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Smart Home Healthcare Settings: A Qualitative Study of the Domain Boundary

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Abstract: Addressing the health problems of the 21st century will require individuals to use a new set of medical and public health resources that extend beyond historic and traditional medical devices and are built on current and smart information technologies. Much of these new medical tools was originally designed by device manufacturers to be used only in clinical settings and by trained healthcare professionals but recently are finding their way into the home nevertheless. Their migration to the home poses many challenges to both caregivers and care recipients. In order to facilitate their migration to the home, it is very important to first understand the domain boundary, its components and their interactions. Little research discusses the context of smart home healthcare and its surrounding entities to date. This paper aims to fill the knowledge gap by developing a framework of smart home healthcare context. To this end, we conducted semi-structured interviews with patients and health professionals served for or by home healthcare agencies on the east coast in the United States. We analyzed the content applying thematic approach. The findings revealed four major components of the framework including person, tasks, technologies, and environments. The findings also revealed us to define the interactions between these components. The findings have significant implications for smart home designers and manufacturers, and service providers.

INTRODUCTION

In the United States, healthcare devices, technologies, and care practices are rapidly moving into the home (Manhattan, 2009). Health Information Technology (HIT) is the key facilitator for this migration. It is impossible to see this migration into practice without HIT (Lewis, 2001). HIT can be defined as an umbrella framework to describe the comprehensive management of health information across computerized systems and its secure exchange between consumers, providers, government and quality entities, and insurers (Karsh et al., 2011). If the target domain is the patient home and the used technology is smart, then we call it smart home healthcare information technology (sH²IT).

The healthcare delivery system is rapidly changing today, and individuals are assuming an increasing role in management of their own health (LaPlante et al., 2011). In these settings, individuals are expected to perform a range of healthcare tasks and interact with a vast array of medical devices and technologies in residential settings (LaPlante et al., 2011). Thus, healthcare that occurs at home is a complex experience, involving various types of persons, tasks, technologies, and environments.

All of these elements—the persons, tasks, technologies, and environments—affect the safety and quality of the healthcare that occurs in the home. To ensure that healthcare in the home is safe, efficient, effective, and responsive to individual needs, it requires identifying potential user groups who will be interacting with home health systems; understanding the capabilities, limitations, needs, and preferences of these populations; and matching these capabilities, needs, and preferences to the demands generated by healthcare and health management tasks, technologies, and the environments in which these tasks occur.

Addressing the health problems of the 21st century will require individuals to use a new set of biomedical and public health resources that extend beyond historic and traditional medical devices and are built on current and emerging information technologies (Hesse, 2005; Karami & Gangopadhyay, 2014, Karami et al., 2015). These new information

technology tools will enable the future healthcare system to become predictive, preemptive, and personalized to the needs of individual providers, care recipients, and caregivers to an extent not previously possible (Gibbons, 2007).

Much of these new medical tools was originally designed by device manufacturers to be used only in clinical settings and by trained healthcare professionals (U.S. food & drug administration, 2010) but recently are finding their way into the home nevertheless (Rialle et al., 2010). Their migration to the home poses many challenges to both caregivers and care recipients (Rialle et al., 2010).

In order to facilitate their migration to the home, we first need to better understand the domain boundary, its components and their interactions. Little research discusses the context of smart home healthcare domain and its surrounding entities using qualitative evidences to date. Domain context enable us to understand and define the important human factors. This paper aims to fill this significant knowledge gap by answering the following research question: How to build a conceptual framework of the domain context? In order to answer this question, we need to first address the following related question: How to classify sH²IT? To this end, we propose a classification scheme of sH²IT that covers the whole range of home healthcare context and conduct a qualitative study to build and discover the main components of the smart home healthcare context.

The paper provides several contributions to the literature. First, it enhances the theoretical foundation of smart home healthcare context, second; it proposes a categorization scheme of sH²IT making it possible to generalize the findings to different types of HIT; third, it develops a conceptual framework of smart home healthcare contexts by identifying the major entities of the domain and the interaction between these entities, fourth; it creates various design artifacts that have significant implications for smart technology designers and manufacturers to improve the provided services.

The paper is organized as follows: next section introduces the home healthcare initiative. Section three proposes a categorization scheme of smart home healthcare context. Section four describes the method design including participants and procedures followed by results and discussion in sections five and six, respectively. The paper concludes by section seven.

