

Communications in Kinesiology

Opinion



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Please cite as:

Ester et al. (2021). Let's build an app for that: challenges and lessons learned in exercise oncology. *Communications in Kinesiology*. doi: 10.51224/cik.v1i2.37

Subject Areas:

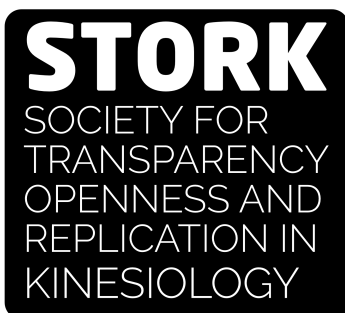
Physical Activity, Health, and Disease

Keywords:

exercise oncology, mobile health, mhealth, electronic health, ehealth, physical activity, cancer, oncology

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Let's build an app for that: challenges and lessons learned in exercise oncology

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The promotion of physical activity behavior change among adults with cancer is a research priority. Within this field, increasing attention is being devoted to the use of health technology, which includes mobile phones and applications, or apps, to support and deliver physical activity behavior change interventions. While building a mobile app is a popular proposal among exercise oncology researchers, little practical information exists on how this process should be done or what considerations researchers should take in collaboration with participants and industry. The present article provides an overview of recent experiences with app development in exercise oncology and outlines several recommendations for future research. **Methods and Results:** After forming an interdisciplinary team of researchers, industry partners, and exercise oncology program participants, an iterative, user-centered app improvement process was followed to collect feedback and make meaningful changes to an existing mobile health app for its use in exercise oncology. Participant feedback was summarized and addressed collaboratively via open discussion and detailed action plans. Changes made include enhanced introductory materials for the app and improvements to usability and personalization. Some requests remain to be addressed in future updates. **Two challenges identified during the app improvement process** were balancing the unique needs and priorities of all parties, as well as addressing the variable feedback from a variable population of adults with cancer. **Conclusions and significance:** A multidisciplinary participant-oriented app improvement process led to meaningful updates to the mobile application of interest, preparing researchers to carry out an evaluation of its effectiveness within exercise oncology. Furthermore, based on lessons learned, the research team present key recommendations to consider in future mobile app research before, during, and after the development process.

1. Introduction

Physical activity (PA) enhances the well-being of adults with cancer, yet most of this population remains insufficiently active (Stout et al., 2017; Thraen-Borowski et al., 2017). Initiating and maintaining PA behavior change is inherently difficult, and barriers to PA may be amplified for this population (Clifford et al., 2017). Therefore, the development, evaluation, and implementation of strategies to support PA behavior change and maintenance for adults with cancer is a research priority.

Effective PA interventions for adults with cancer include in-person and home-based programs, individual and group formats, and interventions that feature technology-based behavior change support (Ester, Eisele, et al., 2021; Sheeran et al., 2019). In line with the ever-increasing popularity and capability of internet-connected devices, efforts to use technology to support PA behavior change are gaining attention (Vandelanotte et al., 2016). Of the available technologies, mobile phones and associated applications, or apps, represent a unique opportunity to deliver real-time, context-specific, personalized behavior change support, that empowers adults with cancer to plan, self-monitor, and gain feedback on PA behaviors (Chan et al., 2020a; Vandelanotte et al., 2016).

As a result, research and development related to PA mobile apps for adults with cancer and other populations has seen rapid growth in recent years (Chan et al., 2020b; Ester, Eisele, et al., 2021; Vandelanotte et al., 2016). For all those who have toyed with the idea, this viewpoint article details the authors' recent experiences with app development in exercise oncology and presents recommendations for future work in this field.

(a) Approach: Tailoring an existing app

Due to the lack of specific apps to support PA behavior change for adults with cancer, the research team set out to tailor an existing app to sustain PA behavior change in this population. The decision to work with an existing app was made to fast-track the development process, reducing time and resource requirements while eliminating the need to “reinvent the wheel” (i.e. build a new app for every objective). Zamplo, a health journaling app for people with chronic diseases that seeks to empower them to take control of their health by tracking health information, was identified as a potential fit for the planned project. Zamplo was developed by Hanalytics Solutions, co-founded by a cancer caregiver with lived experience, ensuring that researcher objectives (supporting PA behavior change) aligned with those of the Zamplo team (enhancing quality of life for adults with chronic diseases). From here, work began on adapting useful app features such as activity and health tracking, graphing, and reminders to establish a positive feedback loop that supports PA behavior change. These features were selected for their potential to promote self-monitoring, review of behavioral goals, and feedback on performance, three behavior change techniques associated with effective PA behavior change in adults with cancer and other populations (Michie et al., 2009; Spark et al., 2012). A detailed overview of the behavior change techniques used within Zamplo and the additional resources provided alongside the app can be found elsewhere (Ester, McNeely, et al., 2021).

