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Enhancing seniors' health-related quality of life: Designing a framework of virtual healthcare information technologies

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ABSTRACT

Virtual healthcare information technologies (HIT) are being adopted during the Covid-19 pandemic. We propose that even after Covid-19, virtual HIT can still have great potentials to address the challenges brought by the aging population on healthcare systems. The key questions are (1) what kinds of virtual HIT will be useful for seniors and (2) how these HIT will affect senior citizens' health-related quality of life (HRQL)? Centered on the concept of HRQL and grounded on task-technology fit (TTF) theory, this paper builds a framework of useful virtual HIT in the context of long-term care for seniors. The framework proposes senior citizens' human characteristics (i.e. restricted mobility, deteriorated working memory and attention, and social isolation) will influence their health-related tasks (task adaptability, autonomy, and interdependence). A set of virtual healthcare systems can be designed to fit seniors' tasks. These HIT will increase seniors' HRQL through increased task-technology fit (i.e. quality of healthcare, timeliness of healthcare, and relationships with seniors). This framework can serve as a base for researchers and practitioners in their endeavor to design more suitable HIT for seniors. © 2020 by the authors. Licensee SSBFNET, Istanbul, Turkey. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

Introduction

Since the Covid-19 pandemic started, ready or not, most people including senior citizens have to use some virtual healthcare information technology (HIT). For example, doctors may call senior patients via telephone or see patients over the Internet instead of face-to-face visits. After the Covid-19, the healthcare system may not go fully back to the face-to-face dominant model. Instead, virtual HIT may stay and play a bigger role in seniors' life than prior-Covid-19 time. More importantly, for seniors, healthy aging means more than just seeing a doctor. As people age, several factors, such as children leaving home, deterioration of physical health, memory and cognitive capacity decreasing, or economic problems after retirement, may contribute to a decrease of senior people's quality of life (QoL). At the same time, a majority of seniors express a strong desire to age in place in their homes/communities; HIT may present an opportunity to reduce healthcare costs by facilitating older adults' ability to age-in-place in more familiar, less restrictive, and less expensive environments (VandeWeerd et al., 2020).

In many countries, healthcare systems are facing challenges brought by aging populations. Global demographics are undergoing clear and rapid transformation, with the aging population emerging as a major worldwide trend. Never before so many people achieved such advanced ages. According to the census report conducted by the U.S.National Institute on Aging (Kinsella & Wan, 2009), between 2008 and 2040 the number of people aged 80 and 85 will have increased by 233% and 165%, respectively; the general population, however, will only have increased by 33%. By 2040, 1 of every 4 Europeans will be at least 65 years old, and 1 of every 7 will be at least 75. The same situation is observed in Oceania, Asia, and elsewhere (Botella et al., 2009). Population aging brings many challenges as well as opportunities to extant technologies in many disciplines. Hence, how to improve senior citizen's quality of life (QoL) especially health-related quality of life (HRQL), is a critical issue in many domains. In the information system (IS) domain, population aging forces academic workers and practitioners to search for new technologies and systems to target improving senior people's QoL.

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QoL includes many facets. It was presented by Borthwick-Duffy (1992) as three perspectives: (a) quality of life defined as the quality of one's living conditions, (b) quality of life defined as one's satisfaction with living conditions, and (c) quality of life defined as a combination of both living conditions and satisfaction. Felce and Perry (1995) added the fourth perspective: (d) quality of life defined as a combination of life conditions and satisfaction weighted by scale of importance. Though people don't have a single common definition for quality of life yet, the four perspectives indicate that QoL should include not only physical conditions but also people's psychological perceptions of their life. For senior people, due to their physical functions decreasing, they are more vulnerable to a variety of health issues than younger people. Therefore, health is a critical facet in senior people's quality of life. All the issues and problems related to health can be defined as health-related quality of life (HRQL) (Guillemin, Bombardier & Beaton, 1993).

