MIRG Final Report

Increasing Treatment Adherence and Self-Management in Metabolic Syndrome Patients

List of Internal PI/Co-PI:

Tricia Burke, Communication Studies
Kelly Haskard-Zolnierek, Psychology
Krista Howard, Psychology
Grayson Lawrence, Communication Design
Dan Tamir, Computer Science

List of External Investigators

n/a

Project Abstract

One-third of U.S. adults meet the criteria for metabolic syndrome, which involves at least three of the following conditions: hypertension, abdominal obesity, high triglycerides, low levels of high-density lipoprotein cholesterol, and elevated blood glucose. Metabolic syndrome patients who manage their diet, physical activity, and medication adherence can significantly reduce the risk of developing cardiovascular disease and diabetes; however, for many patients, unhealthy diet and exercise behaviors are embedded within their lifestyle, making it difficult to enact changes that could benefit their health. Given the prevalence of smartphone applications in U.S. households, as well as people's active use of smartphone technology, this study fused psychological theory on behavior change with practical smartphone application technology to design a mobile dashboard aimed at promoting treatment adherence and healthy behavior change. The first stage of this project involved conducting focus groups to learn about barriers to treatment adherence and mobile application preferences. As a result of these findings, we developed a comprehensive online questionnaire and surveyed people regarding the ways in which they would want to interact with a mobile application to treat chronic health conditions. The findings from this questionnaire helped us narrow down essential design elements for inclusion in our mobile dashboard and spurred further research and testing that identified feasible strategies for implementing users' preferred features (e.g., voice response output and design preferences) and design elements (e.g., user experience). Ultimately, we were able to generate and test a prototype with which users could interact, as well as a script for interacting with voice response technology to input data into the dashboard and search for relevant health and treatment information. The information that we gained from the various stages of research facilitated by this MIRG funding will result in publications, as well as facilitate future grant applications by members of our research team.

External Grants Submitted

We submitted a $300,000 R15 grant to the National Institute of Aging (through NIH). Although our project was scored highly and received positive feedback, it was not funded. We were invited to resubmit our project; although the feedback we received indicated that we had addressed the original issues with our grant proposal, and we were scored highly, we did not receive funding on our revised submission.

External Grants Awarded

None.

Plan for External Grant Submission

We finished data collection and analysis for our MIRG project in fall 2017. Given the progress that we made as a result of the MIRG funding and our shifting research goals as a result of this progress, we are currently evaluating the most effective route for submitting external funding applications moving forward.

Problems Encountered

In conducting focus groups, we learned that participants' preferences for using self-management mobile applications did not align with the theory that we had been using as a framework for our research. This knocked us off track a little bit, and caused us to re-evaluate the components of the mobile application that we wanted to test, as well as our project goals.

Additional Findings from MIRG Project

A more detailed summary of our research project is presented below.

In our first focus groups, we were used IMS and support theory to guide our questions on users' mobile app preferences and health communication. We learned that their preferences deviated from the theories that we were using to formulate our research questions and goals. As a result, we decided to conduct a larger-scale survey to understand more about these preferences. We hired graduate research assistants to help us conduct a more exhaustive literature search (which involved cataloging and summarizing the research).

- Using the database Academic Search Ultimate, they divided up articles from 2010-2017 for an exhaustive literature search of the following keywords: mobile health or mHealth; eHealth; self-management interventions; personalized; tailored; chronic disease
- They specifically searched for articles in the realm of four chronic diseases: cardiovascular diseases including hypertension, metabolic syndrome etc.; diabetes; depression; and thyroid
- Each student created an annotated bibliography summarizing their search and also saved all listed articles and supplementary information to a TRACS site.
- Angela's search yielded 34 articles and she completed annotated bibliographies with summaries of each article for each of the disease categories listed in #2 as well as one for "healthy behavior" articles.
- Kevin's search yielded 37 articles and he also completed annotated bibliographies with summaries for each article. In addition to the disease categories listed above, he also found articles about COPD, physical activity, and general mental health issues.
- Their reviews of the most recent research in mHealth shows the potential of using mobile health technologies to support individuals' self-management. Many articles show the benefit of personalizing intervention approaches to the unique situation of the individual.

Additionally, they helped us create an online questionnaire and also helped with the data analysis from an online questionnaire.