HOME HEALTHCARE

Healthcare can form a significant part of a country's economy. The healthcare industry consumed an average of 9.0 percent of the gross domestic product (GDP) across the most developed OECD countries in 2008. The United States (16.0%), France (11.2%), and Switzerland (10.7%) were the top three spenders (Squires, 2012). Health expenditures in the United States neared \$2.6 trillion accounted for 17.9% of nation GDP in 2010, over ten times the \$256 billion spent in 1980 (Kaiser family foundation, 2012). The rate of growth in recent years has slowed relative to the late 1990s and early 2000s, but is still expected to grow faster than national income over the foreseeable future (Davis et al., 2007, Office of the assistant secretary for planning and evaluation, 2013). Addressing this growing burden continues to be a major policy priority. Furthermore, the United States has been in a recession for much of the past decade, resulting in higher unemployment and lower incomes for many Americans. These conditions have put even more attention on health spending and affordability (Blavin et al., 2012, AHIP center for policy and research, 2010).

Refocusing medical delivery systems to be patient-centered, funding for comparative effectiveness research, and supporting for wider use of health IT in the delivery system are all proposals discussed in a debate to reduce the nation healthcare costs (Davis et al., 2007, Kaiser family foundation, 2012). Part of the patient-centered medical delivery system proposal is the home healthcare which aims primarily not only to control healthcare cost through reducing readmission costs and transportation costs, but also improve post-hospitalization healthcare quality and increasing patient independency (National academies of science, 2010, AHIP center for policy and research, 2010).

Home healthcare can be defined as a system of care provided by skilled practitioners to patients in their homes under the direction of a physician (Ellenbecker et al., 2008). Home healthcare services include nursing care, physical, occupational, and speech-language therapy, and medical social services (Ellenbecker et al., 2008). The main goals of home healthcare services are to help individuals to improve function and live with greater independence, to promote the client's optimal level of well-being, and to assist the patient to remain at home, avoiding hospitalization or admission to long-term care institutions (Ellenbecker et al., 2008).

One of the key facilitators for the success of this home healthcare initiative (Rialle et al., 2010) is Health Information Technology (HIT). It is almost unimaginable to consider this initiative without HIT. HIT is in general increasingly viewed as the most promising tool for improving the overall quality, safety and efficiency of the health delivery system (Wu et al., 2006). Clinical decision support systems, computerized provider order entry, electronic medical records are all different forms of general HIT that have been widely used in most developed countries today. Recently, more attention is being devoted to more potential, specialized, domain-specific and emerging HIT (Poon et al., 2006) that can be used to improve healthcare delivery particularly at home. These technologies are still at early stage of adoption and usage in the United States. These technologies are called smart Home Healthcare Information Technology (sH²IT).

PHASE I: CATEGORIZATION SCHEME OF sH²IT

Although there are no generally accepted categorizations of different sH²IT, there are several related attempts. The National academies of science (2010) classified the technology relevant to home healthcare into two major categories: medical devices and health information technologies (HIT) as shown in Figure 1.

