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Value-inspired elderly care service design for aging-in-place

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Abstract

Most current projects aimed at in-home monitoring for the elderly appear to focus on demonstrating technical feasibility and ensuring safety. In doing so, they often overlook the complexity of the interactions between the elderly and the caregivers. This study explores this complexity by adopting a value-inspired design perspective. Following an action design method, we describe the (re)design of the system and service protocol for an elderly-home monitoring effort. The work requires that we leverage the capabilities (of the technological infrastructure system as well as the service providers) to reconcile the values held by the participants (the elderly and their caregivers). We report design principles developed via this effort, and show that they can enhance the outcomes in such projects.

Keywords: Value-inspired design, Elderly care service, Home-monitoring system

1 INTRODUCTION

The population on the planet is aging (Bottazzi, Corradi, & Montanari, 2006; DESA, 2013). According to the 2013 United Nations Population Report (DESA, 2013), 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 the elderly will increase to more than 2 billion, and the proportion will double from that of the year 2013. The report also indicates that the number of elderly living independently (alone or with their spouse only) is increasing (DESA, 2013), and that most prefer to live in their own place instead of hospitals or nursing homes. Technologies and services to enable such aging-at-home are imminently needed.

Industry and academia are investigating sensor-based solutions for monitoring and intelligent environments that provide them control on their surroundings. Several of these studies develop technology solutions, such as the use of physiological and video sensors and integrated sensor networks (Jiang et al., 2008; Skubic, Alexander, Popescu, Rantz, & Keller, 2009; Wood et al., 2006). These studies focus on recording and analysing motion sensor events and improving the accuracy of the information delivered through sensor layout and connections. Other studies emphasize analytics to make sense of the data captured, for example, 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 (Rantz, Skubic, Miller, & Krampe, 2008; Raptis, Tsiakoulis, Chalamandaris, & Karabetsos, 2009). Studies have also been conducted to examine alerts generated to notify caregivers of changes in a resident's condition so they could intervene and prevent or delay adverse health events (Rantz et al., 2008).

A key limitation of those studies is that they only focus on demonstrating the feasibility and improving the operational efficiency in response to the perceived needs of one of the stakeholders - the elderly or the caregivers - instead of examining and supporting the *interaction* between the elderly and caregivers. Our focus in this paper is to examine the roles and values of both, following the argument that the effectiveness of such technologies can only be achieved by accounting for the values held by both parties.

To address the problem, we follow a design science orientation, which conceptualizes research as learning via building of artifacts (Hevner, 2004; von Alan, March, Park, & Ram, 2004). We argue that the several existing alternatives for software and information systems design (e.g. Babar & Lescher, 2014) are likely to be inadequate in the context of designing elderly care services because they fail to reconcile the different values of the elderly and caregivers, and do not directly account for the integration of capabilities of the caregivers and the technology infrastructure. An important input to our effort is the use of kernel theories, which ensure that our design science efforts are theory-infused (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011).The kernel theories appropriate for this work include the notion of universal values (Schwartz, 2005, 2012; Schwartz et al., 2012) and value-sensitive design (Friedman, 1996). These kernel theories are important and appropriate because of the context of our work – supporting aging at home for the elderly.

The research question we address in this study can, therefore, be articulated as: **How can we design elderly home-monitoring systems that reflect and account for the values of both the elderly and the caregivers?** The interrogative requires a prescriptive solution that we develop by following a design science research orientation; ensuring that we build our work on the nexus of appropriate kernel theories. The solution we seek is a method for value-inspired design of elderly care (with information technologies) that specifically accounts for the values and value-conflicts among the stakeholders. The core contribution of the paper is a set of principles to (re)design the technology infrastructure in a manner that complements the capabilities of the caregivers. The paper first outlines the theoretical background and describes the research approach we follow, before developing and illustrating the method for (re)designing elderly care services. We conclude by pointing to future work and drawing out some implications for research and practice.

2 THEORETICAL BACKGROUND

2.1 Values and Design

Values are not the same as Value. The former refer to ethical, moral or ideological principles that can form the basis of action, while the latter refers to relative economic worth or utility, and is the basis of human endeavors aimed at efficient use of resources, for example, based on concerns such as optimization (Collopy & Hollingsworth, 2011). 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 (Rokeach, 1973).

