Vision: Mobile eHealth Learning and Intervention Platform

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ABSTRACT

Face-to-face health educational and intervention programs are helpful in addressing mental and physical illness challenges in focused groups. However, these programs are expensive, resource-intensive and struggle with scalability and reachability, leading to limited take-up and short-term impact. Digital Health Intervention (DHI) programs incorporate the use of technology - mobile, web, wearables, virtual and augmented reality - to address these limitations while being more cost-effective. DHIs have shown major success in improving physical and mental health outcomes for the general public as well as reducing adverse outcomes or high-risk groups. However, it is still very challenging and expensive to design and run high quality mobile-based DHI programs, in part due to the lack of technical skills of researchers in this field. Our proposed mobile eHealth Learning and Intervention Platform (eHeLP) aims to address these challenges with a novel approach that allows health researchers to focus on their studies, and participants to have access to multiple health programs that meet their needs. The platform caters for identified stakeholders in the DHI field and encourages the development of a new health-tech industry. We present our vision eHeLP, why this idea is worth further research, risks we perceive, and next steps.

CCS CONCEPTS

• **Software and its engineering** → Software development techniques; • **Human-centered computing** → Ubiquitous and mobile devices; • **Applied computing** → Consumer health;

KEYWORDS

mHealth, Digital Health Intervention, eHealth Marketplace, Health Analytics

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1 INTRODUCTION

In Australia, 1 in 5 suffer from some form of mental illness or disorder (e.g. depressive, anxiety and substance use disorder) [1] in any given year, the same as in the United States. This poses an increasing demand on mental and physical health intervention programs that greatly exceed government and health professional capacity [14]. Technology-supported health interventions offer a practical solution to these challenges providing accessible, reachable, effective and sustainable support to individuals with different sorts of health challenges [2, 15]. The past decade has seen the adoption of Telemedicine, eHealth [3] and mHealth [4] as cost-effective alternatives to the traditional face-to-face interventions. Many successful digital health intervention studies and virtual rehabilitation programs (vRP) [3] have successfully complemented and, in some cases, mitigated the lack of accessible face-to-face intervention programs/workshops in different fields including: depression, bipolar disorder, anxiety, mental well-being, physiotherapy, heart cardiovascular diseases, Body Mass Index (BMI), and many more [5] [6] [7] [8] [9].

These intervention programs typically begin by developing a prototype web/mobile application to provide program content and monitor user engagement. For example, deprexis , minddistrict , online-therapy , and many more. Such eHealth platforms usually focus on a single mental or physical illness challenge and often cover some disease and treatment educational content, support, a treatment care plan and cognitive or physical activities.

While many have been shown to be effective, these single target applications do not typically allow the designing of new approaches and provide limited tailoring to individuals. Most Medical and Health researchers do not have the technical expertise necessary to develop new digital intervention platforms and it often takes a long time to find the right technical partner to develop these applications that researchers can use to run their experiments at an affordable cost [10, 16]. This situation gets even more difficult if there is a need to trial wearables (for data collection) or build complex machine learning analytical models [17]. Furthermore, most of these mobile eHealth prototypes are usually unsupported and then disappear at the end of the study or the project. This can cause considerable frustration, and even danger, to participants, who become dependent on the apps [11].

Iterapi [10] introduced a web-development platform that focus on DHIs for eHealth experiment-design and provides multiple features including chatting, visual experiment design, surveys and data security. However, the platform does not have a mobile app, does not support sensor data collection, experiments are developed as separate websites making it difficult for participants to stay across different studies, does not have support for conversational agents, does not provide health apps marketplace capability, and does not provide data analytics and machine learning capabilities to provide personalized DHI programs. Attempts have been made to produce customizable mobile eHealth applications [18, 19, 20]. Most still require considerable technical expertise to use and deploy, and are still limited to particular domains - e.g. obesity, cognitive decline, diabetes. Some tools for generating eHealth mobile apps from high level models have been produced [21, 22]. While promising, the end results suffer challenges of limited integration, usability and technology platform limitations.