- The survey assessed 3 aspects of health management: 1) interest in a particular health topic for tracking information, 2) setting goals related to that topic, and 3) receiving reminders.
- The survey assessed whether participants wanted to share their health data or their health goals with others, either friends/family or anonymous app users, and/or receive support from friends/family or anonymous app users.
- The survey assessed current medication adherence.
- The survey assessed current tools that individuals use to manage their health conditions, including apps, fitbit, alarms, etc.
- The survey assessed general app use, including reason for using app, number of apps on phone, favorite apps, comfort level, and barriers for using apps.
- The survey assessed use and interest in voice response technology.

Total sample size N = 828
mTurk = 500 ($2.00 per participant + $400 fee)
Faculty = 208 ($10 per participant)
Student = 120 ($10 per participant)

Key Findings:

- Top 4 health behaviors that participants are interested in tracking: Physical Activity, Nutrition, Weight Management, and Sleep
- 38.7% taking maintenance medication, 17.6% report forgetfulness; 71.7% interested in "smart pillbox"
- 74.1% used mobile apps to track health behaviors
- 73.8% used fitbit-type devices to track steps
- 19.3% used phone alarm or app as medication reminder
- Top 4 reasons for using apps: Get Information, Social Networking, Get Directions, Help with Task
- Voice Response: 54.7% Do not use voice response; <50% would use voice response in health management
- We also learned more about people's social support preferences with regard to different health behaviors

After analyzing these data, we moved forward with the design and voice response research. For the design part of the study, we followed a variation of IBM Design's iterative three-step design thinking methodology of observation, making, and evaluation.

Observation
The observation portion of the research consisted of a preliminary user group of potential users and a qualitative questionnaire. From both of those evaluations, the participants indicated that they had a wide variety of healthcare interests, ranging from nutrition and exercise, to mood tracking and pain levels. They also indicated that they would be more inclined to use a health-tracking system if there was a way to "talk to it" in order to enter in information, as many of them expressed dissatisfaction with current solutions requiring them to type on phone keyboards.

Additionally, they complained of the complexity of entering in different health information into competing systems and the wish to have one system that tracks all of their health goals instead of multiple apps and web sites that did not communicate with each other. Lastly, the group indicated that they liked the idea of being able to set goals for each of their healthcare concerns, and would like an anonymous forum where they could post tips and messages of encouragement to other users on the system.

In questioning which apps the participants currently use and how they use them, the research indicated that users were device agnostic—using many different devices (phone, web site, tablets) depending on the task and context.

Participants also indicated a wish to understand better how meeting goals in one category helped them to better manage other categories.

Making

Based off of the initial user group results we concluded that creating a system that ran on multiple devices, modular and customizable in design, and which included a voice UI (VUI) component (Google Home, Amazon Alexa, Siri, etc.) would allow the users to choose how they wished to interact with the system, and which health parameters they wish to track and set goals for. In addition, in order to reduce the cognitive burden, some smart devices (FitBit exercise trackers, and an internet connected smart scale) were included as part of the system to allow for automatic data collection whenever possible.

Initial paper prototypes were produced of a simple-to-use, card-based Phone app and Web Site. Cards are the name for a specific type of UI which allows for different information to be segmented into squares on the screen. They also allow for that segmented information to be dealt with separate from other information on the screen, allowing for the user to focus their attention on the information they want, rather than being distracted by other information on the screen. Cards also allow for the ability to re-arrange the information categories on the screen, or remove those categories all-together, in order to give the user more control over the information they are most interested in. Three prototypes were produced at this stage, which helped the research team to determine a more solid direction to take the next stage wireframe prototypes that would be shown to user group participants. From these three paper prototypes, an internal team decision was made as to which prototype showed the most promise.

From the internal discussion, wireframe prototypes (figs. 1 & 2) were developed. Wireframes are designed as computer-rendered screens, stitched together in a prototyping program (i.e. InVision App) in order to make a click-able version of the software. These prototypes can then be loaded onto smartphones and tablets, making it possible to allow the user to interact with the app and Web site as if it were a real, programmed application.