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 may result in undermining of other values (that reflect the possibilities taken away) (Purao & Wu, 2013). 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 (not merely make the designers more aware) so that the designers can create interactions that can serve as guideposts. Incorporating values into design requires the acknowledgement of higher-order human principles other than just efficiency and utility. 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 (Rokeach, 1973). Scholars have recognized this need to inform system and technology design by incorporating values. One example is value-sensitive design, a theoretically grounded approach "that accounts for human values in a principled and comprehensive manner throughout the design process" (Friedman, 1996). It is a position that propounds a proactive approach for the incorporation of values in design (Manders-Huits, 2011), similar to Van den Hoven's (2008) position to "frontload ethics" in engineering endeavours.

2.2 Basic Human Values

The definition of what constitutes "*values*" varies. Researchers argue that values may be held by public, citizen, or the "reasonable man" (Bannister & Connolly, 2014), and that values may exist at different levels such as individuals, organizations and nations. This study focuses on individual values. We build our arguments by drawing on the theory of basic human values (Schwartz, 1992). The theory defines values as desirable, trans-situational goals, varying in importance, that serve as guiding principles in people's lives (Schwartz, 2005). The theory of basic human values (Schwartz, 1992) identifies ten motivationally distinct types of values: *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.

Figure 1. Basic Human Values (Cited from (Schwartz, 2012))

The framework has been applied to understand the values of different population. For example, older people may value tradition, conformity and security, which corresponds to those conservation values (Lyons, Duxbury, & Higgins, 2007). Conversely, they are expected to place little value on stimulation, hedonism, and self-direction. Obligation and control, which is a sub set of achievement and power respectively, have been identified as the major values for caregivers of dementia patients (King, Collins, & Liken, 1995)

Prior research has argued that an understanding of basic human values is an important prerequisite that can take the designers beyond a simple understanding of functional requirements (Liu, Gavino, & Purao, 2015). Instead, acknowledging the possibility of conflict and congruence among values can significantly influence design. If the technological infrastructure or services are developed to help more than one stakeholder, then the effort would require considering the values of all stakeholders. An effort at reconciling the values would then allow surfacing any compromises and conflicts that can inform design, including the possibility of customizing across segments or even individual users. These ideas provide important precursors to our efforts.

3 RESEARCH METHOD

We adopt a design science research orientation for our efforts (Gregor & Hevner, 2013; von Alan et al., 2004). This approach is appropriate for our research because it allows us to address the research question, which seeks a prescriptive solution. Although one may borrow methods from software engineering and systems development, those methods are not sufficient for the problem we have identified because they do not (a) provide an easy path to integrate the capabilities of caregivers and the technological infrastructure, and (b) acknowledge the influence of kernel theories, i.e. concerns such as human values that take us past functional requirements. We, therefore, address the problem by devising a novel method for designing IT-enabled elderly care services. Following work in design science research, we describe our research approach in terms of the following key orientations.

First, our research addresses a 'class of problems,' (Pries-Heje & Baskerville, 2008), which represents an abstraction of concerns observed or anticipated across a set of instances with a similar description. The problem statement outlined in the introduction provides an initial definition of this class of problems: "How can we design elderly home-monitoring systems that reflect and account for the different values of both elderly users and caregivers?"

Second, our work is theory-inspired (Sein et al., 2011). We leverage prior work as kernel theories. In particular, we build upon and extend prior work related to universal values (Schwartz, 2005; Schwartz et al., 2012), value-inspired design (Friedman, 1996; Liu et al., 2015). Third, the outcome from our work can be described as a 'method,' following the terminology suggested by March and Smith (March & Smith, 1995).

Traditional methods test validity through reliability or exhaustive elimination of alternative explanations (Baskerville & Stage, 1996). For elderly care, it will take time to develop more granular data to review the effectiveness of the new implementation of new systems and healthcare delivery models. We, therefore, follow suggestions that stem from action design approach (e.g. authentic evaluation) within the context of our study.

