

Design of Social Media for Health Behavior Change:

An Ontological Approach

BY

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THESIS

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SUMMARY

Use of social media for health behavior change is a complex interdisciplinary problem and has seen a rapid growth in the recent years. Following a systematic approach, an ontological framework was created to conceptualize a lens that exposes the various complexities of this problem. The framework provides an information systems point of view on the research on the use of social media for health behavior change. The framework was used to systematically analyze the current state of the research on this problem by creating an ontological topography of all extant literature. The ontological topography was created at monadic, dyadic and triadic levels and helped expose the bright, light and blind/blank spots in the current body of research. The ontological topography and literature review shed light on the inadequacies of the current research that places social media features at the periphery or compromises by eliminating traditional online health behavior change features. A lack of research that makes use of users' existing social networks was also highlighted. These findings led to a research objective of designing a new prototype for online health behavior change system that enables delivery of a holistic behavior change intervention within a mainstream social networking site (Facebook), using its API. An evaluation of the usability, engagement, perceived social support and perceived privacy of the prototype was performed.

Study findings illustrated that the designed prototype has good usability and resulted in a significant increase in social support. Program engagement parameters have also been found to be better than established benchmarks. The qualitative interviews revealed that the users were able to appreciate the tailored nature of the content provided through the prototype, being able to connect with their existing social contacts and also make new connections. Users were also

SUMMARY (continued)

able to point out the pitfalls of the prototype and offered suggestions on how to improve the design further.

Future research efforts could benefit from incorporating the ontological framework with the prototype (with minimal configuration changes) to rapidly produce the required solutions to achieve a variety of health behavior change solutions for diverse populations.

I. INTRODUCTION

The United States spent 2,809 billion US dollars on healthcare in the year 2012; it represents 17.9% of the per capita GDP (WHO 2014a). The Center for Disease Control (CDC) reports that more than 75% of healthcare spending focuses on chronic medical conditions, with 50% of the population having one or more of these conditions (NCCDPHP 2009). The CDC further adds that chronic diseases are the most preventable of the various forms of diseases. Health-damaging but modifiable behaviors such as tobacco use, insufficient physical activity, poor eating habits, and excessive alcohol use are responsible for much of the illnesses, disabilities, and premature death related to chronic diseases.

The epidemiological data from the World Health Organization (WHO) sheds light on the grim situation globally. The WHO reports that: (1) 80% of premature heart disease, stroke and diabetes which kills 3.3 million people annually can be prevented; (2) a little less than 6 million deaths worldwide are attributed to tobacco use or exposure, with 22% of the world population identified as smokers; (3) approximately 3.3 million deaths annually are attributable to alcohol consumption; (4) approximately 3.2 million deaths worldwide are attributable to insufficient physical activity – 31% of people globally and 40.5% of people in the US are physically inactive; and (5) approximately 1.7 million deaths worldwide are attributable to low fruit and vegetable consumption (WHO 2014b).

Since policy can have only a limited effect on health (Starfield and Shi 2002), individual and group level change of health behavior becomes a necessity to prevent these deaths. Health

behavior change has been shown to reduce rates of infectious diseases, sexual diseases (which affect 498 million people between the ages of 15 and 49 annually), and preventable mental health disorders (Johnson, Scott-Sheldon, and Carey 2010). The barriers faced in changing health behaviors are enormous and require a science that focuses on health behavior change that is defined as ‘behavior patterns, actions, and habits that relate to health maintenance, health restoration, and health improvement’ (Gochman 1997). With the proliferation of information technologies such as the internet, there has been an ever-growing push for technology driven health (eHealth) interventions (Atkinson and Gold 2002).

The year 2014 witnessed the twenty-fifth anniversary of the internet (Fox 2014) and the tenth anniversary of Facebook (Zuckerberg 2014). Eight out of the top fifteen websites in the US are now social media sites, in contrast to none ten years ago (Pratt 2014). Their popularity is rising. Social media are now believed to be used by 73% of online adults (Duggan 2014), with 83% of the US population now being online (Fox 2014). This growth has been further driven by the rapid penetration of mobile technologies, with the report from the International Telecommunications Union claiming a 96% mobile penetration rate globally (Brahima 2013). 58% of American adults are now said to own a smartphone (PEW 2014). The popularity of social media sites can be primarily attributed to their success in user engagement and retention (Constine 2013), which is made possible by the constantly evolving applications with an infinite stream of user generated content (Korda and Itani 2013, O'Neill et al. 2014). The potential for social media content to spread through the friends of its users and word-of-mouth networking has led to what is known as viral marketing (Loss, Lindacher, and Curbach 2014, Miller 2013, Hansen and Johnson 2012, Freeman and Chapman 2008, De Bruyn and Lilien 2008).

This popularity and reach of social media have led to its use in a variety of fields, including public health research and practice (Capurro et al. 2014). Social media can help reach the goals and missions of public health (CDC 2014) by facilitating improved reach and significant influence on individuals and communities that was previously either impossible or too resource intensive. Unlike a medical intervention, changing one's behavior is not quick and requires regular and systematic support from a variety of resources that can be facilitated by social media (Moorhead et al. 2013, Laranjo et al. 2014, Maher et al. 2014).

The intersection of two complex and diverse fields, namely social media and health behavior change, brings forth a new level and dimension of complexity that warrants detailed and systematic research in this area. To this effect, this study aims to (1) develop an ontological framework on the use of social media for health behavior change, (2) map all existing literature (as of 9/22/2014) onto the framework to identify the blind/blank, light, and bright spots in the literature, (3) create a prototype behavior change application, which addresses the various limitations identified by the literature review as well as the ontological mapping of the literature, and (4) evaluate the developed application prototype, in the belief that this effort will help structure and accelerate the inclusion of social media in the rapidly growing field of online health behavior change interventions.

This thesis is organized as follows: Chapter 2 provides a literature review of work in the areas of social media, health behavior change, and the intersection of the two, focusing on topics essential to this research; Chapter 3 presents an ontological framework to enable the reader to visualize the breadth and scope of the problem, a mapping of all extant literature onto the

ontological framework, leading to the research objectives; Chapter 4 presents the methodology to be followed for achieving the research objectives; Chapter 5 presents results and; Chapter 6 provides discussions on the findings and a conclusion.

II. LITERATURE REVIEW

A. Social Media

1. Definition

The term social media is used generously in all fields and practices, however, there is no consensus on the definition of what exactly is social media (Kaplan and Haenlein 2010). A thorough look into the literature, however, demonstrates a consistent and broad agreement on what is a social media (Barnes 2006, Boyd and Ellison 2007, Kaplan and Haenlein 2010, Kietzmann et al. 2011). Accordingly, social media can be defined as a set of web-applications built on a platform designed to deliver rich user experiences, to enable users to share, co-create, discuss, and modify content that is publicly accessible or available to a selected group of people, is creative and not with a commercial context.

2. Types

A website featuring social media functionality is not bound by a clear set of features and cannot be assumed to be a holistic system. The ecology of social media caters to various audiences, purposes, and include various features (Kietzmann et al. 2011, Kaplan and Haenlein 2010). As an example, YouTube, Flickr, and MySpace are focused on the sharing of multimedia; Facebook and Friendster are generic social networking sites; and LinkedIn is a professional networking site.

There is a wide variety of social media. Kaplan et al. (2010) offer a classification of the popular social media based on media richness (Daft and Lengel 1986) and the self-disclosure required (Kaplan and Haenlein 2010), which is as follows: With respect to social presence and media richness, applications such as collaborative projects (e.g., Wikipedia) and blogs score lowest, as they are often text-based, hence only allowing for a relatively simple exchange. On the next level are content communities (e.g., YouTube) and social networking sites (e.g., Facebook) which, in addition to text-based communication, enable the sharing of pictures, videos, and other forms of media. On the highest level, are virtual game and social worlds (e.g., World of Warcraft, Second Life), which try to replicate all dimensions of face-to-face interactions in a virtual environment. From the perspective of self-presentation and self-disclosure, blogs usually score higher than collaborative projects, as the latter tend to be focused on specific content domains. In a similar spirit, social networking sites allow for more self-disclosure than content communities. Finally, virtual social worlds require a higher level of self-disclosure than virtual game worlds, as the latter are ruled by strict guidelines that force users to behave in a certain way (e.g., as warriors in an imaginary fantasy land) (Kaplan and Haenlein 2010).

3. Affordances

The term affordance has evolved significantly since Gibson introduced it in 1977 (Gibson 1977). Here we use affordance as: Resources afforded by the ICTs to help communicators achieve their goals, while features are simply the objective (e.g., transmission speed) and the psychosocial (anonymous communication) characteristics of ICT that result from designers' or users' choices (Markus 2005).

Kietzmann et al. have offered an insight into the building blocks of social media and also elucidate that not every popular social media focused website contained all elements of the building block, nor do they all contain every element of the building block now (Kietzmann et al. 2011). Upon a detailed review of the features specified by the literature (Kaplan and Haenlein 2010, Boyd and Ellison 2007, Kietzmann et al. 2011), the following are presented as affordances of social media:

- i) Identity represents the extent to which users reveal their identities in a social media setting. With numerous users as a part of social media focused websites, the users are able to present themselves using user profiles. Typically, user profiles are represented as forms (single page or multi-page) that enable disclosure of information about oneself in a structured format. User profiles also typically include capabilities to upload pictures. Name, age, gender, and location are some of the common profile fields used by various social media focused websites; however, profile fields also differ from website to website. As an example, LinkedIn, which is a professional networking site, includes fields that are more inclined towards job experience, skills, certifications, etc., while Facebook, which is a social media focused website for generic social networking, includes fields about movie preferences, book preferences, etc. While several fields are included as part of user profiles, most social media focused websites require some of the profile fields to be answered and some are left as optional; for example, first name, last name, gender, and date of birth are required fields in Facebook. This set of required fields

is deemed to be the minimum set of profile fields needed for an individual to establish one's identity in Facebook.

While profile fields form one side of identity management, privacy options make up the other. Privacy options are useful in situations where the users want to enter certain profile fields, but prefer to make them visible to certain members of the social network. The privacy options are usually not limited to just profile fields, but to all activities and information associated with the user in the social media focused website. The profile page(s) that enable uploading and editing of self-presentation information as well as privacy options, offer the affordance of identity management.

- ii) Sharing (content): Some categories of social media focused websites heavily rely on content as the core for the social context; for example, collaborative projects like Wikipedia are built around the main article (content) developed for each topic, while blogs are centered on the content of the various blog posts. YouTube and Flickr, on the other hand, are centered on the videos and pictures uploaded, respectively. Without this core content, the context offered by several social media focused websites would be lost. Content is not just limited to text, but also audio, video, animations, etc. With content created (example: a status update on twitter) or uploaded (example: video uploaded to YouTube) to enable the social interactions around the content, dissemination (share) of the content becomes a necessity. Sharing can occur both within the same social media focused website and also outside (sometimes using third party social media services). Within the same site, dissemination can occur by simple and popular means such as the

“share” button in Facebook and the “retweet” in Twitter. RSS feeds, APIs, and share buttons enabled via JavaScript (connecting to other social media sites) are some of the modes for sharing off-site.

- iii) Relationships: The “social” aspect of a social media is partly afforded by the relationship creation capabilities of social media. Most social media focused websites require a two-way approval process for establishing a mutual relationship. In one-way friendships, the person who has initiated the friendship is often termed as a follower or fan; however, when the friendship becomes mutual, the same person becomes a friend. The process of friendship creation is important when one wants to use a very granular approach to privacy, wherein friends get exposed to more information and activity from the user than compared to non-friends. Friends also might have access to more interaction capabilities with a user, as compared to a non-friend.
- iv) Groups: While relationship creation concentrates on the one-on-one aspects of social networks, group memberships focus on the many-to-many aspects of social networks; for example, the professional networking site, LinkedIn, offers professional networks, while Facebook offers groups as a form of maintaining many-to-many relationships. The networks and groups are typically established to aggregate users on a common thread, which could be as simple as living in the same city, to as deep as members of the same family. Network and group administrators often have a fine level of control on the privacy aspects of the groups; for instance, Facebook groups could be open, closed, or

secret. Social networking sites like Facebook, have also established a form of passive membership, by linking together people based on their various interests (“likes”).

- v) Conversations can be seen as the ‘string of life’ for social media. While the previously explained sharing (content) focuses on the core content in the context of the social media focused website, they only serve as conversation starters, beyond which interactions in several forms take place. Replies, comments, likes, and up/down voting, are some forms of content-centered conversations in social media. Also, traditional interactions such as instant messaging (chat) capabilities are also often used on social media sites to aid interactions. One unique yet very simple form of conversation/interaction used by Facebook is a ‘poke’, where a user pokes another user by clicking a button, which intends to serve as a simple conversation starter.
- vi) Reputation: With millions of users participating in social media, the task of identifying worthy profiles (users) and content becomes complicated. Social media focused websites not only make it possible to maintain existing friendships, but also facilitate in discovery of new friends. The reputation of a profile (user) is represented by different parameters on different sites; for example, the number of users who are in the professional network of a given LinkedIn user is used to assess the professional clout of that user. The number of fans and/or friends is a common measure in several sites. LinkedIn includes reviews of its users made by the users’ friends. People of high reputation typically enjoy a higher influence in the social network. With social media focused websites also serving as a medium for content distribution, identifying good content becomes vital. Several social

media focused websites such as Reddit entirely focus on voting for good content. Facebook includes a 'like' button along with the content, which enables users to convey their sign of approval for the same. Several mainstream media websites including CNN, Washington Post, New York Times, etc., recommend stories to users based on the reputation a story receives in social media focused websites.

The above established affordances of social media play a critical role in understanding any research focusing on social media. These affordances would be used throughout this study as a structured lens to view social media capabilities demonstrated by existing research. The affordances will also be used to conceptualize the necessary features of the to-be-developed prototype behavior change application.

B. Health Behavior Change

1. Introduction

Change of one's behavior is not a simple one-step process but a rather complicated puzzle of events (Glanz and Bishop 2010). Health behavior is highly dependent on several social, cultural, and economic factors (Smedley and Syme 2001). With no simple one-step answer to why a person engages in a desired behavior such as physical activity or undesired behavior such as smoking, evidence points to (a) knowledge, attitudes, reactions to stress, motivation, (b) families, social relationships, socioeconomic status, culture, and (c) geography as important individual determinants of health behavior (Glanz and Bishop 2010). Despite the many challenges to health behavior change, a meta-synthesis by Johnson et al. covering 1011 health

behavior change intervention studies spread across 62 meta-analyses reports that: (a) intervention participants significantly adopted healthier behaviors; (b) none had significantly negative outcomes, and (c) most confirmed statistically significant health promotion effects (Johnson, Scott-Sheldon, and Carey 2010). These interventions have been applied to a wide variety of health behavior change domains. The domains report different size effects of change (Johnson, Scott-Sheldon, and Carey 2010).

The most frequently reported health behavior change domains are: (1) Stress management, (2) Improving participation in health services, (3) Eating and physical activity, (4) Addictions, (5) Screening and treatment behaviors for women, and (6) Sexual behaviors. Not all health behavior change interventions are equally effective and their effectiveness varies by the behavior change domain (Johnson, Scott-Sheldon, and Carey 2010).

2. Health Behavior Change Theories

a. The Need for Theories

A methodical understanding of the key determinants and processes of behavior change will enable the diverse group of professionals in this field to plan interventions effectively. The most successful health behavior change interventions have an understanding of health behaviors and the contexts in which they occur (Glanz and Rimer 1995). Understanding the behavior to be altered and its connection to the context requires a systematic evaluation of the behavior, which is facilitated by health behavior theories. A theory presents a systematic way of understanding events, behaviors, and/or situations (Glanz and Rimer 1995). In the context of behavior change, theories seek to explain why, when, and how a behavior does or does not occur, and the

important sources of influence to be targeted, in order to alter the behavior (Michie et al. 2014). Theories are useful during the various stages of planning, implementing, and evaluating interventions (Glanz, Rimer, and Viswanath 2008). On the importance of theories, Glanz et al. say, “a health educator without a theory is like a mechanic or a technician, while the professional who understands theory and research, comprehends the “why” and can design and craft well-tailored interventions. He or she does not blindly follow a cookbook recipe, but constantly creates the recipe anew, depending on the circumstances, based preferably, on evidence about the intended audience and previous interventions.” (p. 25) (Glanz, Rimer, and Viswanath 2008). Several systematic reviews and meta-analyses have produced evidence that interventions developed with a theoretical base are more effective than those without a theoretical base (Webb et al. 2010, Albada et al. 2009, Albarracín et al. 2005, Glanz and Bishop 2010, Noar, Benac, and Harris 2007, Swann et al. 2003, McEachan et al. 2011). There is also evidence to suggest that multiple-theory driven interventions have larger effects (Ammerman et al. 2002, Legler et al. 2002, Noar, Benac, and Harris 2007). Identification of appropriate theory or theories for changing a particular health behavior requires one to understand the available theories and the ability to use them skillfully (Grol et al. 2007). As an example, if an intervention aimed at affecting a health behavior that is critically influenced by social factors uses a theory that focuses exclusively on knowledge, the resulting intervention design can be reasonably expected to be ineffective.

Theories are generally abstract and not content or topic specific, and often employ unique vocabulary to articulate the specific factors considered to be important, even though the underlying phenomena may be significantly similar. Theories have also been found to selectively choose factors, while omitting other critical factors reported in other theories (West and Brown 2013). Theories can help understand why people do or do not engage in health enhancing behaviors, help choose vital information for an effective intervention strategy, and ultimately guide towards a successful health behavior change intervention program (Glanz, Rimer, and Viswanath 2008). Some theories help explain behavior, while some also suggest how to change behavior. Implementation theories are change theories that link theory specifically to a given problem, audience, and context (Century and Populations 2002).

Health behavior change and the factors influencing it are far too complex to be adequately explained by a single, unified theory, which has led to the rise of several models. Models provide an amalgamation of a number of theories to help understand a specific problem in a particular setting or context, and are often informed by more than one theory, as well as by empirical findings (Earp and Ennett 1991).

Health behavior change interventions embracing an ecological perspective are reported to be more effective than focusing on only the individual (McLeroy et al. 1988, Sallis, Owen, and Fisher 2008). Interventions should not only be targeted at individuals, but should also affect interpersonal, organizational, and environmental factors influencing health behavior (Glanz and Bishop 2010). The phenomenon is eloquently articulated by Glanz et al. (2010) with an example

in the context of groups of employees purchasing food and eating during the work day. An intervention that tries to change the eating habits of the employees needs to consider the contextual and ecological factors such as the source of the food (home versus vending machine/cafeteria), personal preferences, habits, nutrition information, availability, cost, and placement, among other things (Glanz and Bishop 2010). Thus, a behavior change intervention that just tries to educate the employees on nutrition information can be expected to achieve significantly less as compared to an intervention that tries to tackle all the above stated factors. The process is complex and requires interventions that are multi-factor, multi-system, and multi-level (Ellis 1998). Evidence has shown the necessity to think beyond the individual interventions, to the social setting and the environment (Sallis, Owen, and Fisher 2008).

The following sections aim to help the readers, irrespective of their backgrounds or disciplines, understand some of the most important theoretical foundations of health behavior. This is accomplished by providing an overview of the most frequently used health behavior theories for development and implementation of health behavior change interventions, and which is relevant to this research as well. It is to be taken into account that there are several generic health behavior change theories and models, in addition to health behavior domain specific theories (Michie et al. 2014). The intention of this overview is to only report on the most widely used and cited theories, and not to serve as an exhaustive review. For a more elaborate and effective selection of theories and/or the underlying factors for a health behavior change intervention design, compendiums such as the Theoretical Domains Framework (Michie et al.

2005), US National Institute of Health's Grid Enabled Measures (Moser et al. 2011), and Behavior Change Taxonomy (Michie et al. 2008) are available.

b. Overview of Selected Theories and Models

The following overview presents ten different theories, models or frameworks, of which the first five are theories developed from various disciplines such as psychology, sociology etc., and address health behavior change at a generic level. The sixth theory is an integrated theory, or in other words, a summation, of many theories that guide intervention development. The last four (seven to ten) are new-age models or frameworks that try to explain technology-assisted behavior change. Technology-assisted behavior change systems have taken several names such as 'Persuasive Systems' (Oinas-Kukkonen and Harjuma 2009) and 'Behavior Intervention Technologies' (Mohr et al. 2013).

i. Health Belief Model

The Health Belief Model explains health-risk reducing behaviors such as preventing, screening for, or controlling a disease or condition (Becker 1974, Rosenstock 1974). In its original form, the model proposes that people are most likely to take preventive action if they perceive that the threat of the health risk to be serious (perceived severity), that they are personally susceptible (perceived susceptibility), and if they feel there are fewer costs (barriers) than benefits to engaging in protective action. Recently the model has been modified and self-efficacy has been taken into consideration as well (Rosenstock, Strecher, and Becker 1988).

Perceived susceptibility is the extent to which a person believes they are at risk of contracting the disease or condition. Perceived severity is a person's perception of the seriousness of the disease or condition, which includes the emotional response elicited by thoughts of the disease or condition, and the anticipated difficulties that could be created by the disease or condition (e.g. Impact on employment). Both of these perceptions are dependent upon the knowledge about the disease or condition, and together reflect perceptions of the overall threat posed by the disease. It is also postulated that when one perceives a reasonable level of severity, there are more chances of action on it than when the perceived severity is extreme (or beyond control).

The course of action over a perceived threat is controlled by perceived benefits and barriers. Perceived benefits are beliefs about the relative effectiveness of known options for reducing the health threat, and an option is likely to be favored if it is perceived to reduce the perceptions of susceptibility or severity. Perceived benefits are influenced by social norms and social pressures in a person's social group(s). Perceived barriers are beliefs about the negative aspects of taking protective health action (e.g. expense). Even in cases where preventive action is perceived as beneficial, these beliefs can present barriers to action; however, if the perceived benefits outweigh the perceived barriers, action can take place.

When perceptions of severity, susceptibility, and benefit are high and perceived barriers are weak, a 'cue to action' is necessary to take action. The cues can be internal (e.g., discomfort) or external (e.g., screening reminders). The strength of such a cue, necessary to trigger action,

varies according to levels of perceived susceptibility and severity. Where perceptions of susceptibility or severity are weak, intense cues may be necessary and vice-versa.

Self-efficacy is defined as “the conviction that one can successfully execute the behavior required to produce the outcomes” (Bandura 1977). Self-efficacy, which was recently added to the model, influences the decision to act. When there is low self-efficacy combined with low perceived threat or benefits, action cannot be expected to take place.

The Health Belief Model explains that the perceptions of severity, susceptibility, barriers, and benefits, are influenced by sociodemographic factors (e.g., age, gender, ethnicity, socioeconomic status), and knowledge (e.g. knowledge about the disease or condition). Perceptions combined with cue to actions, lead to action (Rosenstock, Strecher, and Becker 1988).

ii. Theory of Planned Behavior

The Theory of Planned Behavior is a model of purposeful human behavior, where the belief that one’s intention about a behavior is a precursor to the behavior itself (Ajzen 1991). This is an extension of its predecessor – the Theory of Reasoned Action (Ajzen and Fishbein 1980).

The theory explains three types of predictors to a person’s intention to perform a particular behavior: (1) A person’s attitude towards trying to perform the behavior, which

includes the degree to which the person has a favorable or an unfavorable evaluation of the behavior, is related to the possible outcomes of trying to perform that behavior; (2) the subjective norms, which is a person's perception of how important others believe that the behavior should be performed; and (3) perceived behavioral control, much similar to self-efficacy (Bandura 1977), considers the extent to which a person feels able to perform the behavior, which can be influenced by personal and external factors, such as having a workable plan, skills, social support, knowledge, time, money, willpower, and opportunity.

When the attitudes and subjective norms are favorable and the perceived behavioral control is high, then it should result in a strong intention to perform the behavior; however, the final execution of the behavior is mediated by the actual control of the behavior. Thus, successful performance of the behavior will be the end result, if individuals have both intention and sufficient control over the internal and external factors that influence it. The perceived behavior control is a proxy to the actual control.

A recent extension of the model has included descriptive norms (Ajzen 2011), which is a person's perception of others' actual performance of a particular behavior, not just others' views on the behavior.

iii. Social Cognitive Theory

Social Cognitive Theory aims to provide a framework for the study and understanding of human thought and behavior (Bandura 1986). The central proposal of the theory is that the

behavior, environment, and personal factors continually interact to influence and be influenced by each other. The basics of Social Cognitive Theory are based on the fact that people learn not only through their own experiences, but also by observing the actions of others and the results of those actions (Bandura 1997).

This widely used theory from psychology has several vital constructs of interest to health behavior change, namely (1) observational learning, (2) reinforcement, (3) self-control, and (4) self-efficacy.

Observational learning is the learning achieved by modelling others' behavior, attitudes, etc. While learning through action can occur, learning by imitation is more effective for enhancing the rate of learning. Observational learning also leads to outcome expectation, by observing the outcomes of others who practice a behavior. Outcome expectation plays a vital role in the process of deciding whether to follow or not follow a behavior (Bandura 1986).

Self-control refers to people's ability to motivate or regulate their own behavior on the basis of their personal standards and evaluations of their behavior. Specifically, self-regulation is defined as the identification of discrepancies between actual behavior and personal or social norms, and the subsequent adjustments to behavior. Self-control may also involve modifications to the external environment through organizing environmental conditions that facilitate or reinforce behavior (Bandura 1986).

Reinforcement or self-reflection is seen as uniquely human, and it enables people to analyze their own experiences, thoughts, and knowledge. This concept of self-regulation has been widely used in health behavior change. Goal setting and behavioral contracting are techniques often used to tap into the human potential to self-reflect on their commitment to the set goal or the behavioral contract (Bandura 1997).

Self-efficacy can also be seen as a form of self-reflective thought, and is the most influential factor for behavior change. Unless a person perceives that he or she can influence their own behavior, change cannot be expected to take place. Perceptions of self-efficacy influence people's choice of action, the effort, the perseverance they invest in the action, and the anxiety or confidence with which they approach actions (Bandura 1997, 1977).

iv. Transtheoretical Model

The Transtheoretical model posits that behavior change involves progress in five sequential stages of motivation/readiness to change: pre-contemplation, contemplation, preparation, action, and maintenance. While the model states that progress through the stages is sequential (i.e., stages are not skipped), moving backward to a previous stage is possible (Prochaska and DiClemente 1982, Prochaska, DiClemente, and Norcross 1992).

Pre-contemplation: People in this stage are not seriously considering behavior change in the foreseeable future, i.e., within the next six months and may be unaware of any need to

change. Alternatively, they may be aware, but are unwilling to think about change, be defensive or resistant to pressures to change, or lack confidence in their ability to change.

Contemplation: People in this stage are aware that there is a problem and are seriously considering behavior change within the next six months, but are not yet committed to act. They are more responsive to information and feedback about their behavior than those in the previous stage; however, people may be ambivalent about the costs and benefits of change, and may remain in this stage for a long time (years).

Preparation: People in this stage are ready for action and seriously intend to change within the next month. They have already taken some preparatory action, such as making reductions to a problem behavior or ‘trying’ novel healthy behaviors (for example, reducing the number of cigarettes smoked per day). They have typically made unsuccessful behavior change attempts in the previous 12 months, and behavior change does not reach the level of effectiveness.

Action: People in this stage have made significant overt effort to change their behaviors, and have met a behavior-specific criterion (e.g., not smoking for 24 hours or more). This stage lasts around six months before progressing to the next.

Maintenance: People in this stage have been able to sustain behavior change for more than six months and are working to prevent relapse. They are typically more confident that they

will continue and maintain health behavior change, and are less likely to relapse than people in the action stage.

It is to be taken into account that the progress through these stages may not be linear because many relapse and do not achieve their aims in the first attempt. Most people are likely to progress through the stages up to action and then relapse, regressing to previous stages of pre-contemplation, contemplation, or preparation. In order to not regress to an earlier stage, however, people need to learn from their experiences before they can progress through the stages again.

The theory also identifies processes of change that lead to transition between the stages, and proposes different processes linked to different stage transitions (Prochaska and DiClemente 1982, Prochaska, DiClemente, and Norcross 1992). There are ten ‘processes of change’ that facilitate or stimulate movement from stage to stage. Different processes are important in facilitating this movement between the different stages, with experiential processes being used more in the contemplation and preparation stages, and behavioral processes being used more in the action and maintenance stages. These processes are:

Consciousness rising. Increasing awareness about the problem, and improving the accuracy of information processing about the problem and about the self (e.g., seeking information, observations, and interpretations). This process is a mediator between the pre-contemplation stage and the contemplation stage.

Dramatic relief. Experiencing and releasing feelings about the problem and the solution (e.g., expressing and feeling upset about risk information). This process is a mediator between the pre-contemplation stage and the contemplation stage.

Environmental reevaluation. Cognitive and affective assessments of how a personal behavior might have an impact on the social environment (e.g., thinking the world would be a better place if everyone stopped smoking). This process is a mediator between the pre-contemplation and the contemplation stage.

Self-reevaluation. A person's cognitive and affective assessments of their self-image in relation to the problem behavior (e.g., thinking that stopping smoking is part of being a responsible person). This process is a mediator between the contemplation stage and the preparation stage.

Self-liberation. A person's belief in their ability to change a particular behavior and their commitment to act on that belief. This process is a mediator between the preparation stage and the action stage.

Helping relationships. Relationships characterized by openness, trust, and empathy, which are supportive in regards to the problem behavior and health behavior change. This process is a mediator between the action stage and the maintenance stage.

Counter conditioning. The adoption of healthier behaviors as substitutes for problem behaviors. This process is a mediator between the action stage and the maintenance stage.

Stimulus control. When a person makes changes to their environment so that the cues for problem behaviors are reduced, and cues for healthier behaviors increased. This process is a mediator between the action stage and the maintenance stage.

Reinforcement management. This occurs when a person is rewarded (by themselves or by others) for engaging in healthy behaviors, or conversely, when they are punished for not engaging in healthy behaviors. This process is a mediator between the action stage and the maintenance stage.

Social liberation. Noticing social, policy, or environmental changes that facilitate health behavior change (e.g., noticing that society has changed in ways that make smoking cessation easier).

There are two additional variables that influence movement from stage to stage: decisional balance and self-efficacy. Decisional balance is influential in the decision to move towards action, and is defined as an evaluation of the pros (advantages and positive aspects) and cons (disadvantages or negative aspects) of behavior change. Self-efficacy is defined as a person's beliefs about their ability to carry out a behavior in any given situation. Self-efficacy relates to both behavior change and to temptations to carry out the problem behavior. Self-

efficacy influences the use of processes of change during the different stages, while temptation influences relapse. High temptation levels and low self-efficacy are characteristic of the pre-contemplation stage, with this gap narrowing during the contemplation and preparation stages. Early in the action stage, self-efficacy and temptation levels are in balance, with self-efficacy rising and temptation falling over time.

v. Diffusion of Innovation Theory

Diffusion of Innovations Theory (Rogers 1962) is one of the oldest theories used in health behavior change and has evolved significantly. While not solely meant for health behavior change, and written for diffusion of technology, the theory describes how a new idea, product, or behavior spreads (diffuses) through a community or social structure. An innovation is communicated through certain channels over time among the members of a social system, leading to gradual adoption and finally reaches a tipping point or critical mass. The diffusion is believed to have been achieved when a critical mass of people have adopted the innovation. The theory lists the innovation, communication channels, time and the social system as the elements which lead to the adoption or rejection of the innovation (Rogers 2010).

The theory lays out a five step process (timeline) for an individual to adopt a technology. The first step is *knowledge*, where the individual is first exposed to an innovation, but lacks information about the innovation, and is not inspired to find out more information about the innovation. During the *persuasion* step, the individual is interested in the innovation, actively seeks related information, and makes a decision in the next step, during which the individual

weighs the advantages/disadvantages of using the innovation, and decides whether to adopt or reject the innovation. Next, during the *implementation* step, the individual employs the innovation to a varying degree, depending on the situation, and determines the usefulness of the innovation. If successful, as a last step, *confirmation* occurs, where the individual finalizes the decision to continue using the innovation (*adoption*) (Rogers 2010).

The theory characterizes the individuals, who are a part of the social network system on their timeline of adoption as: (1) innovators, (2) early adopters, (3) early majority adopters, (4) late majority adopters, and (5) laggards. Identifying the appropriate group of individuals who belong to the first three categories is critical to the successful diffusion of a behavior (Rogers 2010).

The theory also characterizes a successful innovation. An innovation is the idea, behavior, or product by itself that needs to be adopted. The critical characteristics of an innovation, which are related to influence the diffusion, are the innovation's relative advantage, compatibility, complexity, trialability, and observability (Rogers 2010). The relative advantage is the characteristic where for adoption to occur, an individual or group perceives that the innovation is better than the current idea, behavior, or product. The criteria for the relative advantages could be economic, social, utilitarian, and so on. Relative advantage alone does not guarantee widespread adoption, however. Innovations that are compatible with the intended users' or groups' existing values, norms, beliefs, and perceived needs are more readily adopted. Even if not directly compatible, if the innovation can be adapted for compatibility, adoption is facilitated. Innovations perceived as easy to use are more likely to be adopted, whereas more complex

innovations are less successfully adopted. Incremental diffusion of complex innovations is also considered to promote adoption. Innovations with which intended users can experiment on a limited basis are adopted and assimilated more easily. If the benefits of an innovation are easily and quickly felt, the easier and quicker is its adoption (Rogers 2010).