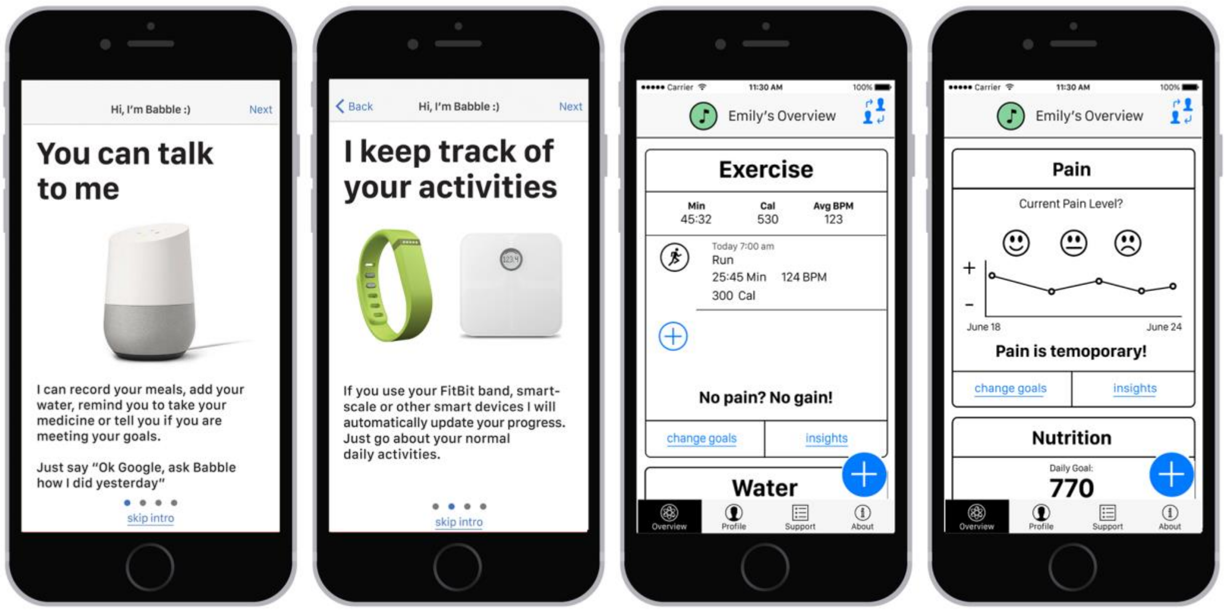

Figure 1: Example wireframe prototype screens from the iPhone application, including instructional and main cards for tracking health information

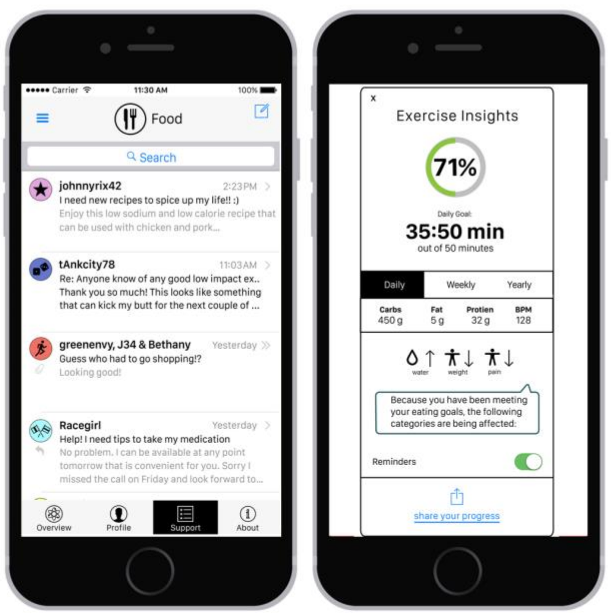

Figure 2: Example wireframe prototype screens, including social support forums, health insights

As part of this system, a video prototype was created in order to show the interaction between the user and the proposed VUI. This prototype showcased an actor who mimicked what it would be like for an average user to use the system throughout the day. The video (http://www.grayscalestudio.com/fileshare/babble_rough_proto_7_24.mp4) started with the actor weighing himself with the smart scale, then moving to the kitchen where he was able to verbally ask Google Home to give him an update of his health progress during the week (fig. 3). A transition to a work environment allowed for the system to use push notifications on the actor's laptop to indicate that it was time to go for a walk and that walking was connected with his stress level. As the actor is going for a walk-break, the video shows his ability to use smart-watches or exercise bands to track his activity, and how he could use Google's VUI on his phone in order to ask the system which restaurants were best for him to eat at to still meet his nutritional goals.

