Beacon: Using ICT to Improve Mental Health Crisis Intervention

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ABSTRACT

Depression and anxiety disorders are very prevalent worldwide, and can be a tremendous burden on those who suffer from the illness as well as loved ones. Left untreated and unchecked, a person's struggles with mental illness may eventually develop into a crisis, where they are no longer able to function normally and may be at risk of harming themselves or others. The ubiquity of mobile technology presents the opportunity to detect and triage the onset of a mental health crisis at any time; moreover, literature on wearable technology and the efficacy of correlating stress with physiological signals suggests that wearables could be an effective means of detecting and triaging stressful events without any significant effort on the user's part. To this end, we present findings that address how to design an effective Information and Communications Technology (ICT) solution for managing and preventing mental health crises, and present a safety plan mobile application that incorporates these findings. In our approach to designing and developing this application, we conducted a systematic review of literature related to ICT solutions for managing mental illness, system analyses of various existing solutions, and user studies to understand better the perspectives and needs of patients and their counselors. At each of these stages, we iteratively refined a prototype application that we would eventually develop into a working system. Our systematic review revealed that physiological markers from wearable sensors may be an effective approach to detecting the onset of a crisis, and that maintaining simplicity is important when designing ICT solutions for mental health management. The latter finding was further reinforced by our system analyses and user studies; we found that simple, focused, and noninvasive approaches to mental health management were most desirable. We implement these findings in a mobile application, Beacon, which aims to be a simple approach to safety planning and mental health management.

Author Keywords

Mental health; anxiety; depression; ICT; coping strategy.

INTRODUCTION

Depression and anxiety disorders are very prevalent worldwide, and can be a tremendous burden on those who suffer from the illness as well as loved ones. Sometimes these conditions can lead to mental health crises, where a person is no longer able to function normally and may be at risk of harming themselves or others. We believe it is feasible to reduce an individual's risk of experiencing a mental health crisis by harnessing ICT, owing to the prevalence of smartphones and the increasing popularity of wearable devices. Therefore, we set out to design a solution that effectively summarizes how to utilize ICT effectively to provide timely interventions and coping strategies for those at imminent risk of crisis, as well as provide support and guidance for those currently experiencing a crisis to ensure they remain safe and get the help that they need.

Naturally, mental illness is a global problem, affecting an estimated 15.5% of the world population in 2006 [21]. The National Institute of Mental Health has estimated that approximately 18.3% of adults in the United States suffer from mental illness annually. Of this percentage, approximately 23.3% suffer annually from serious mental illness resulting in functional impairment [17]. Mental illness imposes a significant burden on those who suffer from it, and its prevalence has profound economic and social consequences: as of 2008, annual lost earnings due to mental illness in the United States is estimated to be $193.2 billion [16]. Finally, suicide is the tenth leading cause of death in the United States, claiming 47,173 lives in 2017 according to the American Foundation for Suicide Prevention [1].

The target users are both people at risk of experiencing a mental health crisis and their families and friends. In addition to the burden that anxiety and depression impose on those suffering from these illnesses, the families and friends of these people often inherit a considerable amount of this burden through efforts to comfort and console their anxious and depressed

loved ones. This application aims to lift the burden of anxiety and depression by providing support for those suffering from it, which by extension reduces the burden of these illnesses on their loved ones. For loved ones, knowing there is a system in place to alert them if the app detects a crisis should provide peace of mind.

Assuming that this solution is only used in the United States, approximately 44.7 million US adults (18.3% of US population) stand to benefit from using such a solution. Moreover, even if it were only used by those who suffer from serious mental illness, still about 10.4 million US adults (23.3% of US adults with mental illness) may benefit from using this solution [17].

We propose Beacon, an application design that serves as a safety plan for those at risk of mental health crisis. Beacon is intended to be a companion for users, always available and able to provide guidance in the event that a user feels especially stressed and potentially on the verge of a crisis. If a user appears to be particularly distressed, Beacon will intervene and provide coping strategies, doing so in two stages: if the user wasn't previously distressed, the application will suggest internal coping strategies that don't involve other people; otherwise, Beacon will encourage the user to reach out to friends or move themselves to a more relaxing environment. In the event that the coping strategies presented to the user fail to provide adequate support, Beacon will intervene and attempt to get the user in touch with close contacts or, in extreme cases, medical professionals.