Communication channels are the ways in which information about the innovation is passed from people or groups, to others. While information exchange can happen through mass media channels to transmit the message quickly, interpersonal channels of communication are believed to be more effective in promoting the adoption of innovations, especially if communication comes from individuals trusted by and/or if the individuals are homophilious to a potential adopter (Rogers and Shoemaker 1971).

Intervention designers, mainly online health behavior change intervention designers, could highly benefit from the recommendations of the Diffusion of Innovations theory.

vi. Integrated Theory of Health Behavior Change

Integrated Theory of Health Behavior Change (Ryan 2009) is a descriptive midrange theory. Midrange theories are more concrete and more easily used to guide practice (Rodgers 2005). Descriptive theory provides a description of what is happening in a situation and reveals the components that exist in a situation (Rodgers 2005).

The Integrated Theory of Health Behavior Change integrates concepts from numerous theories of behavior and behavior change. According to this theory, behavior change is seen as a dynamic and iterative process, in which motivation to change is a necessary precursor of behavior change. Self-reflection and positive social influences are influential in facilitating motivation and willingness to change, and in sustaining behavior change attempts.

Three main factors have a positive influence on health behavior change: knowledge and beliefs, self-regulation skill and ability, and social facilitation. The proximal outcome of these factors is the engagement in self-management behavior, which over time is seen to influence the more distal outcome of health status.

Knowledge and Beliefs: Knowledge is factual and condition-specific information, as beliefs are a person's perceptions regarding their specific condition or health behavior. If knowledge and beliefs are enhanced, increases will occur in a person's understanding of the behavior or condition, their behavior-specific self-efficacy, their outcome expectancy, and their goal congruence. Self-efficacy is a person's confidence in their ability to successfully carry out the behavior, even under conditions of stress. Outcome expectancy is a person's belief that carrying out the behavior will lead to the desired results. Finally, goal congruence is the resolution of confusion and anxiety arising from any competing demands associated with a person's health goals.

Self-Regulation Skill and Ability: Self-regulation is the process by which people incorporate behavior change into their everyday lives, involving: self-monitoring, goal setting, reflective thinking, decision making, planning, plan enactment, self-evaluation, and the management of emotions arising as a result of the behavior change.

Social Facilitation: Social facilitation incorporates social influence and social support. Social influence can result in engagement in health behavior when a credible source influences a person's thoughts and motivation. Social influences can arise from numerous sources such as healthcare professionals, family members, peers, and the media. Social support also facilitates performance of the desired health behavior, and could be emotional, instrumental, and informational.

Knowledge alone is insufficient to lead to health behavior change; however, knowledge and beliefs influence engagement in self-regulatory activities, relevant skills and abilities, in turn improving self-management behavior. Positive influences from social facilitation have a beneficial effect upon both self-regulation and actual self-management behavior. Carrying out self-management behaviors directly and positively influences health status.

vii. Fogg Behavior Model

The Fogg Behavior Model (Fogg 2009) presents a model for understanding human behavior. The model explains three critical factors responsible for adoption or rejection of behavior. The model asserts that for a target behavior to happen, a person must have sufficient

motivation, sufficient ability, and an effective trigger. These three factors must occur at the same moment; else the behavior will not happen.

Fogg uses several examples to explain the relationship between the three factors. In brief, when a trigger (call to action) is provided to a user at the right moment, which is the moment at which the user has the highest possible ability and the highest possible motivation to perform the behavior, the target behavior is achieved. Conversely, if the trigger is provided at a moment of low ability and/or low motivation to perform the behavior, the target behavior cannot be achieved. Fogg also explains the various forms of the three factors as below:

Motivators: (1) Pleasure/pain serve as powerful, immediate motivators to perform a behavior (e.g., the anticipated result of eating a dessert serves as a motivator); (2) hope/fear serve as motivators by stimulating anticipation of an outcome (e.g., to overcome an anticipated fear of being affected with the flu, people are willing to accept a painful shot); (3) social acceptance/rejection serve as powerful motivators irrespective of people's liking of the behavior (e.g., following a dress code for an event, is a result of motivation towards social acceptance).

Ability (simplicity): (1) the less amount of time required; (2) the less money required; (3) the least physical effort required; (4) the less brain cycle required; (5) the less social deviance required; and (6) the least deviation from the routine, the more simple is the behavior.

Triggers: (1) Spark, used to increase the motivation (e.g., a video that inspires hope); (2) facilitator, used to increase the ability (when high motivation exists) (e.g., one click install); and (3) signal, a simple reminder (e.g., alarm for a meeting).

This model explains the psychology behind behavior change in simple terms. This model is successful in changing smaller one-time behaviors, but does not aid in changing long-term behavior. It does not try to change the attitude or intention towards the behavior, but the model could serve as a useful tool in considering and designing individual components of larger intervention programs (Mohr et al. 2014).

viii. The Internet Intervention Model

The Internet Intervention Model posits that a successful intervention is possible when the user, influenced by environmental factors, affects website use and adherence, which is influenced by support and website characteristics. Website use leads to behavior change via different mechanisms of change (e.g., knowledge and motivation). Behavior change impacts physiology and target behaviors to bring about symptom improvement, and treatment maintenance helps users maintain these gains (Ritterband et al. 2009). There are nine major components to the Internet Intervention Model (e.g., Website), and each of the components contains areas that can be observed, evaluated, and in many cases, manipulated (e.g., appearance). A brief overview of the nine components is presented below (Ritterband et al. 2009):

User Characteristics: The user or the intended benefactor of the intervention presents the most complex component of the model, and possesses fixed (e.g., age), modifiable (e.g., attitude towards the behavior change) and targetable (e.g., stage of change) characteristics. There are seven main areas of user characteristics incorporated into this model. They include (1) disease/condition, including diagnosis and severity, and the problem being targeted; (2) demographics, including age, gender, and socioeconomic status (SES); (3) traits, including personality, temperament, and intelligence; (4) cognitive factors, including cognitive style (verbal vs. visual), information processing, developmental stage, goal setting and pursuit, decision making, judgment, self-efficacy, knowledge, and self-regulatory strategies (e.g., planning); (5) beliefs and attitudes, including treatment expectations, intentions, interest, motivation, readiness for change (stage of change), self-efficacy, and perceived benefits and barriers to treatment; (6) physiological factors, including motor functioning; and (7) skills related to both psychological mindedness and computer abilities.

Environment: The environment component is composed of multiple influences, including family/significant others/friends, employer/organization/school, the health care system, community, and societal level influences, such as the media, policy, and cultural factors.

Website: The application by which the treatment is delivered. The website component is made up of eight main areas, including appearance (look and feel), behavioral prescriptions (intervention oriented instructions), burdens (barriers specific to the website content), content (the actual content that is the intervention), delivery (ways in which the content is delivered),

message (source and style of the content), participation (the website's ability to engage and involve the user in the treatment), and assessment (system's ability to measure the needs of the user, personalize the program, and provide tailored content and recommendations).

Website use: The actual utilization of the intervention. Usage is affected by the user characteristics, environmental factors, the actual website, and support.

Support: External support beyond the website and its content, including personalized emails, instant messaging communication, phone sessions, and face-to-face meetings.

Mechanisms of change: Mechanisms for bringing about the desired behavior change such as knowledge/information, motivation, attitude, beliefs, skill building, self-efficacy, cognitive restructuring (self-talk), modeling, self-monitoring, and affect management.

Behavior Change: The immediate expected result of Internet interventions.

Symptom improvement: The ultimate goal of most Internet interventions.

Treatment Maintenance: Relapse prevention provided within the Internet intervention.

ix. Persuasive Systems Design Framework

In response to the lack of a model or framework providing systematic analysis and design methods for developing online health behavior systems, also recently known as persuasive

systems, a framework for Persuasive Systems Design (PSD) (Oinas-Kukkonen and Harjumaa 2009) has been developed. The framework discusses the process of designing and evaluating persuasive systems, and describes the content and software functionality for persuasive systems. The framework also lists 28 design principles for persuasive system content and functionality, describing example software requirements and implementations. The 28 design principles are categorized into four categories: (1) primary task, (2) dialogue, (3) system credibility, and (4) social support (Oinas-Kukkonen and Harjumaa 2009).

The design principles in the primary task category support the carrying out of the user's primary task towards the behavior change. The design principles in this category are: (1) reduction (reduction of complex behavior into simple tasks), (2) tunneling (guiding the users through a process), (3) tailoring (information tailored to the needs, interests and context of the user), (4) personalization (personalization of content), (5) self-monitoring (system that keeps track of one's own performance), (6) simulation (enabling users to immediately observe the link between cause and effect), and (7) rehearsal (means with which to rehearse a behavior).

The capabilities of an interactive system to provide some degree of system feedback to its users, potentially via verbal information or other kinds of summaries is referred to as computer-human dialogue support, and helps users to keep moving towards their goal or target behavior. There are several design principles related to implementing computer-human dialogue support, including: (1) praise (to make users more open to persuasion), (2) rewards (reward target behaviors), (3) reminders (reminds users of their target behavior), (4) suggestion (offering fitting

suggestions), (5) similarity (systems that remind them of themselves in some meaningful way), (6) liking (system that is visually attractive), and (7) social role (system adopts a social role).

System credibility refers to how to design a system so that it is more credible and thus more persuasive. This category of design principles consists of (1) trustworthiness (system that is viewed as trustworthy), (2) expertise (system that is viewed as incorporating expertise), (3) surface credibility (credibility based on a firsthand inspection), (4) real-world feel (system that highlights people or organization behind its content or services), (5) authority (system that leverages roles of authority), (6) third-party endorsements (third-party endorsements), and verifiability (system makes it easy to verify the accuracy of site content via outside sources).

The design principles in the social support category describe how to design the system so that it motivates users by leveraging social influence. The design principles that belong to this category are: (1) social facilitation (enable users to discern that others are performing the behavior along with them), (2) social comparison (be able to compare their performance with the performance of others), (3) normative influence (use of peer pressure to increase the likelihood that a person will adopt a target behavior), (4) social learning (be able to observe others performing the behavior), (5) cooperation (leveraging human beings' natural drive to cooperate), (6) competition (leveraging human beings' natural drive to compete), and (7) recognition (offering public recognition for an individual or group).

Oinas-Kukkonen et al. posit that by adopting all or several of the design principles above, a system shall be able to ‘persuade’ a user towards behavior change.

x. Behavioral Intervention Technologies Model

In response to the most recent growth of sensor-driven, mobile-based technologies and to the lack of models to inform the design of behavioral intervention technologies (BITS) ,Mohr et al. (2014) propose a model that conceptually defines BITS, from the clinical aim to the technological delivery framework (Mohr et al. 2014). The model defines the conceptual and technological architecture of a BIT. The BIT model answers the questions why, what, how (conceptual and technical), and when. The model posits that larger target interventions should be broken into smaller goals, and such goals generally consist of smaller intervention aims such as increase of physical activity or reduction of caloric intake (the ‘why’), and behavior change strategies, such as education, goal setting, monitoring, feedback, or motivation enhancement (conceptual ‘how’) (Mohr et al. 2014). The behavior change strategies are instantiated with specific intervention components or elements such as Information delivery notifications, logs, passive data collection, messaging, or reports (the "what"). The characteristics such as the medium, complexity, or aesthetics of intervention elements may be further defined or modified (technical "how") to meet the needs, capabilities, and preferences of a user. With the why, what, and how answered, a workflow is needed to answer the ‘when’, which is usually decided based on user choice, fixed frequencies, time/task/event based rules or tunneling. Mohr et al. also provide a technological framework (BIT-Tech) that can integrate and implement the intervention

elements, characteristics, and workflow to deliver the entire BIT to users over time (Mohr et al. 2014).

3. Online Health Behavior Change

c. Overview

Ever since the widened adoption of the internet began, slowly but steadily, behavior change interventions that used to be confined to face-to-face and telephonic conversations, started to make use of the flexible and more accessible internet medium. The first reported randomized controlled trial that used online behavior change dates back to 2000, focusing on reducing risk factors for eating disorders (Celio et al. 2000, Webb et al. 2010). Since then, several studies have been published focusing on online health behavior change interventions, highlighting the various advantages, limitations, and challenges for online health behavior change interventions. Several systematic reviews and meta-analyses report a small, but significant positive effect on using online health behavior change programs (Webb et al. 2010, Norman et al. 2007, Vandelanotte et al. 2007, Cugelman, Thelwall, and Dawes 2011). A meta-analysis by Wantland et al. (2004) concluded that “web-based interventions compared to non-web-based interventions showed an improvement in outcomes for individuals using web-based interventions to achieve the specified knowledge and/or behavior change for the studied outcome variables. These outcomes included increased exercise time, increased knowledge of nutritional status, increased knowledge of asthma treatment, increased participation in healthcare, slower health decline, improved body shape perception, and 18-month weight loss maintenance” (p. 7) (Wantland et al. 2004). Achieving an edge over traditional non-web-based interventions is not always possible, however

(Marshall et al. 2003). The barriers or challenges faced by online health behavior change interventions is also vast (Jimison et al. 2008). The following sections provide an overview of the usage, salient advantages, and limitations, and challenges of online health behavior change interventions.

d. Usage

Webb et al. have reported the largest systematic review and meta-analysis of online behavior change research covering 85 intervention studies for 10 targeted behaviors. The predominantly reported theories were: Transtheoretical Model (12 studies), Social Cognitive Theory (12 studies), and Theory of Planned Behavior (9 studies); however, only 37 studies used theory to select or develop intervention techniques, with only 10 studies addressing all the constructs of the theory chosen. Two studies ensured that every intervention technique used was theory driven. Of the behavior change techniques used by the 85 studies, 29 studies provided information on the consequences in general, 28 studies prompted self-monitoring of behavior, 26 studies assisted in barrier identification, 25 studies provided instructions (for solving the barriers), 25 studies offered goal setting, 19 studies provided feedback on performance, 18 studies assisted in action planning, 16 studies provided normative information about others' behavior, 15 studies assisted to plan social support/social change, 14 studies assisted in planning for relapse prevention/coping, 13 studies prompted self-monitoring of behavioral outcome, 12 studies provided information on the consequences for individual, and 11 studies offered emotional control training; while all other behavior change techniques were used by 10 or less studies. Only

30 studies have offered enriched information environment, 18 studies offered automated tailored feedback, and 14 studies offered automated follow-up messages. Of the 85 studies, only 20 studies offered peer-to-peer level communications, while 23 offered access to an advisor (Webb et al. 2010). Other overarching online health behavior change reviews and specific outcome-focused (example: physical activity) online health behavior change reviews also report very similar trends in this domain of research (Wantland et al. 2004, Neve et al. 2010, Bender et al. 2011, Guse et al. 2012).

e. Tailoring

Tailored messaging in behavior change communications refers to the process in which not all intervention recipients receive the same static message(s), but factors such as an individual participant's age, gender, location, self-efficacy, readiness, socioeconomic status, current health status, and targeted behavior change are considered to deliver a 'tailored message'. A large body of evidence has been generated to show that tailoring of messages indeed works in print-based health interventions (Noar, Benac, and Harris 2007) and in online health behavior change interventions (Bennett and Glasgow 2009b, Griffiths et al. 2006, Strecher 2007, Strecher et al. 2008). The method to tailor the messages can range from simple rules-based systems to expert systems (Strecher 2007), and for complex conditions, human assistance can be employed (example: for extreme risk conditions, a health coach could approve the computer generated tailored message). The potential for tailoring, based on progress made by the participants, is significant in online behavior change interventions, where the participants have the potential to be "engaged" with the intervention 24/7. Additionally, the typical resource cost associated with

tailored messaging in print-based or phone-based interventions can be significantly reduced in online health interventions. As seen from the usage data presented from Webb et al.'s systematic review, however, only 18 of the 85 studies offered tailored feedback (Webb et al. 2010). Strecher refers to such online health behavior sites with no tailoring as 'digital pamphlet racks' that simply relate general health information online rather than taking advantage of the opportunity to tailor health messages that are shown to be effective (Strecher 2007, Evers et al. 2003). Tailoring of messages is not only necessitated due to its shown effectiveness, but several popular theories cannot be implemented without a tailored approach. As an example, the Transtheoretical model is widely reported to be used in online health behavior change intervention programs, but to implement an intervention that truly makes use of the theory, the intervention messages need to be tailored based on the participant's stage (pre-contemplation, contemplation, preparation, action and maintenance) (Prochaska and DiClemente 1982).

f. Adherence

Adherence refers to the proportion of participants who continue using an intervention over time. Conversely, attrition refers to the proportion of people who stop using an intervention over time (Eysenbach 2005). Unlike a medical intervention, which typically addresses an acute problem in an immediate fashion with (mandatory) medications, voluntary health behavior change interventions receive a varying 'dose' of the intervention dictated by their adherence. Eysenbach in his article 'Law of attrition' explains two types of adherence: 1) intervention adherence describes the proportion of participants who use an intervention over time, with its opposite called non-usage attrition; and 2) study adherence describes the proportion of

participants who stay in a study over time, with its opposite called dropout attrition (Eysenbach 2005). The law of attrition proposes that study adherence and intervention adherence are correlated, with the relationship explained by participant interest, which is influenced by factors such as usability, push factors, personal contact, positive feedback, peer-to-peer communication, etc. Online health behavior change programs face very severe attrition problems, with one study reporting that only 0.5% of its 19,607 participants completed the program (Christensen, Griffiths, and Jorm 2004, Eysenbach 2005). Cugelman et al. in their meta-analysis study note that shorter interventions generally achieve larger impacts and greater adherence and add that study adherence, intervention adherence, and behavioral outcomes are correlated (Cugelman, Thelwall, and Dawes 2011). Among the 30 studies included in the meta-analysis by Cugelman et al., only 13 studies provided data to calculate (study) adherence rate, of which two studies report 100% adherence, but do not reflect a 'real life' situation and use students as participants. Six studies used students as participants and have an average of 88% adherence (Cugelman, Thelwall, and Dawes 2011), and this could possibly be attributed to the fact that students would exhibit increased adherence out of fear of academic result repercussions. Seven studies that employed more 'real life' samples exhibit a highest adherence of 70.2% and lowest of 26%, with an average of 48% adherence (Cugelman, Thelwall, and Dawes 2011). The 48% adherence cannot be assumed as an average adherence rate for online health behavior change studies, as the reason for the omission of adherence-related data in the 17 other studies in the Cugelman et al. meta-analysis is unknown and can also be due to very low adherence.

C. Social Media and Health Behavior Change

1. Overview

The Pew Research Center's Internet and American Life Project in its recent reports noted that "one in four adults (24%) says that they turned to others who have the same health condition during their last bout with illness ... One in four internet users (26%) has read or watched someone else's experience about health or medical issues in the last 12 months, and 16% of internet users have gone online to find others who might share the same health concerns in the last year." (Fox 2013) and that 'eight in ten internet users looked online for health information' (Fox 2011). With social media now believed to be used by 73% of online adults (Duggan 2014), the role or potential for social media in online health information seeking is obvious.

Social media, in specific social networks, offer several advantages over conventional websites, including but not limited to: 1) social networking sites reach very large audiences; for example Facebook had 1.35 billion active users in September 2014 (Facebook 2014); 2) unlike conventional websites, an user's existing contacts are readily available to help deliver messages in a more influential way (Facebook 2014); and 3) online social networks typically achieve high levels of user engagement and retention (Cugelman, Thelwall, and Dawes 2011).

The past few years have witnessed an explosion of studies focusing on social media and health behavior change. Four significant systematic reviews or meta-analyses have been identified as highly relevant to social media and health behavior change and have been published in the years 2013 and 2014. Maher et al. and Laranjo et al. present systematic reviews focusing

on online health behavior interventions with social media (Maher et al. 2014, Laranjo et al. 2014), with a definition of social media consistent with this dissertation. Chang et al. and Williams et al. present systematic reviews focusing on online health behavior interventions for weight management (Williams et al. 2014, Chang et al. 2013), however, with a looser definition of social media, including Web 1.0 technologies such as pure discussion/bulletin boards, chat rooms, etc. The following sections include observations from the research articles included in these four studies, but by limiting to the earlier established definitions of social media and health behavior change, studies based on participants who are already a part of an online health behavior intervention program, are not included.

While social media is reported to be used widely for health communication (Moorhead et al. 2013), the usage of social media in well-designed research studies (randomized control trials) is very limited, and is reflected by the fact that there are less than 20 social media studies included all together in the four systematic-reviews (Chang et al. 2013, Williams et al. 2014, Maher et al. 2014, Laranjo et al. 2014). All four systematic-reviews conclude that the use of social media for health behavior change is in its infant stages and needs more research; however they show signs of limited positive outcomes.

2. Social Support

Social support plays a vital role in health behavior change as explained in the various theories of health behavior change. Social support is a complex phenomenon and is believed to offer four types of support, namely: 1) Emotional support - focuses on the trusted relationship

between the sources of social support, also known as esteem support or appraisal support; 2) Instrumental support - support in the form of tangible resources such as financial assistance, material goods, or services; 3) Informational support - support in the form of advice, guidance, suggestions, or useful information; and 4) Companionship support - support that provides a sense of social belonging (Eaker 2005). There exists a large body of evidence to show social support in online social media programs, and its role towards health behavior change. Cavallo et al. in their recent research article titled ‘The role of companionship, esteem, and informational support in explaining physical activity among young women in an online social network intervention’ concluded that there was a direct relationship between change in physical activity and esteem support and indirect relationship between change in physical activity and companionship support (Cavallo et al. 2013). Nabi et al., in their study focused on social support, Facebook and stress, conclude that number of Facebook friends was associated with stronger perceptions of social support, which in turn was associated with reduced stress, and in turn less physical illness and greater well-being (Nabi, Prestin, and So 2013). A study by Rui et al., focused on social support offered by healthcare organizations on twitter, concluded that providing informational and emotional support, as well as seeking instrumental support, were the main types of social support exchanged by health organizations through Twitter (Rui, Chen, and Damiano 2013). A study by Frolich et al., which analyzed comments posted on YouTube videos on inflammatory bowel syndrome, found informational support messages most frequently (65.1%), followed by emotional support messages (18.3%), and finally, instrumental support messages (8.2%). A study by Love et al., focused on members of an online social networking group for cancer found that

the community focused on exchanging emotional and informational support (Love et al. 2012). The community was focused on coping with difficult emotions through expression, describing experiences, enacting identity through evaluations of the new normal (life with and after cancer), and communicating membership (Love et al. 2012).

While social support is possible from newly established friendships on a social media site, increased benefits of social support can be reaped by utilizing the already existing social contacts of users in generic social networking sites. Very few of the research studies included in the four identified systematic reviews, however, have attempted to tap into social support from their respective participants' social contacts.

3. Homophily and Modelling

Homophily is the principle that a contact between similar people occurs at a higher rate than among dissimilar people, where the similarity or dissimilarity can be based upon factors such genders, races, ethnicities, ages, class backgrounds, educational attainment, health status, etc. (McPherson, Smith-Lovin, and Cook 2001). With social networks proven to be a primary channel for diffusion of health behaviors (Smith and Christakis 2008), homophily has been shown to strongly influence the diffusion of health behaviors (Centola 2011). Centola, in his extensive research sought to clarify between two possible effects of homophily on adoption of healthy behaviors. First possibility, based on research on diffusion, at the dyadic level homophilous ties can promote the spread of behavior between individuals, as users are more likely to be influenced by sources who are similar to themselves (Centola 2011). Second

possibility, homophily among high health status individuals may help to promote diffusion, but low health status individuals may not find enough influencers among similar individuals to alter their health status (Centola 2011). Centola's research found that exposure and adoption levels were greater in homophilous networks as compared to heterophilous networks, and also that the most effective social environment for adopting the new health behavior was the one in which they interacted with others with similar health characteristics (Centola 2011).

One of the significant components of the social cognitive theory is modelling, which explains the process of learning directly by observation of 'models' (Bandura 1986). Modelling may be effective when: 1) the user identifies with the model; 2) the model demonstrates feasible skills; 3) the model receives reinforcement; and 4) the user perceives a coping model, not a mastery model (Bandura 1986). Kok et al. explain how they employed modeling techniques in a Dutch HIV-prevention program; video scenes were developed as a part of their program, in which models demonstrate the skills for negotiating condom use with unwilling partners (Kok et al. 2004). The models were selected to serve as identifiable models for the target population, and were clearly struggling with their task of persuading their partners to use a condom, though the scenes ended positively (Kok et al. 2004).

Mislove et al. in their exploratory research titled 'You are who you know: inferring user profiles in online social networks' attempt to predict profile attributes of users based on a set of profiles and the social network graph (Mislove et al. 2010). Their research found that users with common attributes are more likely to be friends (in online social networking sites) and often

form dense communities, which is explained by the homophily phenomenon (Mislove et al. 2010). Thus, online health behavior programs with social media features should make use of this natural homophily available in social networks and 'promote' the most adherent users of the programs as 'models'. No earlier research seems to have systematically attempted this very valuable phenomenon/technique, however.

4. Attrition, Engagement and Choice of Social Media

Among the studies taken into consideration from the four systematic-reviews, five studies employed their own health specific social networking systems, five studies employed Facebook, one study employed Twitter and one study employed a Facebook application. The lowest attrition among these studies is 0% from two studies (Foster et al. 2010, Kuwata et al. 2010); however, they both employ a very small sample size of 10, with Foster et al.'s intervention length lasting only for 21 days and Kuwata et al.'s intervention length lasting for 24 days. The largest attrition (84%) is reported by Brindal et al. in their study of 435 participants (Brindal et al. 2012) and they employ a health specific social networking system. As noted by Maher et al., attrition rates significantly varied by study design, with the small scale pilot studies reporting the lowest attrition (0%), the mid-sized randomized controlled trials reporting low attrition (4 -23%) and the large live trials reporting high attrition (ranging from 41% to 84%) (Maher et al. 2014). Maher et al. also examined engagement (intervention adherence) with the social networking component of the intervention in each study and compared it with the intended dosage, to provide an indication of fidelity, and concluded that fidelity was generally quite low (5 to 15%, with the exception of Foster et al.'s pilot study that reports 105%).

As noted earlier, social media-based interventions have either used popular existing online social networking websites, such as Facebook and Twitter, or have developed standalone health-focused online social networks. Amongst these two possible choices, Maher et al. note that standalone health-focused online social networks can be effective for the users they retain over a period of time, but struggle with higher attrition rates in comparison to existing online social networking sites (Maher et al. 2014). Studies that used existing online social networking sites were able to retain higher proportion of their participants (77-96% of users), but still suffered very low engagement (5-15%), with the exception of Foster et al.'s study (105%) (Maher et al. 2014, Foster et al. 2010). Foster et al.'s study delivered their intervention through a Facebook application, which enabled users to share information with their offline or existing connections as opposed to new connections established within the study setting (Maher et al. 2014, Foster et al. 2010). Maher et al. also noted the very short intervention duration (21 days) of Foster et al.'s study, and estimated that the attrition rate (0%) would have increased for a longer intervention period (Maher et al. 2014). The high engagement in the three week period serves as a significant positive observation, however (Maher et al. 2014).

5. Privacy

The fear of lack of privacy is real. 17% of adults say that they engage in 'privacy-protective' behavior by withholding information (Krane 2007). This number further increases for people with chronic illnesses, racial, and ethnic minorities (Forrester 2005). In a national survey about Electronic Medical Records, Americans express concern that such information would be used for purposes other than their own care (Markle 2006). Eight in 10 Americans (80%) say they are

very concerned about identity theft or fraud, and this is particularly worrisome for those in fair or poor health (87%) (Markle 2006). A large proportion of the public (77%) is very concerned about information getting into the hands of marketers, combined with a concern about employers (56%), and health insurers (53%) gaining access to their information (Markle 2006).

On the other hand, research has found that users consistently disclose accurate personal information on their social media profiles, seemingly without much concern (Young and Quan-Haase 2009); however, even users who have a relaxed view on privacy get into a very protective approach following an incident that resulted in the compromise of private information (Strater and Lipford 2008). Young et al. examined the strategies students have developed to protect themselves against privacy threats on Facebook, and found that the privacy protection strategies employed most often were the exclusion of personal information, the use of private email messages, and altering the default privacy settings (Young and Quan-Haase 2009).

The security and privacy risks posed by social media, especially in a healthcare setting, are substantial and when left unattended, can lead to a serious breach of trust amongst the users of the social media site (Williams 2010, Williams and Weber-Jahnke 2010). The following are some of the prominent risks associated with social media for healthcare:

- i. Social media systems, which are complex in structure, make possible sophisticated usage scenarios. This complexity serves as a barrier to users who are trying to assess the risks associated with sharing data in the social media platform. The added complexity also

makes it difficult to draft accurate and comprehensive privacy policies (Kienle, Lober, and Muller 2008, Williams and Weber-Jahnke 2010).

- ii. Social media sites simplify new network formations, resulting in more expansive networks than expected, which results in misjudgment of the actual exposure (Williams and Weber-Jahnke 2010). The possibility of known offline contacts stumbling on information and/or images on Facebook (not intended for them) is reported as a significant privacy concern by users of Facebook (Young and Quan-Haase 2009).
- iii. Networks in social media are built on trust; however, it does not take much effort for duplicitous individuals to create fake accounts in order to obtain information from unsuspecting users (Williams and Weber-Jahnke 2010, Li 2013). The first and primary concern identified by Young et al. in their work on privacy concerns among Facebook users was that their information would be used for potentially harmful purposes by unknown others (Young and Quan-Haase 2009).
- iv. Social media sites are often plagued with the lack of fine-grained privacy controls. Most social media websites look at privacy control in terms of a block of profile fields, while users may wish to keep certain fields more private than others (Maximilien et al. 2009).
- v. Mixed private and public profiles based on user choice is a common practice amongst most social media sites (Zheleva and Getoor 2009). Such mixed private and public profiles make it possible for 'linkage attacks', wherein a given user's friendship and (group) membership information (which is often not hidden) is used to infer sensitive attributes of a user's profile. With friendship links and groups as carriers of significant

information, attribute disclosure occurs when an adversary is able to determine the value of a user attribute that the user intended to stay private. As an example, an individual whose high school information is hidden can still be inferred by seeing the majority of high schools represented by the user's friends or by monitoring the groups the user participates (Zheleva and Getoor 2009, Fung et al. 2010).

- vi. The accumulated personal information on social media websites may be used for other purposes. Site operators may release personal information to a variety of data recipients, including marketers, employers and insurance companies (Williams and Weber-Jahnke 2010, Li 2013). The survey by Young et al. confirm this privacy concern, where the Facebook users surveyed indicated their concern that their information would be used, sold or appropriated without their knowledge or consent (Young and Quan-Haase 2009).
- vii. Users typically have no control over retention periods for personal information or associated metadata. Once users share their health data with social media sites, they typically have no control over retention periods for the data, or for associated metadata that will be maintained in perpetuity (Williams and Weber-Jahnke 2010, Li 2013).
- viii. Leakage of personal information submitted by social media users to third party servers and applications occurs in many social networking applications (Krishnamurthy and Wills 2009).

Practicing ethical and effective privacy practices in an online social media environment is not trivial and requires a holistic approach. Privacy by Design is the concept where privacy-related

issues should not be tackled as an afterthought, but as an integral part of software planning, design and implementation (Li 2013, Williams and Weber-Jahnke 2010). Williams et al. elaborate on the principle of Privacy by Design as follows: 1) Privacy needs to be dealt proactively and not reactively, so that the protected health information breaches are prevented, rather than being remedied; 2) Privacy as default, as opposed to the conventional model of opting in for privacy, enhance privacy must be offered by default and with an opt-out option; 3) Privacy embedded into design, application developers should consider privacy as an integral part of their design rather than trying to retrospectively fix a privacy breach; 4) Privacy need not be in conflict with other business objectives; devoting effort to privacy protection can be win-win proposition; 5) End-to-end lifecycle protection, ensuring privacy protection from the moment of data collection until the time the data is safely destroyed; 6) Visibility and transparency to provide a means of independently verifying that a social media site operates according to a set of understandable and comprehensive privacy policies; and 7) Respect for user privacy - rather than dismissing privacy concerns, empowering users by offering fine-grained control over their data (Williams and Weber-Jahnke 2010).

Based on a preliminary study, Levy et al. have demonstrated an exemplary prototype of a health social networking system, which places privacy at its core, in line with the recommendations of privacy by design principles (Levy, Sargent, and Bai 2011). Levy et al. describe their approach to privacy as protecting the privacy of the social network users, but at the

same time, remaining flexible enough to allow for meaningful interactions between the users. A brief overview of the system proposed and demonstrated by Levy et al. is presented below.

Social media website that enables users to create an account, and once registered, post and edit blogs was created. Each account includes a profile, with optional fields that could be marked public, but are private by default. Similarly, every blog post can be made public or private. Registered users are given the ability to create different tags to be applied to themselves (in the settings pane) and every blog, which can be added, deleted, or modified whenever they choose to. The tags applied to a user's profile or blog post, help in identifying themselves and/or their content with the tags, enabling easy discovery of users and content.

Users can also establish a minimum baseline user trust rating (for other users) to limit the users who can view their (private) blogs or profiles. The trust rating system is very flexible by allowing each user to define who constitutes as a 'trustworthy' user. The system allows users to assign a 'weight' to the various metrics of the trust rating. The metrics used to measure a user's trust rating are: 1) User availability - the number of successful login attempts a user has made; 2) user popularity - the number of profile views a user received; 3) user participation - the number of posts a user creates; and 4) user's level of competency - a user's credibility of their information source. The metrics are all measured in a defined period, such as a week. The user trust rating algorithm is also able to adaptively rate users based on their newness in the community. This is made possible by grouping users based on their newness in the community, and comparing within users of the same group. With the trust ratings being extremely dynamic in

nature, and the criterion for the rating varying for every user, ratings are calculated upon each content request.