In the information systems discipline, research has shown that proper and adequate internet-based intervention (i.e. virtual HIT) can improve senior people's health care quality and quality of life (Marchand, Kettinger, & Rollins, 2000; Berg, 2001; Park & Jayaraman, 2003; Ash et al., 2004; Vogt et al., 2015). Due to the Covid 19, even the elderly people have started to or have got more used to the Internet-based interventions. These Internet-based interventions are ubiquitous and affordable for both individual people and our healthcare systems. As a useful tool, the Internet-based healthcare information system may play an important role to enhance senior people's HRQL. Therefore, research on how to design such kinds of HIT to reach this specific goal is emergent and critical. However, so far very limited work has been done on this, which brings the issue addressed by this paper even more important. That is, how to use internet-based interventions to improve senior citizen's HRQL in a rapidly aging society. The virtual HIT designed for senior people should consider seniors' special characteristics, such as easy to use with decreased eyesight and limited mobility. Therefore, this paper addresses two research questions: (1) what kinds of virtual HIT will be useful for seniors? and (2) how will the HIT affect senior citizens' health-related quality of life (HRQL)?

This paper aims to contribute by designing a framework of virtual healthcare information technology for senior people. These proposed healthcare information technologies are expected to help with healthy aging and improve the senior's quality of life. This framework can serve as a base for researchers and practitioners in their endeavor to design more suitable HIT for seniors.

This paper proceeds as follows. Section 2 does a literature review on aging, healthcare information technologies (HIT) for seniors, and senior's health-related quality of life (HRQL). Section 3 introduces the human-computer interaction (HCI) model as our theoretical foundation. In Section 4, we build a framework on how to design virtual HIT to improve senior citizen's HRQL and develop our propositions. In Section 5, we conclude with some suggestions derived from propositions for more effective design to improve senior citizen's HRQL in information systems. Contributions, Limitations and future work are also described in this section.

Literature review

Age, Aging and age-related changes in physiologic, cognitive and sociologic

For the vast majority of laypeople, "age" is defined simply as "the number of years, months, or days that have elapsed since a particular point in time, usually birth" (Chodzko and Moore, 1994). And "aging process" is also usually defined concerning the passage of time, or more specifically, the passage of calendar time (Chodzko and Moore, 1994). However, varying definitions of age and aging may be adopted in different disciplines. In this paper, we adopt both "Chronological" and "Biological" interpretations of age and aging as Chodzko and Moore in 1994 when they analyze the relationship between physical fitness and cognitive functioning with the aging process.

According to Chodzko and Moore, "Chronological age" refers to the length of time an individual or object has existed, and its measurement is largely unrelated to biological, social, or psychological factors. However, "Biological age" attempts to characterize stages of senescence in terms of discrete biological rather than chronological processes. Aging is a life-cycle stage (Botella et al., 2009). It's a manifold of universal biological processes that, over time, profoundly alter the anatomy, neurochemistry, and physiology of all organisms (Racine & Cabeza, 2009).

With people getting older, physical health, cognitive abilities, social activities decline, and the amount of life remaining decreases (Mather & Carstensen, 2003). Though the frequency of negative affect (emotions) decreases throughout most of adulthood and levels off around age 30, research on aging has emphasized losses (Rowe & Kahn, 1987). Research on age-related changes or losses is mainly from physiological, cognitive, sociological, and behavioral perspectives.

Physiological perspective

No organs or systems escape the impact of aging. The function of physical cells and organisms, even brains recedes with an individual's aging process (Rowe & Kahn, 1987, 1997; Spirduso, Francis, & Macrae, 1995; Li, Lindenberger, & Sikström, 2001). The most obvious problem aging brings to senior citizens is disease vulnerability (Weindruch & Walford, 1988; Chan, 2006). Additional to disease, many other problems may occur with people aging. Rowe and Kahn (1987) state that aging is associated with a progressive decline in bone density for both males and females after maturity. Losing in bone density is a key factor to make falls of elders more fatal than young people. This fear of falling, accompanying with the decreased move regulation function of the brain restrict senior citizen's mobility (Vellas, Wayne, Romero, Baumgartner, & Garry, 1997; Moscufo et al., 2012). Restricted mobility means a high level of extremity movements and unintegrated movements of balance and gait (Moscufo et al., 2012).

