Supporting Longitudinal Change in Many Health Behaviors

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Abstract

We identify the challenges in developing systems that support users in changing multiple health behaviors over time, and a development methodology that addresses these challenges. We describe how these methods were used in the design of a system for supporting young women with "preconception care", involving simultaneous longitudinal behavior change on up to 108 health behaviors. Results from focus group testing, usability studies, pilot studies, and an ongoing clinical trial are presented.

Author Keywords

Health behavior change; preconception care; embodied conversational agent

ACM Classification Keywords

H.5.2 [Information interfaces and presentation]: User Interfaces – Evaluation/methodology; Graphical User Interface; Natural Language; Interaction Style; Theory and method;

Introduction

Motivating and coaching individuals to change a health behavior—such as increasing physical activity, losing weight, or stopping smoking—is a difficult task. Many theories of health behavior change have been developed and leveraged in automated systems that

Health care and programs
  e.g., having health insurance
Relationships
  e.g., physical or sexual abuse
Reproductive health
  e.g., not using birth control
Health conditions and medicines
  e.g., asthma
Genetic health history
  e.g., ethnicity-based health risk
Emotional and mental health
  e.g., depression
Immunizations and vaccines
  e.g., need HPV vaccine
Infectious diseases
  e.g., at risk for STI/STD
Substance use
  e.g., tobacco use
Nutrition and activity
  e.g., overweight
Environmental issues
  e.g., toxoplasmosis
Men and health care
  e.g., partner does not have PCP

Table 1. Domains of Preconception Care
and Example Risks for each

provide support for people trying to change. However, the vast majority of the health behavior change support systems developed to date focus on changing only *one* behavior at a time, and many do not provide ongoing support over the weeks or months that change may require.

Many individuals require support in changing multiple health behaviors at once. Weight loss is a common example, requiring changes to both diet and exercise for maximal effect. Patients with newly diagnosed chronic conditions, such as diabetes, also require multiple lifestyle changes, as well as adherence to medication and self-care regimens. These individuals require significantly more support than people who are only changing a single behavior, since multiple goals and activities must be tracked, prioritized, and coordinated.

One approach to changing multiple behaviors is to address them sequentially; only addressing a new behavior once a prior one has been successfully changed. Individuals who have some success changing one target behavior have been found to be more likely to achieve success on a second behavior [9], and any behavior change success may increase general self-efficacy that increases motivation to change many other health behaviors [13]. However, some behaviors can take weeks or months to address, making an overall sequential intervention potentially years in duration and possibly putting the individual at risk. Some researchers have identified "bundles" of behaviors that can effectively be addressed at the same time [7]. In addition, there may actually be benefits to changing multiple health behaviors simultaneously [7].

Actions that address multiple behaviors and combined suggestions can reduce the total perceived effort that an individual takes, and increases his/her confidence to change. Multiple health behavior change has also been shown to be economically advantageous [7].

In our work we are developing an automated system to provide "preconception care" (PCC) to young African American women. These women are twice as likely to deliver a low birth weight baby and have twice the infant mortality rate compared to White women in the US. In a recent survey, 108 risks in 12 domains were identified as possible factors in determining infant health in this demographic [1] (Table 1). The domains range from substance abuse to nutrition and exercise, and individual risks span flu vaccinations to alcoholism, many of which require longitudinal coaching to change. However, the majority of these risks must be addressed well before pregnancy and traditional prenatal care, thus this area of preventive medicine is referred to as "preconception care" [12]. As just one example, folic acid should be taken at least four weeks *before* pregnancy to prevent neural tube defects.

In our pilot work, we have discovered that the average woman in our target demographic has 23 (range 13-37) preconception risks that need to be addressed [8]. Thus, preconception care represents an application domain in which many health behaviors need to be changed, with the set of behaviors potentially different for each user, and many of which require longitudinal support. Our pilot system screened women on the 108 PCC risk factors, but only provided brief tips on how to address them. In our current work we have extended this system to provide longitudinal coaching (for a year or more) on all risks identified for a given user.

Related Work

Many researchers have applied theories of health behavior change to automated systems designed to support users in changing health behavior. For example, UbiFit Garden encourages users to lead physically active lifestyles by displaying an animated garden on mobile phones whose display elements reflect the users' physical activity levels [5]. The system was designed based on the transtheoretical model (Table 2) and goal-setting theory.