2. Methods and Results

(a) The app improvement process and its impact

To ensure that ongoing Zamplo development led to relevant and useful improvements to the user experience in a PA setting, an integrated knowledge translation approach involving target users as partners throughout the development process was established (CIHR, 2012). This participant-oriented research approach identified priorities of the target users, exercise oncology program participants (CIHR, 2013). Furthermore, a user-centered design framework was followed to align app development with user needs, preferences, barriers, and facilitators (Schnall et al., 2016). An overview of the user-centered app improvement cycles is presented in Figure 1. The app improvement process followed best practices for mobile application development by featuring multiple collaborative cycles of testing, feedback, and improvement (Flora et al., 2014; Flora & Chande, 2013; Vithani & Kumar, 2014). All parties depicted function as key contributors for all steps within the cycle.

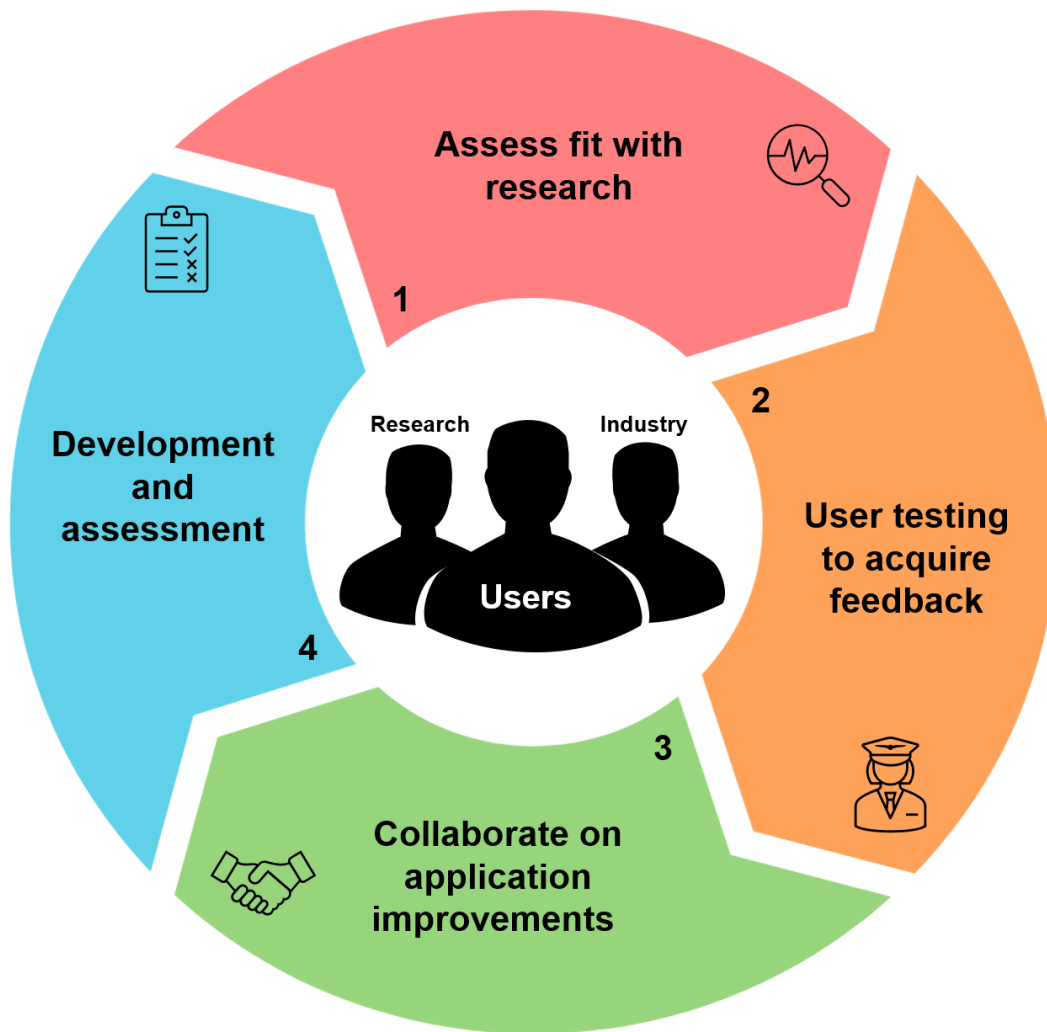


Figure 1. The user-centered app improvement cycle.

Utilizing these strategies during early testing was intended to enhance the app experience for users, increasing app engagement and leading to improved health outcomes. App improvement work to date has focused on steps one to three of the user-centered app improvement cycle in Figure 1. Ongoing work within step 4 is described at the end of this article.

(b) Step 1: Assess fit with research

The initial meetings took place between 1) the research study team, 2) two participant advisors matching the target user demographic (i.e., Adults living with cancer who have established or are seeking to establish PA habits), and 3) the Zamplo app development team to review the existing app, explain the research and goals for using Zamplo, and set out a development strategy. With a set agenda, weekly meetings were scheduled to facilitate ongoing discussion, set a timeline for tasks, and monitor progress. To understand the current capabilities of Zamplo and prioritize feature requests, collaborators downloaded Zamplo and continue to use it on their personal devices regularly. These initial meetings provided the content and basis for the initial experience of Zamplo including the health tracking components that testers would be encouraged to track in step 2.

(c) Step 2: User testing to acquire feedback