Cognitive perspective

Perhaps the most widely acknowledged psychological change with age is the decline in cognitive processes, especially working memory and attention (Braver & Barch, 2002; Hedden & Gabrieli, 2004; Mather & Carstensen, 2005). Basic cognitive functions, such as the abilities to activate, represent, maintain, focus, and process information, decline with age. Cognitive aging phenomena have been studied at various levels, including neurobiological level, information-processing level, and behavioral level. The neurobiological level investigates the aspects of the aging brain which is related to information processing. Information-processing level investigates how aspects of information processing (e.g., working memory capacity, attention, information processing speed etc.) affect senior's fluid intelligence. And behavioral level is on senior citizen's performance and behaviors (Li et al., 2001; Braver & Barch, 2002; Craik & Salthouse, 2011; Marther & Carstensen, 2003, 2005). From prior research, age-related decline in working memory function has been found in many memory span tasks, and age-related decrements in attentional mechanisms have been found in various selective and focused attention tasks (Li et al., 2001; McDowd & Shaw, 2000).

Sociological perspective

Prior studies have shown that isolation (lack of social ties), is a risk factor for an elder's health (Rowe & Kahn, 1997). At least since Durkheim's (1951) classic study of suicide, isolation, and lack of connection with others have been recognized as predictors of morbidity and mortality. Being part of a social network is a significant determinant of longevity, especially for men (House, Landis, & Umberson, 1988). Another similar term studied by many researchers describing the social condition of senior people is "Loneliness". Loneliness is an important indicator of wellbeing among elder people (Holmen and Furukawa, 2002). It can be psychological as well as physiological. Senior people who live alone experience loneliness and isolation more often than those who connect closely with other people (Henderson, Scott, & Kay, 1986). Jeppson et al. (1987) find that stressful situations, such as the loss of relatives and friends, could also lead to experienced loneliness and isolation. To enhance senior citizen's social relations and conquer their isolation, two kinds of supportive activities are emphasized by previous research: socio-emotional (expressions of affection, respect, and the like) and instrumental (direct assistance, such as giving physical help, providing transportation etc.) (Kahn and Byosiore, 1992; Tomaka, Thompson, & Palacios, 2006; Cacioppo, Hawkley, & Thisted, 2010).

Environmental and behavioral perspective

Studies have shown that environmental and behavioral factors are critical in determining the risk of disease late in life (Rowe & Kahn, 1997). For the environmental factor, the most important indicator is senior citizen's living conditions which include whether they live independently by themselves or live with family, friends, and other people who can assist them to do health-related assistance (Monk et al., 2006). For behavioral factors, ample evidences indicate the importance of lifestyle factors in the emergence of risk in old age (Rowe & Kahn, 1997; Hultsch, Hertzog, Small, & Dixon, 1999).

Characteristics of Healthcare Information Systems for seniors

Health care system characteristics are studied in different contexts including primary care, long-term care, Palliative care, and Mental health care. For example, Starfield (1998) develops a primary care framework that encompasses both health system and practice characteristics. The nine health system characteristics include: 1) how much the distribution of resources throughout the country is controlled by the system, 2) Financing, 3) type of practitioner, 4) percentage who are specialists, 5) primary care physicians earnings compared to specialists, 6) cost-sharing, 7) patient lists, 8) requirements for 24-hour coverage, 9) standard of family medicine academic departments. Other health care system characteristics are also investigated by past research including the availability of services, health care policies, urban-rural location, capacity, access, and coordination (Phillips, Morrison, Andersen, & Aday, 1998; Andersen, 1995).

In the context of healthcare for senior citizens, the studies are mainly into three streams dealing with the elder's mobility problem, limited cognitive capacity, and loneliness. Some researchers investigate healthcare system characteristics to detect the negative impact of mobility problems. For example, Terroso et al. (2013) describe a system consisting of a wearable sensor unit, a smartphone, and a website for seniors to detect falls. This wearable system can monitor the senior citizen's health status and deliver data to corresponding devices. Some academics explore ways to provide healthcare to seniors without too much cognitive capacity required including memory and attention. For example, Hwang (2011) presents a personalized healthcare service for the aged on stroke-precaution, followed by its implementation and evaluation. The results indicate aged senior citizens can get accurate stroke-precaution information from the system without using too much effort and time, and consequently, their life quality will be improved. Some other researchers focus on senior citizen's social life and try to investigate how to prevent and alleviate social isolation and loneliness among older people. For example, Botella et al. (2009) introduce a system named the Butler system which aims to help improve the quality of life of older people, by providing resources that promote their social networks, communication, and their training of positive emotions. They imply that peer support and communication are critical to improve senior citizen's social life.