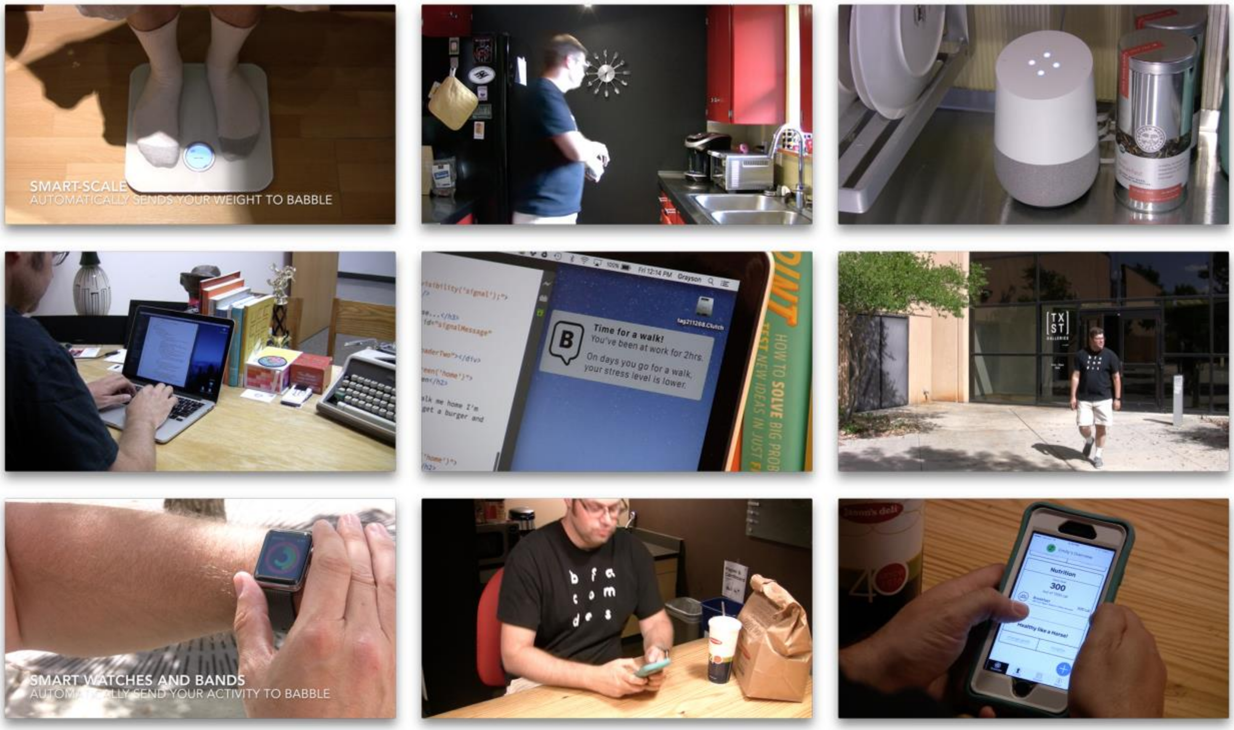

Figure 3: Screen captures from the video prototype demonstrating a normal day in a user's life, from wake-up to bed time.

In order to test the VUI concept, a simple proof-of-concept program was developed for Google Home, which allowed users to tell the system to record their breakfast and to verbally relay their breakfast foods to the VUI (http://www.grayscalestudio.com/fileshare/babble_voice_demo.mov). The VUI developed was able to respond to the trigger prompt from the user, as well as record which breakfast foods they spoke. The software developer taught the system by pre-loading a number of food names collected from a Google search of common breakfast foods. Although the system had a limited vocabulary, it showed the ability to register some foods that were not part of its pre-loaded list when spoken in the same sentence with foods that were preloaded.

Evaluation

In order to gather information on the acceptability of the prototype system, the clickable wireframe, video, and VUI were shown to an initial group of 10 participants on 7/31/2017. This initial set of participants were split into two groups (one group of 4 and one group of 6). We began the session by showing the video prototype. Then, the participants were allowed to try a clickable iPad prototype in order to explore the app by themselves. After the participants were shown the video and iPad prototypes (iPhone prototypes were shown, but not interacted with), the research team asked a number of questions in order to ascertain their acceptance of the various features of the prototypes, and ask for feedback and further suggestions on how we could improve the experience. In order to gauge their ability to interact with the VUI, at the end of the session, participants were handed photos of common breakfast foods and asked to record their breakfast in the VUI.