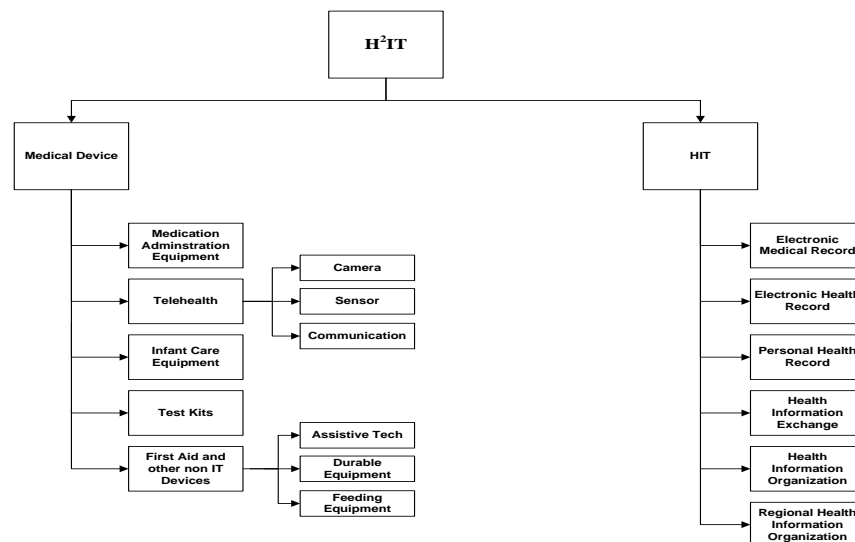


Figure 1. National Academy of Sciences' Categorization of H²IT

Medical devices refer to an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar article that is intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment or prevention of disease (U.S Food and Drug, 2010). Medical devices are further classified into five main categories: medication administration equipment (e.g. medication preparation), telehealth (e.g. facilitating patient-doctor communication), infant care equipment (e.g. sudden death monitoring), test kits (e.g. pregnancy test), and finally non IT devices (e.g. bed, chair and walker). HIT, which refers to electronic records herewith, are further classified into the different subcategories (National alliance for health information technology, 2008): electronic medical record (EMR), electronic health record (EHR), personal health record (PHR), health information exchange (HIE), health information organization (HIO) and regional health information organization (RHIO). One of the major limitations of this classification is that it considers non-IT equipments such as bed, mattress, walker, and wheelchair and is based on whether the technology has a physical presence (i.e. hardware) or not (i.e. software) instead of what the broad functionality of the technology is.

Another classification of H²IT (Cepro, 2008) has been suggested based on the broad functionality of H²IT as shown in Table 1. This classification contains five main categories, namely monitoring systems, medication management tools, A/V communication solutions, telehealth/telemedicine and electronic health records. One of the major limitations of this classification is the comprehensiveness and limited focus primarily on emerging technologies.

Table 1. Cepro's Categorization of H²IT

Category	Description
Monitoring Systems	This category includes Personal Emergency Response (PERS) and activity monitoring systems that utilize broadband to collect and information about the resident. These systems include wearable monitoring and wireless biometric devices that collect physiological information for analysis and reporting.
Medication Management Tools	This category provides automated reminders to take prescriptions.
A/V Communications Solutions	The poster boy for this category is a videophone.
Telehealth/Telemedicine	This category includes a central device that is connected with broadband to care providers. Products include glucometers, blood pressure cuffs, electrocardiogram monitors, weight scales, respiratory devices, pulse oximeters, thermometers and digital cameras.
Electronic Health Records	This is not really a device, but a recurring revenue tool for an integrator to store medical information for clients, such as allergies, medications, medical history and doctor information.

We propose a classification scheme of sH²IT based on the intersection between the two existing schemes, and on the functionalities where sH²IT plays a key role, Figure 2. Specially, we made the following major changes to the two schemes. First, although medication administration deals with the preparation process of the medication (National academies of science, 2010) and medication management deals with the process of reminding the patients to take the medication (Cepro, 2008), these two categories are closely relevant and accordingly combined into one category. Second, both A/V communication and monitoring are separate components of telemedicine and thus they are classified under this category, and relabeled as patient-professional communication and remote monitoring, respectively. Person is the primary component of home healthcare context. Person includes both patients and home healthcare professionals. sH²IT is primarily used to facilitate the connection between them using advanced technologies. Further, patients may be monitored remotely by sH²IT without physical interactions with home healthcare professionals. They can stay independent without any effect on the quality of their life. Third, the various types of electronic records are merged into one. Electronic record is a tool for data storage of individual historical and medical data regardless whether it is a personal health record, electronic medical record, health medical record or others. Their primary goal is to record and store the patient medical information to be accessed by other front-end technologies. Fourth, those non IT items such as durable equipment (e.g., bed, chair and walker) are removed due to low relevance.