Using a participant-oriented approach, n=6 adults with cancer tested the application as Alberta Cancer Exercise (ACE) maintenance program participants, which features twice weekly group-based Zoom exercise classes (McNeely et al., 2019). Testers were urban-based and long-term program participants who were asked to use Zamplo freely for 4 weeks and provide their critical feedback via a survey and/or semi-structured interview. Opinions were mixed on the value of the app, while testers identified a need for improvement in (1) clearer introduction to the app and its functionality, (2) enhanced ease of use (e.g. adding activities), and (3) the ability to personalize content and notifications. This feedback was provided to the Zamplo team and an action plan was developed to address concerns.

As the future use of Zamplo was to be in an online program with rural and remote cancer survivors, a second round of testing over 5 weeks occurred with n=8 rural adults with cancer newly enrolled in the EXCEL exercise program (NCT04478851). Quantitative and qualitative feedback yielded 3 consistent requests: (1) meaningful output (e.g. reports, graphs) to provide feedback to user's self-monitoring, (2) increased simplicity to streamline app functionality and navigation, and (3) notifications to prompt behavior change.

During both testing rounds, participants were purposely invited from our existing exercise oncology programs to capture perspectives from adults with cancer across various ages, genders, cancer types, PA levels, socioeconomic status, technology literacy, and location.

(d) Step 3: Collaborate on application improvements

User input during step 2 highlighted the need for a more detailed introduction to Zamplo to clearly explain its purpose, potential value to the user, functionality, and intended use to support PA. Introductory materials were thus developed, consisting of two PDF user guides with accompanying scenario-based tutorial videos detailing Zamplo functionality and intended use, alongside a live webinar with follow-along in-app practice to educate users on the purpose and potential value of the app. To increase the relevance of content to target users, introductory materials were tailored to the purposeful use of Zamplo to promote PA behavior change in adults living with cancer. Finally, an educational webinar for Zamplo was developed for qualified exercise professionals leading the weekly exercise classes in the pilot study.

Table 1: Changes to Zamplo features for PA behavior change and remaining requests.