Senior's Health-related Quality of Life (HRQL)

The "health" domain ranges from negatively valued aspects of life, including death, to the more positively valued aspects such as role function or happiness (Guyatt, Feeny, & Patrick, 1993). Health status, functional status, and quality of life are three concepts often used interchangeably to refer to the health domain (Patrick, 1990). The health domain is broad enough to include a huge quantity

of issues in one's life. We use the term health-related quality of life (HRQL) because widely valued aspects of life exist that are not generally considered as 'health', including income, freedom, and quality of the environment, although these factors may adversely affect health (Guyatt et al., 1993). At present, there is no single definition of HRQL (Efficace et al., 2003). Nevertheless, there is a broad consensus that it refers to the physical, psychologic, and social functioning of patients and the impact of disease and treatment on their abilities and daily functioning (Schumacher, Olschewski, & Schulgen, 1991; Lepage & Hunt, 1997). According to Wilson and Cleary (1995), the measures of HRQL have three levels: biological and physiological variables, functional status, and general health perceptions. The overall quality of these three levels is overall HRQL. The Nottingham Health Profile (NHP) is a widely used generic tool to measure HRQL, which has been proven to be suitable for the study of the elderly (Fletcher et al., 1992; Orfila et al., 2006).

Prior research shows that people's personalities as well as their perceptions influence the overall senior people's HRQL (Mishra et al., 2012; Martinez-Martin, et al. 2011; Orfila et al., 2006). These factors include age, gender, education, social activity, cognitive capacity, lifestyle, living conditions, and other personalities. In the information system area, many research have shown that internet-based intervention improves senior people's HRQL (Mcmurtrey, Downey, Zeltmann, & Mcgaughey, 2011; Rossi et al., 2010; Demiris, Hensel, Skubic, & Rantz, 2008; Park & Jayaraman, 2003; Bodenheimer, Lorig, Holman, & Grumbach, 2002). These internet technologies include telecare, self-management technology, peer support technology, and other collaborative technologies.

Theoretical foundations

From the human-computer interaction perspective, two basic components in interaction between users and computers are human and technology. With different tasks and contexts, interaction between the two may vary. This implies that the technology must fit a specific task to well perform it, which is the core statement of task-technology fit (TTF) theory. In the following section, we introduce how to use TTF theory as our theoretical foundation to develop our research model in the context of healthcare.

Task-Technology Fit theory

Task-technology fit (TTF) theory holds that IT is more likely to have a positive impact on individual performance and be used if the capabilities of the IT match the tasks that the user must perform (Goodhue and Thompson, 1995). Goodhue and Thompson (1995) developed a measure of task-technology fit that consists of 8 factors: quality, locatability, authorization, compatibility, ease of use/training, production timeliness, systems reliability, and relationship with users. Each factor is measured using between two and ten questions with responses on a seven-point scale ranging from strongly disagree to strongly agree.

In the Goodhue and Thompson (1995) model, the independent factors come from two factors: Task characteristics and technical characteristics. Whether the technology is fit with the task or not affects human performance and technology utilization.

Goodhue and Thompson (1995) introduce a new model named the Technology-to-Performance Chain (TPC) which includes two critical parts: theories of fit focusing task-technology fit (TTF), and theories of attitudes and behavior focusing precursors of Utilization. They focus on testing whether a general measure of TTF (at the individual level) would exhibit the relations suggested by the TPC model. The results suggest that the technology must be utilized, and must be a good fit with the tasks it supports.

According to Goodhue and Thompson (1995), TTF is the degree to which a technology assists an individual in performing his or her portfolio of tasks. In the context of healthcare, the information system is well known to be a critical assistance for senior citizens to get high quality of healthcare. The unique characteristics of elders have special requirements on healthcare information system design. This implies that the design elements of the healthcare system must fit the special needs of senior citizens. Therefore, we use TTF as our theoretical foundation to analyze how to design a healthcare information system to improve senior citizens' health-related quality of life.

