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Value-Inspired Service Design in Elderly Home-Monitoring Systems

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Abstract— The provision of elderly home-monitoring systems to enhance aging-in-place requires the service to meet the needs of both the elderly and their caregivers. The design of such IT services requires interdisciplinary efforts to look beyond the technical requirements. Taking a value-inspired design perspective, the study argues that service design for promoting aging-in-place needs to reconcile the values of both the elderly and caregivers. Drawn from the framework of basic human values and the unique experience of the SHINESeniors project, the study extracts the core values for elderly and caregivers using a multi-method case analysis. We suggest that both system and working protocols should be redesigned concurrently to maximize the benefits of the technology. The resources of users and capabilities of technologies should be leveraged in tandem for service design.

Keywords—*Values; Service design; elderly care; smart homes*

I. INTRODUCTION

Population ageing is a worldwide trend and the proportion of elderly people is constantly increasing [1, 2]. According to the 2013 United Nations Population Report [2], 841 million people reached age 60 or older, accounting for 11.7 percent of the total population in 2013. It is estimated that by 2050, the number of elderly people will increase to more than 2 billion, while the proportion will double from that of the year 2013. The report also indicates that the number of elderly who are living independently (alone or with their spouse only) is increasing [2] and that most elderly people prefer to live in their own places rather than in hospitals or nursing homes. Therefore, technologies and services, which can enable elderly people to live independently, are imminently needed to enhance the quality of their lives. This development towards the increasing independence of the elderly will also release the burden of formal and informal caregivers, as interventions are only provided when notified.

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Both industry and academia are currently investigating sensor-based solutions for monitoring elderly, in intelligent environments. There are many studies conducted in elderly-home monitoring systems. Some of the studies are conducted from technology perspectives, such as using physiological sensor, video sensor and integrated sensor networks [3-5]. These studies focus on recording and analysing motion sensor events and improvement of the accuracy of the information delivered through sensor layout and connections. Some other studies emphasize analytics on how to make sense of the data captured by various technological tools. For example, studies are conducted to look for potential correlations to health events, such as falls, emergency room visits, and hospitalization, to identify patterns in the sensor data which might have offered some clues to predict the events [6, 7]. Studies have also been conducted to look at the alerts generated to notify caregivers of changes in a resident's condition so they could intervene and prevent or delay adverse health events [6]. One limitation in those studies is that they only focus on improving the experience of one group of users of the system. For example, the privacy of the elderly are studied, or the operational efficiency of caregivers are investigated. As both the elderly and caregivers are beneficiaries of such technology, the effectiveness of such technology can only be achieved through concurrently interacting with both parties.

What is lacking in the IT-enabled elderly care service design is the reconciliation of values from all group of users of a single information system. Based on the theoretical foundation of value-inspired design [8], we use a case study of SHINESeniors project in Singapore, to discuss how to express recognition of user values, and how the service could be redesigned based on leveraging the capabilities of the technology and the resources of the users. The research question that this study aims to answer is:

How can we design elderly home-monitoring systems by reconciling different values of both elderly users and caregivers?

II. THEORETICAL BACKGROUND: VALUES IN SERVICE DESIGN

Values are not the same as Value. The former refers to ethical, moral or ideological principles that can form the basis of action,

while the latter refers to relative economic worth of utility, and is the basis of human endeavors aimed at efficient use of resources, for example, based on concerns such as optimization [9]. The focus of our study is on the former. The values perspective draws on domains such as moral philosophy and business ethics to bring forth a sense of right and wrong, and what ought to be [10].

Values have been a central concept in the social sciences. Values refer to some important and shared beliefs by the members of a culture. Values were crucial for explaining social, organizational and personal change. Values have played an important role in many fields such as sociology, psychology and anthropology [11]. Values are used to characterize societies and individuals and to understand the motivational bases of attitudes and behavior [12]. The definition of what constitutes “values” varies. Researchers argue that the values may be held by public, citizen, or the “reasonable man” [13], and that values may exist at different levels such as individuals, organizations and nations. This study focuses on individual values and we will base our discussion on the theory of basic human values [14]. The theory defines values as desirable, trans-situational goals, varying in importance, that serve as guiding principles in people’s lives [15].