From our system analyses, we found that existing mental health management solutions lack the incorporation of physiological sensor data from wearable devices, which may be an effective predictor of the onset of mental health crises according to findings from our systematic review of the literature. Further, our research revealed the importance of simplicity when designing mental health management solutions, a characteristic we sparingly found in our system analyses. To this end, our optimal design aims to provide real-time interventions via wearable sensor data, and to maintain a simple approach to mental health management by distilling the most essential features indicated by our research and minimizing the need for manual input from users.

We envision Beacon as a mobile application, since an app can be readily incorporated into a user's daily routine and allows our app to intervene at any time. Another motivation for targeting mobile is to provide timely interventions for users experiencing distress or crisis through taking advantage of environmental cues and, potentially, biometric information. We hope to find ways to leverage sensor data from the phone itself as well as biometrics from wearables to supplement user self-reporting and more effectively determine when a user needs assistance.

Our final implementation of Beacon targets both iPhone and Android devices. Safety plan storage and user authentication for Beacon are backed by local device storage as well as a database accessible via a REST API. Everything on the application is stored locally for quick, offline access; however, the remote database is necessary to store all the user's information for backup purposes and to provide the user with the ability to switch to a new device without losing their information and having to start over.

RELATED WORK

The papers and systems analyzed during the knowledge based design process are related to our research because they are looking at how to successfully address mental illness, in day to day experiences as well as in the event of a mental health crisis. We have sorted out the different resources relevant to our application and integrated them into our design. Examples of this are the safety plan, surveys, reflections and mood tracking.

Our solution differs from these implementations in many ways. Our design is set up to incorporate wearable devices which no other design implements. We have vastly simplified the user interface from those systems that have similar information and tracking to our implementation which improves ease of interaction, very important for someone dealing with a mental illness. We have also discarded meditation exercises, since they can differ in practice between different cultures and since it is not a method that will automatically work for everyone. Lastly, we have incorporated both internal and external actions the user can do in order to avoid or navigate a crisis, with actions they can perform, and analysis they can review and show others, and support they can reach out to by phone or text message.

We categorize our related work according to the following set of categories:

Monitor

These systems and studies are trying to track user information via user input or input from wearables. We did not find any research that followed through with wearables as a monitoring technique but many sources reported positive findings related to the use of wearable technology. A major finding was the use of the safety planning, PHQ-9 and GAD-7 questionnaires as well as success in wearable device usage to detect and intervene in a mental health crisis. These latter findings ended up being used in the design of our system.

Interactive stress relief

These systems and studies are trying to relieve stress and anxiety by helping the users take time to calm down and by introducing coping strategies, mental training and meditation exercises. The major findings that we used in our own system were the coping strategies. The difference is that we focused more on thought reflection and mood tracking than games and exercises. We also decided not to include meditation exercises, since they are cross-culturally very different and might not work for everyone.

Feasibility of use

These research papers looked into the feasibility of using ICT as a solution to education on mental health. Their major findings were that it was possible to reach many people and provide them with information; however, they needed more research to determine the effectiveness of spreading information this way.

Reflection

These systems provided opportunities to reflect and work towards managing your emotions. They stored user input and prompted for some sort of reflection based on the input. This was something we elected to incorporate into our application; however, we develop the idea further in our ideal design to integrate more analyses based on users' reflections rather than using the reflections solely for journaling. We further provide additional axes for interpreting and understanding user emotions, correlating the journal entries to survey scores and biometric data for broader tracking and better insight.

Interaction

These systems can allow users to express their thoughts and mood in an interactive manner. These tools are companions which function as a listener. Woebot [26] is a chat bot app which can provide guidance using cognitive behavioral therapy tools and ask the user about their mood and thoughts. The other system called Youper [27] also provides quick, simple conversations with a chat bot who will give useful advice and professional coping strategies. These systems can take in any negative thoughts and provide positive and helpful feedback to help ease users out of their negative thoughts and promote mental health and well-being. Our design also provides useful advice and coping strategies to help people with mental crisis; however, we have decided against interactive features to limit the amount of input required of the user. Advice and coping strategies should be available when users need them without requiring any considerable input.