Develop a conceptual framework and propositions

Recall in sections 1 and 3, we state that the information system to improve senior people's HRQL should take senior citizen's special characteristics and requirements into consideration. Senior citizen's limited functions, short memory and cognitive capacity, and other special characteristics require the HIT to be specifically designed to be senior-friendly. This kind of information system is user-centered and interaction friendly. We build our framework based on TTF theory, which is presented in Figure 1.

Figure 1: A conceptual framework for design IS to improve senior people's HRQL

In our framework, whether the two components (task and technology characteristics) fit or not affect healthcare system utilization and senior citizen's performance on getting healthcare. Senior citizen's characteristics determine their task of getting healthcare is different from younger people's. We believe many complicated context and control variables will influence this task as well, such as gender, education, economics, and all other senior's features. Our intents, therefore, are to leave the context or control variables for future research, to reduce the complexity of the framework. In the following parts of this section, we will introduce our concepts in the framework and propositions in detail.

Human characteristics

Recall in section 2, we reviewed age-related changes and losses from different perspectives. From a physiological perspective, it's concluded that constricted mobility is a key issue for senior citizens. From a psychological perspective or cognitive perspective, with people aging, working memory function and attention decrease. Thus, senior citizens tend to show deficits in attention and memory tasks that require the generation and maintenance of internal strategies (Mather & Carstensen, 2005). From a sociological perspective, isolation is a critical issue leading to physical and mental health. With children left, worse physical and cognitive functions, senior citizens are more likely to experience isolation in social networks. All these factors are age-related internal changes or losses. Hence, we name them as intrinsic characteristics of senior citizens. These characteristics decline as people aging.

From an environmental and behavioral perspective, it has been concluded that extrinsic factors, including elements of lifestyle, play a very important role in determining senior citizen's wellbeing (Rowe & Kahn, 1997). For example, a 75-year-old man may live alone, or with his children, or in a long-term caring facility, this extrinsic factor may affect this person's wellbeing. These environmental and behavioral factors are not necessarily age-related internal changes. They are extrinsic and related to the environment. Hence, we name them as extrinsic characteristics of senior citizens.

Task Characteristics

Task is broadly defined by Goodhue and Thompson (1995) as the actions carried out by individuals in turning inputs into outputs. In the context of healthcare, we refer to tasks as the health-related actions carried out by senior citizens in using information systems. To get high quality of healthcare and improve HRQL, senior citizens go to the healthcare information system to seek health information, support from peers and families, or telemedicine. These tasks have special characteristics due to elders' unique features resulting from aging.

The impact of task characteristics on information seeking in information system discipline has been studied in the information science literature since the seventies (Kim & Soergel, 2005). Hackman and Oldham (1976) suggest classifying task characteristics into four aspects: intrinsic task characteristics, extrinsic task characteristics, task performer, relationship between task and performer. Kim and Soergel (2005) summarize the task characteristics as independent variables from literature. We choose our three task characteristics based on the four aspects and elders' unique needs, including task adaptability, task autonomy, and task interdependence.

Task adaptability refers to the degree to which a task is adaptable in different settings (Kim & Soergel, 2005). This is one of the intrinsic task characteristics summarized by Kim and Soergel (2005), which we use to reflect senior's needs with mobility problems. The Healthcare system should be adaptable to enable seniors with mobility problems to get healthcare anytime anywhere, while younger people without mobility problems may not so need the system adaptable.

Task autonomy refers to the extent to which employees have a major say in scheduling their work, selecting the equipment they will use, and deciding on procedures to be followed (Sims, Szilagyi, & Keller, 1976). This is one of the extrinsic task characteristics to describe whether people can personalize or self-manage tasks or not. Task autonomy reflects senior's needs for less memory capacity and effort than younger people.

Task Interdependence refers to the degree to which individuals are dependent on and support others in task accomplishment (Fry & Slocum, 1984). This characteristic is retrieved from the task performer aspect to describe how much support and communication people need to finish tasks.

Kim and Soregel (2005) summarize nine task characteristics from the aspect of the relationship between task and performer. We believe all of them are not specifically for seniors or overlap with the above three characteristics. Therefore, we believe the three task characteristics in our framework are enough to describe the special task needs for seniors with characteristics resulting from aging.