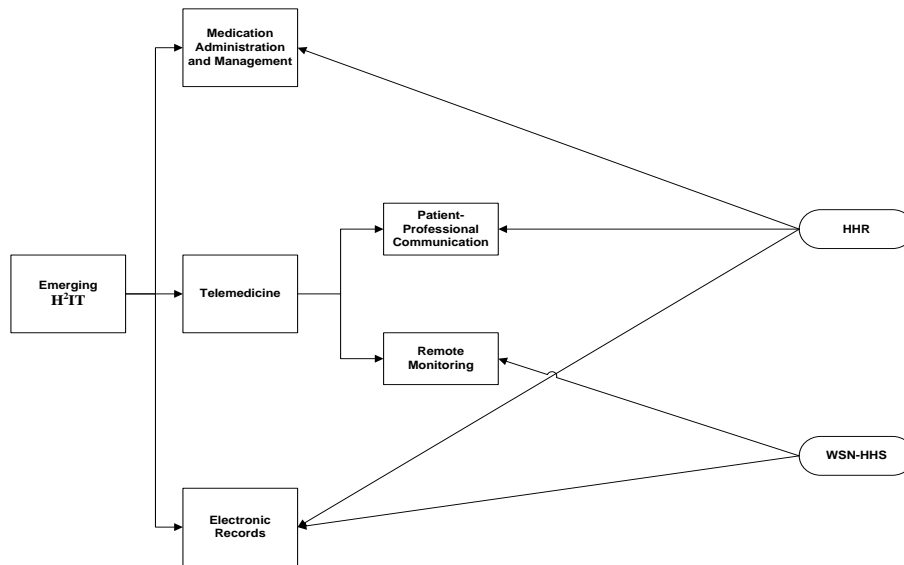


Figure 2. Categorization Scheme of sH²IT

As shown in Figure 2, we classify sH²IT into three main categories: medication administration and management, telemedicine and electronic records. Telemedicine is further categorized into patient-professional communication and remote monitoring. Among other tasks of telemedicine, these two tasks are the most common where sH²IT plays a key role (National academies of science, 2010). Table 2 describes the key tasks of each category, which are defined based on existing categorization schemes and the related literature.

Table 2. Key Tasks for Different Categories of sH²IT

Category	Key Tasks
Medication administration and management	Preparing medication and sending automatic reminders (National academies of science, 2010, Cepro, 2008, Smarr, Fausset, & Rogers, 2010, Skilligent, 2013). For instance, preparing medication by mixing certain level of a drug concentration with others. Sending automatic alarm message to the patient to take the medicine or to the doctor to take care of the patient.
Patient-professional communication	Facilitating the communication between patients at one side and the doctor/physician at the other side through the use of A/V and enable them to conduct diagnostic capabilities such ultra sound and image (National academies of science, 2010, Cepro, 2008) .
Remote monitoring	Collecting information automatically about the resident and posted them on a central device for viewing, analysis and treatment/behavior changes. An alarm message is sent to care provider in case of emergency (National academies of science, 2010, Cepro, 2008, Baker, Armijo, & Belka, 2007, Xuemei, Liangzhong, & Jincheng, 2008).
Electronic records	Storing medical information for clients, such as allergies, medications, medical history and doctor information (National academies of science, 2010, Cepro, 2008, Hennington, & Janz, 2007, Morton, 2008).

Selection of representative sH²IT

To achieve the goal of this paper, it is important to ground and select appropriate representative smart technologies. Selecting representative sH²IT that fits into the above categories is a difficult task. This is because some complex sH²IT cuts across more than one category and such trend is only increasing. We selected the following two

representative smart technologies: Home healthcare robots (HHR) and wireless sensor network-based home healthcare systems (WSN-HHS).

The mapping of these technologies to the categories of sH²IT is shown in Figure 2. Electronic records can be treated as the backend for both HHR and WSN-HHS. HHRs are primarily used to facilitate patient-professional communication (Wada et al., 2013, Skilligent, 2013) and WSN-HHSs for remote monitoring (Baker, Armijo, & Belka, 2007, Xuemei, Liangzhong, & Jincheng, 2008). In addition, HHRs are also used for medication administration and management tasks (Smarr, Fausset, & Rogers, 2010, Skilligent, 2013). Thus, the two selected technologies can cover all the major categories of sH²IT.

To address the issue of overlap in the tasks between the technologies, we draw on the related literature. For instance, although both HHR and WSN-HHS may function for the remote monitoring task, sensors are predominantly used for the task (Baker, Armijo, & Belka, 2007, Xuemei, Liangzhong, & Jincheng, 2008). Additionally, we compared the google search results for the query “sensor, healthcare, monitoring” to those for “robot, healthcare, monitoring”, the number of retrieved papers was much greater for the former than the latter query. To further clarify the tasks associated with selected sH²IT, we designed scenarios in correspondence to the categories that the technologies are mapped to in the user study.

To support further home healthcare research, it is very important to understand the entire context of the home healthcare. Next section aims to define the components of home healthcare context by conducting a qualitative study with different users.

PHASE II: A CONCEPTUAL FRAMEWORK

In this phase, a qualitative study has been conducted to develop the conceptual framework of smart home healthcare context. Next sections describe the method design, results and discussions of major findings of this second phase.