The decision to display or not display a profile or blog is based on three sequential tests, and passing one test bypasses remaining tests. The first test checks if the user requesting the blog/profile is actually the owner of the blog/profile. If not, a test is performed to see if the blog/profile is public. If both tests failed, a third test checks to see if the blog/profile has not been marked private, requesting user's tag is matched with a tag associated with the blog/profile, and the requesting user's rating must be greater than or equal to the blog/profile owner's threshold. If all three tests fail, the post is not displayed, as if it doesn't even exist.

6. Summary

While all identified systematic reviews offer either inconclusive or slightly positive conclusions on usage of social media for health behavior change (Chang et al. 2013, Williams et al. 2014, Maher et al. 2014, Laranjo et al. 2014), there remains several unanswered questions and research inadequacies to be addressed. Following are some of the critical issues to be addressed:

- i. There is a severe dearth of RCTs or even valid pre-post evaluations, thus resulting in less than 20 studies all together being included in the systematic reviews. The literature database searches conducted as a part of the various reviews show that there are a vast number of articles being published. A review focused on the integration of social media with weight loss interventions by Dahl et al. concludes an identified need for

- understanding the effectiveness of social media as an independent delivery method and also recommends study of the positive and negative impacts of social media on weight loss behaviors (Dahl, Hales, and Turner-McGrievy 2016). Maher et al. note that even though social media offers unique insights into health-related behavior, delivery of an intervention that incorporates an established and popular social media platform does not guarantee impact (Maher et al. 2016). They conclude with a call for evaluation in a diverse populace and designing features that sustain engagement and behavior change.
- ii. There are significant challenges and limitations in conducting typical randomized controlled trials involving social media (Vandelandotte and Maher 2015). Traditionally, research has relied on recruiting from offline sources (print campaigns, newsletters, in person, etc.) or static websites. As an example, six of the eight studies in Maher et al.'s systematic review recruited using traditional methods, while only one study used social media. This can be partly explained by the urge to design a strong RCT, with minimum contamination of samples; however, Bull et al. employed a cluster randomized trial with a small number of 'seed' participants in each study group and letting the natural effects of social media take over, whereby participants 'referred' new participants (Bull et al. 2012). By curtailing the natural tendencies of the users of social networking sites, such as involving their social contacts, most studies fail to study the phenomenon in a more ecologically sound environment.
 - iii. The choice between a health specific social networking system and using a mainstream social media website (like Facebook or Twitter) has been disparate. Maher et al.

identifies several advantages of using existing social media sites (higher engagement, low attrition, close ties etc.) (Maher et al. 2014);. however, almost all examined studies that used existing social media websites have forgone the inherent benefits of online health behavior change such as tailoring, personalization, etc. The two choices have either placed social networking features as ‘one another’ component (health specific social networking systems in most cases simply enabled a few social media features on top of an online health behavior change website – the control group) or assumed that by just disseminating the intervention content through existing social media sites without tailoring, personalization, etc. will suffice. A study (Foster et al. 2010) attempted to bring social media to the center stage by utilizing a Facebook app, to allow users to enjoy the natural benefits of the social media site, while also offering the intervention-specific features such as step tracking (self-monitoring) within the social networking platform. A more recent study (Maher et al. 2015) has conducted a randomized control trial to determine the efficacy, engagement, and feasibility of an online social networking physical activity intervention with pedometers delivered via Facebook app. The study, which employed pre-formed teams of size three to eight members, has found that after eight weeks, the intervention arm significantly increased their total weekly moderate-to-vigorous physical activity. The difference was lost in the long term (20 weeks), however, and makes a call for further research.

- iv. Most studies have followed an all-or-nothing strategy with privacy. For less sensitive topics such as physical activity, communication strategies such as Facebook pages (which

are more public) or groups, Twitter conversations, and discussion boards within a health specific social networking site have been employed (Brindal et al. 2012, Valle et al. 2013). On the other hand, for privacy-sensitive topics such as sexual health, where the intervention meant to have two-way dialog, ‘secret’ Facebook groups (where there is extreme privacy to rest of the world, but relaxed privacy amongst members of the group) have been employed (Young et al. 2013). The users have not been offered a more granular choice of privacy by the intervention, beyond the privacy offered by their respective host platforms, however.

- v. Systematic efforts to use social support (by making use of natural social ties), homophily, modeling, and other proven strategies have not occurred within the realm of using social media for online health behavior change.

A clearer picture of the precise contributions of social media to online health behavior change would not be possible without resolving the above-identified issues.

III. ONTOLOGICAL ANALYSIS AND RESEARCH QUESTIONS

A. Introduction

The use of social media for health behavior change represents an interdisciplinary problem, involving two very diverse disciplines, namely information systems and public health. Both of these domains are vast, complex, and constantly evolving. A systematic and systemic view of the problem is necessary to avoid the proverbial story of the five blind men who visualized an elephant as a rock, an arrow, a fan, a rope, and a tree trunk after touching its body, tusk, ear, tail, and leg, respectively (Ramaprasad and Papagari 2009, Ramaprasad and Syn 2015).

The literature review presented a problem with the systematic reviews and meta-analyses focusing on social media and online health behavior change. Due to the requirement of focusing on sound research designs such as randomized control trials, only about 20 articles were included in the reviews, while the literature database search in the systematic reviews indicated a much larger quantity of relevant articles identified. Systematic reviews and meta-analyses methods typically only discuss articles/studies that qualify for analysis, but fail to identify if the included articles have covered the breadth and scope of the problem being reviewed. Secondly, most literature and reviews focus on the behavioral outcomes of the behavior change programs using social media, but do not analyze the information technology (IT) artifact of social media at a significant depth (Williams et al. 2014, Laranjo et al. 2014, Maher et al. 2014, Chang et al. 2013). In their call to theorizing the IT artifact, Orlikowski et al. note that research employing IT

artifacts cannot assume them to be 'natural, neutral, universal, or given' (Orlikowski and Iacono 2006). There is a lack of an information systems point of view on the research on the application of social media for health behavior change.

Ontological topography is a technique for analysis of a problem in its entirety, similar to literature reviews, citation analyses, systematic reviews, statistical meta-analyses, etc. and is adaptable to the subsequent evolution of the domain(s) by enabling the possibility to scale, extend, reduce, refine, and magnify its components (Ramaprasad 2014) as explained later in this chapter. To create an ontological topography, first an ontology of the problem is created, and is then used to map the topography of the problem domain(s) and create visualizations of the knowledge structure (Ramaprasad 2014). The visualizations will help visualize the bright, light, and blind/blank spots of knowledge in the problem's domain(s) and will provide support for navigating the existent knowledge landscape (Kazimierczak et al. 2013), which will in turn aid development of the is this aims of this dissertation.

B. Ontological Framework

An ontological framework is defined as “a logically constructed n-dimensional natural language description of the problem” (Ramaprasad and Papagari 2009, Ramaprasad and Syn 2015). The ontology is logically constructed by inducing the dimensions from the problem statement and developing taxonomies based on the extant literature in the domain to connote each dimension. Such an approach enables a systemic view of the problem and is generative in that it can help generate new solutions or even unidentified problems related to the problem

under consideration. Additionally, due to its multidimensional nature, the ontology makes possible either extension or restriction of the problem under consideration. The overall design of the ontology provides us with a systematic, logical way of examining and reviewing the problem.

In conceptualizing the usage of social media for health behavior change, it is critical to identify the conceptual process or method that would serve as a connecting bridge between the two extreme fields, one from the information system (IS) domain and other from the public health domain. A logical fit for the connection should involve a dimension that encapsulates the various strategies or steps one might need to bring health behavior change, but at the same time should be implementable as an IS feature and/or function. Based on this, we deconstruct our ontology into three dimensions: (1) affordances offered by social media sites, which serve distinct purposes; (2) a health behavior change model, which encapsulates all possible health behavior change strategies; and (3) a list of the most sought after health behavior changes. We thus formulate our problem statement as “How do affordances of a social media website affect phases of health behavior change research and practice?”, which was created by following the iterative procedure for ontological analysis (Ramaprasad 2014). Figure 1 shows the ontological framework for our research statement.

The first dimension of the ontological framework expands on the IT artifact “social media”, titled Social Media Affordances. To help identify the elements of this dimension, based on an exhaustive search of the social media related literature we chose the enumeration by Kietzmann et al. (Kietzmann et al. 2011). As explained earlier, it offers an insight into the building blocks of

a social media site, and suggests that not every popular social media site contains all the building blocks when launched, and may not do so even when fully developed.

| How do affordances of a social media website affect phases of health behavior change research & practice? | | | |
|--|-----------------------|--|---|
| 1. Affordances | | 2. Phases | 3. Health Behavior Change |
| [How do(es)] | 1.1 Identity | 2.1 Recruitment | 3.1 Stress Management |
| | 1.2 Conversations | 2.2 Intervention | 3.2 Participation in Health Services |
| | 1.3 Sharing (content) | 2.2.1 Knowledge & Beliefs | 3.3 Weight Management |
| | 1.4 Presence | 2.2.1.1 Personalizing Content | 3.4 Addiction Recovery |
| | 1.5 Relationships | 2.2.1.2 Increasing Self-efficacy | 3.5 Screening & Treatment Behaviors for Women |
| | 1.6 Reputation | 2.2.1.3 Improving Outcome Expectancy | 3.6 Sexual Behaviors |
| | 1.7 Groups | 2.2.2 Self Regulation | 3.7 Others/Generic |
| | | 2.2.2.1 Goal Setting | |
| | | 2.2.2.2 Self Monitoring | |
| | | 2.2.2.3 Decision Making | |
| | | 2.2.2.4 Planning | |
| | | 2.2.2.5 Self Evaluation | |
| | | 2.2.2.6 Management of Emotional Response | |
| | | 2.2.3 Social Facilitation | |
| | | 2.2.3.1 Social Influence | |
| | | 2.2.3.2 Social Support | |
| | | 2.3 Assessment | |
| Illustrative components of the 833 (7*17*7) possible instances of the research problem: <i>How do conversations in a social media site affect self-regulation for addiction recovery research/practice?</i> <i>How does sharing (content) in a social media site affect self-efficacy for weight management research/practice?</i> <i>How do relationships in a social media site affect social support for stress management research/practice?</i> | | | |

Figure 1: Ontological Framework for Use of Social Media in Health Behavior Change

For our second dimension titled Phases, we first sought to list the major phases of research, which is represented by Recruitment, Intervention, and Assessment. For the Intervention sub-dimension, we sought a model or constructs of a theory, which is more pragmatic (than philosophical) and encompassing the significant constructs of various earlier theories. We chose Ryan's (Ryan 2009), Integrated Theory of Health Behavior Change, which is a descriptive midrange theory. Midrange theories are more concrete and more easily used to guide practice (Rodgers 2005). Descriptive theory provides a description of what is happening in a situation, and reveals the components that exist in a situation (Rodgers 2005). An overview of this theory is presented in Chapter 2.

The third dimension titled Health Behavior Change is the actual outcome sought. There are many health behavior changes sought by individuals, thus a broad grouping of the most popular health behavior changes has been included. The list may be extended. Johnson et al. (Johnson, Scott-Sheldon, and Carey 2010) present a meta-synthesis of various meta-analyses about health behavior change. They identify stress management, improving participation in health services, eating and physical activity, addictions, screening and treatment behaviors for women, and sexual behaviors, as the most frequently addressed targeted health behavior change domains from the literature. A glossary for the framework is provided in Figure 2.

| |
|---|
| <u>Affordances:</u> |
| 1.1 Identity - To be able to self present one's own identity. |
| 1.2 Conversations - To be able to converse with other members of the social network. |
| 1.3 Sharing (content) - To be able to create and disseminate content. |
| 1.4 Presence - To be able to know if other users are available. |
| 1.5 Relationships - To be able to create friendship with other users. |
| 1.6 Reputation - To be able to evaluate the credibility of other users and content. |
| 1.7 Groups - To be able to engage in many to many to relationships. |
| <u>Phases</u> |
| 2.1 Recruitment - To enlist new participants for research. |
| 2.2 Intervention - To take action to improve health behavior. |
| 2.2.1 <i>Knowledge & Beliefs - A combination of factual or perceptual information.</i> |
| 2.2.1.1 Personalizing Content - To present condition/disease specific knowledge and help goal congruence. |
| 2.2.1.2 Increasing Self-efficacy - A person's confidence in their ability to successfully carry out the behavior. |
| 2.2.1.3 Improving Outcome Expectancy - A person's belief that carrying out the behavior will lead to the desired results. |
| 2.2.2 <i>Self Regulation - Process by which people incorporate behavior change into their everyday lives.</i> |
| 2.2.2.1 Goal Setting - To set goals for the short-term and long-term. |
| 2.2.2.2 Self Monitoring - To monitor the progress towards a goal. |
| 2.2.2.3 Decision Making - To make informed decisions towards improved health. |
| 2.2.2.4 Planning - To be able to plan for improved health. |
| 2.2.2.5 Self Evaluation - To evaluate one's health. |
| 2.2.2.6 Management of Emotional Response - To be able to engage in healthy behaviors in spite of competing emotions. |
| 2.2.3 <i>Social Facilitation - To interact with others for support or influence.</i> |
| 2.2.3.1 Social Influence - Influences from other members of a social circle. |
| 2.2.3.2 Social Support - Support offered by members of a social circle. |
| 2.3 Assessment - To perform cross sectional analysis of a phenomenon. |
| <u>Health Behavior Change</u> |
| 3.1 Stress Management - To reduce undue stress faced by individuals. |
| 3.2 Participation in Health Services - To encourage individuals to visit medical professionals for specific purposes. |
| 3.3 Weight Management - To increase physical activity and follow a health diet towards reducing or maintaining weight. |
| 3.4 Addiction Recovery - To help recover from addictions such as alcohol, drugs and smoking. |
| 3.5 Screening & Treatment Behaviors for Women - To promote women specific health behavior change. |
| 3.6 Sexual Behaviors - To promote safe sexual practices. |
| 3.7 Others/Generic - All other health behavior change outcomes. |

Figure 2: Glossary for Ontological Framework

The ontology and its dimensions are structured such that natural language sentences can be constructed by combining elements of the three dimensions. Each such natural language sentence represents a specific problem statement, which can be a topic for further in-depth research. It should be noted that the elements of the dimensions, especially the second dimension, can be applied at any zoom level – one could consider the same problem for just goal setting, self-regulation or intervention. As an example, one sentence reads: “How do conversations of a social media site affect decision making for addiction recovery research/practice?”. The same problem statement can be zoomed to a different level to state "How do conversations of a social media site affect self-regulation for addiction recovery research/practice?”. The ontological framework has a total of 833 ($7 \times 17 \times 7$) instances of the research problem.

The framework presented above is **an** ontological framework for the problem statement and is not **the** ontological framework of the problem. A different set of researchers might include a different dimension, replace a dimension, or even just replace elements in a dimension.

C. Ontological Mapping

Mapping all extant literature onto the ontological framework requires a systematic procedure, which can be verified, replicated, and expanded. The first step in ontological mapping is to identify the data sources and usually includes one or more index databases of literature (Ramaprasad 2014). For the problem under focus, representing two very different disciplines, a combination of two databases of literature was employed, namely PubMed and SCOPUS. PubMed is a premier source of health related literature with access to more than 22 million

citations. SCOPUS on the other hand is a multi-disciplinary database, with over 53 million citations. The second step is to research the major topics/categories of the literature in the domain with the objective of determining the search terms and keywords (Ramaprasad 2014), which leads to the third step, i.e., determining the search terms and keywords that satisfactorily define the domain being mapped. The resultant search terms for the two databases are presented below:

For SCOPUS - (TITLE-ABS-KEY("online social network*") OR TITLE-ABS-KEY("social network site*") OR TITLE-ABS-KEY("youtube") OR TITLE-ABS-KEY("social networking") OR TITLE-ABS-KEY("social media") OR TITLE-ABS-KEY("twitter") OR TITLE-ABS-KEY("facebook") OR TITLE-ABS-KEY("patientslikeme"))AND (KEY(health behavior) OR KEY(health promotion)OR KEY(health communication) OR KEY(ehealth) OR KEY(telemedicine) OR TITLE-ABS-KEY(health behavior) OR TITLE-ABS-KEY(health promotion) OR TITLE-ABS-KEY(health communication) OR TITLE-ABS-KEY(ehealth) OR TITLE-ABS-KEY(telemedicine))

For PubMed - (("social networking") OR ("social network site*") OR ("online social network*") OR ("social media") OR ("facebook") OR ("Youtube") OR ("twitter") OR ("patientslikeme")) AND ((Health Behavior[MeSH]) OR (Health Promotion[MeSH]) OR (Health Communication[MeSH]) OR (Telemedicine[MeSH]) OR (Health Behavior) OR (Health Promotion) OR (Health Communication) OR (ehealth) OR (telemedicine))

The above query strings also took into consideration similar systematic reviews and meta-analysis articles, which focus on topics or problems similar to the problem under focus (Maher et al. 2014, Williams et al. 2014). An iterative approach was required to finalize the search strings above, as very restrictive searches produced approx. 600 articles (but found to not include known relevant articles), while very broad searches resulted in close to 10,000 records. A quick review of the citations yielded by the above two searches indicated that the Journal of Medical Informatics Research (JMIR) produced the most number of relevant articles to our problem, thus as a safety net to ensure that no valid article was excluded, a third search query string (second for PubMed) was included, which was journal specific, but loose on problem-specific terminology. Additionally, all references in relevant systematic reviews were analyzed to ensure that no article was excluded due to a weak search strategy.

JMIR specific query for PubMed - (("Social Media"[Mesh] OR "social media*" OR "social web" OR facebook OR twitter OR youtube OR "social network site*" OR "online social network*" OR (("Social Environment"[Mesh] OR "social process*" OR "social competition*" OR "social norm*" OR "social feedback" OR "social influence*" OR "social comparison*" OR "social network*" OR "discussion group*" OR "support group*" OR "Social Support"[Majr]) AND (ehealth OR e-health OR "information technology" OR "communication technology" OR "web*" OR "website*" OR online OR "mobile*" OR electronic OR Personal Health Record* OR Internet"[Majr] OR "Online Systems"[Majr]))) AND "Journal of medical Internet research"[Journal]

It is to be noted that the above searches (run on 9/22/2014) are not limited to a time period, but run with the intention to download the entire population and not just a sample data (confined to a few years).

As can be seen in the search strings, all peer-reviewed journal articles and conference papers with a main focus on communication for health behavior change, with the involvement of social media were included. Studies not in English, studies with social media not as a focus, other types of publications such as newsletters, review papers, etc., were excluded. Figure 3 shows a PRISMA flow diagram (Moher et al. 2009) to systematically explain the article selection process. It precisely shows the number of articles identified, excluded, and included in the final list of articles for the ontological mapping process.

The references downloaded from the databases were fed to the citation manager EndNote (REUTERS 2011). The references were then exported and imported into the qualitative analysis software QSR NVivo (Bringer, Johnston, and Brackenridge 2004). In NVivo a hierarchical node structure with a node for each dimension and taxonomic category in the ontology was created as shown in Figure 4. All of the articles were first screened by reading titles and abstracts, after which the full text was read for eligibility criteria when needed. Articles that did not match the domain of our study, or meet any of the exclusion criteria above were excluded. The major reasons for exclusion were: not being social media focused, not having a health behavior focus, being a paper of an editorial nature, being a review paper and/or being a conference summary. The final list of articles in our analysis contains 328 articles. All of the included articles were

then coded (mapped) to the node structure represented in Figure 5. This process of coding to the nodes was done by two individuals (two graduate level students of physical therapy) using NVivo. NVivo has the capabilities for users to individually code a given corpus of sources and then be merged. Upon merging, NVivo makes it possible to isolate codings with conflicts (between the two coders), and all codings with such a conflict were discussed to reach a consensus on the coding, in a meeting between the author and the two coders.

D. Ontological Topography of Monads

The ontological topography of the mapped literature of our problem domain (monads) is shown in Figure 5. An article could generally be mapped on all or some of the dimensions. Driven by the inclusion and exclusion criteria for inclusion in the data analysis, all of the 328 articles were coded on all the dimensions.

The number in parentheses adjacent to each element in Figure 5 is the frequency of its occurrence in the articles. The bar below the element is proportional to the percentage contribution of the particular element to its parent element; for example, the blue bar under ‘Identity’ is proportional to $31/464 \times 100$, where 464 is the sum of all the frequencies of codings under the affordances dimension. It is to be noted that the frequency count of various elements would be less than the sum of the frequency of its child elements, due to the fact that articles could be coded at multiple child elements; for example, social facilitation shows a frequency of 64, while the sum of its sub elements, social influence (36) and social support (39), is much higher.

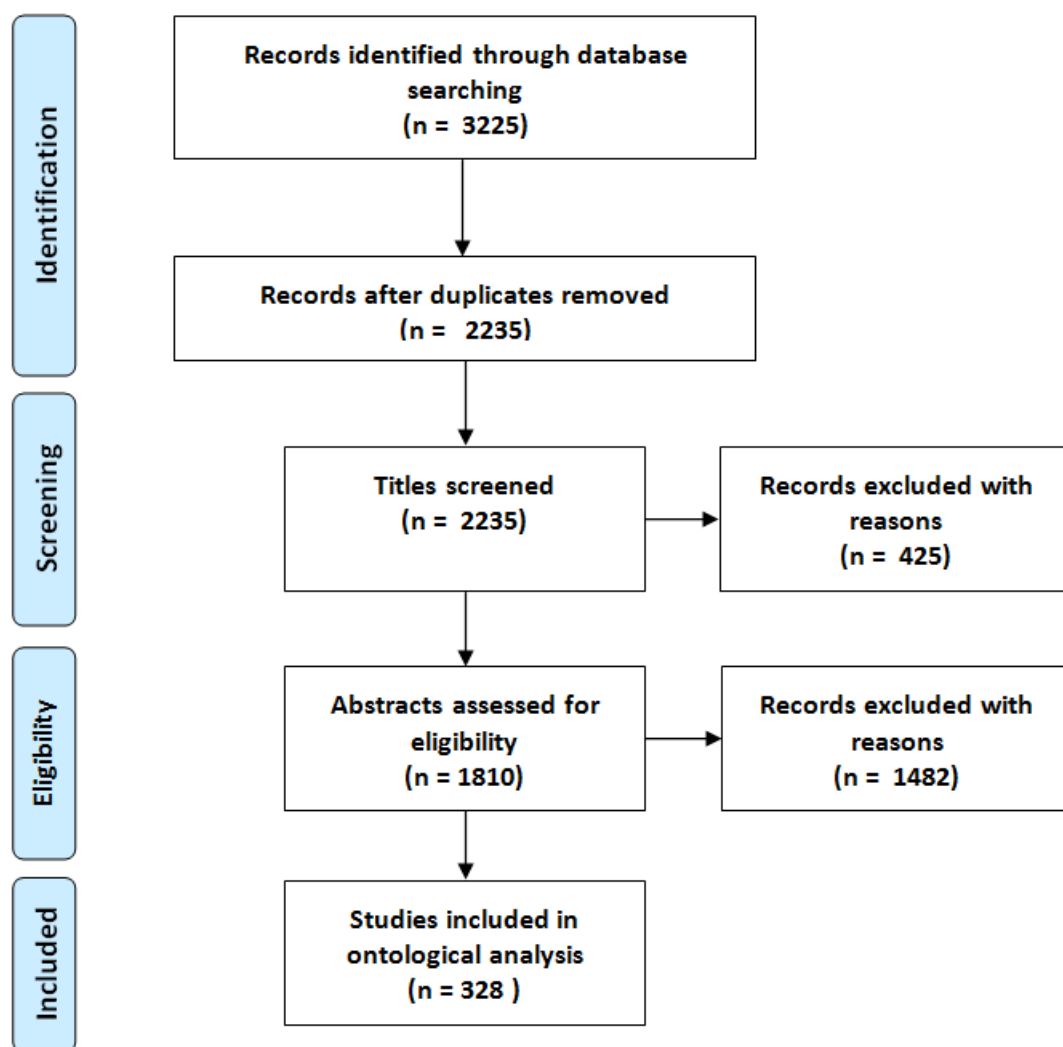


Figure 3: PRISMA Flow Diagram

| 2. Ontology | | | | | | |
|---|---------|------------|--------------------|------------|--------------------|-------------|
| Name | Sources | References | Created On | Created By | Modified On | Modified By |
| 1. Affordances | 0 | 0 | 5/31/2014 11:44 AM | MT | 5/31/2014 11:44 AM | MT |
| 1.1 Identity | 31 | 31 | 5/31/2014 11:46 AM | MT | 6/13/2014 8:37 PM | MT |
| 1.2 Conversations | 81 | 81 | 5/31/2014 11:46 AM | MT | 6/13/2014 8:37 PM | MT |
| 1.3 Sharing (Content) | 260 | 260 | 5/31/2014 11:46 AM | MT | 6/13/2014 8:46 PM | MT |
| 1.4 Presence | 8 | 8 | 5/31/2014 11:47 AM | MT | 6/13/2014 5:21 AM | MT |
| 1.5 Relationships | 23 | 23 | 5/31/2014 11:47 AM | MT | 6/13/2014 8:37 PM | MT |
| 1.6 Reputation | 16 | 16 | 5/31/2014 11:47 AM | MT | 6/13/2014 8:46 PM | MT |
| 1.7 Groups | 45 | 45 | 5/31/2014 11:47 AM | MT | 6/13/2014 7:18 PM | MT |
| 2. Phases | 0 | 0 | 5/31/2014 11:45 AM | MT | 6/15/2014 2:19 AM | MT |
| 2.1 Recruitment | 46 | 46 | 5/31/2014 11:48 AM | MT | 6/13/2014 8:03 PM | MT |
| 2.2 Intervention | 196 | 267 | 5/31/2014 11:48 AM | MT | 6/13/2014 10:30 AM | MT |
| 2.2.1 Knowledge & Beliefs | 97 | 126 | 5/31/2014 11:50 AM | MT | 6/13/2014 10:30 AM | MT |
| 2.2.2 Self Regulation | 53 | 64 | 5/31/2014 11:50 AM | MT | 6/13/2014 10:30 AM | MT |
| 2.2.3 Social Facilitation | 64 | 77 | 5/31/2014 11:50 AM | MT | 6/13/2014 10:30 AM | MT |
| 2.3 Assessment | 102 | 102 | 5/31/2014 11:49 AM | MT | 6/13/2014 8:46 PM | MT |
| 3. Health Behavior Change | 0 | 0 | 5/31/2014 11:45 AM | MT | 11/11/2014 2:26 AM | MT |
| 3.1 Stress Management | 17 | 17 | 5/31/2014 11:56 AM | MT | 6/13/2014 9:55 AM | MT |
| 3.2 Participation in Health Services | 131 | 131 | 5/31/2014 11:57 AM | MT | 11/11/2014 2:26 AM | MT |
| 3.3 Weight Management | 48 | 48 | 5/31/2014 11:57 AM | MT | 11/11/2014 2:25 AM | MT |
| 3.4 Addiction Recovery | 41 | 41 | 5/31/2014 11:57 AM | MT | 6/13/2014 8:46 PM | MT |
| 3.5 Screening & Treatment Behaviors for Women | 7 | 7 | 5/31/2014 11:58 AM | MT | 6/13/2014 10:51 PM | MT |
| 3.6 Sexual Behaviors | 56 | 56 | 5/31/2014 11:58 AM | MT | 6/13/2014 8:41 PM | MT |
| 3.7 Others or Generic | 40 | 40 | 5/31/2014 11:58 AM | MT | 6/13/2014 6:45 PM | MT |

Figure 4: Screenshot of NVivo Node Structure

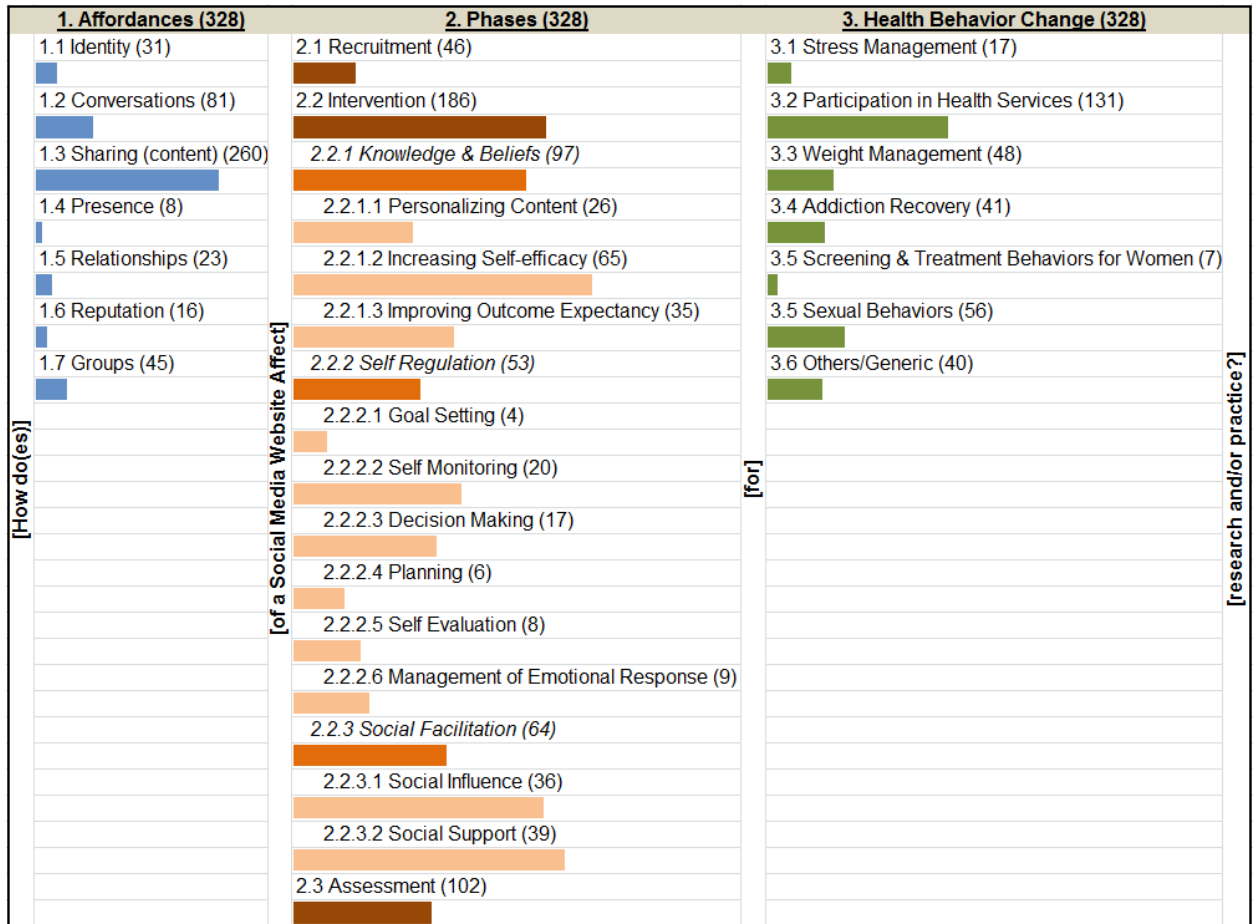


Figure 5: Ontological Topography of Monads

The ontological topography at the monadic level presented in Figure 4 shows a macro image of the problem domain and exposes several bright spots (high frequency elements), light spots (low frequency elements), and blind/blank spots (no frequency elements). The no frequency elements may be ‘blank’ by choice (e.g., practically impossible) or ‘blind’ by oversight and cannot be resolved based on the data.

Out of the 328 papers in our dataset, in view of the social media affordances, 260 focused on Sharing (content), 81 on Conversations, 45 on Groups, 31 on Identity, 23 on Relationships, 16 on Reputation, and only 8 on Presence. Similarly, in the research phases dimension, 186 articles focused on interventions, while 102 focused on assessment, and 46 on recruitment. Among the targeted health behavior change, 131 on participation in Health Services, 56 focused on Sexual Behaviors, 48 on Weight Management, 41 on Addiction Recovery, 17 on Stress Management, 7 on Women's Behaviors, and 40 were either generic or dealt with other health behaviors. The above results of our analysis provide insights on how researchers have emphasized on certain areas of research, while not on others.

As can be seen in the affordances dimension, sharing (content) has received overwhelming attention (bright spot), while identity, presence, relationships, reputation and groups have received limited attention (light spots). One reason for this trend is that the 102 assessment-based studies and 46 recruitment-focused studies almost always relied on content. Relationships and presence have received little focus, and are not a positive trend, as the very basis of exploring the

use of social media in health behavior change is its potential for social interactions on a continuous basis, leading to increased adherence.