The theory of basic human values [14] identifies ten motivationally distinct types of values. They are: *power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity, and security*. Some values inherently contradict one another (e.g., benevolence and power) whereas others are compatible (e.g., conformity and security) (see Figure 1). Actions expressive of any value have practical, psychological, and social consequences that are either in conflict with or will be compatible with the pursuit of other values.



Fig. 1. Basic Human Values (Cited from [12])

Prior research has argued that an understanding of basic human values is an important prerequisite that takes beyond a simple understanding of specific functional requirements for the design of services [16]. The possibility of conflict and congruence among values may influence service design. If the IT services are

developed to help more than one stakeholder, the service should be designed by considering the values of all stakeholders. In particular, the principal of *Value reconciliation* would take the discourse to a consideration of values across different groups. When conflicts are noted, service design may proceed by considering different population segments and allowing the possibility of customizing across segments or even individual users. In addition, the principal of *Value alignment* refers to the situation when a majority of users show consistent value priorities. Such situations provide a clear mandate for the service designers, who can leverage information technology capabilities to drive the design the services, creatively generating features that will ensure that the service offerings are aligned with their dominant values

III. RESEARCH METHOD

As value reconciliation is a complex, multifaceted phenomenon that is inextricable from its original context, an objective approach to research may be difficult, making it more appropriate to examine the phenomenon by interpreting the understanding of the relevant stakeholders [17, 18]. Clear examples and scenarios are necessary to understand and explore these conflict and congruence mechanisms. Thus, a case search method is particularly appropriate for this study.

Based on our research question, two criteria form the basis of case selection. First, the selected elderly home monitoring project should involve the response from a team of caregivers. Second, the project should be ongoing and adaptive to technological and operational changes. In the end, one elderly home monitoring project satisfying the criteria was selected for assessment.

A. Data Collection

Both primary and secondary data were collected for this study. Survey was conducted to all elderlies participating in the project to have a structured understanding of their concerns. When the survey interviews were conducted, the research assistants also took notes of their observation during the home visits, such as the living condition of the elderlies, the personalities of the elderlies, or living patterns of the elderlies.

A focus group interview was conducted with the caregiver team in the volunteer welfare organization responsible for providing care for the elderly surveyed. The organization currently has 16 staff and 101 volunteers taking care of about 1,300 senior residents in the region. A team of 5 staff are involved and 7 volunteers are recruited specifically for the project. The case study presented in this article is based on one focus group interview with the 5 staff, conducted over 2 hour and resulting in a 6000-word transcription script. The interview was conducted with semi-structured interview guides. Each guide had a standard core of questions to understand the team’s way of operation and their concerns. The research assistants also attended internal meetings of the caregiver team and notes were taken down for further analysis.

Secondary data were collected from a variety of sources such as websites, published materials, internal volunteer training

handbook, and working protocols, as well as the data from the monitoring system. The information gleaned from these sources served to enhance our sensitivity to the unique aspects and pertinent issues of the phenomenon and the project under study and provided us with a basis to code and understand the values of the volunteer welfare organization. The methods of data collection are summarized in Table I.

TABLE I. METHOD OF DATA COLLECTION

Primary Data	
Elderly Users	Survey Observation notes during home visits
Caregivers	Focus group interviews Observation notes when attending meetings
Secondary Data	
Elderly Users	Community activities participation record; System data
Caregivers	Business process documents; Response protocols; System data

B. Data Analysis

Analysis was performed in tandem with data collection to take full advantage to the flexibility that the case search method affords [19]. Based on the literature review of values in design, we have identified an initial set of themes (i.e., values of elders and values of caregivers) that were serving as a guide for data collection and data analysis. Data analysis was carried out by recursively iterating among the empirical data, and the theoretical lens, the relevant literature [19]. This process continued until theoretical saturation was reached, where it was possible to explain the finds of the case study comprehensively and no additional data could be collected or added to improve the model developed [19].

IV. FINDINGS

A. Case Background

In collaboration with data scientists, government agencies, health service providers and volunteer welfare organizations, the SHINESeniors project aims to design and develop a sensor-enabled home composed of non-intrusive fixed and mobile sensors customized for older people living in the community, to capture and analyze the living patterns of older people and detect abnormalities. As intensive home-care surveillance prevents hospitalization and improves morbidity rates among elderly patients with chronic diseases, it is believed that a better understanding on elderlies' living patterns and responding to emergencies effectively will improve the health and wellbeing of the elderlies.