METHOD DESIGN

To answer the research question, the study’s data was collected through semi-structured interviews with different users in the home healthcare domain. This qualitative method was selected because relevant domain entities have not yet been identified. Semi-structured interviews gather detailed information about each user’s beliefs without preconceived factors; the method provides opportunities for identifying unanticipated outcomes and is effective in understanding the main components in the situated context (Creswell, 2003). Hence, the results of this qualitative study enable the development of theories and framework of the smart home healthcare context.

Participants

We conducted semi-structured interviews with patients and health professionals served for or by home healthcare agencies on the east coast of the United States. The latter includes any of the following: doctors, physicians, nurses, social workers, therapists, pharmacists, dentists. There were about 150 agencies distributed over 50 cities, which are broadly classified into non-medical (e.g., home aid) and medical homecare (e.g., certified nurse and hospice) categories (Home health compare, 2013). The medical agencies offer nursing care, physical, occupational, speech, and respiratory therapy as well as social services and hospice care; and the non-medical agencies offer primarily home care services such as housekeeping, shopping and meal preparation as well as some health homecare services such as medication administration and assistance in health promotion exercises. Members belonging to these agencies include both patients and health professionals. Their participation was voluntary.

Networking was used to obtain a purposive sample of individuals who 1) participated in home healthcare services (e.g., members of the homecare agencies) and 2) preferably was receiving or providing long-term homecare services; and for patients, who also 3) were preferably elderly, and 4) had the ability to understand the interview questions. A purposive sample is deemed appropriate for exploratory research designed to query respondents who have experienced a domain of interest. Using the networking technique, the researchers identified individuals who have experienced in home healthcare services (e.g., served for or by one of the home healthcare agencies). These respondents were then asked to name additional individuals who have experienced the domain services as well. We used scenarios along

with storyboards in the interviews representing different use contexts of HIT in the home healthcare domain. Scenarios have been selected as a research method by many previous studies (Pommeranz et al., 2011, Znagui-Hassani, 2010). An example of one scenario and storyboard is provided in Appendix A.

Procedure

The current study was designed to employ the qualitative interview technique. With this data collection technique, the respondent is encouraged to describe in depth the personally experienced phenomenon. In using this method rather than attempting to investigate users' opinion by obtaining forced-choice responses to decontextualized variables, the researcher can attempt to learn the respondent's meaning of the experience. The goal is to discover patterns of experiences using interviews that define the context components (Thompson et al., 1989). The interview has been found to be a powerful tool for attaining in-depth understanding of another person's experience (Kvale, 1983). Research analysis of interview-derived information is considered valid because respondents' own words are used for understanding their experiences. Accordingly, respondents in this study were presented with a set of open-ended questions designed to encourage them to discuss and describe their experiences in the domain.

This study was approved on by the UMBC/Institution review board. The study approval ID is Y14LZ12112. All the stored data is deidentified. We used inductive method of analysis to discover the main components of the smart home healthcare domain. Kvale's approach (Kvale, 1983) was used for data collection and analysis, which has seven steps: thematizing, designing, interviewing, transcribing, analyzing, verifying, and reporting.

The guidelines were designed before interviews being conducted with the participants. A simple demographics questionnaire was administered after each interview. During each interview, notes and audio were recorded. Upon completion, collected data were analyzed. All the interview discussions were transcribed and processed by the principal researcher and independent researchers. During processing, pronouns and other indexical terms were replaced with their nominal meanings, so that their surrounding concepts would be clear.

Content analysis applying thematic approach (Ritchie & Spencer, 1994) was used to analyze the conversations between the researchers and participants in the semi-structured interviews. Content analysis is the systematic, objective, and quantitative analysis of message characteristics by inductive methods.

RESULTS

Fifteen users were interviewed including both home healthcare patients and health professionals. The later includes physicians, nurses, therapists and social workers. Specifically, we interviewed six patients, and the rest were health professionals with experiences in home healthcare mostly for long-term home healthcare services. Among them, four are males, seven of the participants belonged to the 60+ years old age group, about three-fifth of the participants had a graduate degree. The statistics also show that all the participants used the Internet and the computer several times a day. The diversity of the participants is beneficial for the purpose of this study. Surprisingly, health professionals provided us with feedback not only about themselves, but also about their patients by assuming that the professionals knew what their patients might think.