Several conversational systems for supporting health behavior change have also been developed. GeriTrack promotes physical activity in older adults via a virtual coach ("Laura"), and incorporates techniques from goal-setting theory [2]. HBCO (Health Behavior Change Dialogue Ontology) was developed to increase physical activity and fruit and vegetable consumption using explicit representations of theoretical constructs from the transtheoretical model and motivational interviewing [3].

Challenges in Designing Systems for Multiple Health Behavior Change

Based on our review of the literature, experience with a prior multiple behavior change system [3], and our PCC pilot work [8], we identified a number of challenges in designing a system to support multiple, longitudinal, behavior change. These challenges, and our approaches to address them, include the following.

- Keeping users organized. With up to 37 health risks to address, simply keeping track of which risks have been considered, acted on, or addressed, can be a daunting task. We help users stay organized by means of a "My Health To Do" list (Figure 1)

Figure 1. My Health To-Do List

Figure 2. Virtual PCC Coach

that lists risks not addressed yet, and goals (actions to perform) on risks that the user has decided to act on.

- Not overwhelming users. It is simply impossible to review all relevant information on 20 risks in a single session, and attempts to do so would likely result in users withdrawing from the intervention. The PCC system supports incremental work on risks by first presenting information on risks, one-by-one, why they are important, and, if the user agrees to take action, incremental, stage-based, behavior change coaching (based on the Transtheoretical Model in Table 2). Users can end their session at any time and resume in a subsequent session.

- Supporting empowerment. Although the 108 risks have been ranked in medical importance by clinicians, it is important that users be given the freedom and flexibility to choose what they work on in a given session in order to maintain their sense of empowerment and self-efficacy. The system suggests faction on the highest-ranked outstanding risk, but allows the user to pick any risk or action to work on.

- Maintaining engagement. Even though risks can be addressed in parallel, many risks can still take months to fully address. Thus, maintaining longitudinal engagement with the intervention is crucial. We use a variety of techniques to keep users engaged, including the use of a virtual coach (Figure 2) and trust-building dialogue [2].

Table 2. Examples of Health Behavior Change Theory Used in PCC Support System

- Scalable development methodology. Developing 108 unique longitudinal behavior change interventions is a herculean undertaking. One approach to dealing with this complexity is to use generalizable and reusable knowledge representations and content. Although we have used this approach on other projects, it only works well if the behaviors in question are very similar [3]. For PCC, we did generalize and reuse representations across behaviors to the extent possible, but because of the diversity of behaviors we took a *design patterns* approach (Table 3). At the start of the development effort we identified behavior change intervention strategies that had been used in prior automated systems (e.g., motivational interviewing, Table 2, for individuals not ready to change, goal setting and positive reinforcement for individuals in later stages of change on acquisition behaviors that are shapeable) and reviewed these with the clinicians on the development team. The team then split up into groups to develop interventions for subsets of the risks using these strategies as templates to fill in.

- Evaluation. There is no single, widely-accepted method for evaluating multiple behavior change outcomes [6]. This is further complicated in our intervention since the number and types of behaviors for each user can be different. Our approach has been to use a modified summative method in which we compute the percent of identified risks discussed, acted on, and addressed for each user, as well as positive progress on "stage of change", as our primary outcome metrics.

- Cross-behavior interventions. As mentioned above, there are many opportunities for promoting multiple health behaviors at once. For example, success in one behavior can lead to increases in generalized self-efficacy, thus reminding users of past successes may be helpful when addressing new behaviors or actions. This remains an active area of research for our project.

The Preconception Care System

The PCC support system is a web-based intervention that begins when a user completes a survey questionnaire to identify her PCC risks. Following this, she can conduct sessions as often as she likes to help her address her risks. The intervention is designed for a recommended weekly session over a one year period of time. Users are guided through each session by the virtual coach (Figure 2) which speaks using synthetic speech and synchronized animated nonverbal behavior [2]. User contributions to the simulated conversation are made via multiple-choice inputs.

Following the survey, the virtual coach introduces the "My Health To-Do List" (Figure 1) and lets users select the identified risks they want to discuss. The coach then describes each risk and why it is important, and offers users the opportunity to take action on it. The pilot version of the system offered brief tips addressing risks that users selected.

Pilot System Test
The initial PCC system was developed using input from eight focus groups (31 women total) and usability testing with 15 women, and evaluated in a two-month pilot study with 9 additional women [8]. Satisfaction was rated highly by all participants, and participants in

Problem Solving
Helps user overcome obstacles to change. Builds self-efficacy.
1. Elicit barrier to change from user.
2. Provide tips, indexed by barrier, for overcoming problem.