In our framework, seniors' characteristics are the antecedents of task features that give seniors' task of getting healthcare unique characteristics. Elders' characteristics may partially elucidate why they have special task needs than younger people, thus affect the three task characteristics in the framework.

Task adaptability could be high if an individual senior person has limited mobility capability or limited eyesight and/or hearing ability. In this case, the senior person may need tasks (e.g. seeing a doctor or house caring) to be delivered to his/her location with malleable features (e.g. flexible schedule, read aloud on a website, big font on paper prints).

Similarly, some seniors with certain characteristics (e.g. living alone in a house, or a stubborn personality) may cherish a higher level of task autonomy. These seniors could have formed certain way of habits, and without little willingness to change or without limit cognitive capability to accept a new lifestyle, they may want to do things in his/her way, thus by himself/herself.

On the other side, some seniors may miss children who left home, miss friends and co-workers after retirement, or have a party-animal personality thus cannot tolerate an isolated lifestyle. These seniors may want a higher level of task interdependence. Thus,

Proposition1: In the context of healthcare for seniors in long-term care, different senior's human characteristics will affect their health-related task adaptability, task autonomy, and task interdependence.

Healthcare Information Technology/System Characteristics

According to TTF theory, technology must be a good fit with the tasks it supports. In the context of senior healthcare, health system design must fit the special task needs of seniors. Therefore, we get our technology design characteristics accordingly to task characteristics, including home monitoring availability, personalization technology such as cookie personalization, self-organizing support, and social network integration ability.

Home monitoring system will fit with seniors' needs of task adaptability and task autonomy. A home monitoring system is a useful HIT to enable people to receive healthcare at home, especially for seniors who are more likely to have mobility problems than younger people. Literature suggest many ways to make home monitoring efficient and ubiquitous, including wireless sensor network, wearable devices etc (Cappuccio, Kerry, Forbes, & Donald, 2004). Different monitoring methods are adopted to do ubiquitous home monitoring, including wireless sensor networks, wearable devices, and other methods. For example, some wearable watch technology can trigger an alarm when a senior person falls. Such HIT can help a senior to live alone at the same time be able to reach for help when he/she needs it. Also, no one single monitoring method is perfect, which requires a backup monitoring method when the main monitoring method doesn't work. The backup monitoring can guarantee the monitoring is ubiquitous and all the data is obtained.

Another kind of home monitoring system could be a telehealth monitoring system. Paired with the doctor's requirements, senior people can monitor their weight, blood pressure, chronic disease symptoms at home. These data can be collected by senior patients or their caregivers at home, and then transferred back to nurses/doctors over the Internet. The nurses/doctors may use data visualization or other data analytic technologies to monitor the senior's health conditions and then book a doctor's appointment when it is necessary. In this way, the senior patient does not have to see a doctor regularly when sometimes the patient is fine, and the senior can see a doctor quickly when some symptoms indicate such a need even before a disease breaks out. For example, a prior study developed a pilot ambient home sensing tools which facilitate remote patient monitoring as well as early intervention and prevention against adverse events - all while catering to older adults' preference to live at home (VandeWeerd, et al. 2020; Yu, An, Hassan, & Kong, 2019). This type of HIT will fit with seniors' needs of task adaptability and task interdependence.

Besides, a self-organizing support system and personalization technologies may satisfy senior citizen's needs of task adaptability and task autonomy. Due to the decreased memory capacity, senior citizens tend to forget things easily and spend more time to do tasks. Therefore, the healthcare system should provide self-organizing support to elders, which can remind, alert, and notify them for upcoming events they are supposed to do. For example, an e-calendar can remind a senior about a coming doctor's appointment. Or a personal health records (PHR) system can remind a senior to refill a prescription, and set alarms to remind the senior when and which medicine and how many pills of medicine should the senior take. Besides, the healthcare system should not only provide personalized recommendations based on data collected by the monitoring system or entered by senior citizens but also provide recommendations based on historical data including computer cookies. In this way, the healthcare system can give more accurate

recommendations faster to seniors to save their time and effort. Personalization technologies may also fit with seniors' needs of task adaptability because personalized technologies indicate personalized services for seniors.