The qualitative analysis reveals four major components of the smart home healthcare context and explore the interactions between them. Table 3 shows some sample quotes taken from the in-depth interviews for each component. These quotes are evidence bases to support the validity of each component in the framework. The four major artifacts that have been discovered are:

- Person
- Task
- Technology
- Environment

Table 1. Sample comments categorized according to the framework component

Component	Sample quotes
Person	<ul style="list-style-type: none"> • If the machine sends me (<i>caregiver</i>) information about him (<i>patient</i>), then it will be helpful to me and him. • It is very efficient when it comes to the <i>medical professional</i> but it might not be as effective as being present with the <i>patient</i>. • It is an efficient system for both the <i>physician</i> and the <i>patient</i>. • Doctors can interact with the patient, but he is also limited from what he can see from the screen and limited by what the patient can say.
Task	<ul style="list-style-type: none"> • If it's just <i>monitoring</i> and <i>sending an alert</i> in case If something wrong happen to him, then sure it will be helpful. • I know some robots used for <i>medicine management</i> and <i>reminding</i> patient to take it. • What an awesome opportunity for a clinician to be able to actually <i>look at a patient a hundreds of miles far away</i>. • A lot of our patients live alone, so it would be nice to be able to <i>check</i> in with them periodically and not have to actually drive down and make an actually face to face visit. • If it can <i>facilitate communication</i> between the patient and their primary care physician, thats very important to a homecare company.
Technology	<ul style="list-style-type: none"> • <i>Technology</i> can vary from a very simple to a more complex technology. • I have a <i>hospital bed type</i> which has sensors to monitor things like your body but it doesn't send messages to anybody. • It is not that the <i>technology</i> won't be sophisticated, but you will still have someone who will understand what the patient need. • I will use the <i>technology</i> as an auxiliary mechanism to help with working with the patient on a more regular basis. • The <i>technology</i> helps you see more patients with fewer providers.
Environment	<ul style="list-style-type: none"> • It will not be really difficult for me to use the emerging technology because I have support from <i>my wife, daughters and doctors</i>. • We've gone to different <i>areas or states</i> to see how they're using programs that we have. • The <i>infrastructure</i> at my home is very modern. • A lot of these homes we go into, the patients are hoarders, the home are unept, and you have to worry about <i>the family members and the dogs and the other animals. And children, grandchildren</i>. • Healthcare is highly regulated so you're not going to get something into the healthcare system without probably <i>some sort of regulation</i>.

To provide a better understanding of the whole context, it is very important to put all its elements together. Figure 3 shows a high level conceptual framework of the smart home healthcare domain context.