App feature	Feedback	Changes made
App improvements		
Sliding symptom scales	Red-green gradient seen as leading and not logical in the context of some symptoms. Lack of meaning associated with individual numbers on the scale made reporting difficult and inconsistent, description needed.	In line with best practices from behavioral design and usability research on digital visual analog scales ^a . the gradient was changed to a more neutral orange and descriptors were added along the scale to provide meaning to numerical values.
Symptom tracking	Not all symptoms were relevant to users, need to reduce burden and allow for customization of tracking.	Reduced the number of tracked daily symptoms from 10 to 2 (fatigue and energy only), while prompting users to customize tracking by adding symptoms relevant to them.
Graphing	Visual representation of health data was unclear due to lack of colors, graph types, and single Y-axis scale. Limited integration of graphs into user interface made them difficult to access. Users suggested to make graphs more prominent to reinforce symptom tracking and reflection. Automatic generation of graphs relevant to the user would add value and encourage continued data entry.	Graphing functionality was enhanced by adding a color selection tool, enabling both line and bar graphs, and allowing for two independent y-axis scales. Graphs were added to the dashboard to enhance visibility each time the app is opened. Graphs are now automatically generated and updated as users report health data via journal entries.
Notifications	Reminders are needed to prompt engagement with the app, preferably via email or smartphone notifications.	Participant profiles now feature pre-set email reminders to complete journal entries at specified times. Push notifications were added for Zamplo use on iOS and android devices.
Overall visual design	Simplify design by reducing user interface redundancy and using a single button to add a journal entry.	A prominent + button was added to the app footer to initiate app features such as journaling, quick notes, and tasks.
Remaining requests		
Positive reinforcement for behavior	The addition of personalized rewards or badges (similar to Garmin or Duolingo) following completion of a task or challenge was suggested to enhance engagement.	Gamification of the app is currently underway, with both rewards and badges being considered. However, due to the significant coding complexity, personalization will remain limited.

Note.

^a Matejka J, Glueck M, Grossman T, Fitzmaurice G. The effect of visual appearance on the performance of continuous sliders and visual analogue scales. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems 2016 May 7 (pp. 5421-5432).

(i) Remaining Requests

In response to feedback gathered during the second testing cycle in step 2, in conjunction with previous feedback from the first cycle, an updated action plan was created to guide ongoing development. Changes made within Zamplo in response to user feedback, as well as remaining requests that may be addressed in future updates, are outlined in Table 1. An overview of Zamplo app improvements with regards to its overall visual design (Figure 2A), push notifications (Figure 2B), graphing (Figure 2C), and the sliding symptom scales (Figure 2D) is presented in Figure 2.