Another significant trend involved posting content on sites like Facebook, Twitter, YouTube as interventions, while not involving the “social” aspects of these platforms (Lyles et al. 2013, Black, Schmiede, and Bull 2013, Litt and Stock 2011, Patrick et al. 2014, Zhang, He, and Sang 2013, George et al. 2013, Pedrana et al. 2013, Jones, Baldwin, and Lewis 2012, Kolt et al. 2013, Park, Rodgers, and Stemmle 2013, Emery et al. 2014, Prochaska et al. 2012), but a few studies combined comprehensive online intervention websites with social networking. Almost all studies that used mainstream services such as Facebook, Twitter or YouTube had foregone the tailoring capabilities of traditional online health behavior intervention systems, in an urge to study the role of social media. On the other hand, the few studies that had their own health intervention websites with social networking features failed to tap into the existing social networks of their users available in mainstream social media websites, thus introducing a barrier to formation of new social networks.

With almost all mainstream social media focused websites offering APIs (Application Programming Interface), interventions that try to implement all the inherent advantages of online health behavior changes, while also integrating with mainstream social media sites, are now possible (Bennett and Glasgow 2009a).

In a related systematic review by Maher et al. (2014), their recommendations for future studies are in congruence with our observation above. They first recommend design of social-networking interventions that can be delivered primarily within the social network setting and follow up with a second recommendation of ‘Examine interventions delivered via existing popular social network websites, such as Facebook, given their proven ability to attract and retain participants and potential for mass dissemination. Such interventions should be responsive to the way people use online social networks (predominantly with existing friends and for entertainment)’ (Maher et al. 2014).

Tapping into the power of QSR NVivo’s coding querying capabilities, it is possible to generate frequency mappings of the ontological topography to expose the frequency of particular combinations of elements of the ontology. While the data for the mappings are made available by QSR NVivo, the visualizations have been created using Microsoft Excel’s conditional formatting capabilities.

E. Ontological Topography of Dyads

Figure 6 shows the ontological topography of dyads for our problem domain. The structure of rows and the columns of the matrix are isomorphic with the ontology. The within-dimension dyads are summarized in the triangular sub-matrices along the diagonal; and between-dimension dyads by the off-diagonal sub-matrices. As an example, the dyads among the Affordances is summarized by the top left triangular sub-matrix; that between Phases and Affordances by the sub-matrix below it. A number in any cell of the topography above represents the frequency of

that combination of elements in the vertical and horizontal axis; for example, the cell representing the intersection of the element Participation in Health Services (Health Behavior Change dimension) and Sharing (Affordances dimension) shows the number 100. This is to be interpreted as out of the 328 studies included in the ontological topography, 100 studies were focused on both these elements. It should be recognized that this combination is the most frequent combination of the dyadic level.

| | | Affordances | | | | | | | Phases | | | | | Health Behavior Change | | | | | | |
|------------------------|-----------------------------|-------------|---------------|-------------------|----------|---------------|------------|--------|-------------|---------------------|-----------------|---------------------|------------|------------------------|-----------------------------|-------------------|--------------------|-------------------------|------------------|----------------|
| | | Identity | Conversations | Sharing (content) | Presence | Relationships | Reputation | Groups | Recruitment | Knowledge & Beliefs | Self Regulation | Social Facilitation | Assessment | Stress Management | Participation in H.Services | Weight Management | Addiction Recovery | S&T Behaviors for Women | Sexual Behaviors | Others/Generic |
| Affordances | Identity | | | | | | | | | | | | | | | | | | | |
| | Conversations | 19 | | | | | | | | | | | | | | | | | | |
| | Sharing (content) | 27 | 57 | | | | | | | | | | | | | | | | | |
| | Presence | 3 | 3 | 4 | | | | | | | | | | | | | | | | |
| | Relationships | 9 | 11 | 16 | 1 | | | | | | | | | | | | | | | |
| | Reputation | 2 | 8 | 12 | 1 | | | | | | | | | | | | | | | |
| | Groups | 6 | 14 | 19 | 1 | 3 | 2 | | | | | | | | | | | | | |
| Phases | Recruitment | 3 | 6 | 38 | 1 | 1 | 2 | 3 | | | | | | | | | | | | |
| | Knowledge & Beliefs | 9 | 34 | 83 | 2 | 4 | 5 | 18 | 2 | | | | | | | | | | | |
| | Self Regulation | 4 | 13 | 43 | 2 | 7 | | 12 | 1 | 9 | | | | | | | | | | |
| | Social Facilitation | 8 | 24 | 42 | 3 | 8 | | 19 | | 17 | 10 | | | | | | | | | |
| | Assessment | 17 | 29 | 86 | 3 | 11 | 10 | 8 | 3 | 1 | | | | | | | | | | |
| Health Behavior Change | Stress Management | 3 | 8 | 11 | 1 | 6 | | 4 | 2 | 4 | 7 | 5 | | | | | | | | |
| | Participation in H.Services | 5 | 14 | 100 | 1 | 4 | 4 | 16 | 18 | 53 | 18 | 24 | 4 | | | | | | | |
| | Weight Management | 7 | 15 | 42 | 1 | 4 | 2 | 8 | 5 | 9 | 17 | 16 | 24 | 2 | | | | | | |
| | Addiction Recovery | 10 | 15 | 33 | | 4 | 4 | 7 | 3 | 4 | 6 | 8 | 15 | 1 | | 3 | | | | |
| | S&T Behaviors for Women | 2 | 4 | 5 | | | | | 1 | 3 | | | 22 | | | | | | | |
| | Sexual Behaviors | 8 | 23 | 43 | 4 | 5 | 4 | 6 | 15 | 15 | 5 | 9 | 18 | 1 | | 2 | 4 | | | |
| | Others/Generic | 6 | 14 | 37 | 2 | 4 | 3 | 6 | 2 | 11 | 2 | 5 | 25 | 2 | 1 | | | | | |

Highest Frequency
 Lowest Frequency (0)

Figure 6: Ontological Topography of Dyads

With Sharing (content) being the most frequent element at a monadic level in the Affordances dimension, this element is the most frequently occurring element in combination with all other elements of the Affordances dimension. In particular, the combination of Sharing (content) and Conversations has a frequency of 57. There has been no study that focusses on both Relationships and Reputation.

Among combinations of elements in the Phases dimension, 17 studies have focused on Social Facilitation and Self-Regulation elements. Another interesting observation is that only 16 out of the 328 studies have focused on more than one behavior change domains, with Sexual Behaviors and Screening & Treatment Behaviors for Women being the most frequented (4) combination. With Sharing (content) being the most (monadic) frequented element in the Affordances dimension, this dimension is found to highly frequent in combination with Knowledge & Beliefs and Assessment elements of the Phases dimension. Assessment (Phases dimension) of Participation in Health Services (Health Behavior Change dimension) finds a very low frequency of 4 in contrast to other similar combinations.

F. Ontological Topography of Triads

Figure 7 shows the ontological topography of triads for the problem, with seven different visualizations in it, one for each element of the Affordances dimension. The first visualization with the title “Affordances: Identity” displays the frequencies of triadic combinations that included the affordance of identity. The dark-colored cell with the number 17 represents the 17 studies that focus on Identity (Affordances dimension), Assessment (Phases dimension) and

Screening & Treatment Behaviors for Women (Health Behavior Change dimension). It should be recognized that triadic combinations, due to multiple elements of the same dimension (within-dimension), are not included in this visualization. The highest frequency at the triadic level is occupied by 42 studies focusing on using Sharing (Affordances dimension), Knowledge & Beliefs (Phases dimension) and Participation in Health Services (Health Behavior Change dimension). While the bleak representation of Presence and Reputation was visualized in the ontological topography of monads and triads, the bleakness is visualized more prominently at the triadic level.

The current ontological topography of triads has been presented with Affordances of social media as the main entry point, as the focus of this study is on the use of social media for the rest of the ontology. The same information contained in the ontological topography of triads could be presented with the Phases or Health Behavior Change dimensions as an entry point.

G. Research Questions

The present study explores the complexities of the interdisciplinary problem of usage of social media for health behavior change. The initial literature review led us to the following research objectives: 1) to create an ontological framework and 2) to systematically analyze the current state of the research on this problem by creating an ontological topography. By systematically analyzing all extant literature using the ontological topography, the bright, light and blind/blank spots were exposed, giving rise to more research objectives. The literature review has also led to the identification of various limitations in the current theories, models

and/or frameworks in being able to accommodate the radical changes in the online health behavior change domain, as a result of the rapid proliferation of social media technologies. A lack of research focusing on all affordances of social media and all essential behavior change techniques, while also tapping into participants' existing social networks, was identified. These findings lead us to our next set of research objectives: 1) design a new prototype of an online health behavior change system, which has all affordances of social media and employs all behavior change techniques (identified in the ontology) and, thereby, enabling delivery of a holistic behavior change intervention within a mainstream social networking site (Facebook), using its API, and 2) perform an evaluation of the usability, engagement, perceived social support and perceived privacy of the newly developed prototype.

Use of social media for health behavior change is an emerging field, and, therefore, there is a lack of clarity on how the intervention systems are to be designed, what is the exact role of social media in those interventions, etc. (Maher et al. 2014). It is hoped that the ontological framework will help guide in offering a wide, yet penetrative lens for researchers focusing on this problem, enabling them to visualize the breadth and scope of research opportunities related to this problem. The ontological topography will help researchers see the current state of the research, and help steer in a direction that enables a holistic solution to the problem at hand. It is also hoped that the prototype system being proposed and the evaluations of the system, will showcase to researchers the extreme possibilities of the use of social media for health behavior change, while ensuring that no benefit of current online health behavior change systems is foregone.

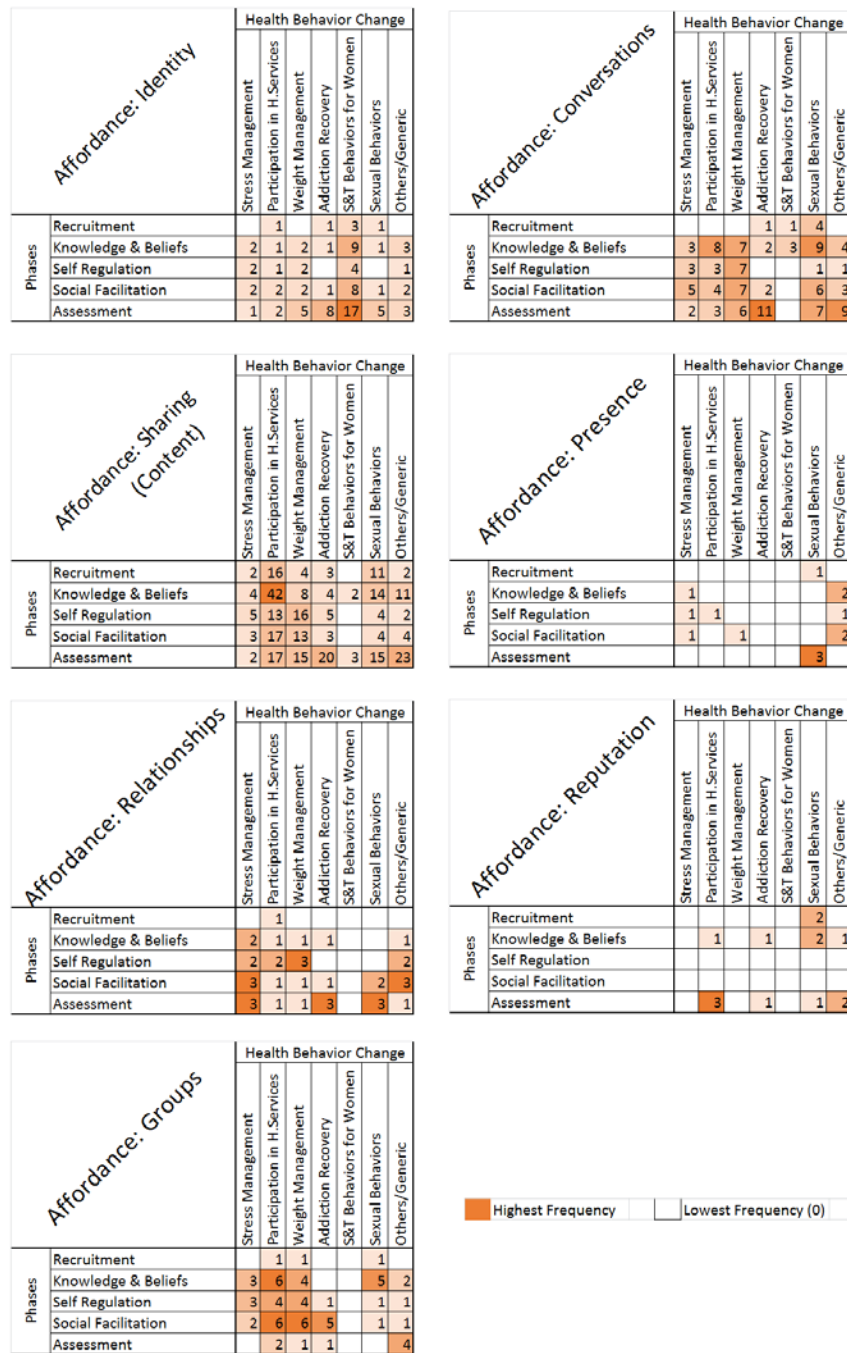


Figure 7: Ontological Topography of Triads

IV. METHODS

To address the research objective of developing a new prototype of an online health behavior change system and perform an evaluation of the usability, engagement, perceived social support and perceived privacy of the newly developed prototype, this chapter will describe 1) the process followed for the design and development of the prototype application that uses social media for health behavior change, and 2) the procedures used to evaluate the prototype.

A. Design Guiding Principles

The prototype developed as a part of this research, intends to fill a gap believed to exist in this domain of research. Thus, it became necessary to enlist a set of principles to guide the design of the prototype and to ensure that the developed prototype is devoid of glaring omissions. Based on the earlier literature review and ontological analysis, the following were listed as the guiding principles for the prototype application:

- i. The prototype will include all social media affordances at the core of the design: With the primary focus of this study on investigation of the role of social media in health behavior change, it is vital that all affordances of social media are included as a part of this design. This inclusion of all affordances will also help reuse of this prototype for other research activities that make use of social media for health behavior change.
- ii. The prototype will implement all behavior change techniques: While the utilization of social media is the primary focus of this study, all essential health behavior change

techniques need to be utilized for a successful health behavior change. The Integrated Theory of Health Behavior Change, which forms the second dimension of the ontology, is integrative in nature and includes all essential behavior change techniques featured in earlier theories. All behavior change techniques recommended by this theory will be included as a part of this prototype.

- iii. The prototype will follow the ‘Privacy by Design’ principles to take a preventative approach, rather than a reactive approach to privacy: With the intersection of health and social media, the fear of loss of privacy is expected to be substantial. Thus, the prototype will take a proactive approach on the protection of privacy instead of as an afterthought.
- iv. The prototype will include adequate anonymized tracking mechanisms to enable detailed evaluation of the prototype: A thorough evaluation of online systems is not possible without detailed usage data collection. General tracking mechanisms such as Google analytics, web server log etc. do not connect to context in which the user was in the online system. To overcome these inadequacies, a tracking mechanism will be integrated with the prototype.

B. Design Guiding Theories, Models and Frameworks

The Integrated Theory of Behavior Change (Ryan 2009) was chosen as the guiding behavior change theory for the prototype. This choice was due to: 1) the ‘integrative’ nature of the theory, wherein the most vital characteristics of all proven earlier theories have been integrated (Ryan 2009), and 2) the mid-range descriptive nature of the theory (Ryan 2009). As explained in the

literature review, the theory suggests that health behavior change is made possible by fostering knowledge and beliefs, increasing self-regulation skills and abilities, and enhancing social facilitation.

While the Integrated Theory of Behavior Change was chosen to guide the selection of behavior change techniques, systematic long term change of behavior was guided by the stages of change presented by the Transtheoretical Model (Prochaska and DiClemente 1982). Following the principles of the Transtheoretical Model, the intervention features and content are tailored based on the ‘current’ stage of the participant.

The Persuasive Systems Design Framework (Oinas-Kukkonen and Harjumaa 2009) and the Internet Intervention Model (Ritterband et al. 2009) were used to ‘translate’ the behavior change techniques to software features to be included in the prototype system and act as a checklist of characteristics of successful behavior change applications.

The Fogg Behavior Model (Fogg 2009) helped guide the moment at which the ‘trigger’ needs to be served, to enable successful behavior change. The model asserts that for a target behavior to happen, a person must have sufficient motivation, sufficient ability, and an effective trigger. These three factors must occur at the same moment; else the behavior will not happen.

C. Content for the Prototype

The last dimension of the ontology (Health Behavior Change) identifies the various major domains of health behavior change. The prototype developed can be used for any health behavior change domain and any population. For the purpose of this study and to enable an evaluation, the prototype targeted increasing physical activity levels of people with physical disabilities. The necessary content and domain specific expertise was provided by the National Center on Health, Physical Activity and Disability, a CDC funded national health promotion initiative for people with disabilities (Rimmer and Braddock 2002).

D. Architecture of the Prototype

The architecture employed for the development and deployment of the prototype can be seen in Figure 8.

The architecture comprised of a web layer hosted as an Ubuntu (Thomas et al. 2009) based micro sized server deployed on Amazon's EC2 (Juve et al. 2009) platform. The server has three different virtual web servers running Nginx (Reese 2008), all running on https. As shown in the figure, one web server was used for production, one for staging and one for testing (Bailey, Cohen, and Stodolsky 2005). This made it possible to first develop and test any changes on the test server, then push the changes to the staging server that mimics the production server in every way and finally push the change to the production server. The web servers were all connected to a cache server. The cache server was an Amazon ElastiCache (Raghavan, Chandra, and Weissman 2014) server of micro size and used Memcached (Fitzpatrick 2004). The key mechanism used was made to include the testing/staging/production servers identification and

thus avoid any potential accidental cache rewrites (Qureshi and Patt 2006). The web layer connected to an Amazon RDS server (Strauch et al. 2011), which ran MySQL 5.6 (Schwartz, Zaitsev, and Tkachenko 2012). The DB layer also used distinct testing, staging and production databases.

Git based bitbucket.org was used as a version control and deployment mechanism (Loeliger and McCullough 2012). Three repositories to match the testing, staging and production environments were created. All deployments of changes were first pushed to the respective repository and pulled over Git.

The Model-View-Controller (MVC) architectural framework was used for the server side programming (Curry and Grace 2008, Deacon 2009, Krasner and Pope 1988, Leff and Rayfield 2001). Briefly, MVC is a software design pattern that divides an interactive application into three distinct components: 1) model – performs data processing based on requests from the controller, 2) view – handles returning the output to the user, and 3) controller – handles input or interactions from the users. PHP (Ullman 2004) was used as the server side scripting language.

The prototype made extensive use of The Facebook SDK for PHP, which provides developers with a modern, native library for accessing the Graph API (Wang et al. 2013, Reuter and Scholl 2014). The prototype was deployed as a Facebook Canvas Application.

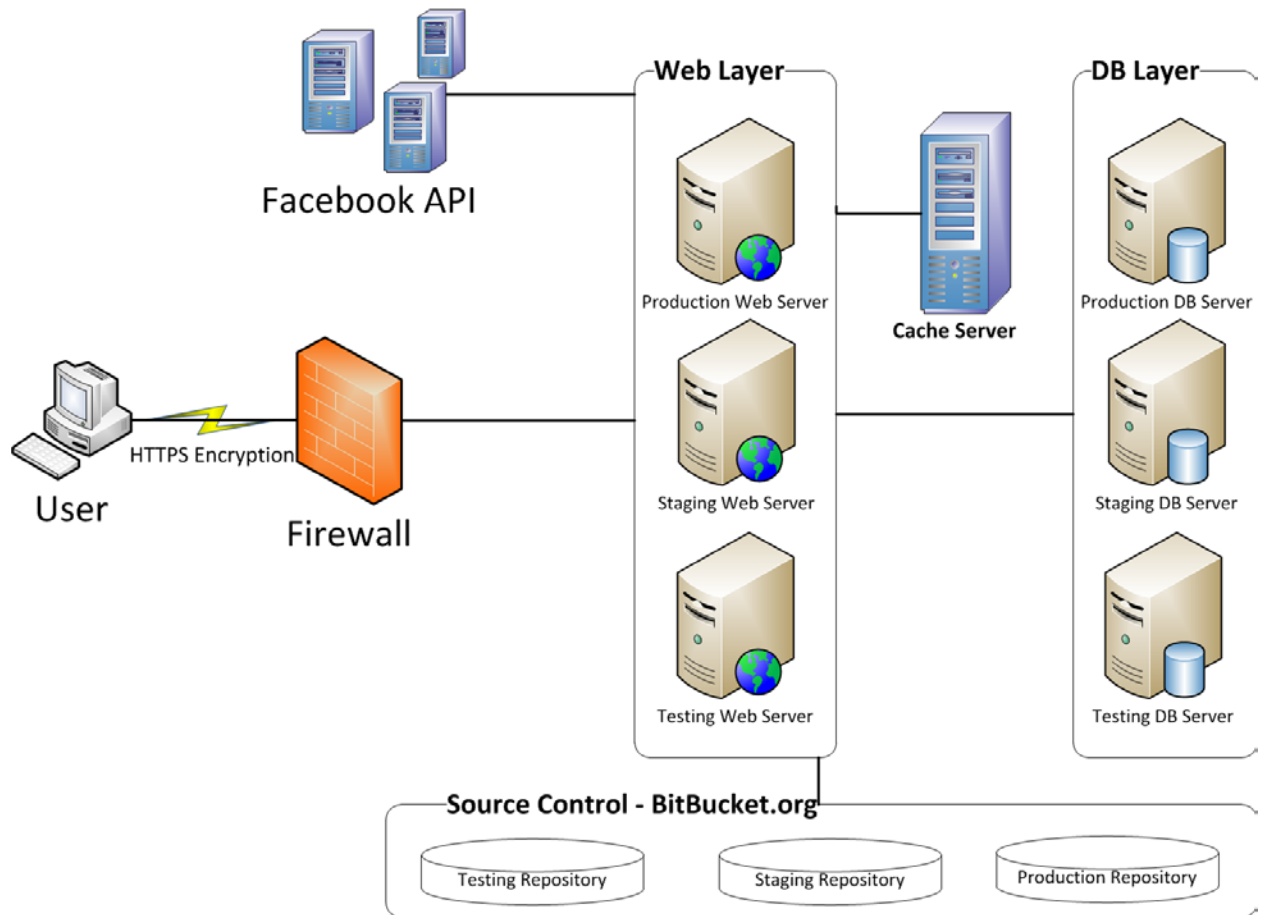


Figure 8: Architecture used for development and deployment of the prototype.

To ease the implementation of the Model-View-Controller architectural pattern and accelerate the development of social media features, the Elgg framework (Balaban and Bubas

2010, Berry 2006, Bryant 2006, Costello 2012, Garrett et al. 2007, Hoffman 2009, Sharma 2008) for PHP was used. The client side design and development made use of the jQuery framework (Paddock and Petersen 2012).

Elgg can be downloaded publicly (<https://elgg.org>) and is available with bundled plugins that make typical social networking scenarios possible with reasonable effort of programming. An overview of the features readily available in Elgg and features for which customized plugins were developed is presented below.

E. Features of the Prototype

The final list of features for the developed prototype was dictated by the above established design-guiding theories, models, and frameworks. Table I below lists the social media affordances and health behavior change techniques (from the ontology) and the matching features that have been included in the prototype.

All features included in the system as shown in Table I have been employed by several research studies. All social media features included in the prototype are standard features included in popular social networking sites such as Facebook and detailed by the literature (Kaplan and Haenlein 2010, Boyd and Ellison 2007, Kietzmann et al. 2011).

Personalizing content using condition-specific personalized/tailored exercise videos has been successfully used in several research studies (Camerini et al. 2011, Geraedts et al. 2014), while

the prototype took the personalization several steps ahead by matching the videos to users' functional capabilities. Increasing self-efficacy and outcome expectance was made possible by educating users through videos, textual articles, and personal stories (Schunk and Zimmerman 2007). All users were required to set their goals during registration (Stenström 1994). Self-monitoring was implemented using physical activity and nutrition logs (Burke, Wang, and Sevick 2011). The behavior change technique of management of emotional response was delivered through textual articles and personal stories (Bailey 2004). Planning was made possible through an exercise scheduling system with notifications capability (Scholz et al. 2008). The stages of change questionnaire that included questions about users' current physical activity was administered every four weeks to enable self-evaluation (Prochaska and DiClemente 1982). Badges were used for social influence (Poirier and Cobb 2012). The social networking capabilities were designed to offer social support (Park, Kee, and Valenzuela 2009). A detailed explanation of the features and screenshots is included in this section.

Elgg was not created to be a platform for conducting research, thus several deep-rooted changes had to be made to make it possible to build a prototype in accordance to the terms of the Institutional Review Board's approval. An overview of the prototype's programming efforts and the resultant capabilities is presented below.

The first significant customization involved not collecting any information (for research purposes) about the user unless they have passed the inclusion/exclusion screening and digitally signed the informed consent. While this could be solved by isolating these steps as outside of

the scope of Elgg, the user burden would increase as data submitted as a part of the screening process is needed for data analysis (after consent) and would require the user to enter the same information twice. Thus, a custom plugin was developed to enable data storage temporarily in a session variable and after consent, data are moved to the matching Elgg user's profile.

Protective mechanisms were established to prevent returning users from repeating the screening/consent process. To reduce confusion for returning users, only a login button was displayed and the register button removed, whenever detected. Whenever possible, auto-login was performed to reduce the number of clicks required to get started with a session. All user authentications were performed by using the Facebook SDK. A custom plugin was developed, enabling the Facebook-based authentication. A sample landing page, which shows both the register (screening) and login buttons, is shown in Figure 9 below.

After passing the screening and providing consent, a login screen from Facebook was presented if the user was not logged into Facebook. If the user was already logged in, a screen was presented to the user by Facebook (Figure 10) asking for permission to allow information sharing. The screen clearly mentioned that this application would not be able to post any information to the user's Facebook. The application was configured as a Game on Facebook, as Facebook allows only games to use its notification system (explained in a later section).

Table I**DESIGN RECOMMENDATIONS AND MATCHING FEATURES**

| Design Recommendations from Ontology | Features |
|---|--|
| Social Media Affordances | |
| Identity | Profile Pages |
| Conversation | Comments, Private Messaging |
| Sharing (content) | Posts, Blogs |
| Presence | Instant Messaging (Chat) |
| Relationships | Friends |
| Reputation | Likes |
| Groups | Groups |
| Behavior Change Techniques | |
| Personalizing Content | Tailored exercise videos |
| Increasing Self-efficacy | Step by step instructions and Personal stories |
| Improving Outcome Expectancy | Textual articles and Personal stories |
| Goal Setting | Goals as a part of profiles |
| Self-Monitoring | Physical activity and nutrition logging |
| Decision Making | Textual articles and videos |
| Planning | Exercise scheduling |
| Self Evaluation | Monthly questionnaires |
| Management of Emotional Response | Textual articles and Personal stories |
| Social Influence | Badges |
| Social Support | Likes on activities |

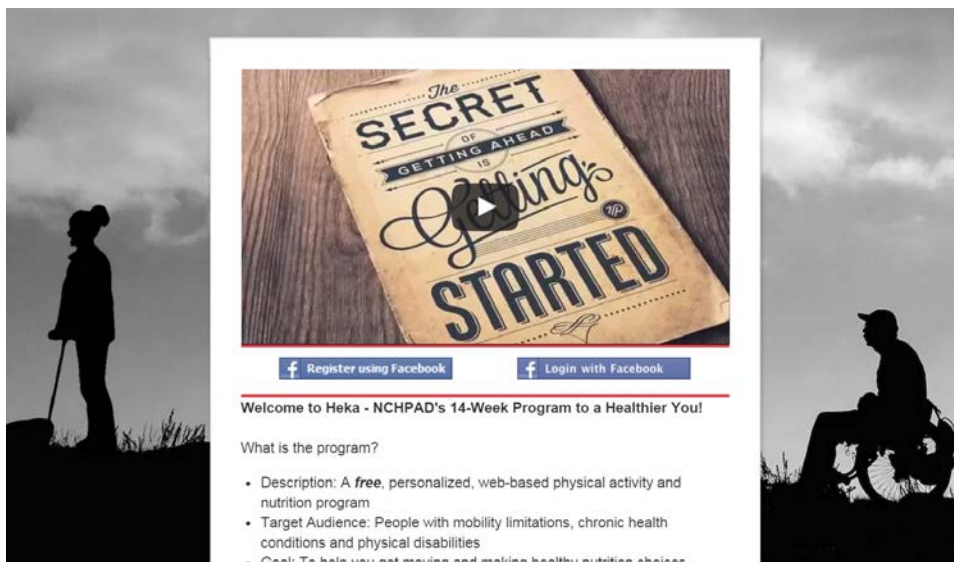


Figure 9: Screenshot of the prototype showing the Login/Registration page.

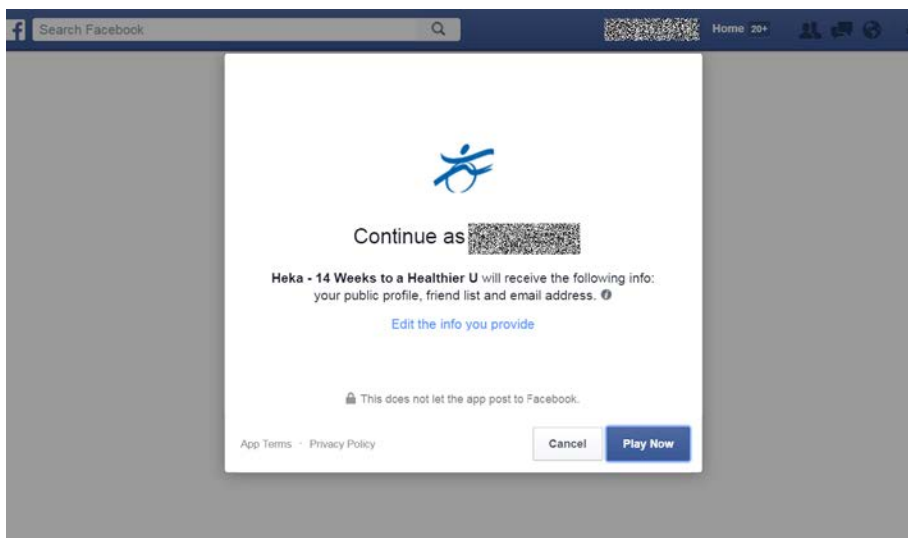



Figure 10: Screenshot of Facebook permissions screen.

After successful login, the user is immediately intercepted by screens that allow the user to enter their demographics and other baseline measures (explained in the next section). At any point the user is due for data collection, the application goes into a lockdown mode, wherein clicking any button on the screen brings the user back to the same data collection screen. To avoid any missing data, the same approach is used for data collection throughout the course of the intervention. A screenshot of one such data collection screen is shown in Figure 11. All screens past the login have a right hand sidebar, while the data collection screens do not have the sidebar.

After completion of all required data collection screens, the user is presented with the home page (while logged in) of the prototype. A sample homepage of a user who is midway through the program is presented in Figure 12, to show the various information that eventually is shown on the home page as the intervention progress. To enable easy explanation of the various portions of the homepage, green colored numbers have been overlaid on the screenshot. This screenshot was taken after the intervention was completed for all registered participants. Several portions of the screenshot have been blurred to ensure privacy.

POWERED BY
NCHPAD 14 WEEKS

ActivityBlogsBookmarksGroupsMembersPosts

HomeMy ProfileMy LogsCardioStrengthFlexibilityMind/BodyNutritionMy FavoritesResources

How Active are YOU?

* - Required Questions

Physical activity or exercise includes activities such as walking briskly, wheeling fast, handcycling, bicycling, jogging, swimming or any other activity in which exertion is at least as intense as these activities.

» I am currently physically active.*

☐ No
☐ Yes

» I intend to become more physically active in the next six months.*

☐ No
☐ Yes

For activity to be *regular*, it must add up to a total of 30 minutes or more per day and be done at least five days per week. For example, you could take one 30-minute walk/wheel or take three 10-minute walks/wheels for a total of 30 minutes.

» I currently engage in *regular* physical activity.*

—

Figure 11: Screenshot of a sample data collection screen.

The screenshot shows the HEKA - 14 Weeks to a Healthier YOU! homepage. The user is logged in, and the page displays various challenges and resources for the 9th week.

Navigation Bar: HEKA - 14 WEEKS, Activity, Blogs, Bookmarks, Groups, Members, Posts.

Main Content Area:

- How are you being healthy?** (Section 4)
- Quote:** "Take care of your body. It's the only place you have to live." - Jim Rohn (Section 5)
- My Goals:** My primary goal in registering for this program:
 - To be physically active
 - To eat a healthier diet
- My Schedule:** My weekly workout schedule: Tuesday at 12:00 pm (Section 7)
- Top Points:**
 - Henry: 4530 points
 - Happy: 1410 points
 - new: 900 points
 - WIKIKA: 750 points
 - Ulice W: 575 points
- Weekly Physical Activity Challenge:** A grid showing challenges for different days of the week, including activities like Cardio, Strength, Flexibility, and Mind/Body.
- My Badges:** A collection of achievement badges (Section 17).
- Week 9:** A video introduction for Week 9 (Section 18).
- Resources:** A list of resources including "Spinal Cord", "Aerobics video", "Interval videos", "Cardio resources", "Strength exercises", "Mind/body exercises", "Recipes", and "Nutrition resources".
- Latest Blog Posts:** A list of recent blog posts, including "Quick & Easy Soup" (Section 16).
- Latest Groups:** A list of recent groups.

