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Golam Mushih Tanimul Ahsan

Jannatul F. Tumpa

Riddhiman Adib

Sheikh Iqbal Ahamed

Daniel Petereit

See next page for additional authors

Authors

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Golam Mushih Tanimul Ahsan
Rapid City Regional Hospital, Rapid City, SD
Jannatul Ferdause Tumpa
Rapid City Regional Hospital, Rapid City, SD
Riddhiman Adib
Rapid City Regional Hospital, Rapid City, SD
Sheikh Iqbal Ahamed
Rapid City Regional Hospital, Rapid City, SD
Daniel Petereit
Rapid City Regional Hospital, Rapid City, SD
Linda Burhansstipanov
Native American Cancer Initiatives, Pine, CO
Linda U. Krebs
University of Colorado Anschutz Med. Campus, Denver, CO
Mark Dignan
University of Kentucky, Lexington, KY

Abstract:
It is necessary for a cancer survivor to have good health behavior. Essential exercise and proper diet are helpful to decrease the risk of recurrence of the disease and the development of a new cancer type. People from low socioeconomic status are more likely to participate in risky health behaviors and have a higher chance of recurrence of cancer. It is important to have a motivational system for cancer survivors that motivates them to perform regular physical activities. In this article, we discuss the development of an mHealth system, which aims to increase physical activity in Native American populations with culturally appropriate motivational text and video messages. The system also includes an e-journal to monitor and maintain proper healthcare. We will also analyze the pilot data to evaluate the usability and the effectiveness of the system.

SECTION I. Introduction

Cancer survival is a hard and long journey, and it does not simply end with being cured. Due to the advancement of modern research as well as improvements in the health sector, more and more people are being cured of cancer. Cancer survival has its own physiological and psychological side effects, a few of them being weight loss, fatigue, nausea, depression, etc. [1] [2] Cancer survivors have a higher chance of developing second cancers and other chronic diseases [3] [4]. There is a higher chance of a decrease in physical and physiological quality of life among these patients. Recurrence is also related to body weight. Studies find that being overweight increases the chance of recurrence and decreases the likelihood of survival [5] [6]. Lack of physical activity is related to colon [7], breast [8] and endometrial cancers [9].

About a third of cancers can be prevented by having a healthy lifestyle, which includes regular physical activities and a balanced diet [4]. Studies conducted on groups of cancer survivors have shown that regular physical exercise has a positive impact on the overall physical performance of these target groups. Such an example is the improvement of walking speed and distance [10] [11] of a cancer survivor group with the help of physical exercise. Exercise leads to the improvement of different vital organs (heart, lungs, etc.). It also reduces the fatigue and improves quality of life of a survivor. Research has found that post-cancer treatment physical activity is very important as this decreases the recurrence rates and increases overall survival rates [5] [6] [12].

Considering these issues, we present a culturally tailored intervention system for physical activity among cancer survivors that focuses on the Native American population from the US Northern Plains. In this paper, we describe our motivation, related research, development, and our findings.

SECTION II. Motivation

Native American people have lower cancer survival rates than other US ethnic and minority groups, especially in the Northern Plains [13] [14]. There are many reasons that lead to this. There is lack of access to cancer treatment among them. Other factors are the inadequacy of health insurance, lack of transportation and services. Because of late diagnosis of the disease and fewer treatment options, several side effects occur and many times ends in death.

A major factor regarding the well-being of a cancer survivor is the socioeconomic status of the person. The quality of healthcare and life depend on a person's socioeconomic status. People with low income have trouble getting a balanced meal. They also do not have the motivation to spare time for physical activities. It should also be noted that people's behaviors are affected by their culture; while developing an intervention system, it is necessary to include cultural components in the intervention process.

With the advancement of network connectivity, people all over the globe are now communicating through the Internet. We seem to find information spread throughout the world within minutes or seconds. Because of that, a trivial approach to reach out our target group would be to build a solution based on the Internet. But we

frequently find places that have little to no Internet connectivity. Keeping that in mind, to reach out to cancer survivors of all different backgrounds, a smarter approach would be to use text message media, given almost all of the cellular devices in the world have text messaging features in it. With less cost and maintainability, text messaging can be considered as viable media to approach and interact with cancer survivors of different backgrounds. Considering these factors, we built an intervention system with notifications and alerts via text messaging system.

