and Write for Children. *Persuasive Technology*, (2006), 142-153.
25. Mascheroni, G. and Ólafsson, K. The mobile Internet: Access, use, opportunities and divides among European children. *New Media & Society 18*, 8 (2016), 1657-1679.
26. Morrison, D., Wyke, S. and Agur, K. et al. Digital Asthma Self-Management Interventions: A Systematic Review. *Journal of Medical Internet Research 16*, 2 (2014), e51.

27. Mosnaim, G., Li, H. and Martin, M. et al. A tailored mobile health intervention to improve adherence and asthma control in minority adolescents. *The Journal of Allergy and Clinical Immunology: In Practice 3*, 2 (2015), 288-290.e1.
28. Mulero, A. Gottlieb: FDA Approvals for Pediatric Devices Continue to Lag. *Raps.org*, 2018. https://www.raps.org/news-and-articles/news-articles/2018/8/gottlieb-fda-approvals-for-pediatric-devices-cont?feed=Regulatory-Focus&utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202018-08-15%20MedTech%20Dive%20%5Bissue:16659%5D&utm_term=MedTech%20Dive.
29. Oinas-Kukkonen, H. and Harjumaa, M. Persuasive Systems Design: Key Issues, Process Model, and System Features. *Communications of the Association for Information Systems 24*, (2009).
30. Ramsey, R., Plevinsky, J., Kollin, S., Gibler, R., Guilbert, T. and Hommel, K. Systematic Review of Digital Interventions for Pediatric Asthma Management. *The Journal of Allergy and Clinical Immunology: In Practice 8*, 4 (2020), 1284-1293.
31. Ren, X., Lu, Y., Oinas-Kukkonen, H. and Brombacher, A. Perswedo: Introducing Persuasive Principles into the Creative Design Process Through a Design Card-Set. *Human-Computer Interaction – INTERACT 2017*, (2017), 453-462..
32. Rooksby, J., Rost, M., Morrison, A. and Chalmers, M. Personal tracking as lived informatics. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, (2014).
33. Scupin, R. The KJ Method: A Technique for Analyzing Data Derived from Japanese Ethnology. *Human Organization 56*, 2 (1997), 233-237.
34. Sekhon, M., Cartwright, M. and Francis, J. Acceptability of healthcare interventions: an overview of reviews and development of a theoretical framework. *BMC Health Services Research 17*, 1 (2017).
35. Senette, C., Buzzi, M., Paratore, M. and Trujillo, A. Persuasive design of a mobile coaching app to encourage a healthy lifestyle during menopause. *Proceedings of the 17th International Conference on Mobile and Ubiquitous Multimedia*, (2018).
36. Sittig, S., Wang, J., Iyengar, S., Myneni, S. and Franklin, A. Incorporating Behavioral Trigger Messages Into a Mobile Health App for Chronic Disease Management: Randomized Clinical Feasibility Trial in Diabetes. *JMIR mHealth and uHealth 8*, 3 (2020), e15927.
37. Trujillo, A., Senette, C. and Buzzi, M. Persona Design for Just-in-Time Adaptive and Persuasive Interfaces in Menopause Self-care. *Design, User Experience, and Usability: Users, Contexts and Case Studies*, (2018), 94-109.
38. van Gemert-Pijnen, L. J. E. W. C., Kelders, S. M., Beerlage-de Jong, N., and Oinas-Kukkonen, H., Persuasive health technology. In L. van Gemert-Pijnen, S. M. Kelders, H. Kip, and R. Sanderman (Eds.), *eHealth Research, Theory and Development: A Multi-Disciplinary Approach* Routledge. (2018).
39. Wennergren, G., Hesselmar, B. and Hedlin, G. Astma är en av de vanligaste kroniska sjukdomarna hos barn. *Läkartidningen*, 2015. https://lakartidningen.se/klinik-och-vetenskap-1/artiklar-1/klinisk-oversikt/2015/11/astma-ar-en-av-de-vanligaste-kroniska-sjukdomarna-hos-barn/.
40. Yardley, L., Ainsworth, B., Arden-Close, E. and Muller, I. The person-based approach to enhancing the acceptability and feasibility of interventions. *Pilot and Feasibility Studies 1*, 1 (2015).
41. Yun, T., Jeong, H. and Hill, T. et al. Using SMS to provide continuous assessment and improve health outcomes for children with asthma. *Proceedings of the 2nd ACM SIGHIT symposium on International health informatics - IHI '12*, (2012).

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