The field of DHI still lacks a reliable and customizable mobile-based DHI platform that can be used to implement and run health intervention studies while removing the need to build web/mobile solutions from scratch every study. We describe eHeLP, our vision of a complete ecosystem for digital, mobile-based eHealth intervention and learning. Below are key research questions that need to be addressed to deliver a flexible digital health intervention platform:

(1) How do we design such a mobile-based eHealth intervention platform to provide a continuous innovation capability that allows practitioners and researchers to design studies, education programs, and improve participation and make sustained health impact.
(2) What critical data do we need to collect in a given study, and what are the potential sensor and other data sources?
(3) How do we design complex platform-to-data source integration - e.g. flexible techniques that allow practitioners to collect heart rate data from a sensor or from a data file stored on the cloud, or provided by another system?
(4) How do we improve participants recruitment, accessibility and engagement in eHealth programs/studies?
(5) How to allow practitioners to use pre-packaged machine learning models for data analytics and information visualization to help decision making?

2 VISION

Over the last few years, we have worked on many cross disciplinary applied research projects with researchers in the domains of Physical Activity, Nutrition, Psychology, Chronic Disease, Mental Health and Dementia [12] [13]. All projects received funding with the aim to transform existing face-to-face interventions to digital/remote solutions. Most of these solutions take many months to design, build, test and reach a stable state so that they are able to be used in real-world experiments. Our proposed eHealth Learning and Intervention Platform - eHeLP, as outlined in Figure 1, aims to better support such projects. Figure 1 shows the key stakeholders involved in DHI, how they interact with the platform, and what capabilities they will have access to.

Group1: Researchers, trainers/experts, and practitioners - these are the health experts who design interventions, run trials, and support patients and end users of the applications;

Group2: Patients, participants, public users, carers - these are the people to whom interventions supported by eHealth mobile applications are targeted, or their supporters i.e. families and friends.

Group3: Health-tech providers (apps, services, equipment, etc.) - these are the technical experts who design, build, deploy and maintain eHealth mobile apps.

Trainers, researchers, and practitioners will have access to a mobile-friendly web app that allows them to: design studies, collect and analyze study data, monitor the progress of their studies, and communicate (chat - using different channels) with participants. Studies will be reviewed and approved by an appropriate ethics committee before they can be published to participants.

Participants and carers will have access to a mobile app (HealthBot), where all studies relevant to their interests will be listed with a Facebook-like posts including teaser video, study timeline, goals, consent, etc. They will be able to track their progress, and will be notified when it is time to start a new module in a given study. Furthermore, participants will be able to see their progress and achievements over the course of a given study. eHeLP will provide the following capabilities to these stakeholders:

(1) **Fully dynamic evidence-based study design** using a visual step-by-step wizard interface and repository of templates to choose from. This will include support for data capture, diverse device integration, care plans and plan implementation, chatting with other stakeholders, and diverse machine learning-based analysis and visualization support for experiment data. Furthermore, necessary ethical protocol approval process details will be completed via the platform, allowing the platform to auto-generate the ethics applications and capture informed consent from end users.
(2) **Participants health learning support** to allow participants to study and utilize publicly published health learning programs. New DHI studies will be published to participants on the platform to facilitate participants' (re)recruitment. A participant can use one app to participate in multiple studies. These studies will be filtered using a recommendation engine using preferences (target users) defined by study designers.
(3) **Clinical, device, participant and other data collection and management** through structured questionnaires designed by researchers accessed as forms by users and sensor data collection from participants' mobile devices or wearables. This requires building capabilities to allow a mobile eHealth study designer to specify what sensor data is needed and should be collected from a repository of defined sensors (pre-developed connectors). It is critical to support information privacy and security to the highest standard [22]. Clinical data must be managed according to approved ethical protocols.
(4) **Packaging and publishing proven (evidence-based) studies/programs** as health apps to allow existing and new participants to benefit from the health intervention and learning programs. This includes personalization/tailoring apps to specific end user needs.
The platform separates study public data from participants' data which are stored in an encrypted data store. Furthermore, the platform will provide capabilities for scheduling and triggering of certain events - e.g. time to release a module to participant P, etc. It will also provide a repository of the key data querying and analytics algorithms with a