Recent Activity (Section 19):

- getrich has a new profile (16 hours ago)
- getrich bookmarked HEKA (16 hours ago)
- Time to EXERCISE!
- HEKA - 14 Weeks to a Healthier YOU! (Section 21)
- Very posted to Post 8 days ago
- Costa Sore trait
- Very posted to Post 11 days ago
- I am back! Let's lose the weight together!
- Very posted to Post 13 days ago
- DEPRESSED

Footer: Proper precautions must be taken before you begin an exercise program. An understanding of your current health status and potential problems is necessary for you to exercise safely. Please contact your physician if you have any concerns. This program is intended to incorporate physical activity into your daily life, but should not be used in place of physical therapy, professional medical advice or treatment. Privacy Policy (Section 22). Contact Us: 9am CDT to 5pm CDT 1-800-900-8086.

Figure 12: Screenshot of Homepage for a logged in user in his/her 9th week.

1. The top bar contains site level notification elements (on the left) and access to the user's account (on the right). Whenever the user is added as a friend by another user or? receives a message or any notification from the system, a red colored notification is received by the user. In the screenshot shown, the user has 6 pending notifications from the site waiting to be read. A sample expanded view of the notification can be seen below in Figure 13.

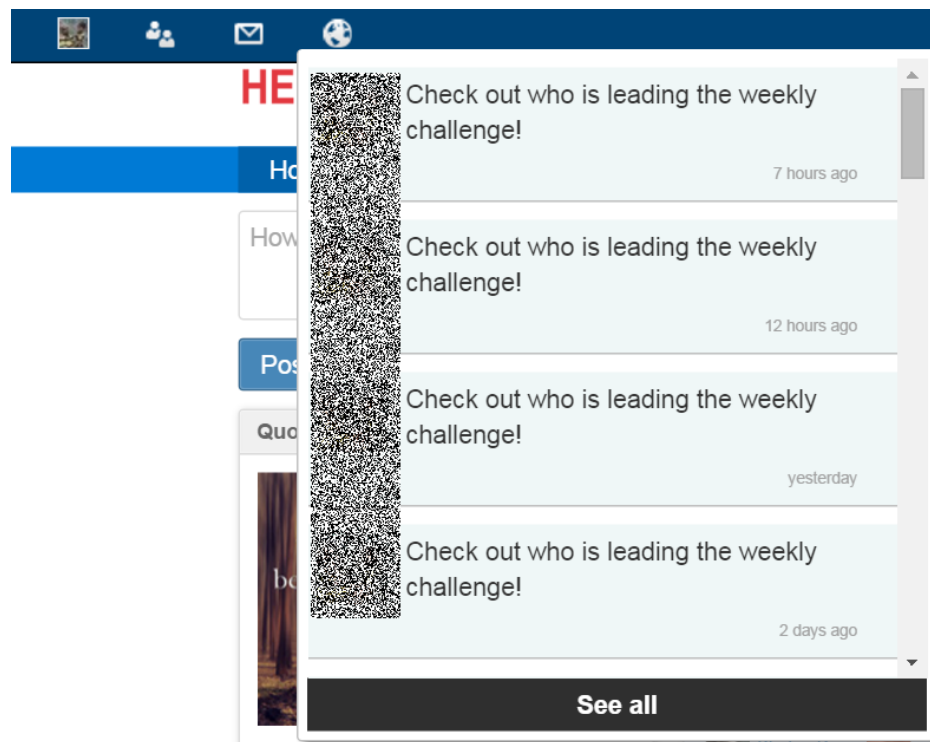


Figure 13: Expanded view of notification.

2. The gray colored top menu bar contains direct links to social media features. Clicking on the activity button, shows all types of social media activities on the site, which can be filtered to show the activities of only the user, the user's friends or everyone in the site (if their privacy setting allowed). Filtering by the type of activity is also possible.

Figure 14 below shows this.

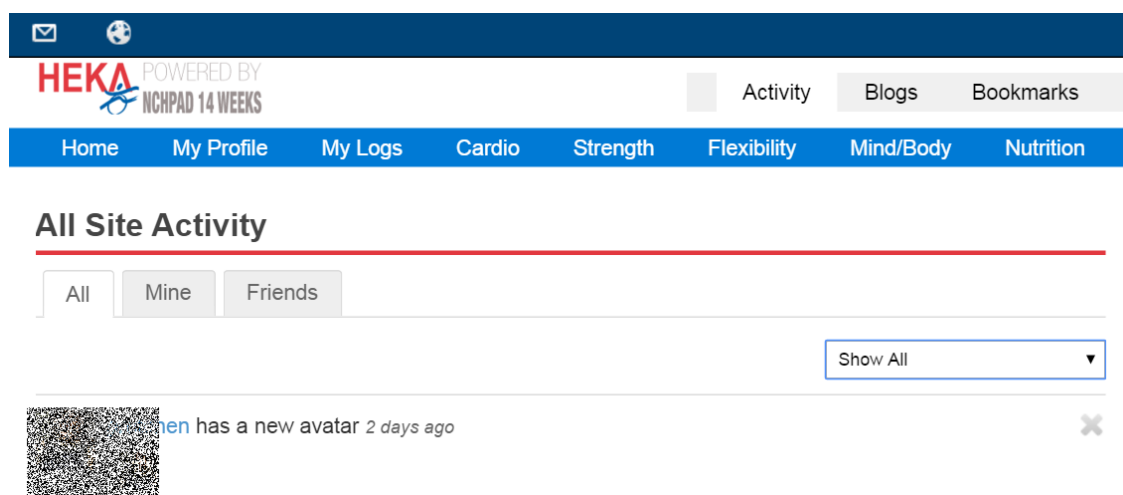


Figure 14: Activity feed of all users.

Similarly, clicking on Blogs, Bookmarks, Blogs, Groups or Posts shows the appropriate page, with the possibility to filter as in Figure 14. Blogs allow users to create extended pieces of text, which can contain images and/or videos. Blogs represent the Sharing element of the Affordances dimension of our ontology. Bookmarks allow users to quickly pin any internal or external links of interest, which can then be reused by the user or shared with other users. Bookmarks also represent the Sharing element of the Affordances dimension of our ontology. Groups is a feature where a user can add other users to form a network and perform all site activity within the group. This represents the Group element of the Affordances dimension of our ontology. Members button allows users to see other profiles of other members and friend them if interested. This represents the Identity and Relationships elements of the Affordances dimension of our ontology. The Posts button takes the user to a page to create and read short blurbs of information (similar to Twitter). This again represents the Sharing element of the Affordances dimension of our ontology.

3. The blue colored top bar contains links to the various intervention features mainly corresponding to the Knowledge & Beliefs and Self-Regulation elements of the Phases dimension of our ontology. My Profile contains basic profile information and other personalization choices that result in tailoring the content presented to the user.

Figure 15 shows the information collected from the user to tailor the content.

HEKA

Activity Blogs Bookmarks Groups Members Posts

Home My Profile My Logs Cardio Strength Flexibility Mind/Body Nutrition My Favorites Resources

Let's Start Customizing ...

* - Required Questions

» Please change your display name to your favorite nick name. This is the name by which other users in this site will identify you.*

» About Me*

Please provide a brief introduction about you. This will help others to discover you and help you make friends.

B I U F S

» What is your gender?*

☐ Female

☒ Male

» Please indicate your level of use of each of the following body segments.

Full use means that you are able to actively move that body part with control and in all directions without assistance from another person or an assistive aid.

Partial use means that you are able to actively move that body part, but movement may be difficult, your control may be more limited, and you may not be able to move it in all directions. You may need some assistance from another individual or an assistive aid for these functions.

No use means that you are not able to actively move that body part on your own. You would need full assistance from another individual or an assistive aid to move that body part.

Head/Neck*

☒ Full Use

☐ Partial Use

☐ No Use

Arms*

☒ Full Use

☐ Partial Use

☐ No Use

Legs*

☒ Full Use

☐ Partial Use

☐ No Use

Trunk*

☒ Full Use

☐ Partial Use

☐ No Use

» Are you able to stand? (This can mean standing with assistance such as a cane, walker, or other balance support.)*

☒ Yes

☐ No

» What is your primary goal in registering for this program?

☐ To lose weight

☒ To be physically active

☒ To eat a healthier diet

☐ To improve my quality of life

☐ To improve my physical function

☐ To improve my self-esteem and confidence

» What hobbies and interests do you have or would you like to learn more about?

☐ Outdoor activities

☐ Indoor activities

☒ Team sports

☒ Individual sports

☐ Water activities

☐ Group exercise classes and/or exercise equipment

Save

Proper precautions must be taken before you begin an exercise program. An understanding of your current health status and potential problems is necessary for you to exercise safely. Please contact your physician if you have any concerns. This program is intended to incorporate physical activity into your daily life, but should not be used in place of physical therapy, professional medical advice or treatment. [Privacy Policy](#)

Friends Online (or Chat: 0)

Figure 15: Information collected from users to tailor intervention content.

My Logs contains features to log both physical activity and nutrition. The physical activity logs allow users to record their physical activity minutes classified as cardio, strength, flexibility, mind/body or other activity and also the users' subjective views on how active or sedentary they were for the day. Users are able to return to previous days to log missed days. The nutrition logs allow users to record their food consumption for breakfast, morning snack, lunch, afternoon snack, dinner and evening snack. If the food item is not available in the database, users are allowed to save their own recipes and the system calculates the nutritional values of the recipe. Users are also able to log their own meals, which represents a combination of food items users consumed often. The system shows the calories and other nutrients consumed in a day and how much more can be consumed based on a 2000 calorie diet. A summary representation of the above mentioned logging capabilities can be seen in Figure 16.

Physical Activity Log

[Logs Home](#)
[Physical Activity Log](#)
[Nutrition Log](#)
[My Meals & Recipes](#)

In the form below, choose the date for which you would like to record your activity. Then, record the number of minutes you spent doing each type of physical activity. After that, include any comments about the activity you did. These comments can be as brief or as detailed as you would like and often include information such as: the specific activity you did, how difficult it was, what equipment you used, and how you felt. Finally, record how active you felt you were that day on the sliding scale and click submit. Your activity for the day will be saved and added to the chart so you can visually see how you are doing.

Date : 2016-01-23 Saturday (Today)

| Type | Minutes | Comments |
|----------------|---------|----------------------|
| Cardio | 0 ▾ | <input type="text"/> |
| Strength | 0 ▾ | <input type="text"/> |
| Flexibility | 0 ▾ | <input type="text"/> |
| Mind/Body | 0 ▾ | <input type="text"/> |
| Other Activity | 0 ▾ | <input type="text"/> |
| Total Minutes | 0 | <input type="text"/> |

How active were you today? Sedentary ▾

PHYSICAL ACTIVITY LOGGING

**Note that your friends will be able to view your Physical Activity logs (NOT nutrition logs)

[Submit](#)



Date: 2016-01-23 Saturday (Today)

Select food item: [Select](#)

Portion: Servings: Meal: [Add](#)

OR

DAILY NUTRITION LOGGING

Add from your Meals & Recipes

You have not added any of your favorite favorite recipes or meals. Want to add one? [Click here](#)

Your food consumption for 2016-01-23 (Saturday)

| Food Name | Calories | Carbs (g) | Fat (g) | Protein (g) | Sodium (mg) | Fiber (g) | |
|---------------------------------|----------|-----------|---------|-------------|-------------|-----------|------------------------|
| BREAKFAST | | | | | | | |
| Apples, raw, with skin | 56 | 15 | 0 | 0 | 1 | 2 | Delete |
| Breakfast TOTAL | 56 | 15 | 0 | 0 | 1 | 2 | |
| Recommended Daily Value* | 2000 | 300 | 65 | 50 | 2400 | 25 | |
| Your TOTAL Intake | 56 | 15 | 0 | 0 | 1 | 2 | |

*Recommended daily values are based on a 2,000 daily caloric intake and may not be suitable for all individuals.

[Done](#)

Save your favorite recipes and meals so that you could quickly add them to your nutrition diary. For example, if you often eat two eggs and a banana for breakfast, you could save it here possibly with a name like "Eggs & Banana". If there is a favorite recipe of yours and is not included in our food items, you can save your recipe ingredients here as well!

Recipe or Meal Name:

Add Food Item: [Select](#)

Portion: Servings: [Add](#)

[Delete this Meal or Recipe](#)

CUSTOM MEAL/RECIPE CREATION

| Food Name | Calories | Carbs (g) | Fat (g) | Protein (g) | Sodium (mg) | Fiber (g) | |
|--|----------|-----------|---------|-------------|-------------|-----------|------------------------|
| Egg, whole, raw, fresh | 160 | 0 | 10 | 14 | 159 | 0 | Delete |
| Milk, whole, 3.25% milkfat, with added vitamin D | 111 | 8 | 5 | 5 | 78 | 0 | Delete |
| Pumpkin, raw | 60 | 15 | 0 | 2 | 2 | 1 | Delete |
| TOTAL | 331 | 23 | 15 | 21 | 239 | 1 | |

[Return to Nutrition Log](#)

Figure 16: Summary of My Log features.

The Cardio, Strength, Flexibility, Mind/Body and Nutrition links lead the users to pages containing respective video content tailored to the information collected using the My Profile page. The videos are all tagged to present the users with the most appropriate exercise recommendation; for example, if an exercise requires a user to be able to stand

to perform and the user indicates the inability to stand (My Profile page), the system will not show such an exercise, but will attempt to find an adaptation of the exercise that doesn't require standing. Every week, new videos are added, and carry a "New" tag. Figure 17 shows a sample video menu page for flexibility exercises. Weekly new test resources are also offered through the right side sidebar.

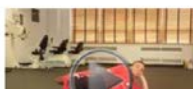
Flexibility Videos

Flexibility is just another way to talk about your ability to move each of your joints through a full range of motion. Adding flexibility training into your comprehensive exercise program can improve physical performance, decrease the risk of injury, reduce muscle soreness, improve posture, reduce the risk of lower back pain, improve muscle coordination and enhance enjoyment of physical activity.

Upper Body Exercises



Lower Body Exercises



Core Exercises



[Invite Facebook Friends](#)
[Live Help Offline](#)
[Bookmark this Page](#)
[Report this Page](#)

Flexibility Resources

Types of Stretching

The purpose of stretching is to increase your flexibility, or the amount of movement at each of your joints, by lengthening your muscles and all of the connective tissues surrounding your joints. Stretching comes in many different shapes and sizes, all of which lead to many benefits. Read this resource to learn all about different types of stretching.

Getting Started

Starting a new physical activity program can be both exciting and a

Figure 17: Sample video menu page for flexibility exercises.

The My Favorites and Resources present a quick way for users to access all the textual resources and users' favorite video content.

4. The home page contains a feature for quickly posting an update (post) and has a leading text that reads "How are you being healthy?"
5. The home page displays a random quote aimed at motivating the users. The quotes were programmed to refresh every time the user visits the homepage and to not repeat any quote unless every other available quote has been displayed.
6. The goals indicated by the user as a part of the My Profile are displayed every time the user visits the home page. This was meant to serve as a regular reminder to the users of their purpose behind using this program.
7. Users are able to set up a workout schedule, based on user preferences, reminders are sent through the site's notification system and also the Facebook notification system. An overview of the exercise scheduling capabilities and the notifications can be seen in Figure 18.

Exercise Scheduler

Schedules help everyone to keep on track in all aspects of life, including physical activity. This is a space where you can plan out your physical activity and create a schedule to help keep yourself accountable. This section can be edited from day to day if you choose, or you can keep the same weekly schedule throughout the program. To add multiple sessions per day, click the "add exercise session" feature. This feature is another way to help you reach your health lifestyle goals!

Do you need help remembering your physical activity schedule? Would you like to receive reminders before each of your scheduled activity sessions? Starting next week, you can receive reminders prior to the times you have added into your schedule here. If you would like to take advantage of this option, please check the appropriate box below.

SUNDAY

Exercise at: 9:00 am ▼ Remind me: 1 hour before ▼ [Cancel](#)

[Add Exercise Session](#)

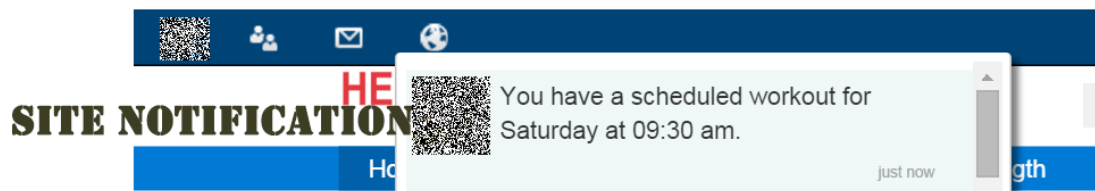
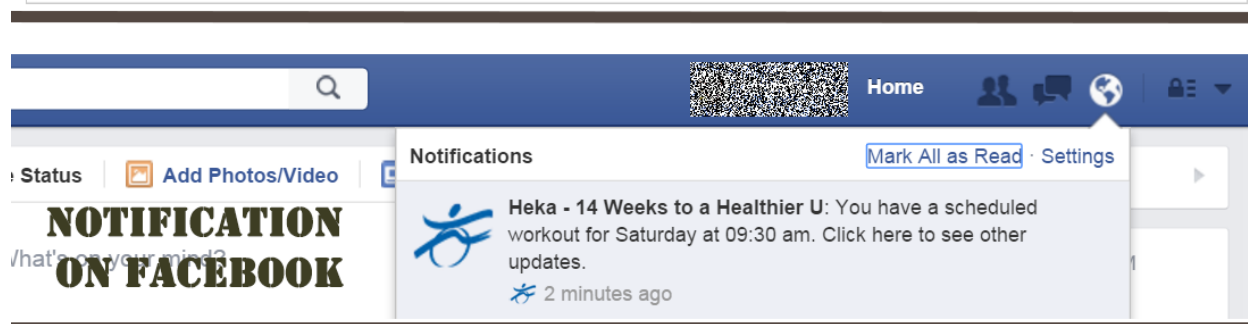


Figure 18: Exercise scheduling and notifications overview.

8. Users are awarded points for various actions they perform on the site. The points are set based on the amount of efforts required to perform the action.
9. A weekly physical activity minutes challenge is conducted among friends and daily notifications about the user's status in the challenge are sent. The home page shows the minutes logged by all the friends, last week's winner and the time period left in the current week's challenge to end. Figure 19 shows a sample notification received by a participant indicating their progress.

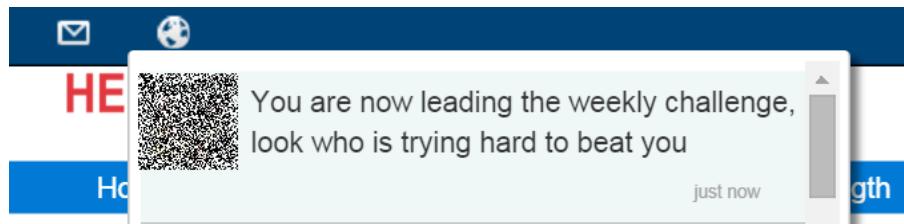


Figure 19: Notification about a participant leading the weekly challenge.

10. The right sidebar of all pages carries a distinct peach colored button that reads “Invite Facebook Friends”. With the developed prototype trying to study the effects of the presence of pre-existing social contacts as a part of a health behavior change program,

the ease of inviting friends is critical. Clicking on the button creates a window in Facebook, which allows the user to choose the friends to share and personal message to add. Figure 20 shows the friends invite window on Facebook.

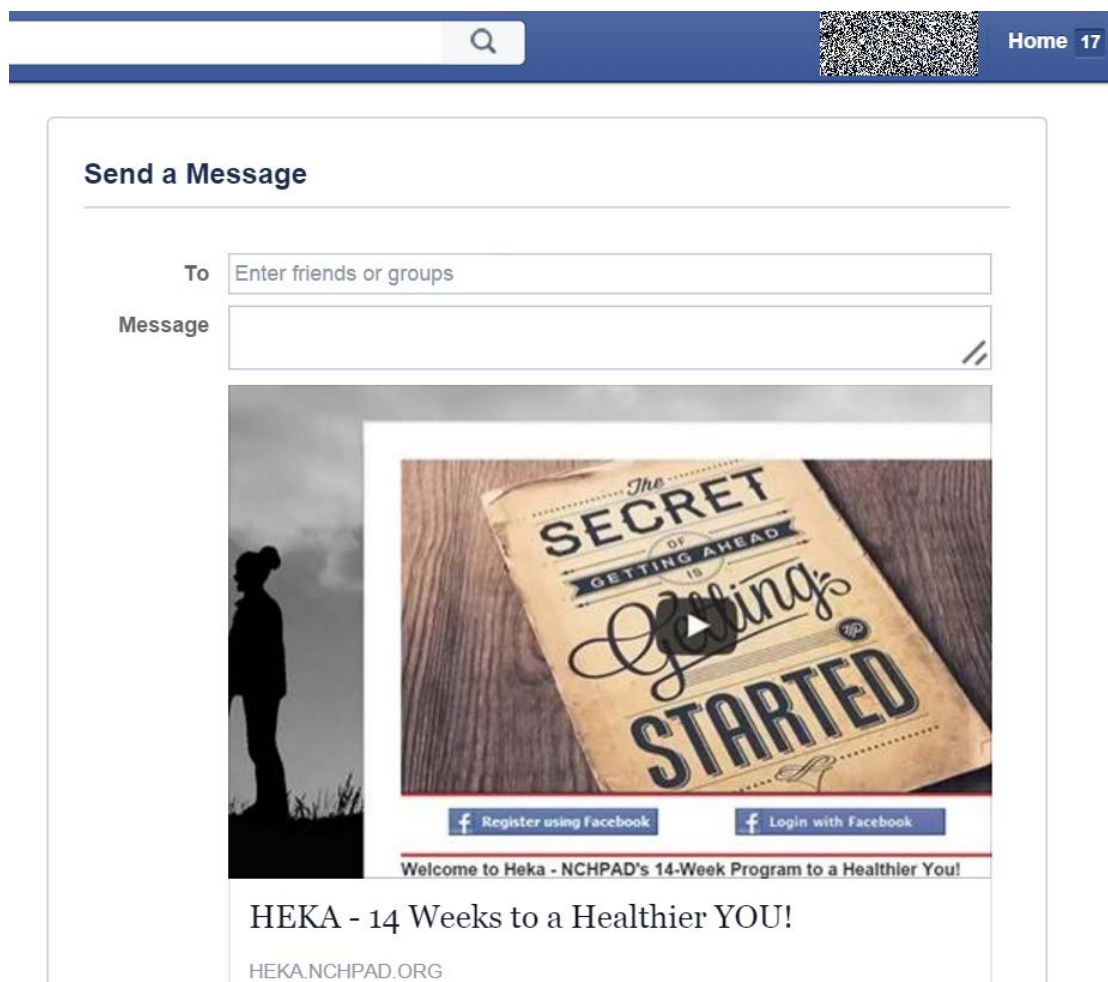


Figure 20: Screenshot from Facebook window to invite friends.

11. During business hours, live help over chat is also made available. This is made possible with the help of the staff at The National Center on Health Physical Activity and Disability.
12. Personal stories of individual journeys towards improved levels of physical activity and nutrition are presented on every login on the home page. The stories were stage matched, i.e., the user's Stages of Change and the story's Stages of Change were matched.
13. Weekly, a text based motivation resource is also made available through the home page.
14. To make it easy for the current members of the site to easily identify the newest members of the site and to promote relationships, the profile links to the newest members are displayed on the home page.
15. The most recent groups that were created are also displayed on the home page to help users find about the creation of the group and encourage their participation.
16. Similarly, the most recent blog posts are displayed on the home page as well.

17. In addition to the points mechanism, which is based on the social media activity, badges are awarded for various other aspects of the intervention. As examples, setting a goal, logging X minutes of exercises, completing all weekly intervention content, etc. resulted in badges. Users are able to scroll the mouse over the badges to learn the reason for the award. Figure 21 shows the badges accumulated by one of the participants.

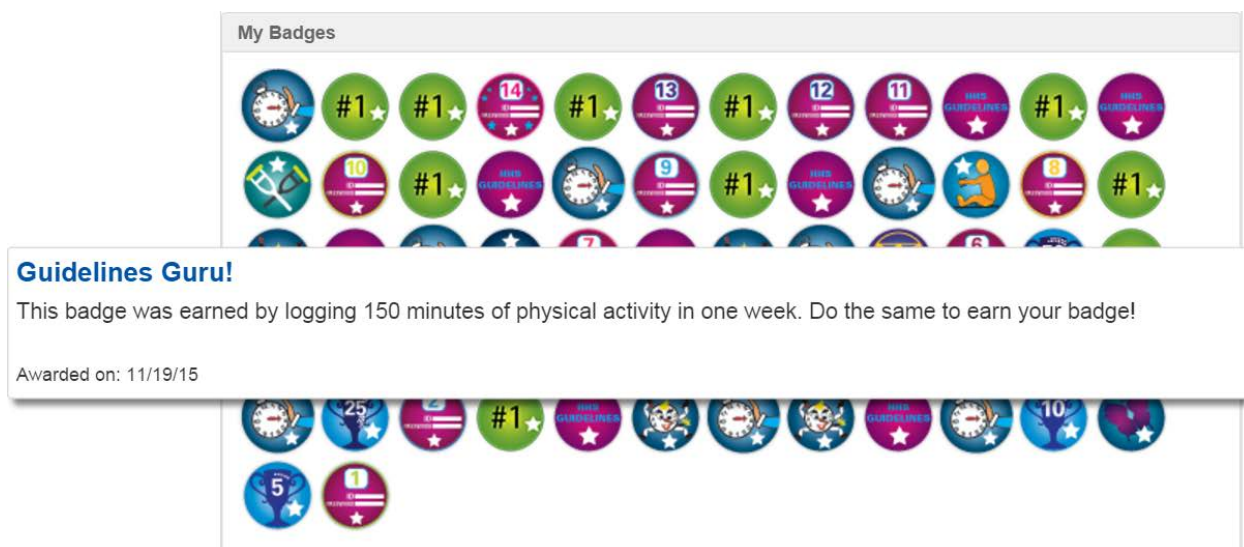


Figure 21: Screenshot of badges earned by a participant.

18. A weekly introductory video that summarizes all newly posted materials is made available on the home page. This video is meant to provide the user with motivation and keep them informed on the progress thus far. The video is accompanied by text that lists out all the newly released content for the week.
19. A small five-item feed of the most recent social network activity is also made available on the home page. This is meant to promote participation, if the user and the poster are not friends.
20. Users are able to comment on blog posts, bookmarks, and other intervention content posted. Similarly, users are also able to “like” other users’ activities.
21. Instant visual thumbnail and textual preview are enabled for any link posted to the site.
22. The footer carried a disclaimer, provides links to the privacy policy and also a number to call for more questions.
23. A bottom bar, which stuck to the bottom of the window even when scrolled, is enabled and shows the number of friends who are online. When friends were online, users are able to chat synchronously.

All notifications sent to Facebook contained a clickable link that leads to a Facebook Canvas Application (categorized as a game) as required by Facebook. A mini version of the home page, carrying elements that frequently changes is featured in the Facebook specific home page.

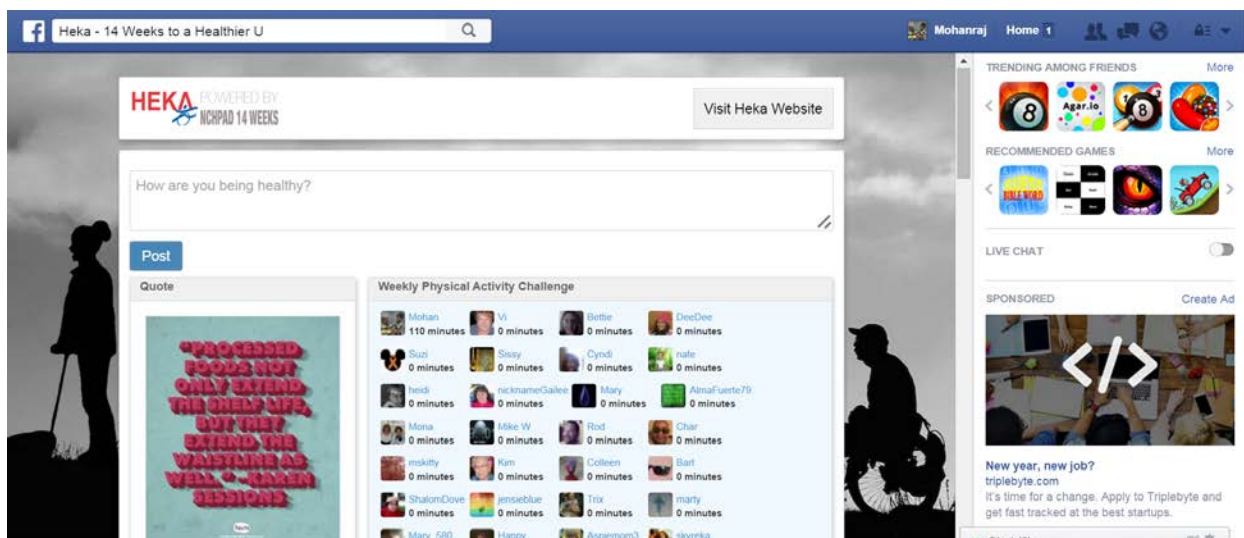


Figure 22: Home page with the Facebook canvas

F. Measures

A sound evaluation of the developed prototype is critical to demonstrate the success or failure of the developed prototype. Any system's success or failure is first evaluated by measuring its usability (Brooke 1996). Engagement in self-management behaviors is seen as the proximal outcome influencing the long-term distal outcome of health behavior change (Ryan 2009). Thus, an evaluation of the engagement offered by the prototype becomes essential. The effect of social media in a health behavior change system is expected to influence the social support, which is proven as a strategy to improve health (Reblin and Uchino 2008, Cavallo et al. 2013). Thus, perceived social support was also chosen to be evaluated. The security and privacy risks posed by social media, especially in a healthcare setting are substantial and when left unattended, can lead to a serious breach of trust amongst the users (Williams 2010, Williams and Weber-Jahnke 2010). To this effect, perceived privacy was also evaluated. All evaluations were conducted after 12 weeks of usage of the prototype.

1. Quantitative Measures

Sociodemographic information such as age, gender, disability status, etc. was collected. Usability of the proposed system was quantitatively evaluated using the System Usability Scale (SUS) (Brooke 1996). The SUS is a simple, ten-item Likert scale, giving a global view of subjective assessments of usability. Various studies have shown that the SUS is a highly robust and versatile tool for usability professionals (Bangor, Kortum, and Miller 2008). The SUS produces a score ranging 0 to 100, which can be compared to the reported average SUS score of 68, to produce normalized percentile scores (Sauro 2011). The SUS scale is generally used after

the respondent has had an opportunity to use the system being evaluated, but before any debriefing or discussion takes place (Brooke 1996). Figure 23 shows the system usability scale.

Engagement in online health behavior change systems is a major topic of interest, thus a very rigorous analysis of ‘patterns of engagement’ in the system is vital to engagement evaluation. Morrison et al. in their recent article titled ‘Analyzing Engagement in a Web-Based Intervention Platform Through Visualizing Log-Data’ presented a cutting edge exploratory methodology to visualize engagement (Morrison and Doherty 2014). The approach uses log data to better understand the process of engagement and patterns of use. The method uses exploratory sequential data analysis to highlight sequential aspects of the log data, such as time, to provide insights into engagement. They present four exploratory visualizations that allow inspection of content or feature usage, detection of different patterns of use to consider personalization in future design process, and detect usability issues (Morrison and Doherty 2014). The system was designed to collect anonymized and detailed system usage data.

| | Strongly disagree | | | | Strongly agree |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1. I think that I would like to use this system frequently | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 2. I found the system unnecessarily complex | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 3. I thought the system was easy to use | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 4. I think that I would need the support of a technical person to be able to use this system | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 5. I found the various functions in this system were well integrated | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 6. I thought there was too much inconsistency in this system | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 7. I would imagine that most people would learn to use this system very quickly | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 8. I found the system very cumbersome to use | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 9. I felt very confident using the system | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |
| 10. I needed to learn a lot of things before I could get going with this system | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1 | 2 | 3 | 4 | 5 |

Figure 23: System Usability Scale

As seen in the literature review, the most significant expected contribution of the social media features of the developed prototype system is ‘Social Support.’ Thus, a preliminary evaluation of the system’s capability to offer social support was conducted as a proxy to the system’s capabilities to achieve the desired outcomes. Cavallo et al. examined the relationship between social support and physical activity, and found that encouraging companionship and esteem support (sub elements of social support) had a small, but significant effect on the physical activity levels in their Facebook delivered health behavior change program (Cavallo et al. 2013). Perceived social support for physical activity was measured using the positive subscales from Chogahara’s Social Influence on Physical Activity questionnaire with an internal reliability ($\alpha = .84-.90$) and test–retest reliability ($r = .75-.88$) (Chogahara 1999), which was later adapted for a college-aged population with an internal reliability ($\alpha = .85-.89$) for the modified subscales (Okun et al. 2003). Cavallo et al. adjusted wordings of the scale to reflect an online (Facebook) usage scenario and a six-week intervention period instead of the original six-month intervention period (Cavallo et al. 2013). The scale as used by Cavallo et al. has been used.