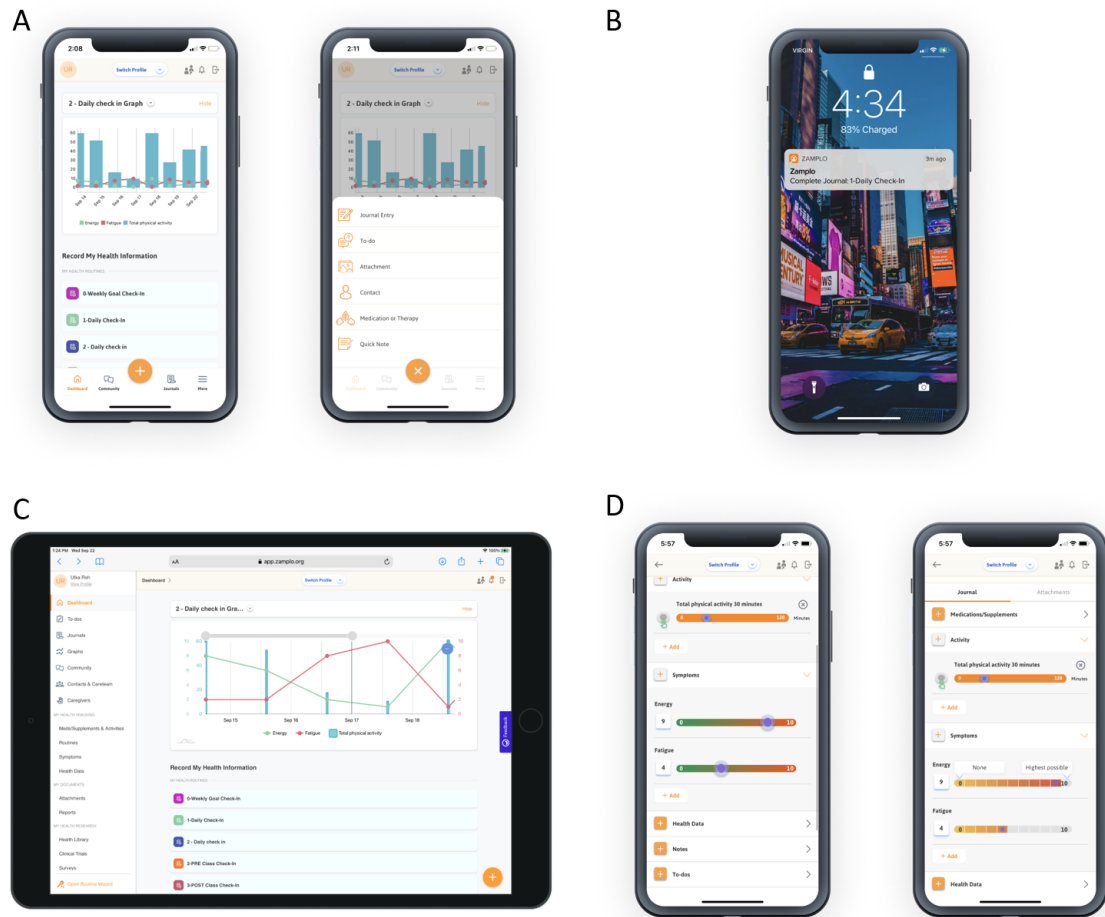


Figure 2. Overview of Zamplo app improvements made in response to user feedback. [A] dashboard showing overall visual design. [B] push notifications. [C] graphing. [D] sliding symptom scales before (left) and after (right).

In summary, app changes were guided by a user-centered model for designing mobile health apps, with qualitative feedback from target users leading to important improvements to the onboarding experience and the core features of the Zamplo app that will be used to support PA behavior change in adults with cancer participating in an online PA program.

3. Discussion

(a) Challenges and opportunities

To help researchers anticipate, address, and overcome challenges in future app development work, two key challenges from the development process are highlighted below.

(b) Challenge 1: The balancing act between researchers, users, and industry

When working with participants and industry partners, the challenge of balancing the differing needs of all parties is critical. From a research perspective, priorities included collecting high quality data and integrating evidence-based PA behavior change principles to maximize effectiveness and understanding the impact of the app. Meanwhile, users focused on the need for enhanced clarity/usability, reduced burden, and receiving feedback from the app so that it would support their PA habits. Finally, industry partners faced resource requirements, technical limitations in development, as well as the need to have an app applicable to a diverse set of target users (including those outside of oncology). It is therefore crucial to clearly define priorities and resource-based limitations as early as possible. By balancing the agility and resources of entrepreneurial work, checks and balances of research, and user preferences and needs, interdisciplinary teams can establish realistic expectations, guide effective app development, and ultimately move to implementation and evaluation faster.

(c) Challenge 2: Variable population means variable needs and preferences

Users testing included participants with varying backgrounds with regards to cancer type, age, technology literacy, as well as existing PA habits and use of tracking tools. Accordingly, their feedback on overall impressions, usability, value, and fit within PA habits varied widely, making it challenging to develop an app that ‘works for everyone.’ However, this challenge may be viewed as an opportunity to better address diverse backgrounds and needs, while clearly communicating the purpose of Zamplo for PA behavior change with users and to enhance engagement. The combination of variable user input, a flexible app early in development, alongside agile collaborative researcher and industry teams, supported significant, rapid, and meaningful changes. Early involvement of a range of target users is crucial to align the end product with varying needs in terms of functionality and preferences.

(d) Recommendations for researchers and next steps

The multidisciplinary participant-oriented approach used herein has laid the groundwork to evaluate the effectiveness of Zamplo within an exercise oncology program as part of step 4 in the user-centered app improvement cycle. In preparation for evaluation, ongoing collaborative planning with the Zamplo team ensures that study participants have a positive experience with Zamplo. A cluster-randomized trial is underway to examine the effectiveness of Zamplo for supporting PA maintenance within project EXCEL (NCT04790578). This research will provide key effectiveness data while providing a platform for continued feedback, collaboration, and development, informing the integration of effective digital tools to support PA maintenance in exercise oncology implementation research.

Based on the lessons learned during the app development process, several recommendations for research on mobile app use for PA behavior change in oncology are presented in Figure 3.