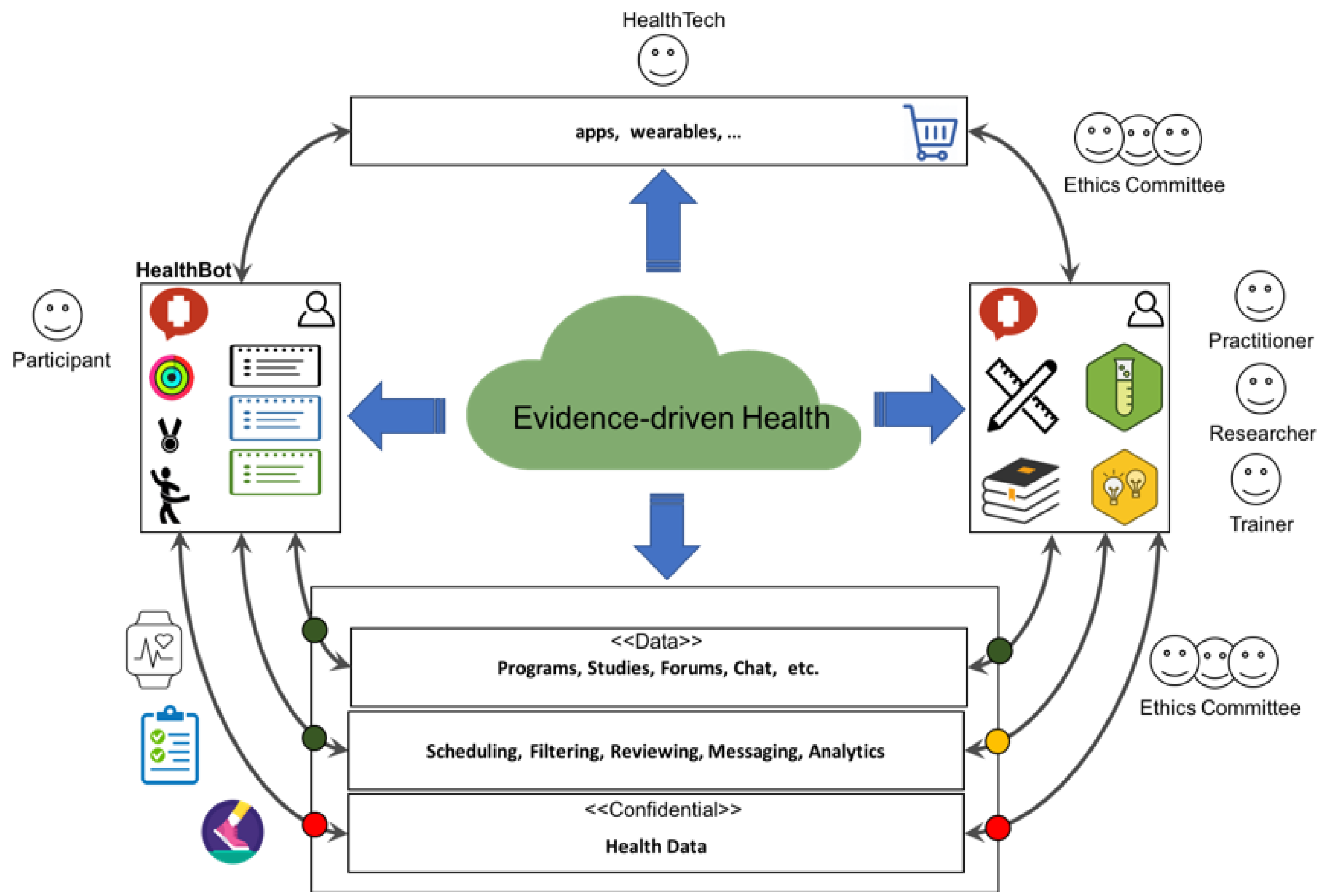

Figure 1: Proposed eHealth learning and intervention Platform

user-friendly description to allow researchers to analyze data collected from their studies.

3 WHY IS IT NEW?

Our proposed mobile eHealth application design and deployment platform will introduce a novel digital health ecosystem that will disrupt how we conduct digital health research and develop health applications. The platform caters for all stakeholders involved in the eHealth industry and line them in a new ecosystem. The platform enables and is driven by evidence-based research and applications will not be published unless backed by proven research studies.

Fundamentally, eHeLP will cut the development time of DHI studies development from months to weeks or even days with a focus on the underlying theories, content and delivery models rather than the development of the technology. Studies will have consistent quality across the board, and participants will have the same high quality experience. Best practice security and data management, collaboration, care plan reuse, data analytics and visualization approaches will be highly reusable across DHI apps.

Recruitment is always a challenge to run a successful, proven study - usually requiring a large number of participants. Maintaining a mobile eHealth app after a research study completes is notoriously difficult. eHeLP will address these problems by combining learning, health industry and innovators together. This gives researchers better access to a community of practice and their challenges and needs. As a common infrastructure is used for applications and content, once a study is successful in achieving its goals it is easier to maintain and keep it running.