RESEARCH METHOD

The research methods we used were Systematic Literature Review, System Review and User Interviews. These methods and our process are further explained as follows:

Systematic Literature Review

First, as a part of the knowledge-based design process, a systematic literature review was done. This was done in three phases, first planning, then conducting, and lastly reporting the review. For the first phase, the research questions addressed were as follows:

- What is the research goal of this paper?
- What are the major contributions this paper?
- How does your project relate to this paper?
- How does your project differ from this paper?
- What aspects of this paper did you like most? Why?
- If you have to do the same research, how will you do it differently? Why?

For the second phase, search keywords were identified in order to find primary studies to review and answer the research questions from the first phase. The key words we used were "ict," "mental health," "crisis," "technology," "depression," "anxiety," "ict solution," "technology solution," "wearable sensors," "wearables," "fitbit" and "biometrics." These keywords were used in different databases for research papers. The following papers were found:

- Above Water: An Educational Game for Anxiety [25]
- Innovative ICT Solutions to Improve Treatment Outcomes for Depression: The ICT4Depression Project [24]
- Emerging mHealth and eHealth Interventions for Serious Mental Illness: a Review of the Literature [15]
- Young People & Mental Health: The Role of Information and Communication Technology [20]
- Mobile Mental Health: A Challenging Research Agenda [18]
- ICT-based Bracelet for Early Detection of Depression [10]
- A Wearable and Mobile Intervention Delivery System for Individuals with Panic Disorder [4]
- Towards Multi-modal Anticipatory Monitoring of Depressive States through the Analysis of Human-Smartphone Interaction [9]

Each project member got two research papers to review and extract relevant data from. These findings were then compiled into the Related Work section in this report in the third phase of the literature review. After the literature review was completed, we individually made prototypes first and then together in the project group we compared, contrasted, and combined our designs.

System Analysis

The second part of the knowledge-based design process consisted of a system analysis. First, different databases and search engines were used in order to find systems similar to the application planned in this project. We searched the Google Play store as well as the Apple App Store using keywords such as "depression," "anxiety," "journal," "anxiety help," "depression help," "meditation," and "daily journal." The following systems were found:

- DARE [3]
- Pacifica [19]
- Woebot [26]
- Daylio [5]
- Self-Help for Anxiety Management [23]
- Depression Test [13]
- Happify [7]
- HeadSpace [8]
- MoodKit [22]
- Youper [27]
- My3 [11]
- MoodTools [14]

Each project member got three systems to review. The analysis were both a quantitative and qualitative analysis of the system. The following questions were used for this analysis:

- Why do you think that this system is a successful/failure system?
- If you have to do implement the same system, how will you do it differently? Why?
- What lessons have you learned from the system that may be useful for your final project? How?
- After the system analysis was completed, a new design prototype was developed, first individually and then together as a team.

User Interview

After the knowledge-based design process was completed, a user study was conducted as a part of the human-centric participatory design process. Firstly, the primary, secondary and tertiary users were defined. Primary users are defined as people suffering from depression or anxiety, secondary users as psychologists and therapists, and tertiary users are friends and family. After deciding to focus on both primary and secondary users, each group member was assigned to find one participant for the study each. The recruitment for the secondary user was done by reaching out to Western Washington University psychology faculty via email. We found primary users by reaching out to people known by someone in the group to struggle with depression or anxiety. We took care to be very conscious, as this can be a very sensitive topic when recruiting primary users. Three primary users and one secondary user was found.

Two different interview questionnaires were designed: one for primary users and one for secondary users. Below, one can see a sample from the primary user questionnaire:

- When you feel depressed/anxious, whom do you typically go to for help, or you prefer to be alone?
- Do you have any experience with technical solutions such as phone applications as a tool to help you with depression/anxiety? (If yes, what technical solution? Are they helpful?)
- If there were an app to help you with depression/anxiety, what functions do you think it should have?
- To you, what technological tool would be ideal to help people avoid a crisis or help if one should occur?
- What information related to your mood do you think would be beneficial for you to track over time?