Sequential Discrete
Helps user achieve change comprised of multiple, discrete steps.
- For each step:
    1. Explain importance of step.
    2. Elicit commitment from user.
    3. Follow up on subsequent sessions until complete.

Shaping
Helps user incrementally change a shapeable/continuous behavior.
1. Identify long-term change criteria.
2. Decompose change into short-term goals.
3. Each session:
    a) Elicit commitment to next change increment
    b) Follow up on commitments

Homework
Provides a stage-appropriate activity to help user move to next stage of change
1. Index homework exercise by stage
2. Elicit commitment from user
3. Follow up on subsequent sessions

Table 3. Example Design Patterns for Behavior Change

the pilot study conducted an average of 10.5 sessions, agreed to discuss 52% of the 128 total risks identified, and fully addressed 35% of these.

PCC with Longitudinal Change Support
We enhanced the pilot PCC system with longitudinal interventions for most risks, following the principles described above. Our overall approach is stage-based (Table 2). Once a user has agreed to work on a risk, their stage of readiness to address the risk is assessed. If a woman is not ready to take concrete action, the system uses techniques from motivational interviewing to motivate her to take the first step (Table 2). Motivational strategies vary significantly among behaviors, and so were designed individually for each. Once a user has moved beyond the "precontemplation" stage, other behavior change strategies are deployed incrementally over time, based on the behavior and the user's needs. The majority of these interventions were developed using design patterns and templates (Table 3).

Usability Testing of Longitudinal System
We conducted usability testing with five women, and made several modifications based on these. Changes included more user orientation to the intervention and virtual coach during early sessions, more coaching on how to talk to a doctor about various risks, and more explanation on medical terms and acronyms such as "STI" (sexually transmitted infection).

Ongoing Clinical Trial
We are nearing completion of a six-month randomized clinical trial to evaluate the longitudinal PCC system. We recruited 100 women for the study, aged 23.8 (sd 5.9), from a national group of women trained to be "Preconception Peer Educators" by the DHHS Office of Minority Health. Of the 90 who completed the risk assessment survey, the most prevalent risks included: being at risk for an STI (91%), listeriosis (87%), exposure to plastic bottles or food containers (84%), caffeine (81%), bad diet or food choices (76%), and needing more iron (72%). The number of risks by domain is shown in Table 4.

Half of the study participants were randomized to the intervention group, and 42 conducted at least one online session. These women conducted an average of 4.12 (sd 3.15) sessions over the six months of the study. Of the 23.2(sd 6.12) risks identified per woman in this group, participants chose to discuss 32.1% of them with the virtual coach, and chose to take some action on 7.9% to date.

Conclusion
The longitudinal PCC system has been successful at screening women for their preconception care risks, and providing initial counseling for 84% of the study participants. Women chose to discuss one third of their risks with the virtual coach. Boosting longitudinal engagement and use remains a challenge.

Future Work
To improve longitudinal use and trust in the system's recommendations we are currently implementing social chat for the virtual coach, in which it will relate a fictitious personal "backstory" to users about aspects of its professional and personal life. A previous study demonstrated that this can lead to increased use of longitudinal interventions with health coach agents [4].

PCC Domain	N=90 Num(%)
Emotional and Mental Health	40(44.4%)
Environmental Issues	86(95.6%)
Genetic Health History	89(98.9%)
Health Care and Programs	47(52.2%)
Health Condition and Medicines	55(61.1%)
Immunizations and Vaccines	79(87.8%)
Infectious Diseases	90(100.0%)
Men and Health Care	57(63.3%)
Nutrition and Activity	90(100.0%)
Relationships	51(56.7%)
Reproductive Health	77(85.6%)
Substance Use	52(57.8%)

Table 4. Prevalence of risks by domain

We are also developing methods to promote change in multiple behaviors at once, by identifying and prioritizing common actions that can address multiple risks (e.g., making a doctor's appointment), reminding users of past change successes when starting on new behaviors, and identifying bundles of behaviors that can be effectively changed at the same time.

Finally, we are developing a module to assist a woman in developing a reproductive life plan. The current system assists in contraception selection [11], but we are expanding this to fit preconception care and contraception support within a woman's lifetime career and family goals.

Acknowledgements

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