From this initial evaluation group, the researchers were able to target a number of areas for improvement in the system. The group indicated that they liked the idea of the VUI and being able to get information from and write information to the system via that interface. They also liked the ability to re-arrange the various health information cards and to remove the ones they were not interested in tracking. Participants were happy with the idea of wearables like a Fit Bit exercise band and IoT devices like the smart scale recording information automatically, but expressed concern about added cost. The participants were interested in the app's ability to share certain cards with their physicians to facilitate discussion about those subjects. Mixed levels of acceptance for the social forum part of the app—allowing for users to anonymously ask for advice on health subjects—were expressed. Those participants that did like the idea of social sharing wished for the addition of categories to the forum, rather than the catch-all version presented where all questions were posted in an unsorted screen. For improvements to the system, they expressed interest in not only tracking their own health, but tracking the health of family members under their care. Participants also asked for cards to track other health information, not initially presented (i.e. menstrual cycle tracking, mood) and for changes to the exercise card to track more than just steps (i.e. weight lifting, yoga).

Testing of the VUI prototype showed promise that the Google Home system could be implemented. One user had difficulty telling the system which foods they ate because they paused between words (likely expecting a response for each word), causing the system to time-out. The other 9 participants talked to the VUI at a normal pace and were more successful in recording their meal. The system was able to recognize or partially recognize the food names spoken to it. It did exhibit difficulty in connecting quantities of food (i.e. two eggs vs eggs) from a logical perspective.

Making, round 2

In order to address the changes requested by the first group of users, a second version of the clickable iPad and phone prototypes were created. The designers added the ability to track a loved-one's health information, added additional cards to track the requested health goals, improvements to the forums, and general usability improvements were made. No additional changes to the video prototype or VUI were made.

Evaluation, round 2

A second set of user groups—consisting of 9 users—were convened on 8/21/2017 in order to gauge acceptance to the system and additional changes. The initial process of showing the video, allowing for iPad prototype exploration and questions were followed similarly as the initial group. An exception was made at the end of this group to replace the VUI interaction with a display of various IoT devices, including a FitBit band, FitBit smart scale, and smart blood pressure cuff. These devices were placed on the table along with price tags to allow for discussion among the participants and researchers about which devices they were most likely to purchase.

Responses from this second phase of making, resulted in confirming the changes to the initial prototype were sound. The participants liked the idea of adding abilities to track loved-one's health goals if they were in a caretaker role.

At the same time, this interdisciplinary effort involved computer science (CS) researchers engaged in evaluating the merit of advanced technology in increasing treatment adherence. The CS team has concentrated on two technology aspects.

First, the team has explored the utility of adding a voice response output to the adherence app / dashboard. The team has evaluated several voice synthesis application programming interfaces (API) and has recommended the use of the Speech Synthesis API by Mozilla for future projects / proposals.

Second, the team has evaluated the use of an AI engine that can interact with the patient and supply advice in case the patient has questions related to her medication and treatment program. This is referred to as the conversation service engine. For the conversation service engine, the team has explored the use of the IBM Watson AI engine. Watson is a high end engine, yet it is an expensive and complex system. Hence, the team has developed an app that mine data from the Internet as the source for maintaining useful conversation with the patient. The team has concluded that the self-developed app gives good results and could be further explored as a part of the next research phase.

The following is an example that can demonstrate the use and utility of the voice response as well as the conversation service engine. Under this example the systems can prompt the patient using the app display and / or synthesized voice and inquire whether she has taken a reading of her heart rate in the last 24 hours. The patient might respond that she did not take the measurements yet as she has just acquired a new heart rate measurement system and needs further instructions on how to use it. In response, our system can check (mine) the Internet for instructions on using the particular heart rate measurement model, as specified by the patient, and provide the patient with operation instructions (via the app display and / or via verbal interface). The significance of this example is two-fold. First, the use of mining means that the system has additional level of "intelligence" where some of the responses are not pre-programed into the system. Second, the patient has an option to get the response via synthesized voice that has the same audio quality as in current smart-phones and Home Control systems. For many users, this would provide a usable and user friendly environment.

Overall, we gained valuable insight into users' preferences regarding health communication and mobile technology that will aid us in our future research endeavors, including publishing and presenting the data obtained using this MIRG funding and seeking external funding in support of our research questions. Thank you for investing in our team.