Social network (social media) system can also be a type of HIT which fits senior's needs of task interdependence. For example, a senior can share his/her e-calendar with his family members so that sometimes his family members can take the senior to doctor's appointments. A senior may facebook or video conference his children who left home. Many healthcare systems are designed to have messenger or other social network tools integrated to engage users (e.g., Practicefusion, Eclinicalworks). Messenger is mostly used by these systems for physicians to communicate with patients. For socially isolated senior citizens, communications with physicians and peers are important for them to get psychological satisfaction. Senior citizens can communicate with each other and get support from peers via messengers integrated into the healthcare system. A low level of messenger integration ability may only allow communication between seniors and physicians, while a high level of messenger integration ability (e.g. facebook.com) may not only allow communication between seniors and physicians but also allow communication with other seniors and sharing information. Social media integration can allow seniors to find their communities, communicate within communities via text, pictures, or video, thus reduce their sense of isolation.

Other types of social network integration may satisfy the senior's needs of task autonomy. For example, reduced income after retirement could be one human characteristic that reduces senior's autonomy. However, a senior may upload videos at youtube.com to earn some income from online ads, or use ebay.com to sell some handicrafts, or use some social media to teach foreigners English or chess skills to make some money, or through social media to reach some young university students to exchange housing for homecare services.

Task-Technology Fit

In Goodhue and Thompson's paper (1995), eight system factors are used to measure task-technology fit including quality, locatability, authorization, compatibility, production timeliness, systems reliability, ease of use/training, and relationship with users. Based on that, we suggest three variables to measure Task-Technology Fit in this paper due to the special characteristics of the healthcare system. The three variables include quality of healthcare, timeliness of healthcare, and relationships with users. To improve senior citizen's health-related quality of life, it is important to deliver the right healthcare to the right person at the right time. The quality variable is related to the measure of right healthcare, the relationship-with-users variable is related to the concept of the right person, and the timeliness variable represents the concept of right timing.

The definitions of these three concepts can be adapted to the seniors' long-term healthcare context. In this study, the quality of healthcare refers to whether elders get the necessary healthcare assistance at the right level of detail or not. Timeliness of healthcare refers to whether the healthcare system meets pre-defined healthcare schedules. Relationship with users includes whether the healthcare system understands elders' objectives and supports their needs, whether the healthcare system keep its agreements.

In the context of healthcare for seniors in long-term care, what tasks elders are using the healthcare system for, whether the task is adaptable and controllable influence the quality, timeliness of healthcare, and relationships with users. For example, two groups of elders are using the healthcare system to enter health data to get health assistance. The first group can choose the way to enter their data and what issues they want the health assistance for, while the second is not. Normally, the first group can get better quality of healthcare. Because elders feel more comfortable when they can choose the way they like to enter data, and they may enter data completely and soundly. In this way, physicians can get complete and good data to analyze and give feedback quickly, while they for the other group may not. Consequently, the relationships of the healthcare system with the first group will be better than with the second group.

Besides task characteristics, health system characteristics influence quality, timeliness of the healthcare system, and relationships with elders as well. When the system has a backup monitoring method to make monitoring ubiquitous, the health data is complete and good to be analyzed, so elders can get good quality of health assistance quickly. When the system can provide good recommendations based on elders' cookie, the recommendations are accurate and shorten elders' search time. That is, the quality of health assistance is good and it's timely. For the healthcare system integrated with social networks such as messengers, elders can communicate not only with physicians but also with other elders. They can get health information and psychological support from others. In this situation, they get health assistance from both peers and physicians, which improves the quality and timeliness of health assistance. Consequently, the health system has a good relationship with elders. Based on the discussion, we have the following proposition:

Proposition2: In the context of healthcare for seniors in long-term care, the availability of certain HIT designed for their target tasks will increase task-technology fit (i.e. the quality of healthcare, timeliness of healthcare, and relationships with seniors).

Proposition2a: For seniors with higher needs of task adaptability and task autonomy, the availability of a home monitoring system or telemonitoring system will increase task-technology fit.

Proposition2b: For seniors with higher needs of task adaptability and task autonomy, the availability of a self-organizing support system or personalization technologies will increase task-technology fit.