Our goal is to develop a motivational system for cancer survivors to motivate to be more physically active. To achieve that goal, we planned the following tasks:

- Develop a cell phone application that motivates users to become more active physically and works as a self-submitted e-journal
- Develop a text message system for motivation
- Develop a data collection/survey application

SECTION III. Related Works

Mobile phone text messaging is widely used and is a potentially powerful tool for behavior change because of its availability, low-cost, efficiency, convenience, and less intrusiveness compared with a mobile phone call [15]. Various text-message based intervention systems and mobile applications [16] [17] have been built for reducing the risk of various diseases like Diabetes [18] [19], for smoking cessation [20] [21] and also to increase physical activity [22] [23]. Many research studies have been conducted to show how behavior change can reduce risk of several diseases [17] as well as on the effectiveness of text-messages and video-messages for behavior change [15] [22].

Phillip et al. [17] conducted an interventional randomized controlled trial where a treatment group was provided with a mobile phone application designed to encourage and facilitate behavior change. The result showed that the ubiquitous nature of the mobile phone excelled as a delivery platform for the intervention, enabling the dissemination of educational intervention material while simultaneously monitoring and encouraging positive behavior change, resulting in desirable clinical effects.

Pamela et al. [22] did a pilot study to assess whether a text message intervention would increase physical activity in African American adults using a pre-/post-questionnaire non-randomized design. The text messages provided strategies for increasing physical activity and were based on constructs of the Health Belief Model and the Information-Motivation-Behavioral Skills Model. The results of this pilot study suggest that text messaging may be an effective method for providing options for motivating individuals to increase physical activity.

Robyn Whittaker et al. [20] carried out a randomized controlled trial to assess the effectiveness of a multimedia mobile phone intervention for smoking cessation. The intervention group received an automated package of video and text messages over six months that was tailored to self-selected quit date, role model, and timing of messages. Feedback from participants indicated that the support provided by the video role models was important and appreciated.

Chandra et al. [19] explained the development and feasibility of an intervention system using text-messaging and interactive voice response for low-income diverse adults who were suffering from diabetes. The types of challenges encountered in design were related to providing text message content with valued information and support that engaged patients.

The design process also highlighted the value of obtaining mixed methods data to provide insight into legitimate versus illegitimate missing data, patterns of use, and subjective user experiences.

Brian mentioned in his article “Text Message Behavioral Interventions: From Here to Where?” [24] about how to design text message behavioral intervention and what limitations exist while using text-messages for behavioral interventions. According to him, the development process can be divided into six steps: (1) needs assessment, (2) specifying performance and change objectives, (3) selecting theory-based intervention methods and practical applications, (4) designing and organizing the intervention, (5) specifying adoption and implementation plans, and (6) generating an evaluation plan.

The Multiphase Optimization Strategy developed by Collins et al. [25] offers a guide to more efficient behavioral program development. It consists of a screening phase, in which interventions components are efficiently identified for selection for inclusion, a refining phase, in which the selected components are fine-tuned, and a confirming phase, in which the optimized intervention is evaluated in a standard randomized confirmatory trial. Finally, Mohr et al. [26] published an integrated conceptual and technological framework for eHealth interventions that mapped intervention behavioral aims to technological strategies.

Considering the rewarding contribution of the text-messaging motivational systems for a variety of populations, we developed a customized intervention system solely for cancer survivors in low socioeconomic status that will encourage them to engage in physical activities, get their feedback for further improvement and make the overall system helpful to their health.

SECTION IV. Our Approach

A. Architecture

The architecture of the solution system can be described through four layers: user layer, application layer, integration layer and data layer. We present the architecture diagram in Figure 1. On the very bottom, we have the data layer, implemented by a MySQL database server. This server runs on a virtual machine created by the Microsoft Azure portal. On top of the data layer, is the integration layer. The main server runs on Apache Tomcat that uses Java and Spring Frameworks. The application layer has several components. There is website for administrators and researchers to use, SMS gateway for text messaging, iPad application for periodic surveys and Android application for activity tracking and the e-journal used by individual participants. Finally, the user layer has the participants, the researchers and the administrators of the system.

B. Functionalities

The iPad app is used for participant enrollment and biweekly in-person surveys. Community Research Representatives (CRRs) use the iPad application to enroll the participant and collect baseline and biweekly survey data from them.