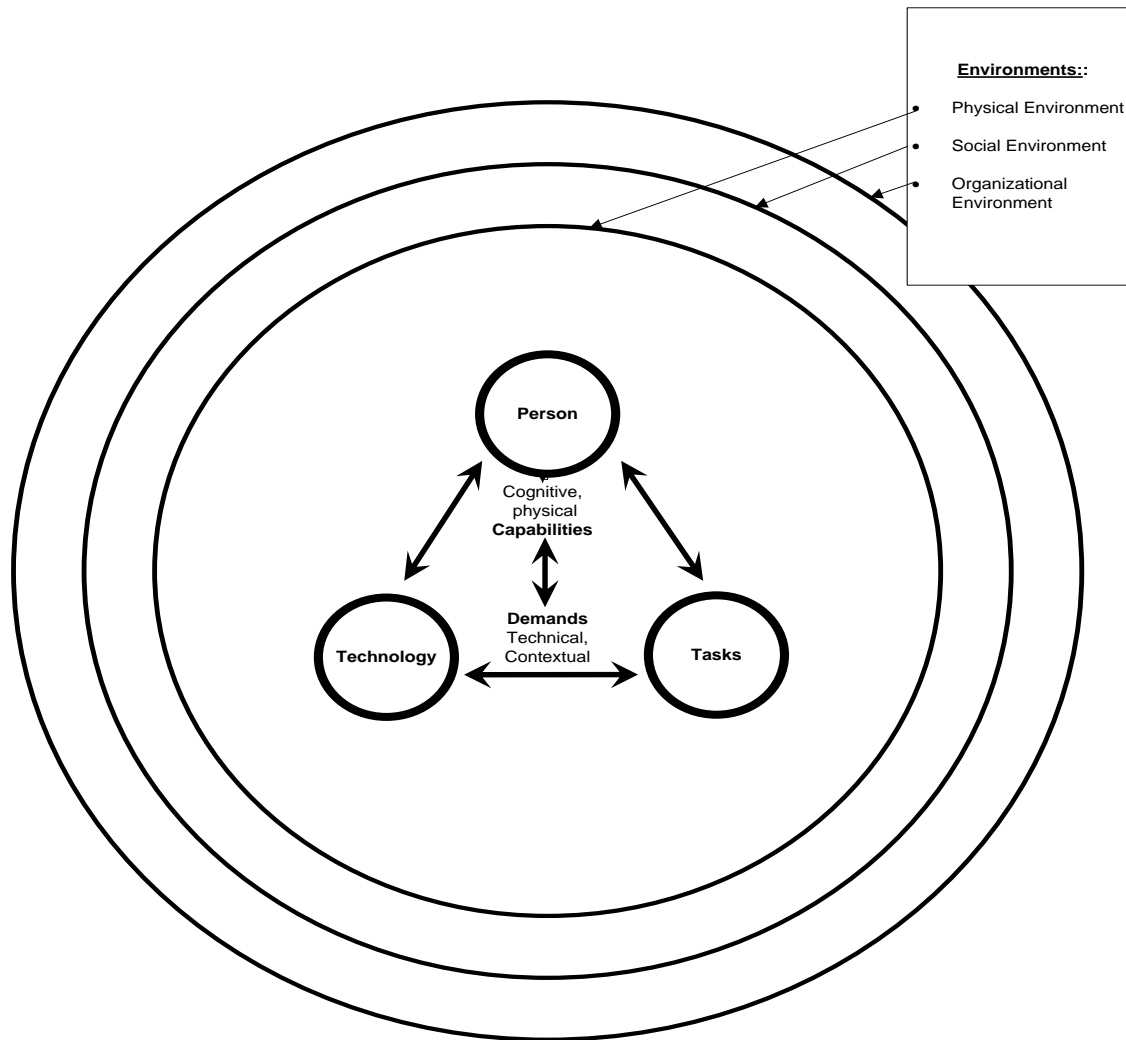


Figure 1. A Conceptual Framework of Smart Home Healthcare Context

As depicted in the framework, people have different characteristics, skills/ abilities, education, experiences, culture and attitudes. As a result, they vary with respect to their cognitive, and physical capabilities with which to interact with tasks and technology. Interactions are represented by the double arrows in the framework. Tasks and technology also have different characteristics. The type of technical and contextual demands placed on people by these tasks and technology vary and are directly related to personal capabilities. The multiple environments in which the person, tasks, and technology reside interact with each other and are represented by overlapping circles in the framework. These environments also have different characteristics and place varying enablers and barriers on a person's successful completion of tasks and use of technology.

DISCUSSION

All the four components of the conceptual framework guide and support further home healthcare research and thus discussed in details in the following sub-sections.

- **Person**

The roles involved in healthcare in the home include people receiving care, who may care for themselves, and those providing care, who may be professionals (Montgomery et al., 2005). The population of people who receive care is

very diverse and possesses variable skills, knowledge, and experiences. They also differ on a number of other characteristics, such as age, cultural and ethnic backgrounds, education, and living arrangements (Humprey & Milone-Nuzzo, 2009). These individuals have a wide range of personal and health literacy skills, social needs, and economic and social resources. People have different perceptions of the power differential between care recipient and the healthcare system, different cultural views about health and illness, and different language capabilities and preferences. All of these can affect the form and quality of healthcare received from healthcare system and professional caregivers.

The majority of people providing care in the home varies and may include physicians and physician assistants, nurses, nurse practitioners, social workers, physical, occupational and speech therapists, pharmacists, and home health aides (Montgomery et al., 2005). They also differ on a number of characteristics, such as age, cultural and ethnic backgrounds, education, variable skills, resources, knowledge, and experiences (Humprey & Milone-Nuzzo, 2009). The design of the technology component or the specification of the task component is driven by how the person perceives them. Therefore, the different kinds of human factors related to person such as emotional and cognitive factors, resulted from the complex interactions with other components, are worth for further exploration.

- **Task**

In general, these tasks involved in caring for oneself or others at home may be quite simple, such as taking brisk walks to promote cardiovascular fitness (Annett & Duncan, 1967). At the other extreme, they may be far more complex, such as recovery from major surgery or acclimating to new chronic care regimens (Lewis, 2001). Complex tasks often require nuanced understanding of a health condition and its treatment as well as the ability to manage symptoms, detect complications, provide hands-on care, offer emotional support, and communicate effectively with healthcare providers to participate in decisions and manage logistical aspects of healthcare.