2. Qualitative Measure

As opposed to quantitative research, which is based on structured data, qualitative research is about exploring the issues and phenomena behind human behavior and answering questions by analyzing unstructured data (Berg and Lune 2004, Strauss and Corbin 1990). Qualitative measures have widely been used to better understand eHealth systems (2014, Ahern et al. 2013, Almunawar et al. 2012, Betsch, Renkewitz, and Haase 2013, Bondy and Bercovitz 2013, Franklin et al. 2008, Zhang, He, and Sang 2013, Stinson et al. 2010, Short et al. 2014).

In this study, semi-structured interviews (Bernard 1988) will be used to understand the phenomena behind the usability, engagement and perceived safety of the proposed system. Semi-structured interviews have the potential to provide a rich picture of any potential usability or privacy issues in the proposed system, and will also help understand how they lead to the engagement or disengagement with the program. Semi-structured interview is a formal interviewing method, where the interviewer develops and uses an interview guide. The interview guide is a list of questions and topics that need to be asked during the interview. The interviewer generally follows the guide, but is able to stray from the guide when he or she feels this is appropriate. Semi-structured interviews make it possible to collect all necessary data in one attempt from the responder, due to its structured format. Additionally, they make the responses from all respondents comparable, as all respondents have responded to a minimum common set of interview questions.

The interview guide of the semi-structured interview was modelled based on Short et al.'s research study titled 'Examining Participant Engagement in an Information Technology-Based Physical Activity and Nutrition Intervention for Men: The Manup Randomized Controlled Trial' (Short et al. 2014). Short et al. designed their interview questions to explore the attributes associated with participant engagement and disengagement in the intervention materials (Short et al. 2014). In addition to the questions used by Short et al., one question ('How secure did you feel using this system?') was added to understand the users' sense of perceived privacy in the system. This approach is chosen to measure perceived privacy rather than a direct question or

survey, based on the work of Braunstein et al. that shows that directly asking about a privacy issue may result in an emotional reaction and a biased response (Braunstein, Granka, and Staddon 2011). Leading questions about specific intervention attributes was avoided, and instead, questions were designed to allow participants to voice their own views, values, and experiences with standard prompting techniques as necessary (Short et al. 2014). Following are the questions from the interview guide:

1. What was the reason you participated in the study?
2. What did you expect to get out of the program?
3. What did you like about the program?
4. Did the program meet your expectations?
5. What did you like about the program?
6. How secure did you feel using the program?
7. What didn't you like about the program?
8. What would you suggest to improve the materials?

Short et al. note that questions 1 to 3 above help understand the 'points of engagement,' questions 4 and 5 help understand the phenomena behind 'engagement,' and questions 7 and 8 help understand the phenomena behind 'disengagement' (Short et al. 2014). Question 6 has been introduced to learn about the users' perception about privacy in the program and could contribute to either 'engagement' or 'disengagement'. Question 3 and 4 are the same, but used for different

purposes and thus posed to the user only once. The procedure followed in processing the interview data is presented in the section about data analysis below.

G. Sample Size

SUS Scale: Faulkner in his research on the optimal sample size for usability testing (using the SUS scale) indicates that a sample size of 20 is capable of finding a minimum of 95% of usability problems, while finding 98.4% problems as an average (Faulkner 2003). For this study, this scale would be presented to all participants of the study, dictated by the sample size requirements of the scales below.

Qualitative Interviewing: Following the methodology of Short et al., initially 20 participants will be interviewed, and the data will be checked for 'theoretical saturation' (Morse 2000). If saturation has not occurred, more participants will be interviewed as required.

Perceived Social Support: Sample size here is calculated on the assumption of an expected power of 80%, a one-sided paired t-test and type 1 error rate of 0.05. Data from Cavallo et al suggest that effect size (Cohen's d) for variables esteem support, companionship support, and informational support at approximately 0.4. Thus, assuming an effect size of 0.4 for our study, a sample size of 41 is required to detect an effect size Cohen's d of 0.4. This sample calculation was performed using the G* Power 3 software (Faul et al. 2007).

Attrition rates are considerable in online health behavior change studies (Maher et al. 2014), and though this research aims to reduce attrition, attrition needs to be assumed for sample size calculations. Based on the various studies included in Maher et al.'s systematic review, we assume an attrition rate of 40%, thus our above sample size of 41 increased to 58.

H. Recruitment

After IRB approval, recruitment for this study was performed through Facebook and the website of the National Center on Health, Physical Activity, and Disability. Users were able to 'invite' their friends to the study.

To qualify for the study, participants needed to be able to speak English, have a physical disability, have access to high speed internet and to a desktop or laptop computer, have an account on Facebook.com, be 18 years old or older, and be able to make independent decisions.

I. Data Collection

All quantitative measures were administered as an integral part of the prototype system, only upon consent to participate in the research study. Qualitative interviews were conducted over the telephone, and the conversation was recorded with participant consent (Bernard 1988) and IRB approval.

J. Data Analysis

All quantitative data analysis was performed using IBM's SPSS Statistics 22.0 (Field 2009). The SUS scale was scored using the scoring procedure established by Brooke, and the

normalized percentile score is reported (Brooke 1996). A paired t-test was conducted on the social support scale data using SPSS. Site usage statistics and the resulting engagement were obtained from the anonymized log data recorded.

The semi-structured interview recordings were transcribed and processed using QSR NVivo (Bringer, Johnston, and Brackenridge 2004, Richards 1999). More specifically, the transcribed interviews were coded using the engagement-specific coding schema used by Short et al. (Short et al. 2014). Additionally, NVivo's exploratory capabilities such as word cloud and other features were utilized to investigate for additional themes. Relevant qualitative findings are reported.

V. RESULTS

As a part of the research objective, a prototype holistic online health behavior change system with social media was developed. An evaluation of the developed prototype is necessary to demonstrate the success or failure of the developed prototype. To this effect, results generated from the evaluation of the usability (Brooke 1996), engagement (Ryan 2009), perceived social support (Reblin and Uchino 2008, Cavallo et al. 2013), and perceived privacy (Williams 2010, Williams and Weber-Jahnke 2010) is presented in this chapter. Additionally, demographic information and other relevant data collected from the participants are also presented.

A. Study Participation

Recruitment for the study was conducted primarily through Facebook posts. Table II below illustrates the number of participants who registered for the program, eligible for research, consented for research, completed baseline measures, and completed post measures. The study had an attrition rate of 29% with 19 participants who completed baseline measures not completing the post measures, resulting in a final sample size of $n=46$. With no means to contact the participants who dropped out of the study (as discussed in Chapter VI), the reason for the participants attrition remains unknown. The approval provided by the Institutional Review Board allowed the participation of research subjects in the intervention without being a part of the research data collection procedures. This available option was explicitly spelled out to the users in the consent form and perhaps explains the reason for nine users not consenting to research.

Table II
STUDY PARTICIPANTS SUMMARY

| Participants | n |
|--|----------|
| Registered for the Program | 93 |
| Met Eligibility Criteria | 84 |
| Consented for Research | 75 |
| Completed Baseline Measures | 65 |
| Completed Post Measures (Quantitative) | 46 |
| Interviewed (Qualitative) | 20 |

B. Participant Baseline Characteristics

A total of 65 participants completed baseline measures and their sociodemographic characteristics are presented in Table III below. The sex (male vs female) ratio of the participants is skewed. Similarly the number of users with limited or no use of their body segments and their standing ability (with assistive aids) is also of particular interest.

Table III
PARTICIPANT SOCIODEMOGRAPHIC STATISTICS

| Characteristic (n=65) | Total(%) |
|---|-----------------|
| Sex | |
| Male | 8(12.31) |
| Female | 57(87.69) |
| Age Group | |
| Adult | 32(49.23) |
| Older adult | 33(50.77) |
| Disability Status | |
| Only physical disability | 44(67.69) |
| Physical disability & at least one other type of disability | 21(32.31) |
| Level of use of body segments | |
| <i>Head/Neck</i> | |
| No use | 0(0) |
| Partial use | 9(13.85) |
| Full use | 56(86.15) |
| <i>Arms</i> | |
| No use | 0(0) |
| Partial use | 19(29.23) |
| Full use | 46(70.77) |
| <i>Legs</i> | |
| No use | 8(12.31) |
| Partial use | 38(58.46) |
| Full use | 19(29.23) |
| <i>Trunk</i> | |
| No use | 1(1.54) |
| Partial use | 22(33.85) |
| Full use | 42(64.62) |
| Standing Ability | |
| Yes | 54(83.08) |
| No | 11(16.92) |

The goal behind participants registering for this intervention program was also collected and is represented in Table IV below. Participants were able to select more than one goal. The dominant goal is to improve one's quality of life; the least dominant is to improve self-esteem and confidence. At least 45% of the respondents seek each of the six goals.

Table IV
SUMMARY OF PARTICIPANTS' GOALS

| Goals (n=65) | Total(%) |
|--|-----------------|
| To lose weight | 35(53.85) |
| To be physically active | 43(66.15) |
| To eat a healthier diet | 34(52.31) |
| To improve my quality of life | 47(72.31) |
| To improve my physical function | 42(64.62) |
| To improve my self-esteem and confidence | 30(46.15) |

C. Stages of Change

Participants' Stages of Change based on the Transtheoretical Framework (Prochaska and DiClemente 1982) was measured at baseline and after the intervention. Users' progression or retrogression in the Stages of Change can offer an understanding of the broader implications on the participants of the study.

Table V below shows the Stages of Change of the participants' pre- and post-intervention. It is important to note that 63% of the participants were in the Contemplation stage during registration (baseline).

Table V
SUMMARY OF STAGES OF CHANGE (n=46)

| Stage of Change | Baseline (%) | Post (%) |
|------------------------|---------------------|-----------------|
| Pre-contemplation | 2 (4.34) | 2 (4.34) |
| Contemplation | 29 (63.04) | 6 (13.04) |
| Preparation | 5 (10.87) | 16 (34.78) |
| Action | 3 (6.52) | 15 (32.61) |
| Maintenance | 7 (15.22) | 7 (15.22) |

The value of 2 for both pre and post in the pre-contemplation stage does not mean that no one from that stage moved to the next stage, but rather represents a combination of progression, retrogression and no change. To better observe the changes at each stage, Table VI below shows the movement of stages. Based on the stages in the pre- and post-measurements, every participant's Stage of Change movement was coded as "Progressed," "Retrogressed," or "No Change." Table VI shows how many participants progressed, retrogressed or had no change within a given stage of change computed at baseline. A chi square test of good fit was performed to test the fit of the observed stage progression codings to the expected equal distribution of frequencies. The results were significant, $X^2 (2, N = 46) = 27.177, p < .01$, indicating that the observed distribution of stage progression codings is significantly different from the assumed equal distribution.

D. Usability

Any system's success or failure is first evaluated by measuring its usability (Brooke 1996). The System Usability Scale (SUS) was administered at the end of the intervention period. The mean SUS score was found to be 75.1 (SD = 5.5) amongst the participants (n=46) who completed the post intervention measures. While the SUS score is reported in a range of 0 to 100, SUS scores are not percentages. Aaron et al. have established an adjective rating scale to correspond to any given SUS score (Bangor, Kortum, and Miller 2009). Based on this scale, our score of 75.1 translates to a "Good" and belongs to the "Acceptable" range of SUS scores. A

score more than 80 would have yielded a rating of “Excellent”, while more than 90 would have yielded “Best Imaginable”.

Table VI
PROGRESSION OF STAGES OF CHANGE (n=46)

| Baseline Stage of Change | Coding | Total (%) |
|---------------------------------|---------------------|------------------|
| Pre-contemplation (n=2) | <i>Retrogressed</i> | 0(0) |
| | <i>No change</i> | 0(0) |
| | <i>Progressed</i> | 2(100) |
| Contemplation (n=29) | <i>Retrogressed</i> | 2(6.9) |
| | <i>No change</i> | 3(10.34) |
| | <i>Progressed</i> | 24(82.76) |
| Preparation (n=5) | <i>Retrogressed</i> | 2(40) |
| | <i>No change</i> | 0(0) |
| | <i>Progressed</i> | 3(60) |
| Action (n=3) | <i>Retrogressed</i> | 0(0) |
| | <i>No change</i> | 0(0) |
| | <i>Progressed</i> | 3(100) |
| Maintenance (n=7) | <i>Retrogressed</i> | 3(42.86) |
| | <i>No change</i> | 4(57.14) |
| | <i>Progressed</i> | 0(0) |

E. Perceived Social Support

The effect of social media in a health behavior change system is expected to influence the social support, which is proven as a strategy to improve health (Reblin and Uchino 2008, Cavallo et al. 2013). Thus, perceived social support was also chosen to be evaluated. Perceived social support for physical activity was measured at baseline and after the intervention using the positive subscales from Chogahara's Social Influence on Physical Activity questionnaire. Table VII below presents a summary of the various social support scales measured.

Table VII

PERCEIVED SOCIAL SUPPORT (n=46)

| Social Support Subscale | Baseline – Mean(SD) | Post – Mean(SD) | Cohen's d |
|--------------------------------|----------------------------|------------------------|------------------|
| Informational Support | 1.8207(1.06) | 2.1576(1.08) | 0.3149 |
| Esteem Support | 1.7935(0.99) | 2.0163(1.07) | 0.2161 |
| Companionship Support | 1.3533(0.65) | 1.6033(0.85) | 0.3304 |
| Encouragement Support | 1.8261(0.88) | 1.9720(0.97) | 0.1575 |

Paired-samples t-test was conducted for all the four subscales to compare the level of social support at baseline and end of intervention. For informational social support, the baseline ($M=1.8207$, $SD=1.06$) and post-intervention ($M=2.1576$, $SD=1.08$) score differences were found to be statistically significant $t(45)=3.492$, $p = 0.0005$. For esteem social support, the baseline ($M=1.7935$, $SD=0.99$) and post-intervention ($M=2.0163$, $SD=1.07$) score differences were found to be statistically significant $t(45)=2.063$, $p = 0.0225$. For companionship social support, the baseline ($M=1.3533$, $SD=0.65$) and post-intervention ($M=1.6033$, $SD=0.85$) score differences were found to be statistically significant $t(45)=3.354$, $p = 0.001$. For encouragement social support, the baseline ($M=1.8261$, $SD=0.88$) and post-intervention ($M=1.9720$, $SD=0.97$) score differences were found to be statistically significant $t(45)=1.980$, $p = 0.027$. These results suggest that the developed prototype really does have an impact on positive social support.

F. Program Engagement

Engagement in self-management behaviors is seen as the proximal outcome influencing the long-term distal outcome of health behavior change (Ryan 2009); however, there exists no standardized simple tool to measure and understand engagement in online behavior change systems. Web analytics are frequently used to estimate the engagement that an online behavior change system offers. Similarly, qualitatively semi-structured interviews are used to understand the various reasons behind the presence or absence of engagement. This study collected traditional web analytics data (using Google analytics) and also utilized context-rich tracking data to further explore the engagement of participants. Data from the web analytics and a sample visualization based on the prototype's in-built tracking mechanism is presented below. It is

followed by the results from the semi-structured interviews, which provide a rich overview of factors that led to engagement or disengagement of participants.

1. Web Log Data

All web log data reported below are limited to only the participants who registered for the program. All web traffic resulting from non-registered users have been filtered out.

Across the active intervention period of all the participants, 1,315 sessions were registered, resulting in 6,497 pageviews (4.94 pages/session). The average session duration was 2.30 minutes and with a bounce rate of 33.61%. The number of sessions is a measure that shows how many times users logged into the prototype. The pages/session, derived from the number of sessions and pageviews, helps us understand the average level of engagement every time a user logs into the prototype. The average session duration also shows the average engagement in each session, measured in minutes. The bounce rate represents the ratio of users who exit the prototype immediately following the first pageview.

Google analytics provides benchmark data; in this case, the data are based on 384,089 other similar-sized (based on traffic) websites in the United States to help benchmark a website. Based on this benchmark data, the pages/session registered by the prototype is 110.95% more than other reported sites (4.95 pages/session vs 2.35 pages/session). Similarly, the average session duration is 41.25% more than other reported sites (2.31 minutes vs 1.47 minutes), and the bounce rate is 46.42% less than other reported sites (33.61% vs 62.74%).

Figure 24 below shows a representation of the page depth spread across the various sessions and pageviews. This visualization helps us understand the spread of the number of pageviews per session.

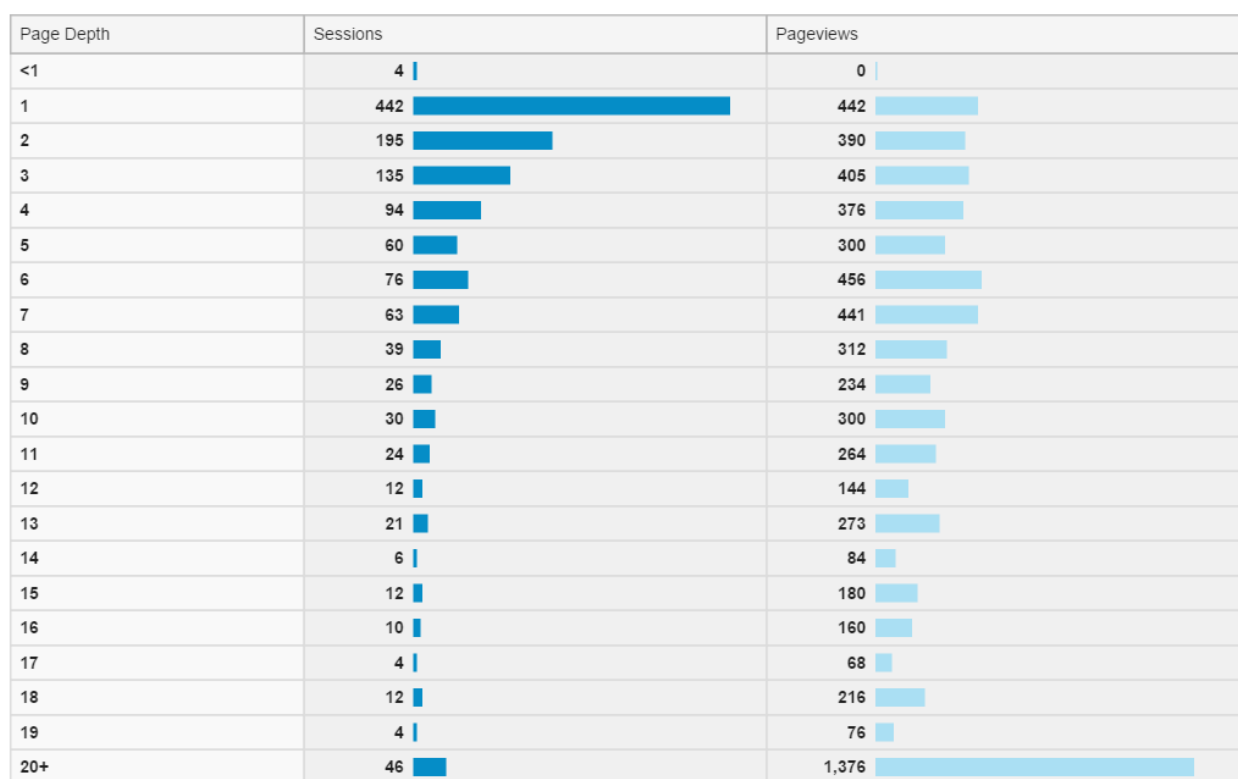


Figure 24 Page Depth Spread across Sessions and Pageviews

Table VIII below shows the top five types of pageviews registered by the prototype. The high number of pageviews registered by the mini homepage with Facebook and the logs are of particular importance.

Table VIII
SUMMARY OF TOP TYPES OF PAGEVIEWS

| Type of Page | Pageviews |
|--------------------------------------|------------------|
| Homepage | 1552 |
| Intervention content | 1362 |
| Mini homepage within Facebook | 823 |
| Log pages | 765 |
| Profile pages | 345 |
| Other pages | 1653 |
| Total | 6497 |

At recruitment, desktop users were targeted. The effect of this targeted recruitment was observed in the web log data, with 89.73% of the sessions being registered from desktop devices, 7.83% from mobile devices and 2.43% from tablets.

The “Invite Facebook Friends” button was used by 24 users and resulted in 14 users having at least one of their Facebook friend also registered in the prototype. Within the prototype, a total of 128 friendships were found. Focusing on other social media features, 82 likes, 23 comments, 32 private messages, 8 instant chat sessions, 11 bookmarks, 24 posts and 1 blog post were registered. No user created any group.

The intervention contents (videos and text) were offered in weekly batches, thus until the end of the intervention, there was always a set of intervention content not available to the user. Also, if, based on the profile (functional capabilities) of the user, an exercise and all of its adaptations could not be performed, the exercise was never displayed to the user. The prototype was setup such that any user who was able to acquire the link to any intervention content on the prototype was able to view it. This was due to the possibility that users could share, blog about, post about, comment or like intervention content and, in the process, the link to the intervention content could be displayed to other users (friends or all users, depending on the privacy settings of the user). The web log collected by the prototype registered every pageview’s intended week number, the week number the user was currently in and several other details. Based on this data, the following visualization (Figure 25) has been generated. The size of the bubbles represents the number (proportion) of intervention content (assigned to a particular week – Y axis) viewed by users belonging to a week number (X axis). The empty triangle in the top left, the fading triangle in the bottom right and steady large bubbles on the diagonal are of particular interest in this

visualization (discussed in Chapter VI). This visualization has been generated to showcase the richness of the web log data collected by the prototype.

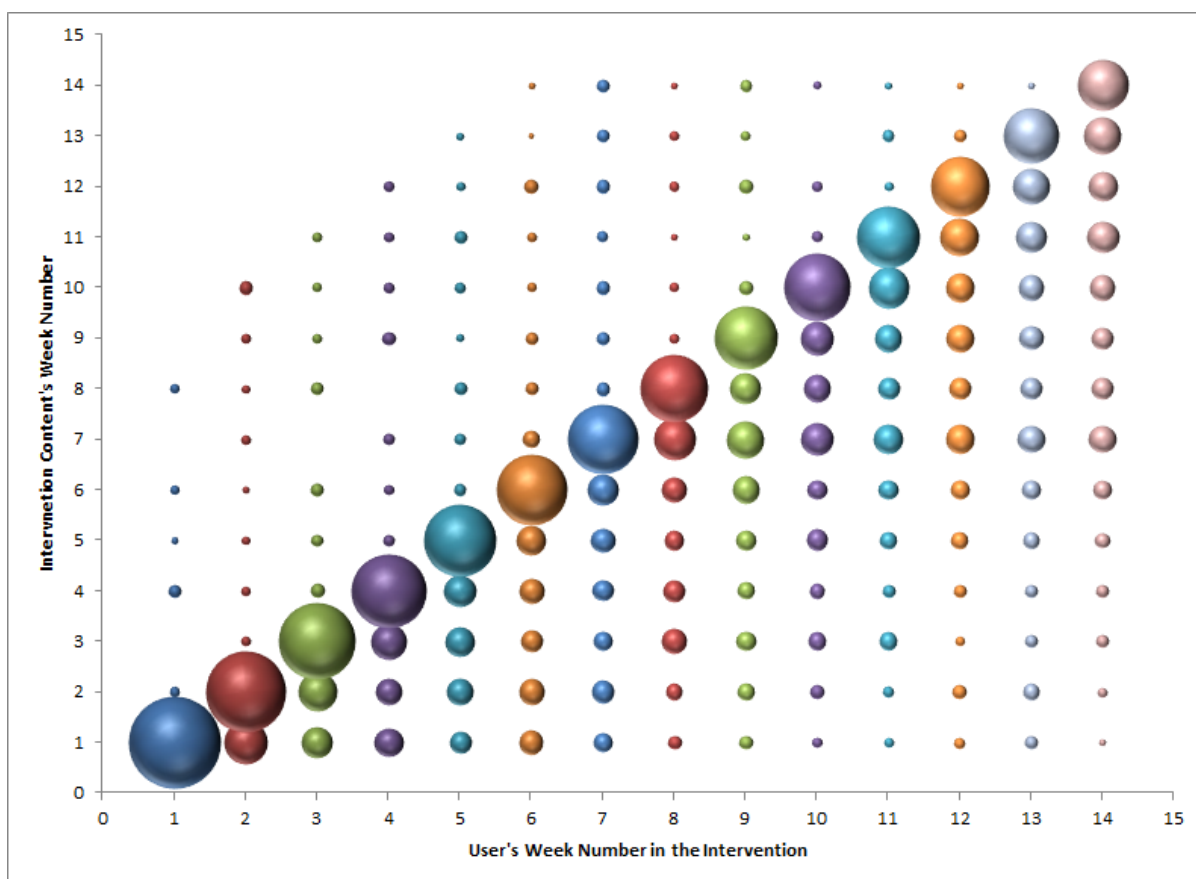


Figure 25: Program Engagement Visualization

2. Semi Structured Interviews

While the web analytics present quantitative estimations of engagement, the underlying reason for the engagement are best understood by conversing with the participants. To enable this, semi-structured interviews were conducted with randomly chosen 20 participants. All of the responses to the interviews were analyzed using nVivo, as described in Section J of the Methods chapter. The transcribed text was repeatedly reviewed to create six logical themes, which matched the five themes identified by Short et al. (Short et al. 2014), with an additional theme focused on security. The identified themes were: 1) users' motivations, 2) users' desired outcomes, 3) users' positive emotions, 4) users' negative emotions, 5) users' sense of security, and 6) attributes desired by users. A summary of each of these themes, along with representational quotes, is presented below.

g. Users' Motivations

The primary motivation for registering in the program was found to be a match between participants' expectations and their perception of the program's offerings. An expectation of being able to achieve their health goals in the comfort of home was often cited as a motivation. The program's promise to offer a personalized intervention for people with disabilities, free of cost, served as a major motivation. Several participants found this approach as innovative, as they had never heard about such a program for people with disabilities. A few users were able to recall the Facebook post that attracted them to the program. The expected motivation of being invited by friends or family to be a part of the program was also noted as a motivation for

registering in the program. Users were also motivated by the possibility of finding others similar to them.

Given below are a few representational quotes belonging to this theme:

- “Losing weight online sounded interesting.”
- “Who wouldn't want to join a free program to improve health?”
- “My best friend invited me, she knows what I need.”
- “Your Facebook post was promising.”
- “Was hoping to meet other people with disabilities like me.”

h. Users' Desired Outcomes

The motivations identified above were ultimately driven by the outcomes the users desired from the program. The primary outcome involved being able to learn how to increase physical activity while having a disability. Some users knew how to exercise, but hoped that the program will provide the necessary motivation. A majority of users referred to their expectation of being able to increase their levels of physical activities and eating healthier. Being able to manage

disability specific symptoms such as pain, fatigue, spasms, etc. was also indicated as expected outcomes. A few users also anticipated being able to make new friends as an outcome.

Given below are a few representational quotes belonging to this theme:

- “I wanted to know what exercises I can do.”
- “The video tapes never motivated me, I hoped this program would.”
- “I wanted to get healthy, you know, doing exercise and eating healthy.”
- “This fatigue has been draining, controlling it is important to me.”
- “I wanted to make more friends.”

i. Users’ Positive Emotions

Several positive aspects of the program were highlighted by the participants and offered an explanation of their reason for engagement with the program. Almost all interviewed participants felt that this was the first time they have encountered a structured series of exercise videos for people with disabilities. Participants also liked the simple, but health-focused recipes provided by the program. Several participants felt engaged due to the new possibility of being able to compare their physical activity with other members (friends) in the program. Badges were

mentioned by several participants as something that encouraged them to login weekly. With several users having never tried an online health behavior change program, the capability to self monitor (logging) their physical activity and dietary intake was seen as a reason to return to the program. The notifications sent through Facebook were reported as a factor of engagement. Some participants were excited about the new habit of exercising and thus wanted to continue as far as they could. Participants' friends' being present in the program was also referred as a motivation to stay engaged with the program.

Given below are a few representational quotes belonging to this theme:

- "The weekly set of exercises, especially for people like me made me come back."
- "A new breakfast, lunch, dinner and snack recipe with affordable and healthy ingredients every week was something I cannot miss out on."
- "It got the kid out of me, in a good way. I wanted to earn more and more badges."
- "I always thought that my friend NAME REMOVED was more active than me, but after starting to log my minutes and seeing that I was more active than her, it got me going!"

- "I am always on Facebook and when I get these notifications, I get reminded to come to the site."

j. Users' Negative Emotions

Several participants highlighted that the length of the videos was shorter and thus they could not use it in a follow-along format. Participants also expressed disappointment over having to make a minimum of three clicks to watch the next video. Factors external to the program, such as health problems, internet access issues, and other family responsibilities were specified as reasons to be not able to regularly login to the website. Some users felt that the program offered too much information, and they were overwhelmed. A few others felt the navigation of the website was too complicated. Some users wanted to be able to restart from week one or rewind to a specific week when they returned after a break of a few weeks due to various reasons. Some users expected the tailoring capabilities of the website to precisely match to their disability and expressed disappointment over the tailoring capabilities of the website. A few users expressed that the notifications were sent too often.

Given below are a few representational quotes belonging to this theme:

- "I was hoping that I would watch the video on the computer and do the exercise; however, it ends too soon."

- "Remembering all exercise is impossible, so you have to come to the computer and move it to the next video."
- "My dog died, and I felt like everything was gone. By the time I was out of it, four weeks were gone."
- "The home page has a million things and it takes me a few minutes to figure out what are all these."
- "With so much button on the top of the website, I am just lost very often."
- "They said it was personalized for me, but I never saw a person with a cane."
- "I had an asthma attack and the doctor told not to do any exercise. When I came back to the site, I was hoping to again start from the beginning."

k. Users' Sense of Security

Users generally felt secure. Participants expressed that by using a nickname and not their actual name from Facebook, a sense of security prevailed. A few users even recalled that they were able to go to the settings pages and change privacy settings. With many users playing games on Facebook, no one had any hesitation with using Facebook to login into the program.

Few users did note that, they would have preferred to totally not use Facebook to login. A few users also expressed that it was tricky to find the link to the privacy settings.

Given below are a few representational quotes belonging to this theme:

- “I play Candy Crush on Facebook, if I felt secure with that, why would I not feel secure with this.”
- “My real name was not even seen on the website, so yes, I did feel secure.”
- “At times I take off from Facebook, but I had to use Facebook to use this program”
- “Once I found the page to change my privacy settings it was good, but finding it was a challenge”

1. Attributes Desired by Users

Users offered several valuable suggestions for program improvement, leading to increased engagement. Many users suggested videos that last for the entire duration of the exercise. A few tech savvy users suggested playlists to enable an uninterrupted exercise session. Users who expressed negative emotions on increased levels of notification desired features to control the frequency of notifications. One user suggested that all possible badges and ways to get them be

displayed, as that would motivate to work towards those badges. A few users also referred to mobile phone-based fitness tracking apps, as opposed to manual entry physical activity minutes.

Given below are a few representational quotes belonging to this theme:

- “Instead of telling us to repeat eight times on each side, it would be better if those actors did the exercise eight times on each side. I would not have to focus on remembering the steps.”
- “The long list of videos could have been in a playlist. My daughter creates playlists for me on YouTube and it is so easy.”
- “The program was sending notifications on the challenge at midnight. I wish I could change that time.”
- “My daughter uses her cell phone to log her movements, it is so easy. Why not do something like that?”

The above presented qualitative results from semi-structured interviews expose a deeper understanding of why some users might have found the prototype more usable and engaging than others. These results also possibly provide an answer to the attrition of 29% of the participants. Finally, these results have provided several valuable suggestions to revisit the design of the

prototype features. An iterative process of designing and similar interview process can help clear most obstacles faced by a majority of users.

VI. DISCUSSION

The present study focuses on a complex interdisciplinary problem of usage of social media for health behavior change. Following a systematic approach, an ontological framework was created to conceptualize a lens that exposes the various complexities of this problem. The framework was then used to systematically analyze the current state of the research on this problem by creating an ontological topography of all extant literature. The ontological topography was created at monadic, dyadic and triadic levels and helped expose the bright, light and blind/blank spots in the current body of research. The ontological topography and literature review shed light on the inadequacies of the current research that places social media features at the periphery or compromises by eliminating traditional online health behavior change features. A lack of research that intends to make use of users' existing social networks was also highlighted. These findings led us to our research objectives of designing a new prototype for online health behavior change system that enables delivery of a holistic behavior change intervention within a mainstream social networking site (Facebook), using its API. An evaluation of the usability, engagement, perceived social support and perceived privacy of the prototype was performed.

Study findings illustrated that the designed prototype has good usability and resulted in significant increase in social support. Program engagement parameters have also been found to be better than established benchmarks. The qualitative interviews revealed that the users were able to appreciate the tailored nature of the content provided through the prototype, being able to

connect with their existing social contacts and also make new connections. Users also were able to point out the pitfalls of the prototype and offered suggestions on how to improve the design further.

The following sections explore each of the findings and their implications, followed by a discussion of the study limitations, future directions, and a conclusion.

A. Ontological Framework and Analysis

The ontological framework and topographies presented a systematic framework to view this problem domain and also visualize the current status of the research in this problem domain. A few observations about the methodology followed in generating the ontological topographies have to be highlighted to ensure an accurate interpretation of the topographies.

A monad/dyad/triad is instantiated when its constituent elements are in a paper's title and/or abstract, indicating their inclusion in the paper's focus. Such an instantiation is likely when the authors of the paper perceive or know of a relationship between the constituent elements. Sometimes, their occurrence may be accidental. The present method of coding does not discriminate between the two possibilities; for example, several papers focused on posting content in Facebook groups and reported on users making comments and likes. These papers have been coded to include the "Group," "Sharing (content)," "Conversations" and "Reputation" elements of the Affordances dimension. This coding does not necessarily mean that the authors

of these papers made a purposeful effort to analyze the combinational effect of these coded elements.