By the time the study is written, Passive Infrared (PIR) sensors have been installed in fifty households for elderlies living alone. Their movements in the living room, bedroom, kitchen, and bathroom are captured by PIR sensors. Whether the elderly has left their house is also monitored by door contact sensors. In addition, the elderly are provided with a push-button for alerting the

caregivers of emergency situations. The sensor network, including the push-button, communicates wirelessly to an aggregator called 'the gateway'. The gateway is plugged into a mains power line and has 3G connection to a server. The data in the server pushes information through two applications. One is a web based dashboard to track activity and the other is a mobile app that allows the caregivers to track activity and receive notifications when an emergency situation occurs or if there is extended non-movement.

B. The Values of The Elderly

As one elderly participant refused to participate in the survey, all the information presented is based on the data collected from 49 people. Social demographic information, psychosocial and mental health status and technology acceptance of the elderly participants are collected in the survey. Figure 2 shows that many elderly participants have more than one chronic conditions.

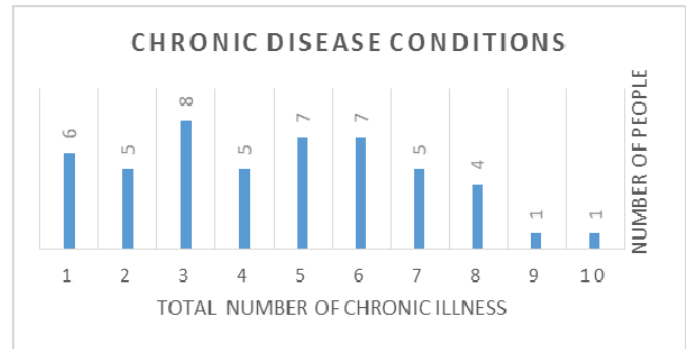


Fig. 2. The health status of Elderly Participants

The elderly participant's mental health is measured in terms of depression by GDS-15 [20]. One summative GDS score is calculated based on the answers to the 15 questions. Scores of 0-4 indicate normal conditions; 5-8 indicate mild depression; 9-11 indicate moderate depression; and 12-15 indicate severe depression. The distribution of the Depression status is summarized in Table II.

TABLE II
THE DEPRESSION STATUS OF ELDERLY PARTICIPANTS (N = 49)

	GDS Score	Number of Elderlies
Severe	12 - 15	4
Moderate	9 - 11	2
Mild	5 - 8	7
Normal	0 - 4	36

We also collected information on the participants' privacy concern, and we found that most of the elderly people have a moderate or low level of privacy concern. In terms of mobile phone ownership, more than 20 of the elderly people are using mobile phone (Figure 3), but only three of them have 3G/4G connections with their phone.

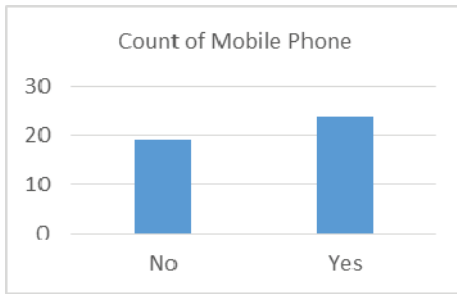


Fig. 3. Mobile phone ownership of participating elderlies

Previous study shows that older people are expected to value tradition, conformity and security, which corresponds to those conservation values [21]. Conversely, they would be expected to place little value on stimulation, hedonism, and self-direction. Through the analysis on the data we collected, the elderly we surveyed showed similar value orientation. They care more about their safety and security as most of them are living alone and having several chronic illness. In addition, although they are resistant to use new technology, they would like to have the sensors installed in their home to have their safety ensured and they are less worried about how their daily activities are captured given the technology is non-intrusive. Thus, tradition, and conformity and security would be the values that the elderly value most in this case.

C. The Values of Caregivers

The caregivers from the VWO have collectively raised two major values during the focus group interview: **obligation** and **control**, which have also been identified in the context of caregivers of dementia patients [22]. The caring team agrees that they are obligated to take better care of the elderlies. They have expressed a few resources enabling them to achieve this and also challenges they are facing. (Table III).