3.1 Research Setting

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.

At the time of this writing, Passive Infrared (PIR) sensors have been installed in fifty households for elderlies living alone to capture their movements in the living room, bedroom, kitchen, and bathroom. A door contact sensor also captures data about whether the elderly individual has left their house. In addition to the PIR sensors that capture data in an involuntary manner, 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 the main 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 prolonged non-movement.

3.2 Data Collection

To understand the unique problem in the context of study, both primary and secondary data were collected. Structured survey interviews were conducted with all elderly individuals participating in the project to arrive at a collective understanding of their concerns. The interviews were conducted as part of home visits. During these, the research assistants took notes based on their observation of the living condition, the personalities of the individuals and the living patterns.

In addition, 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 data presented in this article is based on one focus group interview (following a semi-structured guide) with the 5 staff, conducted over 2 hours and resulting in a 6000-word transcript. 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 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 1.

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

Table 1. Method of Data collection

4 SURFACING VALUES AND CAPABILITIES

4.1 The Values of the Elderly

Following cues from prior research about the importance of values such as tradition, conformity and security for the elderly (corresponding to conservation values (Lyons et al., 2007)), the survey questionnaire was designed to understand the manner in which the elderly value these values. Our intent was to discover whether and how they would comply with the home monitoring system when faced with these values. The survey also collected demographic information, psychosocial health

status and attitudes towards technology from the elderly participants. To ensure a better snapshot of the setting, we also noted the number of prevalent chronic conditions (e.g. diabetes, hypertension and others) for each participant. This revealed that many elderly participants have multiple chronic conditions they must manage (see Figure 2). The survey data corresponded with these observations in that a combination of multiple chronic conditions with living alone meant that almost all of the elderly participants were clear in stating that they would like to ensure safety and security through using the sensor-enabled home monitoring system – without any explicit consideration of how this may support or conflict the conservation values. The interviews did, however, surface concerns related to privacy.

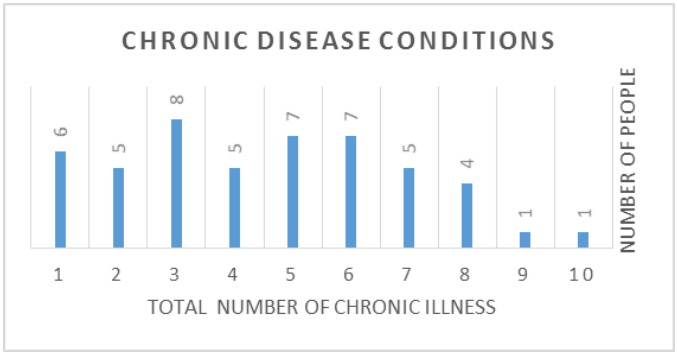

Figure 2. The health status of Elderly Participants (N=49)

As we collected information about the participants' privacy concern, we found that most of the elderly participants exhibited a moderate or low level of concern. Our interpretation of this result was that they were more inclined to comply with the technology solutions as along as their safety is enhanced. In other words, if values such as tradition and privacy conflicted with security, the later won. The answers from the participants indicated that 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. Although it is difficult to infer this directly, we attribute the answers to the non-intrusive nature of the technology. As one indicator of their sense of comfort in interacting with new technology, we gathered data about the use of phones. This showed that more than 20 (more than 40%) of the elderly participants were using mobile phones although only three described phones with 3G/4G connections, which may allow them the ability to use more advanced applications and sophisticated ways of interacting. Prima facie, these results and initial analysis suggested that the elderly participants in this study did bring up the values of tradition and conformity but were more driven by the value of security, sometimes at the expense of values such as privacy.