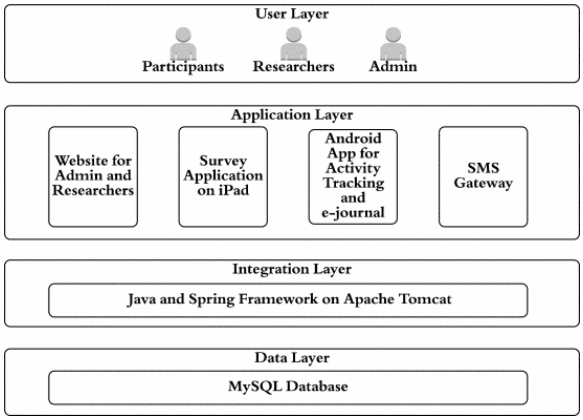

Fig. 1. Architecture diagram of the solution system

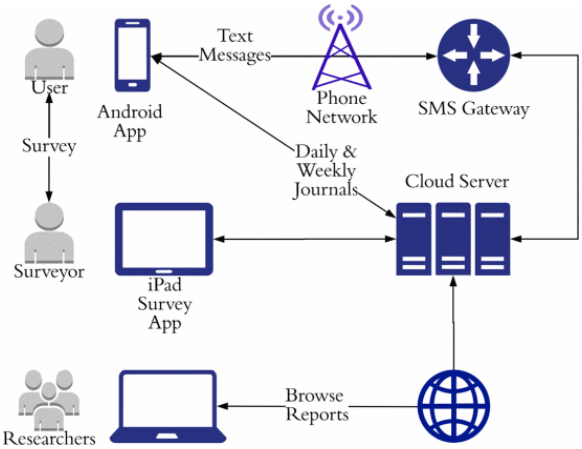

Fig. 2. Data flow diagram of the solution system

Collected data is sent to the main server and then stored in the database.

The website was used for multiple purposes. The administrators use this to update participants' information. It is also used to add text and video messages that are culturally tailored. The website is also used by the researchers to check the progress and status of the participants.

To ensure seamless text message transaction, we utilized a third party text messaging gateway system, Clickatell. Anytime a text or video message was required to be sent to a participant, the main server sent the message to Clickatell gateway, and then it was sent to the appropriate person. The selection of the text message was done by the server itself. Every day, at four different times, the server created the outgoing text message list. To ensure each participant was getting the appropriate messages, it looked into the participant's preferred setting, their current phase of the program, etc. to generate a pool of text messages. From that pool, a single message was selected for each participant. Then the message was sent to the text message gateway to send it to the participant.

The final application layer component is the personal android application. There are several functionalities of the application. With this application, the participants can submit their daily and weekly e-journal. The journals contain sets of questions regarding their current physical activities and their well-being from the past week. The application also includes tutorial videos for the application. There is also a settings menu, where the participants can update their text messaging settings. We present the data flow diagram in Figure 2.

C. Text/Video Message Generation

With the help of our research group's expertise in developing mobile healthcare (mHealth) tools and culturally appropriate behavior and community-based research, we developed the text message system, which is a low-cost and efficient system. In the system, the participants received daily text/video messages throughout the day. These messages included motivational quotes and specific strategies related to physical activity. The video messages were created from filmed interviews of Native American cancer survivors. These survivors shared their experiences and stories regarding their motivation for physical activity. Culturally significant motivating texts were collected by the research team and converted into text messages of 160 or fewer characters. These messages were sorted with different keywords e.g. traditional, motivational, information etc.

For the video messages, our team decided to send the links of the video messages as text messages. The output of this method was twofold. It decreased the data traffic for the participants. Another issue is that the pilot was set up in a rural area, where the connectivity to wireless network is poor. So, even if text messages were able to reach the participants, it would have been not possible for the video messages to reach them. Our setup made it possible for them to find a strong wireless or wi-fi network and then watch the videos at their preferred time.

D. e-Journal

The e-Journal was another important component of the system. Many cancer survivor websites and research groups encourage keeping a journal to track the person's daily experience and improve their quality of life. In our system, we had two separate journals: daily journal and weekly journal. Using these journals, the participants input their daily physical activities and their concerns. The daily journal collected data such as, how is the person feeling on that day, whether they were able to do everything they wanted or not, how long they were able to do those works and if their emotional state was good or not. For the weekly journal, there were two types of questions. In one set, there were questions about their overall physical activity, its effects, and their overall feelings during that period. In the other set, there were questions regarding the app, the text messages, the e-Journal and their overall performance in the participant's view. Figure 3 shows some screenshots from weekly and daily journals.

E. Periodic Survey

Another important component of the system was the periodic survey. The first and baseline survey also worked as the enrollment process. During enrollment, the CRRs informed the participants with the study overview and the aims of the system using the iPad application. If all the eligibility criteria were met and none of the exclusion criteria were selected, the participant was guided to the consent screen. After agreeing with the consent information, the participant was enrolled, and the participant answered the questions for their baseline visit. The study went for about three months, and there were bi-weekly surveys. The participants visited the health center, and their assigned CRRs met with them to collect information regarding their progress and health status. The questions included queries about their current health status, and if there were any issues in the past two weeks. Sample screenshots from the iPad survey app are presented in Figure 4.