Proposition2c: For seniors with higher needs of task interdependence, the availability of social media system will increase task-technology fit.

Utilization and Performance impacts

Utilization is the behavior of employing the technology in completing tasks (Goodhue and Thompson, 1995). Measures such as the frequency of use or the diversity of applications employed (Davis, Bagozzi, & Warsaw, 1989; Thompson, et al., 1991; 1994; Goodhue and Thompson, 1995) have been used. We use frequency of use to measure utilization in our study, which is straightforward to understand.

According to TTF, performance impact relates to the accomplishment of a portfolio tasks by an individual and it's hard to measure (Goodhue and Thompson, 1995). The objective of our study is to investigate how to design a healthcare system for seniors in the context of long-term care to improve their HRQL. Therefore, we use an elder's HRQL to measure the performance of the individual as well as the system.

When people get high quality of health assistance timely from the health system, they are satisfied with the system and want to continue to use it, that is, the utilization will be improved. Therefore, task-technology fit has a positive impact on utilization.

Proposition3: In the context of healthcare for seniors in long-term care, quality of healthcare, timeliness of healthcare, and relationships with seniors will positively influence the utilization of the healthcare system.

Goodhue and Thompson (1995) suggest performance impact is influenced by both task-technology fit and utilization. In our study, when elders use the health system frequently, this will enhance their capabilities, give them physical and psychological satisfaction which consequently improves their HRQL. But using the health system frequently itself cannot improve elders' HRQL, or at least always. For example, if a senior wants to use the health system for cancer care, but she/he mistakenly uses a health system designed specifically for patients with a heart attack. She/he may not benefit from this health system, because the system doesn't fit with her/his objectives. Therefore, whether the health system fits elders' goals or not will influence, or at least have explanation power on improving elders' HRQL.

Proposition4: In the context of healthcare for seniors in long-term care, quality of healthcare, timeliness of healthcare, and relationships with seniors will also positively influence the performance impacts beyond utilization.

Proposition5: In the context of healthcare for seniors in long-term care, a higher frequency of use of virtual HIT will increase seniors' HRQL.

Conclusions

Recent and projected substantial increases in the relative and absolute number of senior citizens in our society pose a significant challenge for biology, social and behavioral science, medicine, and IT. With the age-related losses in physical, cognitive, sociological for senior citizens, to improve their Health-related Quality of Life (HRQL), we believe an urge to design health information system specifically to reduce the impact of these losses on senior citizen's seeking for health assistance.

In this paper, we review the literature on people's changes with aging from physiological, cognitive, sociological, and environmental perspectives, and summarize the core losses senior citizens face. With restricted mobility, deterioration of working memory function and attention, lack of social connections, accompanying with living conditions and unhealthy lifestyle, senior citizens find it more difficult to access high-quality health assistance they need than younger people. To solve this problem, we introduce a conceptual framework from the HCI perspective and provide suggestions on information system design elements.

We propose that all the characteristics of senior people and information system in our framework have some impact on senior citizens' access to or quality of health assistance, and consequently influence their HRQL, in the context of HCI. Correspondent designing features of information system help senior citizens conquer age-related changes when they are using technologies for health assistances. We propose that for specific senior citizens with one or more age-related losses, health systems should be designed specifically to reduce the negative impact of such losses on senior citizens' HRQL. We suggest that health information systems with the designing features, such as telecare availability, personalization, self-organizing availability, peer-support functions, and collaborative technology, are more efficient and effective than those systems without providing access to high-quality health assistance for senior citizens.

Though some limitations, such as control variables are not provided in the framework, we believe the conclusions of this paper brighten a new light to improve elder's HRQL. This paper broadens the academic body of internet-based intervention on improving senior citizens' HRQL by providing a conceptual framework from the HCI perspective, and suggestions about designing elements. The suggestions benefit actual implementation as well. When design an information system for senior citizens, designers may consider the designing features to shorten senior people's effort and time, to fit their lifestyle, mobility, and social needs.

The framework in this paper can be a basis for future research on how to use technologies to improve senior citizen's HRQL. One direction can be adding more age-related characteristics of senior people and providing more correspondent designing elements.

Another direction can be digging deeper on one or more designing elements, and investigating how these elements help senior people for better access to and quality of health assistance.

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