A sample of questions from the secondary questionnaire is listed below:

- What kind of experience do you have working with persons with depression and anxiety?
- Do you have any experience with technical solutions such as phone applications as a tool for helping people with depression or anxiety?
- Have you suggested such a technical solution to any of your patients?
- Do you have any experience with wearables?
- How should they be integrated in an application?

After the interviews, every project member transcribed and coded the interview for material that could be used to improve the current prototype design further. The lessons learned were compiled and used for redesigning a third prototype, first individually and then together as a group.

We followed iterative research by redesigning our prototype following the completion of each research method. We incorporate participatory research through our user studies to gain important insight from potential primary and secondary users.

FINDINGS

Existing resources to incorporate

The systematic literature review design phase revealed resources already available for anxiety and depressive crises such as GAD-7 (for anxiety) and PHQ-9 (for depression), evaluations which provide scores to evaluate a user's mental state over time. These two surveys were therefore integrated into the journal. The safety plan concept is also widely used by mental health professionals, therefore, it was digitized and used as the base for the application.

Another finding during the systematic literature review was to let the user categorize negative thought patterns in form of cognitive distortions, such as catastrophizing, splitting, or overgeneralizing. Tracking these cognitive distortions will allow a user to better recognize negative thought patterns and help the user with their analysis of what kinds of situations provoke happiness or distress in them This insight is also very valuable to mental health professionals, as it can expedite the process of understanding a patient's thought patterns and allow professionals to provide treatments that more effectively cater to individual patients and the dynamics of their moods.

Wearables

One secondary user study with a psychologist who was a certified biofeedback practitioner revealed much useful information about wearables. This interview suggested that biofeedback could be really helpful in this type of application. the interviewee recommended heart rate as the most useful bio measure since most people responds quickly to it. An example of use was a patient who experienced panic attacks, his instructions was then to measure his heart rate, start breathing, and then watch how the heart rate goes down. This would calm him, since he could regain control by himself and see the results from it as feedback from the heart rate. The advantage of heart rate measurements was also that it could be used by anyone. There are wearables such as Fitbits, but also simple phone applications such as Instant Heart Rate [2] that can measure the heart rate via placing a finger on a device's camera lens for those who do not want to spend the money on a dedicated wearable device. This choice also makes an application more available economically for everyone.

One issue emerged from the above user study was about physical activities that could raise the pulse, different blood pressures on different time of the day, and the fact that simple differences such as walking, standing, sitting or laying down could

have different effects on the heart rate. One could therefore conclude that if heart rate would be used, it is important to make sure that there are routines for when and how these measurements should be done. This depends mostly on how this functionality could be used. If this data was to be stored and analyzed, the user should not do any pulse-raising activities right before measurements. However, we also found that there are effective algorithms that seek to filter out biometric data as a result of stress events versus biometric data from physical activities.

Research and user studies about wearables directed the design towards incorporating sensory and biometric data into the journal entries. Correlating this data with the user's current activities would decrease the responsibility of the user to input a lot of journal information that could take up too much time or make them feel down and unmotivated without removing the analytic abilities on the users mood and progress. Simple features such as correlating the users heart rate towards journal entries expressing stressed or depressed states was suggested. But also keeping it even more simple, such as simply storing information about heart rate, location and events in the calendar that could be stored automatically without any actions from the users themselves. This data collected was also proposed to be used for triggering intervention strategies from the application towards the user, to not only be able to cease an ongoing crisis, but also prevent future ones from even happening.

Existing systems

System analysis of multiple applications revealed that many systems incorporate a journal of some sort, and to good effect—this allows users to monitor their mental health over time and keep track of what causes anxiety or stress, and it provides mental health counselors with valuable insight into their patients' behavioral dynamics. This led us to incorporate reflection of what may lead a user to their current mental state. Additionally, we found that some existing solutions were not focused enough in what solutions they offered or what problems they aimed to address; these applications felt too bloated or difficult to navigate, which may lead to confusion or frustration. Further, some of these applications required considerable manual input from users, which may be discouraging to some. The simpler, more focused systems we reviewed felt much easier to use continuously without incurring any cognitive burden. To this end, maintaining simplicity is an important factor in both system efficacy and user retention.