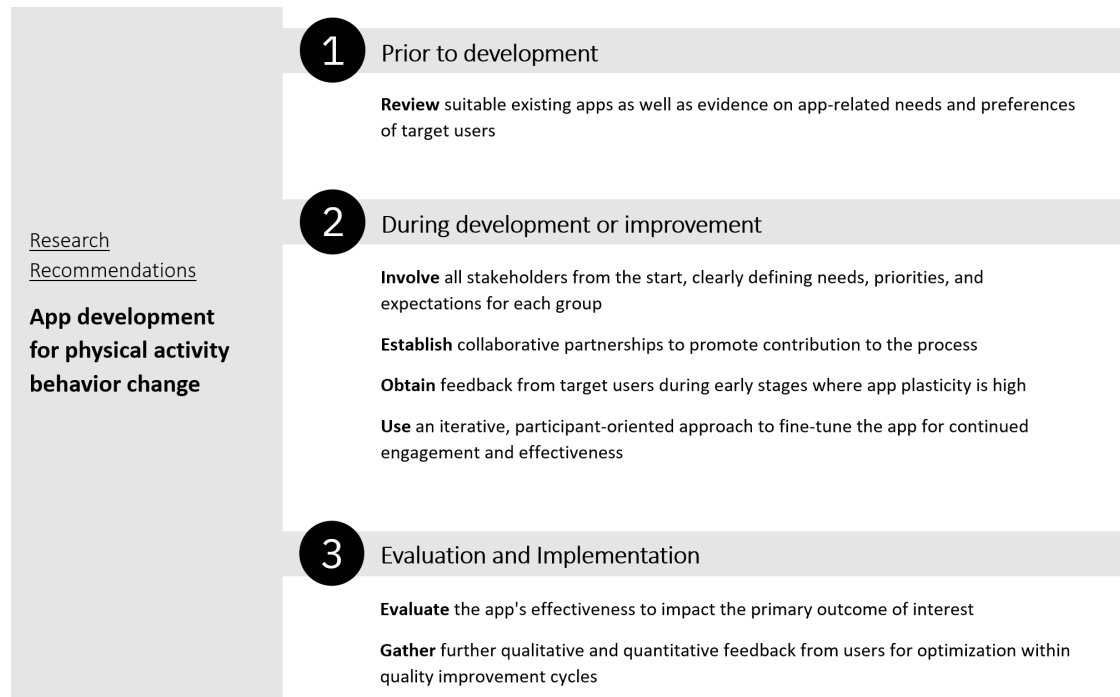


Figure 3. Research recommendations for physical activity behavior change in exercise oncology app development

The recommendations align with the principles of participant-oriented research and are intended to enhance the reach (app uptake, scalable support for PA behavior change), effectiveness (initial app engagement, impact on PA behavior), and maintenance (continued app engagement, maintenance of PA habits) of apps and their respective PA behavior change interventions (Glasgow et al., 1999). Researchers may wish to draw upon these recommendations, in combination with existing recommendations, to inform effective development and implementation of apps within the field of exercise oncology (Chan et al., 2020b; Groen et al., 2015; Middelweerd et al., 2014; Robertson et al., 2017).

4. Additional Information

(a) Data Accessibility

Feedback collected by participants was summarized for the sole purpose of app improvement and testers did not provide consent for data sharing beyond the research team. Therefore, there is no data, code, or supplementary material presented for the present article.

(b) Author Contributions

- Contributed to conception and design: ME, JD, US, SP, SNCR
- Contributed to acquisition of feedback: ME, JD, US
- Contributed to analysis and interpretation of feedback: ME, JD, US, SNCR
- Drafted and/or revised the article: ME, JD, US, SP, SNCR
- Approved the submitted version for publication: ME, JD, US, SP, SNCR

(c) Conflict of Interest

Manuel Ester, Julianna Dreger, and S.Nicole Culos-Reed have no conflicts of interest to declare. Utkarsh Subnis and Shaneel Pathak work for Hanalytics Solutions, and in this app improvement process, were involved in taking user feedback from the research team and making required changes to build an app that will best support PA behavior change. Hanalytics Solutions employees have no direct role in the subsequent research using the app but are integral to the 'building the app' process described herein.

(d) Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. Hanalytics Solutions did not provide any financial incentives to the research team or participants to conduct or participate in the app improvement process.

(e) Acknowledgments

We would like to thank Maximilian Eisele and Mannat Bansal for their help in conducting the user testing. We would also like to thank our patient advisors for taking part in the initial planning meetings and our testers who volunteered their time to provide feedback.

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