F. Development and Deployment

The cloud server was deployed in a virtual machine designed by Microsoft Azure portal. The database was designed in a MySQL server. The iPad application was developed in Objective-C with the development tool XCode. The android application was developed in Java with Android Studio. The main server ran on Apache Tomcat and used Java and Spring frameworks. All the server components were deployed in the cloud.

G. Control of Data

All personal data of the participants were anonymized. The system only stored auto-generated IDs to identify participants to ensure their privacy. The database had different authorization roles to ensure secure data access to administrators and researchers.

SECTION V. Evaluation

The pilot study went on for about three months. Seven participants were selected for the pilot study with the eligibility criteria in Figure 4. We have evaluated our intervention system considering the following perspectives:

- Usability
- Efficacy

A. Usability

There were several components of the system. They differed in access roles as well. For example, the website was used by the administrators, the iPad survey application by the CRRs, and the android application by the participant cancer survivors. These components were accessed according to each user's role. There were no concerns raised by the participants regarding usability. Moreover, there was a tutorial provided for the participants about the use methods of the application.

B. Efficacy

The weekly journal had specific questions about the efficacy of the system. Five of the participants answered the efficacy questions. The questions are shown in Table I. The participants answered on a scale of 0 to 5, where 5 represented strongly agreed, and 0 represented strongly disagreed. From the user feedback, we note that the application and text messages were considered useful by the participants.

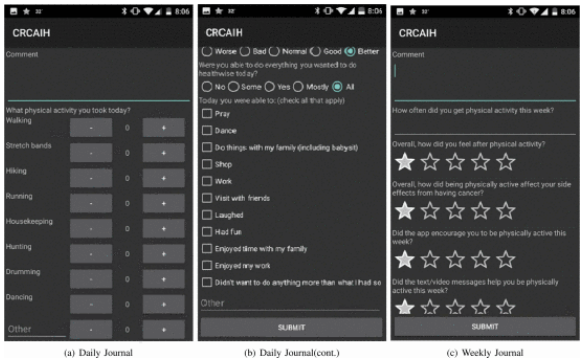

Fig. 3. Daily and weekly e-journalView All

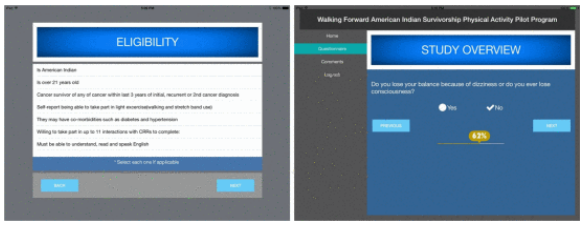

Fig. 4. Screenshots of survey application

Table I Efficacy of the system

Question	Average Rating
Did the app help you to be physically active?	5
Did text/video messages help you to be physically active?	4.44
Did the eJournal encourage you to be physically active?	5
Overall how satisfied are you the system?	3.44

SECTION VI. Limitations and Future Works

A. Limitations

Since we conducted a pilot study and had a small number of participants, we encountered few limitations:

- From the feedback of the participants, we could not identify any pattern about how to improve our system for improving overall satisfaction with the system.
- Since the data received from the participants were self-reported, it was not possible to verify whether they watched the video or not, or which videos were more helpful to them.

B. Future Works

After the optimistic response from the participants of the pilot study, we sketch our future works to be as follows:

- We plan to conduct the study among a larger population to gather more data so that we can find the pattern for making further improvements in our system and to test the effectiveness of the system.

- We also intend to extend our work to monitor the emotional states of cancer survivors so that we can provide better support to them.
- In order to verify the self-reported data from the users of our system, we plan to incorporate a pedometer feature in our application so that we can keep track of some physical activities of the users and give them feedback about how they are doing.

SECTION VII. Conclusion

In this study, we developed the intervention system with several components. Though the pilot study was small in size regarding participants, as our design is implemented in a scalable platform, it requires little change to implement the whole system for a larger population. In the pilot data, it shows that having such a system helped the participants to get motivated for physical activity.

In this paper, we described the development stages of all the components of our solution system. We described how each component works and the communication among them. We also described our initial findings from the pilot data. This system is ready for a larger population, and we believe it will help many cancer survivors by motivating them to be more active physically and improve their quality of life.

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