Feedback from users

The user studies received multiple responses for a simple Journal aspect. Users did not feel like they would put in the effort to fill out a lot of information in an entry and wanted it to be as simple as possible. In response to this, the journal entries were changed to use two sliders to indicate how a user was feeling. This information could then also be explicitly used as data in the Analytics section. Another important feedback from the user studies was that the journal entries should have a more positive tone, since that motivates the user more to fill them in. It was suggested to be better to have the user send a thumbs up or down rather than having to express that they are depressed.

Another primary interview offered great insight into another way to look at a mental health crisis. We had been looking through the lens of someone who is overwhelmed, likely by anxiety, and needs intervention so they can calm down. Conversely, however, there is the equally important condition where someone does not feel like they can do anything, likely from depression, and they might just lay in bed and do nothing. This can also be debilitating, as is an anxiety attack. The aid discussed in the interview that would be helpful in these situations was some sort of task suggestion: if the user has spent a lot of time without moving then they will be notified with a potential task they can do from their list of coping strategies. With this in mind, we have incorporated this as a new Actions feature, which merges the Internal Coping Strategies and External Coping Strategies sections from from the safety plan into a unified view of internal and external strategies and automatically suggests coping actions for users experiencing either depression or excessive stress. A useful feature suggested for these task suggestions was to incorporate location data, such that these notification can analyze this data and for example send the user a notification after spending the entire day in bed to perhaps get up and make some tea.

One secondary user study with a psychologist revealed that the ability to get an overview over the user's mood and progress and correlate different journal events to this data was greatly appreciated. This was something that the subject already asked the patients to do, but on a more low-tech scale by writing events, feelings and heart rate down on a piece of paper. To get this information gathered and analyzed would greatly benefit the therapy sessions, and a request was to be able to easily upload this data to the own computer of the psychologist for further analyses. However, it was important to consider the privacy issues of sending this personal and sensitive data. Finally, one issue found during the same user study was introducing technology to elderly people. Many older patients are not technologically sophisticated. Therefore, it is important to keep the application simple and user friendly.

SYSTEM DESIGN

The final prototype we made includes a Signup section, Safety Plan, Journal section, and Analytics section. In the Signup section, the user is guided through creating an account. After entering authentication information, the user will fill out a initial plan which will include:

- A list of warning signs which can be used to determine whether the user is at imminent risk of having a crisis
- A list of internal and external actions which the user can take when they are feeling anxious or depressed
- A list of emergency contacts such as parents or friends whom the user can call when they need support, as well as professional contacts who can provide support and coping strategies in the event of a major crisis

After filling out the plan, the user will be directed to the main interface, shown in Figure 1. This view contains four sections:

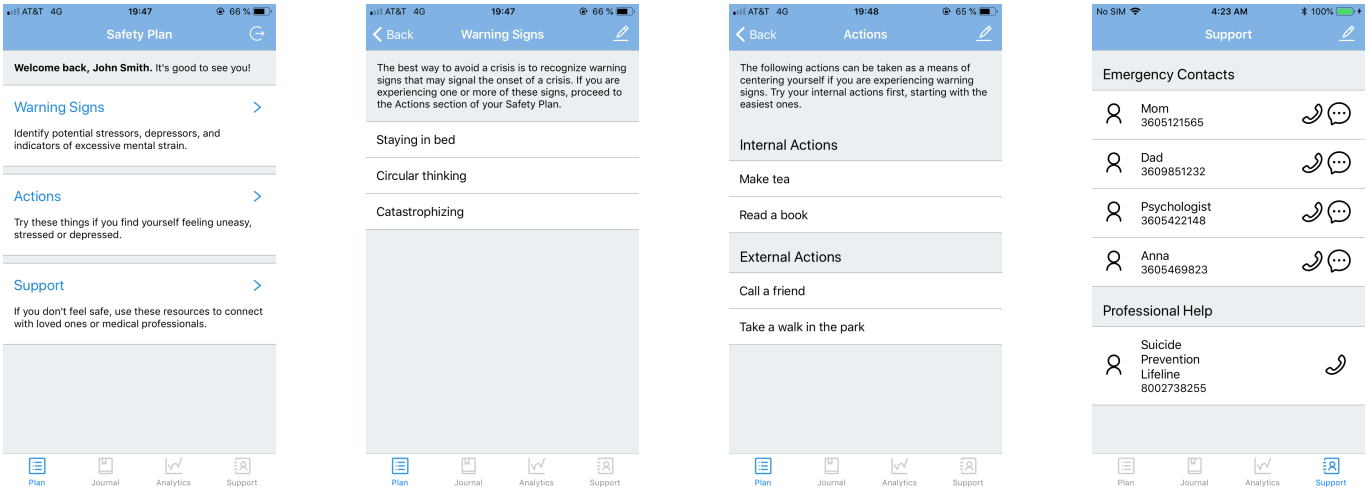

Figure 1. Screenshots of the main Safety Plan and Support sections, from left to right: home screen, list of warning signs, list of actions, and Support.

the Plan, the Journal, Analytics, and Support. The Plan and Support sections will display the content the user entered during registration, and the user can modify and edit this information at any time.

In the Journal section, shown in Figure 3, the user can choose to create a standard journal or a survey journal. For the standard journal entries, the user can write their thoughts and feelings, as well as the location when they have those thoughts and feelings. They can choose the level of anxiety and depression they are experiencing on a scale from 1 to 10. The user can also specify whether their thoughts are negative, then choose specific cognitive distortions which may apply to their thoughts. If the user doesn't understand the meaning of a certain cognitive distortion, we have included a page which contains descriptions of each cognitive distortion. Finally, we give users space to try and interpret their negative thoughts and reframe them in a more positive manner. After finishing and submitting the journal, the data will be displayed in the journal section, where the user can review it at any time. For the survey entries, we have created a PHQ-9 and a GAD-7 survey. The user can voluntarily complete these two surveys every two weeks. Each question of the survey asks whether the user has experienced various negative aspects of depression or anxiety within the last two weeks. For each question, the user can choose from "not at all," "several days," "more than half the days," and "nearly every day." After submitting the survey, our system can generate a score that indicates the user's level of depression and anxiety and save the user's scores to our database.

In the Analytics section, shown in Figure 2, the user can review their current progress through a chart displaying the survey scores, and an overview of the journal entries. Blue indicates the PHQ-9 score and orange indicates the GAD-7 scores. The dash line indicates whether the user is having bad thoughts when the user takes the survey. There is also a section saved for biometric data from a wearable which we will implement in the future.

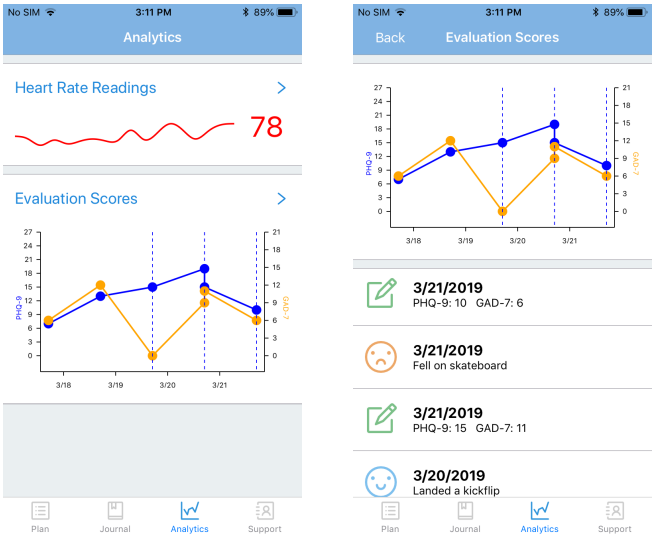

Figure 2. The main Analytics view and drill-down of evaluation scores.

We used React Native to implement our system along with the Expo toolchain, which allowed us to target iOS and Android using the same JavaScript codebase. We also used MongoDB as our database to store all user information, safety plan data, and journal and survey entries. A backend provides user authentication and remote storage via a REST API implemented in Node.js using Express and Mongoose. Our database was hosted on a free-tier MongoDB Atlas instance [12], and the backend itself was hosted on Glitch, an open and collaborative platform for Node.js development that provides free hosting [6].