Data collection and management is a major challenge. Currently researchers spend a lot of time to collect user-generated data and face many challenges on how they are going to store and process these data. eHeLP will address this issue by introducing a secure data collection and management capability allowing researchers to declaratively specify what sensor and user generated data they want to collect, the platform will provide capability to automatically start collecting these data items upon user permission.

More health data will be available for deeper research across research projects and in a consistent form. This introduces an enormous opportunity for healthcare researchers to get access to valuable health data across different demographics and addressing different challenges. This enables disruption in how we carry out and understand personalized health and disease management and contribute to personalized treatment programs - the "precision health" agenda.

An eHealth market introduces an innovative capability for health-related apps, tools and wearables. Finding a personal trainer, therapist, etc. becomes easier. Such market resources can be used to run the health apps - e.g. a rehabilitation app that requires practitioner supervision can be scaled up if we can recruit practitioners to keep it running. Privacy in regards to health-related data is always a challenge. We separate public data from participants' private data which is kept secure. The platform will allow anonymous sharing for research purposes under the authorization of participants - i.e. individuals will have full control to share or not their data with researchers.

We are interested in investigating and building declarative Human-Computer-Interface capabilities in a multi-disciplinary innovation platform including conversational agents, VR/AR intervention mechanisms with analytics capabilities to allow researchers assess their innovations.

4 RISKS

The development of the health ecosystem is difficult. A key risk of the proposed vision is the development of the health ecosystem which requires commitment and engagement of all the stakeholders. The vision aims to produce a win-win arrangement for all parties, but it definitely takes time to build. We will focus on the researchers and participants in the initial iterations. This would allow to create good momentum toward wider adoption of the platform.

Sensors diversity. The number of sensors and wearables currently available for health usage is increasing dramatically. These sensors are developed by different vendors and often require different ways to integrate. Furthermore, the data generated by these sensors varies between different versions and quality is sometimes unpredictable. It is very important to provide a declarative (and abstract) layer/interface for researchers to be able to link these sensors as a data source that need to be considered in their studies.

Security of health data. The amount of data generated from these study surveys and sensors is massive. Hosting this amount of critical data makes it a target for attackers and malicious insiders. It is very important to securely maintain these health data. We plan to follow HIPAA security requirements which include confidentiality, integrity and availability of data at rest (storage) and transmission, and identifying and protect against potential security threats. It also requires a robust security management process.

Machine learning registry. There is a gap between machine learning concepts and models, and researchers/participants goals and hypotheses. Employing declarative machine learning models is a key capability to analyze study data or personal sensor data, but still there is a misalignment (gap) between the researcher/participant domain knowledge (goals), and machine learning models to be developed. An initial solution will be to develop a set of ML models backed by a model selection flowchart to help researcher choose the right model for their study. In the feature these ML models can be packaged and made available on the marketplace for researchers and participants to download. These models will need to be re-trained regularly to address changes in the datasets used.

Machine learning decision/recommendations are hard to explain. One of the key challenges facing applying AI/ML-based approaches in the health domain is the lack of explain-ability. We can develop ML models that can classify, predict, etc. but these models can only learn how to do the task without understanding why, which makes it hard to explain decisions made by a machine learning model.

Dev Team and new roles. The team required to build this platform will involve both researchers (software engineering, machine learning as well as domain experts from different fields), software and mobile apps developers, data scientists, and designers. There is a big challenge to manage such diverse team. In addition to, the lack of experience in building such platform with such diverse stakeholders. The data science and software engineering processes are not well-proven for production usage - i.e. the software development lifecycle for AI/ML based systems. Furthermore, there is a big lag between research and development speed, a challenge to assure using state-of-art while conducting development.

5 NEXT STEPS

We have identified a list of key tasks to deliver this new eHeLP platform:

Task 1- Develop intervention study and care plan designs. what should a study/program/care plan include, and how can we support building of these capabilities in a researcher-friendly way. We will review existing approaches, run brainstorming sessions with researchers and health app developers across different disciplines, and prototype different solutions.

Task 2- Develop HealthBot app platform. This task aims at investigating how to present participants with study content, keep them engaged, track their progress, and provide them with notifications with appropriate automation support and all on a reusable, reconfigurable mobile platform.

Task 3- Develop sensor and user-generated data collection protocols and interfaces. This task aims at investigating what data items we need to collect across multiple studies, different data sources we need to integrate with, data storage and management. We will develop a catalog of sensors that researchers can use in their studies.

Task 4- Develop data processing and presentation capabilities. We aims to develop a catalog of data processing techniques that researchers can use as a black-box. Information must be presented to users and researchers to support the health intervention and study data analysis.

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