The single largest coded element (260) in the ontology is Sharing (content) from the Affordances dimension. In line with the methodological observation made above, one should not interpret that the 260 studies focused on creating or assessing content. Rather, it only means that 260 studies utilized content in social media as a part of their study.

The over-representation of Sharing (content) (260) and? Conversations (81), in contrast to the under representation of Relationships (23), Reputation (16), and Presence (8), highlights a very broadly skewed state of research in this problem domain. Content and conversations in online environments pre-date social media and Web 2.0. With the predominant focus on such traditional elements, the more radical affordances have not received their due focus. As an example, amongst studies that focused on Recruitment, 38 studies focused on Sharing (content) and 16 studies on all of the other elements of the Affordances dimension. Only one study focused on Recruitment and Relationships. This shows that studies that focused on Recruitment have failed to take advantage of the numerous relationships that exist in social media sites. This study also focused on recruiting using participants' relationships existing in social media sites (Facebook).

Only 16 out of the 328 studies have focused on more than one behavior change domain, with Sexual Behaviors and Screening & Treatment Behaviors for Women being the most frequented

(4) combination. No study has tried to research the effect of the same social media setup and/or behavior techniques across different behavior change domains.

B. Study Participants and Their Friends

While the focus of this study was on the design of a prototype and its evaluation, the results of the recruitment produced interesting observations. Recruitment for this study was predominantly done through Facebook and the National Center on Health, Physical Activity and Disability website. Participants of the site invited their Facebook friends of choice (privately). Among the 93 participants who registered in the program, 84 (90%) users were eligible to participate in the study (eligibility criteria in Method chapter, section H). This high rate of screening was possibly due to the careful (appropriate) invite of friends by the participants of the website, aided with the dissemination through a population-targeted web site.

Only 14 participants registered in the program had one or more of their Facebook friends also in the program. This calls for an extended research on the factors to motivate users of a health behavior change program to invite their friends. This behavior can change by the population and health behavior targeted; for example, a teenager-targeted study focusing on sexual safety and an adult-targeted study focusing on alcohol addiction can produce very different results.

During the period this study was conducted, (Maher et al. 2015) conducted a randomized control trial to determine the efficacy, engagement, and feasibility of an online social networking physical activity intervention with pedometers delivered via the Facebook app. This study

employed pre-formed teams of size three to eight members (with pre-existing social ties); participants with less than three members in their team were ineligible to participate. This study design makes it possible to research the effect of existing social ties in an online social networking site for health behavior change, but compromises on the real world possibility of every person being able to bring a team member along to participate in an intervention.

The skewed ratio of sex (12.31% Males vs 87.69% Females) is in agreement with the higher level of registration by women than men registered by several other studies (Anderson-Bill, Winett, and Wojcik 2011, Glasgow et al. 2011, Vandelanotte et al. 2007).

The number of participants with partial or no use of body segments and the inability to stand (with assistive aids) demonstrates the strong need for tailored intervention content to match the functional capabilities of the user.

C. Usability

The developed prototype included all possible social media features and most behavior change techniques used by online behavior change systems. Such an approach was used for demonstrative purposes and also to serve as a platform for future research use. The system has been designed to activate or deactivate specific social media and behavior change features by simply activating or deactivating plugins however, it was speculated by the investigator that users would be overwhelmed with the multitude of buttons on the top navigational bars. To compensate for this and to reduce the user burden, a dashboard style home page was designed

that summarized all recent updates to the website. The established balance of several features and a home page that summarized everything for the user resulted in a usability score of 75.1. This score places the design in an acceptable range, but informs the investigator that navigational simplification and feature reduction is required for widespread adoption of this prototype in an unedited form.

D. Outcome Measures

Evaluation of outcomes showed positive outcomes. It has been shown that the intervention resulted in several participants progressing on the Stages of Change continuum. It has also been shown that the intervention resulted in a small, but significant increase in social support. While these proximal outcome variables have shown improvement, a direct objective measure of the actual physical activity levels using sensors would have offered a more reliable and accurate measure of outcome remotely.

E. Program Engagement

The quantitative evaluation of program engagement has depended on the benchmark data provided by Google analytics from similar sized websites. The benchmark data are based on 384,089 other similar-sized (based on traffic) websites in the United States and thus can be assumed to be a high quality benchmark data. The pages/session registered by the prototype is 110.95% more than other reported sites (4.95 pages/session vs 2.35 pages/session). Similarly, the average session duration is 41.25% more than other reported sites (2.31 minutes vs 1.47 minutes) and the bounce rate is 46.42% less than other reported sites (33.61% vs 62.74%).

It is to be noted that with the home page and the Facebook-specific mini home page containing most of the information the user would need (other than exercise videos), a significant amount of sessions ended on the home page (as intended). One of the technological limitations of client side web analytics such as Google analytics is that in the data reported from the last page the user visited, the time visited on that last page never gets reported. With a majority of the users visiting multiple times as a result of the notifications they received, the average session duration is prone to severe under-reporting. Similarly, the one-page visits also result in drastic reduction of the average pages/session. This behavior can be confirmed from Figure X23X, which shows that 442 sessions had one page per session.

The overall usage of social media features in this prototype was as follows: 128 friendships (Relationships), 82 likes (Reputation), 23 comments (Conversations), 32 private messages (Conversations), 8 instant chat sessions (Presence), 11 bookmarks (Sharing), 24 posts (Sharing) and 1 blog post (Sharing) were registered. No user created any group (Groups). 343 profile (Identity) views were registered. Contrasting these results with the ontological topography of monads, several contradictions can be observed. First, Relationships and Reputation belong to the highly used affordances in this prototype, but they belong to the underrepresented elements in the topography. Similarly, Groups found a medium level (45) of representation in the ontological topography of monads; however, no user created a group in this study. These anomalies can possibly be explained by the reason that 1) a majority of research focused on assessment type of research, and 2) significant research was based on participants consuming

content through social media (researchers created content/groups). This observation, calls for research focused on specific interactions with social media sites focused on health behavior change.

The sample program engagement visualization demonstrates the rich graphics that can be generated by collecting engagement data by using mechanisms beyond regular practices such as Google analytics or web server-based logs. The prototype was designed to anonymously log every visit to the site, paired long with the information about the user (age, gender, days since registering, stage of change), temporal data (such as time of day), site usage data (number of friends), page specific data (owner of the page, type of page), etc. This rich collection of data can enable visualization that can lead to exploratory findings that would have not been possible in traditional hypothesis driven research.

The produced sample visualization (Figure 25) contains three dimensional data and can provide insights to a variety of stakeholders involved in a successful health behavior change system design. A few observations are discussed here:

- All of the bubbles to the left of the thick diagonal line of bubbles represent intervention content views intended for users belonging to weeks ahead of the users' current week number. This was allowed to happen by design and an intended effect of social media activity such as liking, commenting, and bookmarking intervention content.

- The empty triangular region in the top left of the visualization provides a confirmation that until the first set of registered users were eligible for a particular week's content, the link was never exposed. From the visualization, the time gap of registration between the first and last user is about nine weeks. Thus, no user in week one was able to get a link beyond nine weeks (through the effect of the social media features).
- In the bubbles to the right of the diagonal line of bubbles, a fading effect is observed and by the end of the program, views on the week one content trickle to negligible levels. For an intervention content designer, this can help make decisions if the content that needs to be reviewed regularly can be placed in the initial weeks or repeated at later weeks.
- Similarly, amongst the horizontal bars of bubbles to the right on the diagonal line of bubbles, the horizontal bar corresponding to week seven is performing better than weeks around it. This provides an opportunity of the content designer to assess the reason for this favorable reaction and try to replicate it.

The above discussed visualization is only one among the several possible visualizations. If the same study were repeated with a substantially larger sample, several interesting findings could result.

The qualitative interviews offered several valuable inputs that help identify which features and characteristics of the website were desired or not desired. Users also offered several

suggestions on the desired features of this prototype; however, the findings from this qualitative interviewing could be biased and is discussed in the following section.

F. Study Limitations

The objective of this study was to provide an overarching view of the use of social media for health behavior change, design a prototype system that attempts to overcome some deficiencies identified in the current body of literature and evaluate the prototype designed. A number of study limitations are to be recorded.

The sample size of this current study is significantly smaller in comparison to many studies (Bull et al. 2012, Cavallo et al. 2012, Graham et al. 2011, Ma, Chen, and Xiao 2010) that focus on online health behavior change.

To facilitate a smooth experience of data collection from the user and to ensure no missing data, all assessment questionnaires were offered as an integral part of the prototype. The unintended consequence of such an approach was that data from non-responders to the intervention program could not be acquired. The lack of this data could introduce a systemic bias in the data collected; for instance, the usability score of 75.1 is derived from users who successfully completed the program. Data from people who stopped using the program could be different, however.

To facilitate anonymous communications with the participants, all communications between the participants and the investigator were facilitated by the messaging feature of the prototype. These communications were initiated only for requesting phone interviews. This approach again could have introduced systemic bias, wherein users who disliked or were not capable of using the system did not respond to the messages.

The content used for this program was directly ported from an already existing health behavior change program. While the purpose of this study was not to evaluate the content used in the prototype, the content would have had an impact on the data collected. This effect would be magnified, as the considered behavior change and the targeted population is very complex. The very same prototype could generate very different results when used for a different health behavior change, population or with different content.

G. Future Directions

The current study has created a platform for research focused on the use of social media for health behavior use; however, the current study has considered the problem in its broadest form by including all possible features. Future research is required to compare the various affordances of social media and their effect on health behavior change. In a similar process, the effect of pairing social media affordances with different health behavior change techniques also needs to be researched. Any combination of social media affordances and behavior change techniques can have very different effects on various health behavior change domains.

The ontological framework created as an outcome of this study can help researchers formulate the various possible research questions that remain to be answered. As noted in Chapter III, the ontological framework by itself exposes the researchers to a minimum of 833 different research questions needing answers. The ontological framework created can be combined with the prototype (with minimal configuration changes) to rapidly produce the required solutions for new research problems.

H. Conclusion

Use of social media for health behavior change has seen a rapid growth in the recent years. An ontological framework has been created to help systematically analyze this topic of research. The ontological framework was used to analyze all extant relevant literature to expose the bright, light and blind/blank spots. A thorough literature review was conducted to identify all other limitations of current research. This led to the design of a holistic online health behavior change prototype, which has all affordances of social media and employs all behavior change techniques. An evaluation of this prototype was performed.

The evaluation findings demonstrate that the developed prototype had good usability, program engagement and proximal outcomes. The study results and discussions highlight the necessity for future research with more specific research questions. The capabilities of the prototype to rapidly reuse it for any research problem covering the breadth and scope of the ontological framework has been demonstrated. The visualizations that can be generated from the

context rich data collected by the prototype and suitability for exploratory analysis have been demonstrated.

Future efforts could incorporate the findings and products of this study to achieve a variety of health behavior changes for diverse populations in need of health behavior change interventions.

APPENDICES

APPENDIX A

UNIVERSITY OF ILLINOIS AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice Initial Review (Response To Modifications)

May 22, 2015

Mohanraj Thirumalai, M.S., M.E.
Business Administration
University Hall, Room 2404
M/C 294
Chicago, IL 60612
Phone: (312) 218-7740 / Fax: (312) 413-0385

RE: Protocol # 2015-0360
“Design of Social Media for Health Behavior Change: An Ontological Approach”

Dear Mr. Thirumalai:

Your Initial Review (Response To Modifications) was reviewed and approved by the Expedited review process on May 18, 2015. You may now begin your research

Please note the following information about your approved research protocol:

| | |
|--|-----------------------------|
| <u>Protocol Approval Period:</u> | May 18, 2015 - May 17, 2016 |
| <u>Approved Subject Enrollment #:</u> | 333 |
| <u>Additional Determinations for Research Involving Minors:</u> These determinations have not been made for this study since it has not been approved for enrollment of minors. | |
| <u>Performance Sites:</u> | UIC, Lakeshore Foundation |

Sponsor:

None

Research Protocol(s):

- a) Design of Social Media for Health Behavior Change: An Ontological Approach; Version 2, 04/06/2015

Recruitment Material(s):

- a) Recruitment Flyer; Version 3, 05/11/2015
- b) Invitation Script; Version 1, 05/21/2015

Informed Consent(s):

- a) Social Media and Health Behavior Change; Version 3, 05/11/2015
- b) A waiver of documentation of informed consent has been granted under 45 CFR 46.117 and an alteration of consent has been granted under 45 CFR 46.116(d) for this research; minimal risk; electronic consent will be obtained at enrollment.

Your research meets the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific category(ies):

(6) Collection of data from voice, video, digital, or image recordings made for research purposes., (7) Research on individual or group characteristics or behavior (including but not limited to research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Please note the Review History of this submission:

| Receipt Date | Submission Type | Review Process | Review Date | Review Action |
|--------------|---------------------------|----------------|-------------|------------------------|
| 03/20/2015 | Initial Review | Expedited | 03/26/2015 | Modifications Required |
| 04/27/2015 | Response To Modifications | Expedited | 04/30/2015 | Modifications Required |
| 05/13/2015 | Response To Modifications | Expedited | 05/18/2015 | Approved |

Please remember to:

→ Use your **research protocol number** (2015-0360) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the enclosure,
"UIC Investigator Responsibilities, Protection of Human Research Subjects"

(<http://tiger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0924.pdf>)

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 355-0816. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Alison Santiago, MSW, MJ
IRB Coordinator, IRB # 2
Office for the Protection of Research

Subjects

Enclosure(s):

- 1. UIC Investigator Responsibilities, Protection of Human Research Subjects**
- 2. Informed Consent Document(s):**
 - a) Social Media and Health Behavior Change; Version 3, 05/11/2015
- 3. Recruiting Material(s):**
 - a) Recruitment Flyer; Version 3, 05/11/2015
 - b) Invitation Script; Version 1, 05/21/2015

cc: Stefanie Lenway, Business Administration, M/C 075
Arkalgud Ramaprasad (Faculty Sponsor), Business Administration, M/C 294

CITED LITERATURE

2014. "20th Americas Conference on Information Systems, AMCIS 2014." 20th Americas Conference on Information Systems, AMCIS 2014.
- Ahern, A. L., E. J. Boyland, S. A. Jebb, and S. R. Cohn. 2013. "Participants' explanatory model of being overweight and their experiences of 2 weight loss interventions." *Ann Fam Med* 11 (3):251-7.
- Ajzen, Icek. 1991. "The theory of planned behavior." *Organizational behavior and human decision processes* 50 (2):179-211.
- Ajzen, Icek. 2011. "The theory of planned behaviour: reactions and reflections." *Psychology & Health* 26 (9):1113-1127.
- Ajzen, Icek, and Martin Fishbein. 1980. "Understanding attitudes and predicting social." *Behaviour. Englewood Cliffs, NJ: Prentice-Hall.*
- Albada, Akke, Margreet GEM Ausems, Jozien M Bensing, and Sandra van Dulmen. 2009. "Tailored information about cancer risk and screening: a systematic review." *Patient Education and Counseling* 77 (2):155-171.
- Albarracín, Dolores, Jeffrey C Gillette, Allison N Earl, Laura R Glasman, Marta R Durantini, and Moon-Ho Ho. 2005. "A test of major assumptions about behavior change: a comprehensive look at the effects of passive and active HIV-prevention interventions since the beginning of the epidemic." *Psychological bulletin* 131 (6):856.

- Almunawar, M. N., Z. Wint, K. C. P. Low, and M. Anshari. 2012. "Customer expectation of E-Health Systems in Brunei Darussalam." *Journal of Health Care Finance* 38 (4):36-49.
- Ammerman, Alice S, Christine H Lindquist, Kathleen N Lohr, and James Hersey. 2002. "The efficacy of behavioral interventions to modify dietary fat and fruit and vegetable intake: a review of the evidence." *Preventive medicine* 35 (1):25-41.
- Anderson-Bill, E. S., R. A. Winett, and J. R. Wojcik. 2011. "Social cognitive determinants of nutrition and physical activity among web-health users enrolling in an online intervention: the influence of social support, self-efficacy, outcome expectations, and self-regulation." *Journal of Medical Internet Research* 13 (1):e28.
- Atkinson, Nancy L, and Robert S Gold. 2002. "The promise and challenge of eHealth interventions." *American Journal of Health Behavior* 26 (6):494-503.
- Bailey, Patricia Hill. 2004. "The dyspnea-anxiety-dyspnea cycle—COPD patients' stories of breathlessness: "It's scary/when you can't breathe"." *Qualitative health research* 14 (6):760-778.
- Bailey, Shannon T, Ross Cohen, and Daniel Stodolsky. 2005. Method and apparatus for testing request-response service using live connection traffic. Google Patents.
- Balaban, Igor, and Goran Bubas. 2010. "Educational potentials of ePortfolio systems: Student evaluations of Mahara and Elgg." *Information Technology Interfaces (ITI)*, 2010 32nd International Conference on.
- Bandura, Albert. 1977. "Self-efficacy: toward a unifying theory of behavioral change." *Psychological review* 84 (2):191.

- Bandura, Albert. 1986. *Social foundations of thought and action*: Englewood Cliffs, NJ Prentice Hall.
- Bandura, Albert. 1997. *Self-efficacy: The exercise of control*. New York: Freeman.
- Bangor, Aaron, Philip Kortum, and James Miller. 2009. "Determining what individual SUS scores mean: Adding an adjective rating scale." *Journal of usability studies* 4 (3):114-123.
- Bangor, Aaron, Philip T Kortum, and James T Miller. 2008. "An empirical evaluation of the system usability scale." *Intl. Journal of Human-Computer Interaction* 24 (6):574-594.
- Barnes, Susan B. 2006. "A privacy paradox: Social networking in the United States." *First Monday* 11 (9).
- Becker, Marshall H. 1974. "The health belief model and personal health behavior."
- Bender, J. L., A. Radhakrishnan, C. Diorio, M. Englesakis, and A. R. Jadad. 2011. "Can pain be managed through the Internet? A systematic review of randomized controlled trials." *Pain* 152 (8):1740-1750.
- Bennett, G. G., and R. E. Glasgow. 2009a. The delivery of public health interventions via the internet: Actualizing their potential. In *Annual Review of Public Health*.
- Bennett, Gary G, and Russell E Glasgow. 2009b. "The delivery of public health interventions via the Internet: actualizing their potential." *Annual review of public health* 30:273-292.

- Berg, Bruce Lawrence, and Howard Lune. 2004. *Qualitative research methods for the social sciences*. Vol. 5: Pearson Boston.
- Bernard, Harvey Russell. 1988. *Research methods in cultural anthropology*: Sage Newbury Park, CA.
- Berry, Miles. 2006. "Elgg and Blogging in primary education." *Coming of age: an introduction to the new world wide web*: 44.
- Betsch, C., F. Renkewitz, and N. Haase. 2013. "Effect of narrative reports about vaccine adverse events and bias-awareness disclaimers on vaccine decisions: A simulation of an online patient social Network." *Medical Decision Making* 33 (1):14-25.
- Black, S. R., S. Schmiede, and S. Bull. 2013. "Actual versus perceived peer sexual risk behavior in online youth social networks." *Translational Behavioral Medicine* 3 (3):312-319.
- Bondy, S. J., and K. L. Bercovitz. 2013. "'hike up yer skirt, and quit." what motivates and supports smoking cessation in builders and renovators." *International Journal of Environmental Research and Public Health* 10 (2):623-637.
- Boyd, Danah m, and Nicole B. Ellison. 2007. "Social Network Sites: Definition, History, and Scholarship." *Journal of Computer-Mediated Communication* 13 (1):210-230.
- Brahima, Sonaou. 2013. "ICT Facts and Figures." Accessed 10/28/2014. <http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2013-e.pdf>.

- Braunstein, Alex, Laura Granka, and Jessica Staddon. 2011. "Indirect content privacy surveys: measuring privacy without asking about it." *Proceedings of the Seventh Symposium on Usable Privacy and Security*.
- Brindal, E., J. Freyne, I. Saunders, S. Berkovsky, G. Smith, and M. Noakes. 2012. "Features predicting weight loss in overweight or obese participants in a web-based intervention: randomized trial." *Journal of Medical Internet Research* 14 (6):e173.
- Bringer, Joy D, Lynne H Johnston, and Celia H Brackenridge. 2004. "Maximizing transparency in a doctoral thesis1: The complexities of writing about the use of QSR* NVIVO within a grounded theory study." *Qualitative Research* 4 (2):247-265.
- Brooke, John. 1996. "SUS-A quick and dirty usability scale." *Usability evaluation in industry* 189:194.
- Bryant, Todd. 2006. "Social software in academia." *Educause quarterly* 29 (2):61.
- Bull, S. S., D. K. Levine, S. R. Black, S. J. Schmiede, and J. Santelli. 2012. "Social media-delivered sexual health intervention: A cluster randomized controlled trial." *American Journal of Preventive Medicine* 43 (5):467-474.
- Burke, Lora E, Jing Wang, and Mary Ann Sevvick. 2011. "Self-monitoring in weight loss: a systematic review of the literature." *Journal of the American Dietetic Association* 111 (1):92-102.
- Camerini, Luca, Michele Giacobazzi, Marco Boneschi, Peter J Schulz, and Sara Rubinelli. 2011. "Design and implementation of a web-based Tailored Gymnasium to enhance self-management of Fibromyalgia." *User Modeling and User-Adapted Interaction* 21 (4-5):485-511.

- Capurro, D., K. Cole, M. I. Echavarría, J. Joe, T. Neogi, and A. M. Turner. 2014. "The use of social networking sites for public health practice and research: A systematic review." *Journal of Medical Internet Research* 16 (3).
- Cavallo, D. N., D. F. Tate, A. V. Ries, J. D. Brown, R. F. DeVellis, and A. S. Ammerman. 2012. "A social media-based physical activity intervention: A randomized controlled trial." *American Journal of Preventive Medicine* 43 (5):527-532.
- Cavallo, David N, Jane D Brown, Deborah F Tate, Robert F DeVellis, Catherine Zimmer, and Alice S Ammerman. 2013. "The role of companionship, esteem, and informational support in explaining physical activity among young women in an online social network intervention." *Journal of behavioral medicine*:1-12.
- CDC. 2014. "The Public Health System and the 10 Essential Public Health Services." Last Modified 6/14/2014 Accessed 6/14/2014. <http://www.webcitation.org/6QKgaJbtb>.
- Celio, Angela A, Andrew J Winzelberg, Denise E Wilfley, Dori Eppstein-Herald, Elizabeth A Springer, Parvati Dev, and C Barr Taylor. 2000. "Reducing risk factors for eating disorders: comparison of an Internet-and a classroom-delivered psychoeducational program." *Journal of consulting and clinical psychology* 68 (4):650.
- Centola, D. 2011. "An experimental study of homophily in the adoption of health behavior." *Science* 334 (6060):1269-72.
- Century, Institute of Medicine . Committee on Communication for Behavior Change in the 21st, and Improving the Health of Diverse Populations. 2002. *Speaking of health: Assessing health communication strategies for diverse populations*: Joseph Henry Press.

- Chang, T., V. Chopra, C. Zhang, and S. J. Woolford. 2013. "The role of social media in online weight management: systematic review." *Journal of Medical Internet Research* 15 (11):e262.
- Chogahara, Makoto. 1999. "A multidimensional scale for assessing positive and negative social influences on physical activity in older adults." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 54 (6):S356-S367.
- Christensen, Helen, Kathleen M Griffiths, and Anthony F Jorm. 2004. "Delivering interventions for depression by using the internet: randomised controlled trial." *Bmj* 328 (7434):265.
- Constine, J. 2013. "Facebook's Q2: Monthly Users Up 21% YOY To 1.15B, Dailies Up 27% To 699M, Mobile Monthlies Up 51% To 819M." Accessed 10/28/2014. <http://techcrunch.com/2013/07/24/facebook-growth-2/>.
- Costello, Cash. 2012. *Elgg 1.8 social networking*: Packt Publishing Ltd.
- Cugelman, Brian, Mike Thelwall, and Phil Dawes. 2011. "Online interventions for social marketing health behavior change campaigns: a meta-analysis of psychological architectures and adherence factors." *Journal of medical Internet research* 13 (1).
- Curry, Edward, and Paul Grace. 2008. "Flexible self-management using the model-view-controller pattern." *Software, IEEE* 25 (3):84-90.
- Daft, Richard L, and Robert H Lengel. 1986. "Organizational information requirements, media richness and structural design." *Management science* 32 (5):554-571.

- Dahl, Alicia A., Sarah B. Hales, and Gabrielle M. Turner-McGrievy. 2016. "Integrating social media into weight loss interventions." *Current Opinion in Psychology* 9:11-15.
- De Bruyn, Arnaud, and Gary L. Lilien. 2008. "A multi-stage model of word-of-mouth influence through viral marketing." *International Journal of Research in Marketing* 25 (3):151-163.
- Deacon, John. 2009. "Model-view-controller (mvc) architecture." *Online* [Citado em: 10 de março de 2006.] <http://www.jdl.co.uk/briefings/MVC.pdf>.
- Duggan, Maeve. 2014. "Social Media Update 2013." Accessed 6/14/2014.
- Eaker, Elaine D. 2005. "Social Support and Physical Health: Understanding the Health Consequences of Relationships." *American Journal of Epidemiology* 161 (3):297-298.
- Earp, Jo Anne, and Susan T Ennett. 1991. "Conceptual models for health education research and practice." *Health Education Research* 6 (2):163-171.
- Ellis, Rodney A. 1998. "Filling the prevention gap: Multi-factor, multi-system, multi-level intervention." *Journal of Primary Prevention* 19 (1):57-71.
- Emery, S. L., G. Szczypka, E. P. Abril, Y. Kim, and L. Vera. 2014. "Are You Scared Yet? Evaluating Fear Appeal Messages in Tweets About the Tips Campaign." *Journal of Communication* 64 (2):278-295.
- Evers, Kerry E., Janice M. Prochaska, James O. Prochaska, Mary-Margaret Driskell, Carol O. Cummins, and Wayne F. Velicer. 2003. "Strengths and Weaknesses of Health Behavior Change Programs on the Internet." *Journal of Health Psychology* 8 (1):63-70.

Eysenbach, Gunther. 2005. "The law of attrition." *Journal of medical Internet research* 7 (1).

Facebook. 2014. "About Facebook." Facebook. <http://newsroom.fb.com/company-info/>.

Faul, Franz, Edgar Erdfelder, Albert-Georg Lang, and Axel Buchner. 2007. "G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences." *Behavior research methods* 39 (2):175-191.

Faulkner, Laura. 2003. "Beyond the five-user assumption: Benefits of increased sample sizes in usability testing." *Behavior Research Methods, Instruments, & Computers* 35 (3):379-383.

Field, Andy. 2009. *Discovering statistics using SPSS*: Sage publications.

Fitzpatrick, Brad. 2004. "Distributed caching with memcached." *Linux journal* 2004 (124):5.

Fogg, BJ. 2009. "A behavior model for persuasive design." Proceedings of the 4th international Conference on Persuasive Technology.

Forrester. 2005. "National Consumer Health Privacy Survey 2005." Forrester Research, Inc. <http://www.chcf.org/publications/2005/11/national-consumer-health-privacy-survey-2005>.

Foster, D., C. Linehan, B. Kirman, S. Lawson, and G. James. 2010. "Motivating physical activity at work: Using persuasive social media for competitive step counting." Proceedings of the 14th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2010.

- Fox, Susannah. 2011. "Profiles of Health Information Seekers." Pew Research Center. <http://www.pewinternet.org/2011/02/01/profiles-of-health-information-seekers/>.
- Fox, Susannah. 2014. "The Web at 25 in the U.S." Accessed 6/14/2014. <http://www.webcitation.org/6QKoyukdR>.
- Fox, Susannah; Duggan, Maeve. 2013. "Peer-to-Peer Health Care." Pew Research Center. <http://www.pewinternet.org/2013/01/15/peer-to-peer-health-care/>.
- Franklin, V. L., A. Greene, A. Waller, S. A. Greene, and C. Pagliari. 2008. "Patients' engagement with "Sweet Talk" - a text messaging support system for young people with diabetes." *Journal of Medical Internet Research* 10 (2):e20.
- Freeman, B., and S. Chapman. 2008. "Gone viral? heard the buzz? A guide for health practitioners and researchers on how web 2.0 can subvert advertising restrictions and spread health information." *Journal of Epidemiology and Community Health* 62 (9):778-782.
- Fung, Benjamin, Ke Wang, Rui Chen, and Philip S Yu. 2010. "Privacy-preserving data publishing: A survey of recent developments." *ACM Computing Surveys (CSUR)* 42 (4):14.
- Garrett, Nathan, Brian Thoms, Mariana Soffer, and Terry Ryan. 2007. "Extending the Elgg social networking system to enhance the campus conversation." *Second Annual Design Research in Information Systems (DESRIST), Pasadena, California*:14-15.
- George, D. R., C. Dellasega, M. M. Whitehead, and A. Bordon. 2013. "Facebook-based stress management resources for first-year medical students: A multi-method evaluation." *Computers in Human Behavior* 29 (3):559-562.

- Geraedts, Hilde AE, Wiebren Zijlstra, Wei Zhang, Sjoerd Bulstra, and Martin Stevens. 2014. "Adherence to and effectiveness of an individually tailored home-based exercise program for frail older adults, driven by mobility monitoring: design of a prospective cohort study." *BMC public health* 14 (1):570.
- Gibson, JJ. 1977. "The concept of affordances." *Perceiving, acting, and knowing*:67-82.
- Glanz, K, and B Rimer. 1995. "Theory at a glance: a guide for health promotion practice. NIH publication no. 97-3896. Bethesda, MD: US Department of Health and Human Services." *Public Health Service, National Cancer Institute*.
- Glanz, Karen, and Donald B Bishop. 2010. "The role of behavioral science theory in development and implementation of public health interventions." *Annual review of public health* 31:399-418.
- Glanz, Karen, Barbara K Rimer, and Kasisomayajula Viswanath. 2008. *Health behavior and health education: theory, research, and practice*: John Wiley & Sons.
- Glasgow, R. E., S. M. Christiansen, D. Kurz, D. K. King, T. Woolley, A. J. Faber, P. A. Estabrooks, L. Strycker, D. Toobert, and J. Dickman. 2011. "Engagement in a diabetes self-management website: usage patterns and generalizability of program use." *Journal of Medical Internet Research* 13 (1):e9.
- Gochman, David S. 1997. *Handbook of health behavior research IV: Relevance for professionals and issues for the future*: Springer US.
- Graham, A. L., G. D. Papandonatos, H. Kang, J. L. Moreno, and D. B. Abrams. 2011. "Development and validation of the online social support for smokers scale." *Journal of Medical Internet Research* 13 (3):e69.

- Griffiths, Frances, Antje Lindenmeyer, John Powell, Pam Lowe, and Margaret Thorogood. 2006. "Why are health care interventions delivered over the internet? A systematic review of the published literature." *Journal of medical Internet research* 8 (2).
- Grol, Richard PTM, Marije C Bosch, Marlies EIJL Hulscher, Martin P Eccles, and Michel Wensing. 2007. "Planning and studying improvement in patient care: the use of theoretical perspectives." *Milbank Quarterly* 85 (1):93-138.
- Guse, K., D. Levine, S. Martins, A. Lira, J. Gaarde, W. Westmorland, and M. Gilliam. 2012. "Interventions using new digital media to improve adolescent sexual health: a systematic review." *J Adolesc Health* 51 (6):535-43.
- Hansen, D. L., and C. Johnson. 2012. "Veiled Viral Marketing: Disseminating information on stigmatized illnesses via social networking sites." Miami, FL.
- Hoffman, Ellen. 2009. "Evaluating social networking tools for distance learning." TCC Worldwide Online Conference.
- Jimison, Holly, Paul Gorman, Susan Woods, Peggy Nygren, Miranda Walker, Susan Norris, and William Hersch. 2008. "Barriers and drivers of health information technology use for the elderly, chronically ill, and underserved."
- Johnson, B. T., L. A. Scott-Sheldon, and M. P. Carey. 2010. "Meta-synthesis of health behavior change meta-analyses." *Am J Public Health* 100 (11):2193-8.
- Jones, K., K. A. Baldwin, and P. R. Lewis. 2012. "The potential influence of a social media intervention on risky sexual behavior and chlamydia incidence." *Journal of Community Health Nursing* 29 (2):106-120.

- Juve, Gideon, Ewa Deelman, Karan Vahi, Gaurang Mehta, Bruce Berriman, Benjamin P Berman, and Phil Maechling. 2009. "Scientific workflow applications on Amazon EC2." E-Science Workshops, 2009 5th IEEE International Conference on.
- Kaplan, Andreas M, and Michael Haenlein. 2010. "Users of the world, unite! The challenges and opportunities of Social Media." *Business horizons* 53 (1):59-68.
- Kazimierczak, Karolina A, Zoë C Skea, Mary Dixon-Woods, Vikki A Entwistle, Deb Feldman-Stewart, James MO N'dow, and Sara J MacLennan. 2013. "Provision of cancer information as a "support for navigating the knowledge landscape": Findings from a critical interpretive literature synthesis." *European Journal of Oncology Nursing* 17 (3):360-369.
- Kienle, Holger M, Andreas Lober, and HA Muller. 2008. "Policy and Legal Challenges of VirtualWorlds and Social Network Sites." Requirements Engineering and Law, 2008. RELAW'08.
- Kietzmann, Jan H., Kristopher Hermkens, Ian P. McCarthy, and Bruno S. Silvestre. 2011. "Social media? Get serious! Understanding the functional building blocks of social media." *Business Horizons* 54 (3):241-251.
- Kok, Gerjo, Herman Schaalma, Robert AC Ruiter, Pepijn Van Empelen, and Johannes Brug. 2004. "Intervention mapping: protocol for applying health psychology theory to prevention programmes." *Journal of health psychology* 9 (1):85-98.
- Kolt, G. S., R. R. Rosenkranz, T. N. Savage, A. J. Maeder, C. Vandelanotte, M. J. Duncan, C. M. Caperchione, R. Tague, C. Hooker, and W. K. Mummery. 2013. "WALK 2.0 - Using Web 2.0 applications to promote health-related physical activity: A randomised controlled trial protocol." *BMC Public Health* 13 (1).