One difference between the initial and final prototype is that we decided to exclude wearable sensor data analytics from this implementation due to a lack of time. The section for biometric data has been filled with placeholder data in order to provide a vision of how the biometrics will look after weara-

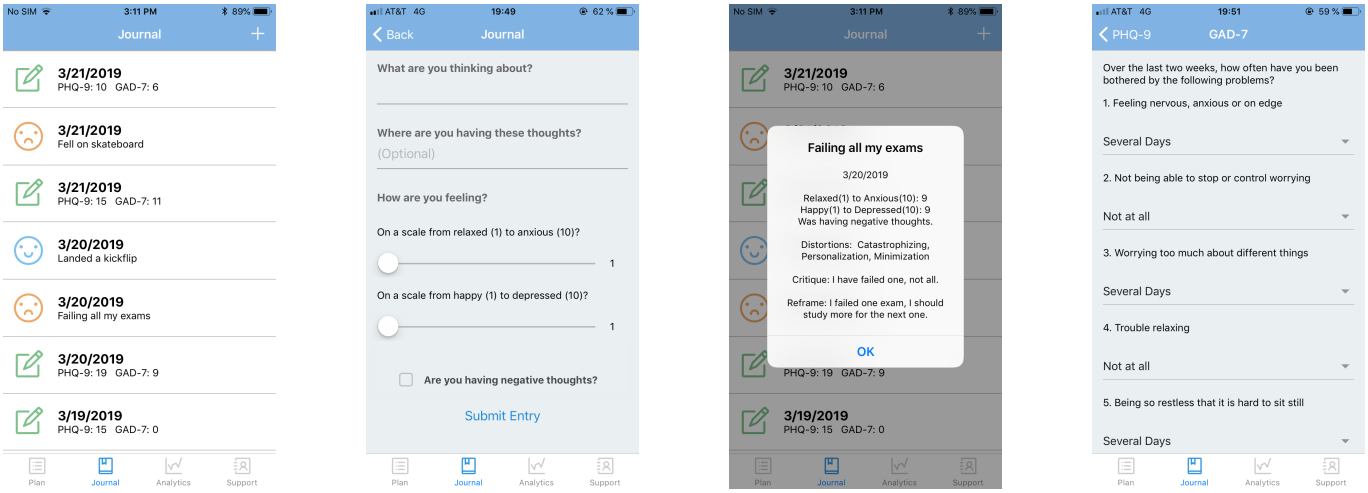

Figure 3. Screenshots of the Journal section, from left to right: journal entry list, new standard journal entry creation, standard journal entry view, and survey entry creation.

bles have been incorporated. We also elected to omit a section of Analytics dedicated to ranking a user's top cognitive distortions because we received feedback that this could create a negative feedback loop by placing an emphasis on negative information. We put this aspect on hold until we reach the implementation phase where we incorporate methods to share data with a user's counselor.

DISCUSSION AND IMPLICATIONS

The research question for this project was how to design an effective ICT solution for managing and preventing mental health crises. One finding was that there are existing resources used by professional psychologists and therapists available that can be digitized and used in ICT solutions such as safety planning and PHQ-9/GAD-7 surveys.

Our findings also revealed the importance in keeping the application simple to use and navigate. Many existing systems did not fully accomplish what they aimed for since the complex design confused the user such that they could not find all the resources and features available. It was also found important since the elderly users might not have enough knowledge and experience with technology to be able to use a complex application, which would exclude a large group of the target population. Therefore, our design aimed for simplicity and understandability.

Another important finding was that incorporating wearables that gather biometric data put less responsibility on the user to self-report while still providing the opportunity to analyze and correlate a large amount of useful data. Even though tracking mood and progress and correlating biometric data to events are useful for psychologists, keeping journal entries simple and positive motivates the user to actually complete them, which is important for the system to be able to make a difference.