4.2 The Values and Capabilities of the Caregivers

We followed similar reasoning for surfacing the values of caregivers. Following cues from prior work, that suggests obligation and control as the two dominant values for caregivers of dementia patients (King et al., 1995) – which map to achievement and power respectively (in the Schwartz framework of basic human values). In the focused group interview, the caregivers from the VWO. collectively surfaced similar values by emphasizing that they are obligated to take better care of the elderlies ensuring their own autonomy. The caregivers also expressed that they would be more inclined to leverage the technology to suit their needs instead of led by the technology and change their ways of supporting the elderly. Among the issues they raised were also concerns about reliability of the system, their expectations about what the technological infrastructure would enable them to do, such as delivery of better service and delivering their services better. They suggested that this may be accomplished by providing more information on the elderly so that they can plan for health promotion programs or other outcomes such as social activities that respond to the information provided by the system. This set of results, thus, showcased the possibility that the caregivers were appreciative of the potential of the technological infrastructure but saw it not as one that would dictate how they delivered services to the

elderly. Instead, they saw it as one that would play an enabling role that would (significantly) improve how the caregivers would provide care to the elderly. In other words, they conceptualized the technological infrastructure primarily as a platform that would enhance their own capabilities.

These capabilities were also identified through the data collection process. For example, the caregivers expressed that that the expanding manpower and the good relationship with volunteers and the elderlies are important resources that they can leverage.

Capabilities	**Sample Quotes**
Commitment and passion by the VWO team	*"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…"* *"…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…"*
Communication within the VWO team is clear	*"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…"*
Manpower of VWO team	*"the manpower is still expanding so that is a good thing for us".*
Strong volunteer support from the neighbourhood	*"…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…."* *"So they are just supposed to go up and interact with the seniors but if there's anything that comes up, they are supposed to inform us in situations where they need to make certain decisions, they need to inform us too."* *"…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…"*
Help extended by the neighbours	*"…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."*
Good relationship has been established between VWO team & elderly	*"…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"*

Table 2. Identifying caregiver capabilities

4.3 Mapping Values and Capabilities

Armed with the values from both sets of stakeholders and an initial understanding of the capabilities articulated by the caregivers, we performed a mapping across the technology features and caregiver capabilities. Table 3 below shows this mapping. It shows the values (from both stakeholders) in the first column, and how these values are realized in the capabilities of the technological platform as well as those of the caregivers. Implicit in the two right columns is a first answer to the question about how the two sets of capabilities may work together to account for and respect the values articulated in the first column. An examination of the table may then surface questions such as: whether the design of the technological infrastructure is / is not able to address the values of the elderly and caregivers at the same time, and whether the caregivers' capabilities are fully supported / utilized for delivering quality service to the elderly. The absence in several cells is also telling in that it points to a possible

disconnect between the technology capabilities and the caregiver capabilities, i.e., it shows whether and how the technology capabilities and caregiver capabilities are integrated to meet the values of the elderly and the caregivers.

Values		**Capabilities**	
		Technology capabilities	**Caregivers capabilities**
Elderly	Tradition	Passive and unobstrusive sensing system, so elderly does not need to have direct interaction with technical devices.	
	Conformity	Lower level of privacy concern ensures the successful installation of the system	
	Security	Non-movement detection and alarm management detects anomaly	Commitment and passion by the VWO team, strong volunteer support ensure all notification sent by the system are attended by VWO staff
Caregiver	Achievement	Passive and unobstrusive sensing system promotes a safer living environment for the elderly	Commitment and passion by the VWO team, strong volunteer support ensure all notification received are attended in short time
	Control	Caregivers are not able to control what notification and when the notification is sent to them.	

Table 3. Mapping Values and Capabilities

5 THE (RE)DESIGN OF TECHNOLOGY AND RESPONSE PROTOCOL

During the research project we describe, after the first implementation, it appeared that the elderly home monitoring system was (at least partially) 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 based on frequent detection of extended non-movement (alerting the caregivers of a potential problem). Although this design was intended to ensure the safety of the elderly, it also caused alarm fatigue for the caregivers. They mentioned that "*if it beeps too often, it also lowers down our guard".* The elderly were also irritated by unsolicited home visits triggered by false alarms. The caregivers were eager to take control of the caring process, but not to be reminded and chased by repetitive fictions. One way to understand this is simply a problem with the technology feature. Based on our analyses, we were able to trace the problem to a potential conflict between the caregivers' values of power and elderlies' value of security.