- Korda, H., and Z. Itani. 2013. "Harnessing Social Media for Health Promotion and Behavior Change." *Health Promotion Practice* 14 (1):15-23.
- Krane, David. 2007. "Many U.S. Adults are Satisfied with Use of Their Personal Health Information." Public Affairs and Policy Research, Harris Interactive. <http://www.harrisinteractive.com/vault/Harris-Interactive-Poll-Research-Health-Privacy-2007-03.pdf>.
- Krasner, Glenn E, and Stephen T Pope. 1988. "A description of the model-view-controller user interface paradigm in the smalltalk-80 system." *Journal of object oriented programming* 1 (3):26-49.
- Krishnamurthy, Balachander, and Craig E Wills. 2009. "On the leakage of personally identifiable information via online social networks." Proceedings of the 2nd ACM workshop on Online social networks.
- Kuwata, Shigeki, Shin-ichi Taniguchi, Atsuko Kato, Kazuoki Inoue, Naoya Yamamoto, Tsuyoshi Ohkura, Kei Teramoto, Chiaki Shigemasa, and Hiroshi Kondoh. 2010. "Metaboli-Net: online groupware system providing counseling guidance for patients with metabolic syndrome." *Stud Health Technol Inform* 156:65-70.
- Laranjo, L., A. Arguel, A. L. Neves, A. M. Gallagher, R. Kaplan, N. Mortimer, G. A. Mendes, and A. Y. Lau. 2014. "The influence of social networking sites on health behavior change: a systematic review and meta-analysis." *J Am Med Inform Assoc*.
- Leff, Avraham, and James T Rayfield. 2001. "Web-application development using the model/view/controller design pattern." Enterprise Distributed Object Computing Conference, 2001. EDOC'01. Proceedings. Fifth IEEE International.

- Legler, Julie, Helen I Meissner, Cathy Coyne, Nancy Breen, Veronica Chollette, and Barbara K Rimer. 2002. "The effectiveness of interventions to promote mammography among women with historically lower rates of screening." *Cancer Epidemiology Biomarkers & Prevention* 11 (1):59-71.
- Levy, K., B. Sargent, and Y. Bai. 2011. "A trust-aware tag-based privacy control for eHealth 2.0." SIGITE'11 - Proceedings of the 2011 ACM Special Interest Group for Information Technology Education Conference.
- Li, J. 2013. "Privacy policies for health social networking sites." *J Am Med Inform Assoc* 20 (4):704-7.
- Litt, D. M., and M. L. Stock. 2011. "Adolescent Alcohol-Related Risk Cognitions: The Roles of Social Norms and Social Networking Sites." *Psychology of Addictive Behaviors* 25 (4):708-713.
- Loeliger, Jon, and Matthew McCullough. 2012. *Version Control with Git: Powerful tools and techniques for collaborative software development*. " O'Reilly Media, Inc."
- Loss, J., V. Lindacher, and J. Curbach. 2014. "Online social networking sites-a novel setting for health promotion?" *Health and Place* 26:161-170.
- Love, B., B. Crook, C. M. Thompson, S. Zaitchik, J. Knapp, L. Lefebvre, B. Jones, E. Donovan-Kicken, E. Eargle, and R. Rechis. 2012. "Exploring psychosocial support online: A content analysis of messages in an adolescent and young adult cancer community." *Cyberpsychology, Behavior, and Social Networking* 15 (10):555-559.
- Lyles, C. R., A. López, R. Pasick, and U. Sarkar. 2013. "'5 Mins of uncomfyness is better than dealing with cancer 4 a lifetime": An exploratory qualitative analysis of cervical and

- breast cancer screening dialogue on twitter." *Journal of Cancer Education* 28 (1):127-133.
- Ma, X., G. Chen, and J. Xiao. 2010. "Analysis of an online health social network." IHI'10 - Proceedings of the 1st ACM International Health Informatics Symposium.
- Maher, C. A., L. K. Lewis, K. Ferrar, S. Marshall, I. De Bourdeaudhuij, and C. Vandelanotte. 2014. "Are health behavior change interventions that use online social networks effective? A systematic review." *Journal of Medical Internet Research* 16 (2):e40.
- Maher, Carol, Monika Ferguson, Corneel Vandelanotte, Ron Plotnikoff, Ilse De Bourdeaudhuij, Samantha Thomas, Karen Nelson-Field, and Tim Olds. 2015. "A Web-Based, Social Networking Physical Activity Intervention for Insufficiently Active Adults Delivered via Facebook App: Randomized Controlled Trial." *Journal of Medical Internet Research* 17 (7):e174.
- Maher, Carol, Jillian Ryan, Jocelyn Kernot, James Podsiadly, and Sarah Keenihan. 2016. "Social media and applications to health behavior." *Current Opinion in Psychology* 9:50-55.
- Markle John. 2006. "Survey Finds Americans Want Electronic Personal Health Information to Improve Own Health Care ". Lake Research Partners. http://www.markle.org/sites/default/files/research_doc_120706.pdf.
- Markus, M Lynne. 2005. "Technology-shaping effects of e-collaboration technologies: Bugs and features." *International Journal of e-Collaboration (IJeC)* 1 (1):1-23.
- Marshall, Alison L, Eva R Leslie, Adrian E Bauman, Bess H Marcus, and Neville Owen. 2003. "Print versus website physical activity programs: a randomized trial." *American journal of preventive medicine* 25 (2):88-94.

- Maximilien, E Michael, Tyrone Grandison, Tony Sun, Dwayne Richardson, Sherry Guo, and Kun Liu. 2009. "Privacy-as-a-service: Models, algorithms, and results on the facebook platform." *Proceedings of Web*.
- McEachan, Rosemary Robin Charlotte, Mark Conner, Natalie Jayne Taylor, and Rebecca Jane Lawton. 2011. "Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis." *Health Psychology Review* 5 (2):97-144.
- McLeroy, Kenneth R, Daniel Bibeau, Allan Steckler, and Karen Glanz. 1988. "An ecological perspective on health promotion programs." *Health Education & Behavior* 15 (4):351-377.
- McPherson, Miller, Lynn Smith-Lovin, and James M Cook. 2001. "Birds of a feather: Homophily in social networks." *Annual review of sociology*:415-444.
- Michie, S, M Johnston, C Abraham, R Lawton, D Parker, and A Walker. 2005. "Making psychological theory useful for implementing evidence based practice: a consensus approach." *Quality and safety in health care* 14 (1):26-33.
- Michie SF, R West, R Campbell, J Brown, and H Gainforth. 2014. "ABC of Behaviour Change Theories."
- Michie, Susan, Marie Johnston, Jill Francis, Wendy Hardeman, and Martin Eccles. 2008. "From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques." *Applied psychology* 57 (4):660-680.
- Miller, A. S. 2013. "The Zombie Apocalypse: The Viral Impact of Social Media Marketing on Health." *Journal of Consumer Health on the Internet* 17 (4):362-368.

- Mislove, Alan, Bimal Viswanath, Krishna P. Gummadi, and Peter Druschel. 2010. "You are who you know: inferring user profiles in online social networks." Proceedings of the third ACM international conference on Web search and data mining, New York, New York, USA.
- Moher, David, Alessandro Liberati, Jennifer Tetzlaff, and Douglas G Altman. 2009. "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement." *Annals of internal medicine* 151 (4):264-269.
- Mohr, D. C., M. N. Burns, S. M. Schueller, G. Clarke, and M. Klinkman. 2013. "Behavioral Intervention Technologies: Evidence review and recommendations for future research in mental health." *General Hospital Psychiatry* 35 (4):332-338.
- Mohr, D. C., S. M. Schueller, E. Montague, M. N. Burns, and P. Rashidi. 2014. "The behavioral intervention technology model: an integrated conceptual and technological framework for eHealth and mHealth interventions." *J Med Internet Res* 16 (6):e146.
- Moorhead, S. A., D. E. Hazlett, L. Harrison, J. K. Carroll, A. Irwin, and C. Hoving. 2013. "A new dimension of health care: systematic review of the uses, benefits, and limitations of social media for health communication." *Journal of Medical Internet Research* 15 (4):e85.
- Morrison, Cecily, and Gavin Doherty. 2014. "Analyzing Engagement in a Web-Based Intervention Platform Through Visualizing Log-Data." *J Med Internet Res* 16 (11):e252.
- Morse, Janice M. 2000. "Determining sample size." *Qualitative health research* 10 (1):3-5.
- Moser, Richard P, Bradford W Hesse, Abdul R Shaikh, Paul Courtney, Glen Morgan, Erik Augustson, Sarah Kobrin, Kerry Y Levin, Cynthia Helba, and David Garner. 2011.

- "Grid-enabled measures: using Science 2.0 to standardize measures and share data." *American journal of preventive medicine* 40 (5):S134-S143.
- Nabi, R. L., A. Prestin, and J. So. 2013. "Facebook friends with (health) benefits? Exploring social network site use and perceptions of social support, stress, and well-being." *Cyberpsychology, Behavior, and Social Networking* 16 (10):721-727.
- NCCDPHP, CDC. 2009. "Chronic Disease Prevention and Health Promotion." <http://www.cdc.gov/chronicdisease/resources/publications/aag/chronic.htm>.
- Neve, M, Philip J Morgan, PR Jones, and CE Collins. 2010. "Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis." *Obesity Reviews* 11 (4):306-321.
- Noar, Seth M, Christina N Benac, and Melissa S Harris. 2007. "Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions." *Psychological bulletin* 133 (4):673.
- Norman, Gregory J, Marion F Zabinski, Marc A Adams, Dori E Rosenberg, Amy L Yaroch, and Audie A Atienza. 2007. "A review of eHealth interventions for physical activity and dietary behavior change." *American journal of preventive medicine* 33 (4):336-345. e16.
- O'Neill, B., S. Ziebland, J. Valderas, and F. Lupiáñez-Villanueva. 2014. "User-generated online health content: A survey of internet users in the United Kingdom." *Journal of Medical Internet Research* 16 (4).
- Oinas-Kukkonen, Harri, and Marja Harjumaa. 2009. "Persuasive systems design: Key issues, process model, and system features." *Communications of the Association for Information Systems* 24 (1):28.

- Okun, Morris A, Linda Ruehlman, Paul Karoly, Rafer Lutz, Chris Fairholme, and Rachel Schaub. 2003. "Social support and social norms: do both contribute to predicting leisure-time exercise?" *American Journal of Health Behavior* 27 (5):493-507.
- Orlikowski, Wanda J, and C Suzanne Iacono. 2006. *Desperately seeking the 'IT' in IT research: a call to theorizing the IT artifact*. Chichester, UK: John Wiley & Sons Ltd.
- Paddock, Rod, and John V Petersen. 2012. *Practical jQuery*: Apress.
- Park, H., S. Rodgers, and J. Stemmler. 2013. "Analyzing health organizations' use of twitter for promoting health literacy." *Journal of Health Communication* 18 (4):410-425.
- Park, Namsu, Kerk F Kee, and Sebastián Valenzuela. 2009. "Being immersed in social networking environment: Facebook groups, uses and gratifications, and social outcomes." *CyberPsychology & Behavior* 12 (6):729-733.
- Patrick, K., S. J. Marshall, E. P. Davila, J. K. Kolodziejczyk, J. H. Fowler, K. J. Calfas, J. S. Huang, C. L. Rock, W. G. Griswold, A. Gupta, G. Merchant, G. J. Norman, F. Raab, M. C. Donohue, B. J. Fogg, and T. N. Robinson. 2014. "Design and implementation of a randomized controlled social and mobile weight loss trial for young adults (project SMART)." *Contemporary Clinical Trials* 37 (1):10-18.
- Pedrana, A., M. Hellard, J. Gold, N. Ata, S. Chang, S. Howard, J. Asselin, O. Ilic, C. Batrouney, and M. Stooze. 2013. "Queer as F**k: reaching and engaging gay men in sexual health promotion through social networking sites." *Journal of Medical Internet Research* 15 (2):e25.
- PEW. 2014. "Mobile Technology Fact Sheet." Accessed 10/28/2014. <http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/>.

- Poirier, Josée, and Nathan K Cobb. 2012. "Social influence as a driver of engagement in a web-based health intervention." *Journal of medical Internet research* 14 (1):e36.
- Pratt, Siofra. 2014. "Then & Now: The Most Popular US Websites 2004 vs. 2014." Accessed 6/14/2014. <http://www.webcitation.org/6QKn5ZSVC>.
- Prochaska, J. J., C. Pechmann, R. Kim, and J. M. Leonhardt. 2012. "Twitter=quitter? An analysis of Twitter quit smoking social networks." *Tobacco Control* 21 (4):447-449.
- Prochaska, James O, and Carlo C DiClemente. 1982. "Transtheoretical therapy: Toward a more integrative model of change." *Psychotherapy: Theory, Research & Practice* 19 (3):276.
- Prochaska, James O, Carlo C DiClemente, and John C Norcross. 1992. "In search of the structure of change." In *Self Change*, 87-114. Springer.
- Qureshi, Moinuddin K, and Yale N Patt. 2006. "Utility-based cache partitioning: A low-overhead, high-performance, runtime mechanism to partition shared caches." Proceedings of the 39th Annual IEEE/ACM International Symposium on Microarchitecture.
- Raghavan, Ajaykrishna, Abhishek Chandra, and Jon B Weissman. 2014. "Tiera: towards flexible multi-tiered cloud storage instances." Proceedings of the 15th International Middleware Conference.
- Ramaprasad, Arkalgud, and Sridhar S Papagari. 2009. "Ontological design." Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology.

- Ramaprasad, Arkalgud, and Thant Syn. 2015. "Ontological Meta-Analysis and Synthesis." *Communications of the Association for Information Systems* 37 (1).
- Ramaprasad, Arkalgud; Syn, Thant. 2014. "Ontological Topography: Mapping the Bright, Light, Blind/Blank Spots in Healthcare Knowledge." *Information Systems Frontiers* In Press.
- Reblin, Maija, and Bert N. Uchino. 2008. "Social and Emotional Support and its Implication for Health." *Current opinion in psychiatry* 21 (2):201-205.
- Reese, Will. 2008. "Nginx: the high-performance web server and reverse proxy." *Linux Journal* 2008 (173):2.
- Reuter, Christian, and Simon Scholl. 2014. "Technical Limitations for Designing Applications for Social Media." *Mensch & Computer 2014-Workshopband*.
- REUTERS, THOMSON. 2011. "EndNote®." *Bibliographies Made Easy*TM <http://www.endnote.com>.
- Richards, Lyn. 1999. *Using NVivo in qualitative research*: Sage.
- Rimmer, James H, and David Braddock. 2002. "Health Promotion for People With Physical, Cognitive, and Sensory Disabilities*: An Emerging National Priority." *American Journal of Health Promotion* 16 (4):220-224.
- Ritterband, Lee M, Frances P Thorndike, Daniel J Cox, Boris P Kovatchev, and Linda A Gonder-Frederick. 2009. "A behavior change model for internet interventions." *Annals of Behavioral Medicine* 38 (1):18-27.

- Rodgers, Beth L. 2005. *Developing nursing knowledge: Philosophical traditions and influences*: Lippincott Williams & Wilkins.
- Rogers, E.M. 1962. *Diffusion of innovations*: Free Press of Glencoe.
- Rogers, Everett M. 2010. *Diffusion of innovations*: Simon and Schuster.
- Rogers, Everett M, and F Floyd Shoemaker. 1971. "Communication of innovations: A cross-cultural approach."
- Rosenstock, Irwin M. 1974. "Historical origins of the health belief model." *Health Education & Behavior* 2 (4):328-335.
- Rosenstock, Irwin M, Victor J Strecher, and Marshall H Becker. 1988. "Social learning theory and the health belief model." *Health Education & Behavior* 15 (2):175-183.
- Rui, J. R., Y. Chen, and A. Damiano. 2013. "Health organizations providing and seeking social support: A twitter-based content analysis." *Cyberpsychology, Behavior, and Social Networking* 16 (9):669-673.
- Ryan, P. 2009. "Integrated Theory of Health Behavior Change: background and intervention development." *Clin Nurse Spec* 23 (3):161-70; quiz 171-2.
- Sallis, James F, Neville Owen, and Edwin B Fisher. 2008. "Ecological models of health behavior." *Health behavior and health education: Theory, research, and practice* 4:465-485.

Sauro, Jeff. 2011. Measuring usability with the system usability scale (SUS).

Scholz, Urte, Benjamin Schüz, Jochen P Ziegelmann, Sonia Lippke, and Ralf Schwarzer. 2008. "Beyond behavioural intentions: Planning mediates between intentions and physical activity." *British journal of health psychology* 13 (3):479-494.

Schunk, Dale H, and Barry J Zimmerman. 2007. "Influencing children's self-efficacy and self-regulation of reading and writing through modeling." *Reading & Writing Quarterly* 23 (1):7-25.

Schwartz, Baron, Peter Zaitsev, and Vadim Tkachenko. 2012. *High performance MySQL: Optimization, backups, and replication*: " O'Reilly Media, Inc."

Sharma, Mayank. 2008. *Elgg social networking*: Packt Publishing Ltd.

Short, E. Camille, Corneel Vandelanotte, W. Marcus Dixon, Richard Rosenkranz, Cristina Caperchione, Cindy Hooker, Mohan Karunanithi, S. Gregory Kolt, Anthony Maeder, Hang Ding, Pennie Taylor, and J. Mitch Duncan. 2014. "Examining Participant Engagement in an Information Technology-Based Physical Activity and Nutrition Intervention for Men: The Manup Randomized Controlled Trial." *JMIR Res Protoc* 3 (1):e2.

Smedley, Brian D, and S Leonard Syme. 2001. "Promoting health: Intervention strategies from social and behavioral research." *American Journal of Health Promotion* 15 (3):149-166.

Smith, Kirsten P, and Nicholas A Christakis. 2008. "Social networks and health." *Annu. Rev. Sociol* 34:405-429.

- Starfield, Barbara, and Leiyu Shi. 2002. "Policy relevant determinants of health: an international perspective." *Health Policy* 60 (3):201-218.
- Stenström, CH. 1994. "Home exercise in rheumatoid arthritis functional class II: goal setting versus pain attention." *The Journal of rheumatology* 21 (4):627-634.
- Stinson, Jennifer, Patrick McGrath, Ellen Hodnett, Brian Feldman, Ciaran Duffy, Adam Huber, Lori Tucker, Ross Hetherington, Shirley Tse, Lynn Spiegel, Sarah Campillo, Navreet Gill, and Meghan White. 2010. "Usability Testing of an Online Self-management Program for Adolescents With Juvenile Idiopathic Arthritis." *J Med Internet Res* 12 (3):e30.
- Strater, Katherine, and Heather Richter Lipford. 2008. "Strategies and struggles with privacy in an online social networking community." Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction-Volume 1.
- Strauch, Steve, Oliver Kopp, Frank Leymann, and Tobias Unger. 2011. "A taxonomy for cloud data hosting solutions." 2011 IEEE Ninth International Conference on Dependable, Autonomic and Secure Computing.
- Strauss, Anselm, and Juliet M Corbin. 1990. *Basics of qualitative research: Grounded theory procedures and techniques*: Sage Publications, Inc.
- Strecher, V. J., J. McClure, G. Alexander, B. Chakraborty, V. Nair, J. Konkel, S. Greene, M. Couper, C. Carlier, C. Wiese, R. Little, C. Pomerleau, and O. Pomerleau. 2008. "The role of engagement in a tailored web-based smoking cessation program: randomized controlled trial." *Journal of Medical Internet Research* 10 (5):e36.

- Strecher, Victor. 2007. "Internet methods for delivering behavioral and health-related interventions (eHealth)." *Annu. Rev. Clin. Psychol.* 3:53-76.
- Swann, Catherine, Kate Bowe, Michael Kosmin, and Geraldine McCormick. 2003. *Teenage pregnancy and parenthood: a review of reviews. Evidence briefing*: Health Development Agency London.
- Thomas, Keir, Jaime Sicam, Andy Channelle, Adam Thomas, and Chivas Sicam. 2009. *Beginning Ubuntu Linux*: Apress.
- Ullman, Larry. 2004. *PHP for the world wide web: visual quickstart guide*: Peachpit Press.
- Valle, C. G., D. F. Tate, D. K. Mayer, M. Allicock, and J. Cai. 2013. "A randomized trial of a Facebook-based physical activity intervention for young adult cancer survivors." *Journal of Cancer Survivorship* 7 (3):355-368.
- Vandelanotte, Corneel, and Carol A. Maher. 2015. "Why We Need More Than Just Randomized Controlled Trials to Establish the Effectiveness of Online Social Networks for Health Behavior Change." *American Journal of Health Promotion* 30 (2):74-76.
- Vandelanotte, Corneel, Kym M Spathonis, Elizabeth G Eakin, and Neville Owen. 2007. "Website-delivered physical activity interventions: A review of the literature." *American journal of preventive medicine* 33 (1):54-64.
- Wang, Rui, Yuchen Zhou, Shuo Chen, Shaz Qadeer, David Evans, and Yuri Gurevich. 2013. "Explicating SDKs: Uncovering Assumptions Underlying Secure Authentication and Authorization." *USENIX Security*.

- Wantland, Dean J, Carmen J Portillo, William L Holzemer, Rob Slaughter, and Eva M McGhee. 2004. "The effectiveness of Web-based vs. non-Web-based interventions: a meta-analysis of behavioral change outcomes." *Journal of medical Internet research* 6 (4).
- Webb, Thomas, Judith Joseph, Lucy Yardley, and Susan Michie. 2010. "Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy." *Journal of medical Internet research* 12 (1):e4.
- West, Robert, and Jamie Brown. 2013. *Theory of addiction*: John Wiley & Sons.
- WHO. 2014a. "Health System Financing Profile by Country." Accessed 10/28/2014. http://apps.who.int/nha/database/Country_Profile/Index/en.
- WHO. 2014b. "Risk factors." Accessed 10/28/2014. http://www.who.int/gho/ncd/risk_factors/en/.
- Williams, Gillian, Michele P Hamm, Jocelyn Shulhan, Ben Vandermeer, and Lisa Hartling. 2014. "Social media interventions for diet and exercise behaviours: a systematic review and meta-analysis of randomised controlled trials." *BMJ open* 4 (2):e003926.
- Williams, J. B., and J. H. Weber-Jahnke. 2010. "Social networks for health care: Addressing regulatory gaps with privacy-by-design." PST 2010: 2010 8th International Conference on Privacy, Security and Trust.
- Williams, James. 2010. "Social networking applications in health care: threats to the privacy and security of health information." Proceedings of the 2010 ICSE Workshop on Software Engineering in Health Care.

- Young, Alyson L., and Anabel Quan-Haase. 2009. "Information revelation and internet privacy concerns on social network sites: a case study of facebook." Proceedings of the fourth international conference on Communities and technologies, University Park, PA, USA.
- Young, S. D., W. G. Cumberland, S. J. Lee, D. Jaganath, G. Szekeres, and T. Coates. 2013. "Social networking technologies as an emerging tool for HIV prevention." *Annals of Internal Medicine* 159 (5):318-324.
- Zhang, Y., D. He, and Y. Sang. 2013. "Facebook as a platform for health information and communication: A case study of a diabetes group." *Journal of Medical Systems* 37 (3).
- Zheleva, Elena, and Lise Getoor. 2009. "To join or not to join: the illusion of privacy in social networks with mixed public and private user profiles." Proceedings of the 18th international conference on World wide web.
- Zuckerberg, Mark. 2014. "Today is Facebook's 10th anniversary." Accessed 2/4/2014.

VITA

Mohanraj Thirumalai

EDUCATION

University of Illinois **Chicago, IL**
Candidate for Doctor of Philosophy

University of Illinois **Chicago, IL**
Masters of Engineering **December 2009**

University of Illinois **Chicago, IL**
Masters of Science in Computer Engineering **May 2003**

University of Madras **Chennai, India**
Bachelor of Engineering in Electrical and Electronics **May 1999**

PROFESSIONAL EXPERIENCE

Director of Information & Communication Technology
Rehabilitation Engineering Research Center on Interactive
Exercise Technologies and Exercise Physiology for People
with Disabilities **Birmingham, AL**
Aug 2012 to Current

Director of Information & Communication Technology
National Center on Health, Physical Activity & Disability **Birmingham, AL**
Aug 2012 to Current

Information Systems Manager
UAB/Lakeshore Research Collaborative
School of Health Professions
University of Alabama at Birmingham

Birmingham, AL
Aug 2012 to Current

Senior Network Analyst
National Center on Physical Activity and Disability
RERC on Recreational Technologies
Department of Disability and Human Development
University of Illinois at Chicago

Chicago, IL
May 2003 to Aug 2012

Graduate Research Assistant
National Center on Physical Activity and Disability
RERC on Recreational Technologies
Department of Disability and Human Development
University of Illinois at Chicago

Chicago, IL
August 2000 to May 2003

CERTIFICATIONS

Zend Certified Engineer

Designing Universally Accessible Web Resources
 UIUC, Champaign, IL

Microsoft Certified Professional
 Six different MCP certifications, which earned a MCSD certification.

Professional Diploma in Systems Development

- NIIT, India

Web Programmer
 SSI, India

OTHER EXPERIENCE AND PROFESSIONAL MEMBERSHIPS

2015 Referee for Hawaii International Conference on System Sciences (HICSS)
 2015 Referee for Disability and Health Journal

PUBLISHED WORK

Bruce L. Lambert, Clement Yu, **Mohanraj Thirumalai**, A System for Multiattribute Drug Product Comparison, Journal of Medical Systems, Volume 28, Issue 1, Feb 2004, Pages 31 – 56

Padalabalanarayanan Sangeetha, **Thirumalai Mohanraj**, John Sam F, Fay Brian, RERC RecTech's Online Solutions Database for Assistive Technology Equipment, submitted for RESNA 2005.

Jennifer Gray-Stanley, MA, James Rimmer, PhD, Cheeri Ong, MS, **Mohanraj Thirumalai**, MS, Onar Vikingstad, Developing a responsive consumer request service system. Presented at the annual meeting for American Public Health Association, 2006.

Amy Rauworth, MS, RCEP, **Mohanraj Thirumalai**, MS, Using Social Media to Promote Positive Health Behavior Change in Individuals with Disabilities. Presented at the annual meeting for American Public Health Association, 2011.

Vijay Vasudevan, MPH, Ming-De Chen, MS, OT, **Mohanraj Thirumalai**, MS, James Rimmer, PhD Database of Systematic Evidence on Physical Activity and Disability (DOSE-PAD). Presented at the annual meeting for American Public Health Association, 2011.

Ramaprasad, Arkalgud and **Thirumalai, Mohanraj**, Managing Population Health: An Ontological Framework (December 1, 2012). 2012 Summit on the Science of Eliminating Health Disparities, Washington DC, USA, December 2012.

Ramaprasad, Arkalgud and Syn, Thant and **Thirumalai, Mohanraj**, An Ontological Map for Meaningful Use of Healthcare Information Systems (MUHIS) (March 1, 2014). HEALTHINF 2014: Proceedings of the International Conference on Health Informatics, Marta Bienkiewicz, Christine Verdier, Guy Plantier, Tanja Schultz, Ana Fred and Hugo Gamboa, eds., SCITEPRESS, 2014.

Laurie A. Malone, Sangeetha Padalabalanarayanan, **Mohanraj Thirumalai**, Casey Herman, Christopher Mills, Audrey B. Cody, David Ryan, & James H. Rimmer, Making active video games accessible for youth with physical disabilities. NARRTC 2014

Laurie A. Malone, Sangeetha Padalabalanarayanan, **Mohanraj Thirumalai**, Casey Herman, Christopher Mills, Audrey B. Cody, David Ryan, & James H. Rimmer, Identification Of Accessibility Barriers Encountered By Youth With Physical Disabilities During Active Video Game Play. RESNA 2014

Malone, L., Padalabalanarayanan, S., **Thirumalai, M.**, Herman, C., Fidopiastis, C., Rowland, J., & Rimmer, J. (2014). Designing Interactive Gaming Environments for Youth with Disabilities. ISBNPA Pre-Conference Symposium, Games for Increasing Physical Activity: Mechanisms for Change. Houston, TX.

Thirumalai, M., & Ramaprasad, A. (2015, January). Ontological Analysis of the Research on the Use of Social Media for Health Behavior Change. In System Sciences (HICSS), 2015 48th Hawaii International Conference on (pp. 814-823). IEEE.

Perspectives on Active Video Gaming as a New Frontier in Accessible Physical Activity for Youth With Physical Disabilities Jennifer L. Rowland, Laurie A. Malone, Cali M. Fidopiastis, Sangeetha Padalabalanarayanan, **Mohanraj Thirumalai**, and James H. Rimmer PHYS THER published ahead of print August 27, 2015, doi:10.2522/ptj.20140258

RESEARCH SUPPORT

Ongoing Research Support

HHS U59DD000906 4/1/2012–3/31/2016
Centers for Disease Control and Prevention (CDC)
National Center on Health, Physical Activity and Disability
The central goal of this national practice center (funded by CDC since 1999) is to develop leadership, policy training and telehealth initiatives that support the health and wellness of people with disabilities.
Role: Director of ICT

DED H133E120005 10/1/2012 - 9/30/2017
Dept of Education/NIDRR
Rehabilitation Engineering Research Center on Interactive Exercise Technologies and Exercise Physiology Benefiting Persons with Disabilities.
The Center addresses measurement issues and access to recreation and exercise using virtual reality and other forms of technology in adults with physical and cognitive disabilities.
Role: Director of ICT

H133A130044 10/01/2013 - 09/30/2018
Dept of Education/NIDRR
Dose-Response Effects of Transformative Exercise in Improving Health and Function in Adults with Spinal cord Injury an Multiple Sclerosis
Longitudinal study focused on collecting information on a range of variables to investigate the differential influences of factors on health and function in spinal cord injury and multiple sclerosis participants.
Role: ICT Lead

H133A120102-12A 10/01/2013 - 9/30/2015
Dept of Education/NIDRR
UAB Obesity Research Project on Prevalence, Adaptations and Knowledge Translation in Youth and Young Adults with Disabilities

This project addresses significant gaps in the literature related to prevalence, risk factors and consequences of obesity in youth and young adults with disabilities.

Role: ICT Lead

NIH 1R21HD073487-01A1

9/18/2013– 8/31/2015

National Institute on Child Health and Human Development

Internet Based System for Managing Obesity in Children with Disabilities

The proposed feasibility study will develop and pilot test an innovative telehealth system to promote improved physical activity and nutrition in children with spina bifida. POWERS (Personalized Online Weight and Exercise Response System) is a novel, multifocal family-centered tailored intervention utilizing an innovative online tool designed to facilitate improvements in physical activity and nutritional behaviors.

Role: ICT Lead

Selected Completed Research Support

Agency for Healthcare Research and Quality (AHRQ), 5/1/10-5/31/13. Improving Health Care Quality through Health IT for Persons with Intellectual Disabilities (Grant #HHS 1R21HS018766)

Role: ICT Lead

Centers for Disease Control and Prevention, 4/1/08-3/31/12. National Center on Physical Activity and Disability (Grant #U59DD000437)

Role: ICT Lead

Centers for Disease Control and Prevention, 9/30/06-9/29/10. Personalized Physical Activity and Nutrition Intervention for Overweight/Obese Adults with Mobility Disabilities. (Grant #1R01DD000134)

Role: ICT Lead

Centers for Disease Control and Prevention [Supplement], 2/26/13-9/29/13. Customization of a self-management health promotion program for people with hemophilia. (Grant # 1U59DD000906-01).

Role: ICT Lead

National Institute on Disability and Rehabilitation Research (NIDRR), 10/1/07-9/30/12. Rehabilitation Engineering Research Center on Recreational Technology and Exercise Physiology Benefiting Persons with Disabilities. (Grant # H133E070029).

Role: ICT Lead

National Institute on Disability and Rehabilitation Research (NIDRR), 11/1/06-10/31/10. Obesity and Obesity-Related Secondary Conditions in Youth with Disabilities. (Grant # H133A060066).

Role: ICT Lead

Centers for Disease Control and Prevention, 4/1/03-3/31/0. National Center on Physical Activity and Disability.

Role: ICT Lead

National Institute on Disability and Rehabilitation Research (NIDRR), 11/1/02-10/31/07.

Rehabilitation Engineering Research Center on Recreational Technology and Exercise Physiology Benefiting Persons with Disabilities. (Grant # H133E020715).

Role: ICT Lead

Centers for Disease Control and Prevention, 4/1/99-3/31/03. National Center on Physical Activity and Disability.

Role: ICT Lead