Much of the research implied that wearables would be a good feature to integrate into an application for preventing and coping with mental health issues; however, very few of the existing systems actually incorporated them. Even though our implemented application did not reach the ideal design from the design process with wearables, the actualization of this integration is a contribution to the academic and research community, since it provides a model for wearables integration to build further on.

The Actions section of the application is a contribution to the academic and research community. We gained this insight during user interviews and after exploring what was originally suggested as "tasks" to do in order to get up and do something when not feeling motivated, we came up with actions. These internal and external actions, as described above in Findings - Feedback from users, can be readily incorporated with wearables in order to have personalized interventions when a user shows signs of a mental health crisis.

Another useful finding was the tracking of cognitive distortions. By categorizing and tracking negative thought patterns, the user and their counselor can gain a better understanding of what situations provoke their happiness or distress. This provides the application with more professional and recognized methods, along with the safety plan and surveys, which gives more scientific background and credibility.

However, feedback from users and professionals also revealed that it is important not to focus too much on the negative sides of the user's health. Constantly having to fill in forms about a user's reasons for feeling depressed or anxious and also having to analyze them thoroughly may impact the user's mood even more negatively. An attempt to solve this was to add positive journal entries, such that the user can focus also on the good happening in life and not dive in deep into an ocean of negative thoughts when opening their journal, and also to make the cognitive distortion categorizations and reflections optional so that the user is not forced to fill them in. As discussed before, a future improvement for this would be to let the wearables do more of the analysis. However, a wearable cannot get into the user's head and analyze their thoughts—that is, physiological data can only tell us so much

about how a user is feeling. Therefore, more research is needed on how to automate the classification and analysis of a user's thought patterns. One possible research direction would be applying machine learning techniques that could classify the user's expressions, speech patterns, habits, or other indicators of moods and thought patterns.

This application aims to relieve the user from worrying about how to design their journey towards better mental health by providing a simple, usable application that gathers everything one can need in one place. It could be incorporated into the user's therapy sessions and used as a professional tool to gather useful information and tracking to the therapist, without putting more work or responsibility on the user. The contribution this application has towards the user is a ICT tool that can be integrated into their daily routine to help their recovery without giving them more reasons to be depressed or anxious.

Through our research findings and design process, we found that a sustainable ICT solution can be very helpful to users who are suffering from a variety of daily difficulties and life struggles. Such a system can make it easier for user to find ways to cope, reach out to others, and seek support—things that may seem easy to some, but can be exceptionally difficult for someone struggling with severe anxiety or depression.

CONCLUSION

In this work, we present findings that suggest effective ways of harnessing ICT to improve the lives of those at risk of mental health crises. We conducted an investigation in three phases—systematic literature review, systems analyses, and user studies—and iteratively refined a design at each step. Our systematic literature review design phase revealed resources already available for anxiety and depressive crises such as GAD-7 (for anxiety) and PHQ-9 (for depression), evaluations which provide scores to evaluate a user's mental state over time. The safety plan concept is also widely used by mental health professionals, and other systems have made use of virtual safety plans to good effect, so we digitized this form. System analysis of multiple applications led us to incorporate reflection of what may lead a user to their current mental state. It also made us aware of the need to ensure design simplicity to avoid overwhelming or frustrating users, and to make sure that users' interactions with the system are not too invasive or bothersome. Finally, our user studies gave us insight into what sorts of crises should be addressed with an ICT solution; we initially focused on anxiety-related crises, but our interviews revealed the importance of also focusing on depressive crises where the user needs help with motivation.

Having completed our review, we present our findings as a functional mobile application, Beacon, which serves as a virtual safety plan, journal, and resource for those at risk of crisis. Our design and implementation heavily emphasize simplicity, ease-of-use, and affordance to ensure that users are comfortable with the system.

Moving forward, we hope to incorporate wearable device data into the Journal and Analytics sections. These data would add biometric and location features to correlate users' journal and survey entries with their wearable device data, providing physiological insight into how they are doing. This additional modality will also allow the app to provide interventions by suggesting Actions according to how users are feeling and where they are, creating a personalized app experience and more effective avoidance of a mental health crisis. Finally, following the integration of wearable device data, we would like to perform a user study to evaluate empirically the efficacy of the application's design.

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