TABLE II. IDENTIFYING CAREGIVERS VALUES WITH SAMPLE QUOTES OBLIGATIONS (ACHIEVEMENT)

Challenges	Sample Quotes
Lack of continuous monitoring of the elderly people	<i>(for home visit) "There are two types, one is a weekly visit, and the other one is once or twice every month."</i>
Lack of two-way communication between VWO and the elderly people	<i>"...seniors may not have a hand phone nor a home phone so for those seniors without this equipment, how would we be able to talk to them if there was an emergency that is activated so that's when one of the equipment we are looking at allows that two way communication and does not compromise our staff's contact numbers..."</i>
Difficulty of introducing technology into the lives of the elderly	<i>"The methods used must be non-intrusive. The seniors will feel that they are monitored by the system when they see new things hanging somewhere or things protruding out from the wall. Perhaps a vibration sensor on the water pipe could be done so that we don't have to install things inside the house."</i>

Resources	Sample Quotes
Commitment and passion by the VWO team	<i>"I think if it's an emergency, we wouldn't mind, being in this field (after office hour/ over the weekend), we are also willing to step forward to help..."</i> <i>"...it's more of a concern rather than stress. In the past, when the system was working well, I did contact my colleagues to see if anyone is in the office to check whether the senior is okay or not..."</i>
Communication within the VWO team is clear	<i>"Programmes staff will plan programmes and coordinate and implement them. Case workers and social workers, they have to do case counselling...If there is some of the information that the elderly comes to us with, that pertains to case management that is when the programme staff will share the information with the case worker..."</i>

In the meantime, the caregivers also expressed the concern that they are more willing to leverage on the technology rather than be led by the technology. They raised a few issues related to the reliability of the system and they expect that the technologies should be used to enable better services. They also expressed that the expanding manpower and the good relationship with volunteers and the elderlies are important resources that they can leverage on.

TABLE III. IDENTIFYING CAREGIVERS VALUES WITH SAMPLE QUOTES CONTROL (POWER)

Challenges	Sample Quotes
Lack of reliability in the Sensor system	<i>"...if it beeps too often, it also lowers down our guard. Because if there are twenty beeps and all are not emergencies and the twenty first beep is of emergency and we chose to ignore it, I'm not saying that we will but it will lower our guard..."</i>
Lack of information to organise programmes for the elderly	<i>"The primary thing we want is safety. Other things are good to have. If the data collected can help us to formulate some programme ...that will be helpful. E.g. a lot of seniors having prolonged use of toilet, there is a trend and do we need to look at bowel/colon care? Then that becomes a concern for us and we can bring in doctors, nurses, caregivers to do certain talks."</i>
Resources	Sample Quotes
Manpower of VWO team	<i>"the manpower is still expanding so that is a good thing for us".</i>
Strong volunteer support from the neighbourhood	<i>"...we appreciate our volunteers coming back to us to report on their daily assessment, meaning that after they have visited the homes, they can actually come back to tell us what the updates are like for this senior e.g. medical condition, whether they have improved...."</i> <i>"So they are just supposed to go up and interact with the seniors but if there's anything that</i>

	<p>comes up, they are supposed to inform us in situations where they need to make certain decisions, they need to inform us too.”</p> <p>“...it’s literally like social responsibility that they pass by the house, they visit their friends and see that their friends are in trouble and they activate the ambulance...”</p>
Help extended by the neighbours	<p>“...some of the incidents we know occurred where they actually shouted and the neighbours will come by because...they have common corridors so that has been quite helpful and there were incidents which have occurred but they shouted for help and the neighbours do come by so those have been informed to us as well of such incidences.”</p>
Good relationship has been established between VWO team & elderly	<p>“...we face the seniors daily, there was one incident whereby this male senior, he actually disappeared for two days and didn’t come to the centre and we were quite concerned ...because of that relationship we have with him, he actually did inform us when he’s here at the centre”</p>

D. System and Response Protocol Redesign

It seems that the elderly home monitoring system is able to align caregivers’ values of achievement with the elderly peoples’ values of security, tradition and conformity. However, after the initial installation of the system, a few false alarms were sent to the caregivers as extended non-movement was frequently detected. Although the design is intended to ensure the safety of the elderly, it also causes alarm fatigues to the caregivers. They mentioned that “if it beeps too often, it also lowers down our guard”. The elderly was also irritated by unsolicited home visits triggered by false alarms. The caregivers intend to take control of the caring process, but not to be reminded and chased by repetitive nonfictions. Thus, we see potential conflicts between caregivers’ values of power and elderly’s value of security.