The three common tasks that broadly cover the different activities of home healthcare context are patient-professional communication, remote monitoring and medication administration and management. In the home settings, the patient health status needs to be continuously monitored and the professionals need updated information about these status. Further, in case of emergency, the patients, especially elder patients, need to communicate remotely with the professionals. Although it is possible to accomplish some of these tasks using traditional methods, HIT can potentially make executing these tasks more effectively and efficiently.

- **Technology**

The devices and technologies for healthcare in the home cover a vast range, from simple first aid tools to respiratory equipment, and from meters and monitors to computer equipment, software associated with interconnected electronic systems to emerging technologies such as robots (Smarr, Fausset, & Rogers, 2010) and sensors (Hao & Foster, 2008). Some of this equipment was designed only for professional use but is finding its way into the home nevertheless (Rialle et al., 2010).

In connecting the technology with task component discussed earlier, the emerging technologies that cover all the tasks are HHR (Wada et al., 2013, Skilligent, 2013) and WSN-HHS (Baker, Armijo, & Belka, 2007, Xuemei, Liangzhong, & Jincheng, 2008). In the home settings, WSN-HHS are used to keep monitoring patient health status and alarm the professional in case of emergency such as patient fall. HHR are used to facilitate the communication between patients and professionals remotely especially for elder people who are unable to visit the hospital repeatedly.

The person interacts with the technology to achieve certain tasks; these interactions are influenced by the technician issues associated with the nature of the technology itself such as security and privacy issues. In addition, given that these technologies are used for different purposes, they vary in terms of several factors such as cost, size, interactivity, and legal and emotional support.

- **Environment**

The environments of healthcare delivered in the home also have subcategories: physical, social and organizational environments as shown in the framework. With few exceptions, they are not designed for this use and often contain numerous barriers, such as stairs that block a wheelchair user, low lighting that makes device controls difficult to see,

or insufficient electrical supply for power-hungry medical equipment. If the home does not have Internet access, the occupants lack connectivity to enable any type of telehealth activity (e.g., data transfer, remote monitoring, information seeking) (Rialle et al., 2010). Each physical home environment resides within its respective social environment of family, friends, or colleagues, which is affected by the community environments of neighborhood and town and by the health policy environment defined by the presiding health and social service organizations and governmental bodies.

All these above surrounding environmental conditions influence the user's adoption decision making process (Drury, 2010). For instance, if the infrastructure support is not sufficient, then the person has no choice to use the emerging technology. Further, if the governmental policy does not provide a support to the use of emerging technologies due to legal issues, then no need for manufacturers to design them. Therefore, understanding all these environmental issues is the key for success of the technology.

CONCLUSION

This research aims to develop a conceptual framework of smart home healthcare context. The study's data was collected through semi structured interviews with patients and health professionals served for or by home healthcare agencies on the east coast in the United States. Content analysis applying thematic approach was used to analyze the conversations between the researchers and participants. The findings reveal four major components of the framework including person, tasks, technologies, and environments. The findings also revealed us to define the interactions between these components. The findings provide significant implications for smart technology designers and manufacturers, and service providers.

This research has various limitations. The categorization scheme was built based on the existing literature not based on empirical evidences. The framework was developed using qualitative feedback collected from samples located on the east coast of the US, generalizability of findings to other states or cultures isn't guaranteed. Sample size of the research was small. In the future, we plan to include more samples and collect the data from participants resided in different states of the US. Further, we plan to conduct qualitative study to test the validity of the framework.

APPENDIX A

Scenario and storyboard of remote monitoring for fall detection:

“Joan, 75, lives by herself. She suffers from visual impairment in addition to general health problems that come with aging. One day while she was trying to go to the toilet she suddenly fell down. She tried to get to landline phone but could not stand. Fortunately, there was a mobile phone next to her. She called 911 seeking help. She is better now but worried what could have happened if there were no mobile phone next to her. To address this concern, she has purchased a sensor based system for detecting fall automatically. The system consists of a set of sensors embedded in furniture, shelves and walls throughout the home. The system is primarily designed to monitor behavioral changes resulting from sudden fall by detecting motion and heart acceleration. Whenever a fall is detected, the system automatically sends an alert message to the doctor. She is now safe in case of emergency.”



1) Joan is trying to go to the toilet



2) Joan suddenly fell down



3) Bed sensors detect Joan falling by recognizing her sudden change in movement



4) Also, wall sensor detects Joan falling by recognizing her heart rates acceleration



5) An Alert message is sent from the sensors to the doctor desktop at his office



6) Help arrives immediately

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