To address the problem, the research team worked closely with the software team and caregiver team to redesign the service experience. A few changes have been made to reduce the false alarms from the backend system, including adjusting the threshold of non-movement detection and specifying the thresholds differently for day and night activities. The notifications have also been classified according to different levels of urgency. For example, the notification generated by emergency call is expected to be attended to by caregivers immediately. On the other hand, each notification triggered by non-movement detection would first be checked to reduce the likelihood of false alarm, thus requiring a longer response time.

The redesign process leverages the volunteer resources of the VWO in the following way: if the caregivers are not able to visit the elderly after office hour, they can activate a volunteer to attend to the elderly. It also contributes to the redesign of the hierarchy of escalation in the system and response protocol. Instead of all the five team members responding to the system alerts at the same time, the staff members of the VWO came up with a schedule that allows only two staffs to respond to the

notifications at one time. The changes are summarized in Table IV below.

TABLE IV. SYSTEM AND RESPONSE PROTOCOL REDESIGN

Actions Taken	System Protocol Redesign	Response Protocol Redesign	Resources leveraged
Adjust the threshold of non-movement detection based on day and night.	✓		
Classify the notifications by level of urgency	✓	✓	Manpower of VWO team
Redesign the hierarchy of escalation in the system		✓	Strong volunteer support from the neighbourhood
Assign two staff members to respond to system notifications every time instead of five.		✓	Clear Communication within the VWO team

V. FINDINGS AND DISCUSSION

The use of pervasive technologies to promote aging-in-place cannot be successful without strong support from caregivers. Most of the time, the design of elderly-home monitoring system focuses on improving the security and safety of the elderly but neglects the requirements from caregivers. Taking a values-based design perspective and a case study of the SHINESeniors project, the study has identified a few important strategies to maximize the benefits of elderly-home monitoring system in terms of helping both caregivers and the elderly at the same time.

First of all, the study reveals the importance of understanding the values of all user groups who could benefit from the technology directly and indirectly. There is an increased attention to the integration of human values into the conception, design, and development of emerging IT. Researchers have argued that the design of information systems should be seen as not just the meeting of requirements but as the promoting of some values (via design) and undermining of other values [23]. Design is a choice to inscribe in the information system values we value to eventually shape life, work and society accordingly, and take away choices that we do not value. Thus, it is important to understand how values can inspire design efforts (and not merely make the designers more aware) so that the designers can create interactions that can serve as guideposts. The study further points out the possibility that when technology serves more than one user groups, all of their values should be considered in the design.

Second, based on a field case study, the study suggests that redesigning system protocols and response protocols are equally important in values-oriented service redesign. Incorporating

values into service design requires the acknowledgement of higher-order human principles other than just efficiency and utility. Thus, incorporating values into IT-enabled service involves both the design of information system protocol to improve efficiency and accuracy, and the design of the protocol for human to process and react to the information provided by the system.

Thirdly, the value-inspired redesign of the system and response protocol should leverage on the capabilities of IT and resources of prospective users. The redesign of the services should consider the potential resources that can be leveraged on. In the case of the SHINESeniors project, the strong volunteer support and clear communications among VVO team members are essential for redesigning the notification protocols according to their level of urgency and allowing the staff to take turns to respond to the notification from the home-monitoring system.

VI. CONCLUSION

It is important to have strong caregiver support for using home-monitoring systems to enhance aging-in-place. The design of such information systems and services requires interdisciplinary efforts to look beyond the technical requirements. Taking a value-inspired design perspective, the study argues that service design for promoting aging-in-place needs to reconcile the values of both the elderly people and their caregivers. Drawn from the successful experience on the SHINESeniors project and the framework of basic human values, the study extracted the core values for elderly and caregivers using a multi-method case analysis. The interviews we conducted, the analyses, and the findings we have shared in the paper suggest that it is indeed feasible to infer basic human values for both elderly and caregivers. As we argued at the outset, an understanding of basic human values is a more important prerequisite beyond a simple understanding of specific functional requirements for the design of elderly care services. We suggest that both system and response protocol should be redesigned concurrently to maximize the benefits of the technology. The resources of users and capabilities of technologies should be leveraged in the service design process.

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