To address the problem, the research team worked closely with the software team and caregiver team to redesign the experience. A few changes were 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 were also classified according to different levels of urgency. For example, the notification that is generated by an emergency call (requiring action from the elderly) is expected to be attended to by caregivers immediately. On the other hand, each notification triggered by non-movement detection (a passive alert that requires no action from the elderly) would first be checked to reduce the likelihood of false alarm, thus requiring a longer response time. The redesign process leveraged the volunteer resources of the VWO in the following way: if the caregivers were not able to visit the elderly participant after office hours, they could activate a volunteer to attend to the elderly. This also contributed 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 allowed only two staff members to respond to the notifications at any given time. The changes are summarized in Table 4 below.

(Re)design		Capabilities Leveraged	
Technology Infrastructure	**Response Protocol**	**Caregiver**	**Technology Infrastructure**
Adjust the threshold of non-movement detection based on day and night.			Analytics, Data storage
Classify the notifications by level of urgency		Manpower of VWO team	Alert Management
	Redesign the hierarchy of escalation in the system	Strong volunteer support from the neighbour-hood	
	Assign two staff members (instead of all) to respond to notifications .	Clear Communication within the VWO team	Scheduling

Table 4. System and Response Protocol Redesign

After the redesign, the number of false alarm reduced to less than five a week. The caregivers were less stressed about the frequent beeps, and the elderly continue to receive unobtrusive home monitoring.

6 EMERGENT DESIGN PRINCIPLES

Following a values-inspired design perspective, the study has identified some key strategies to maximize the benefits of elderly-home monitoring for both caregivers and the elderly. Initial versions of these, codified as design principles (P1 to P3) are shown in Figure 3 below.

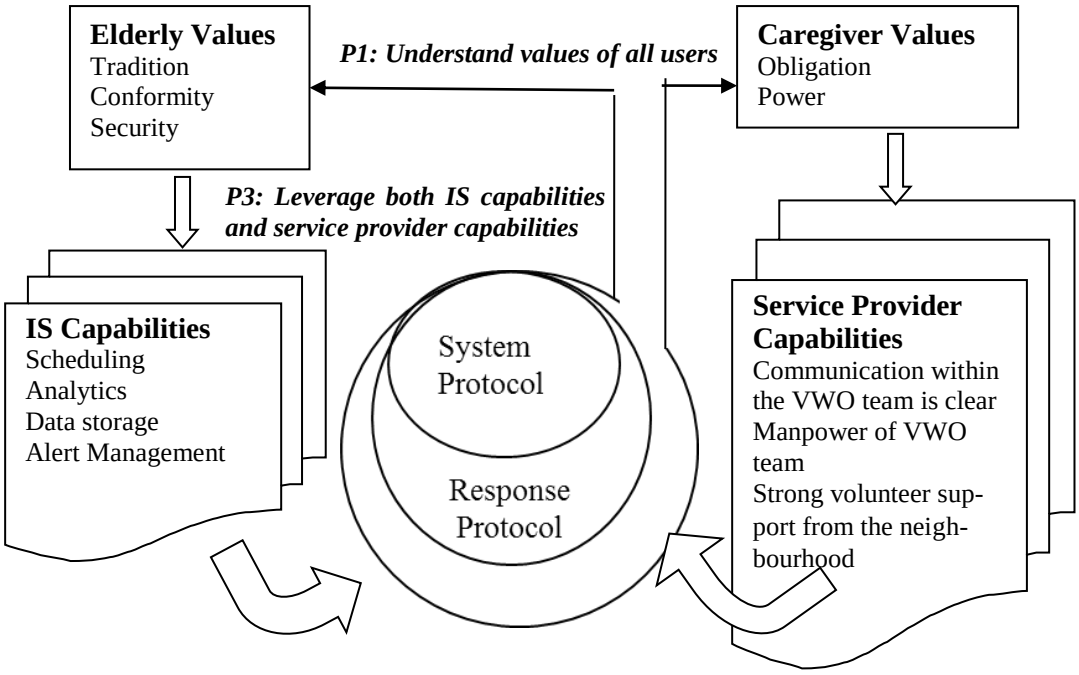

Figure 3. Illustration of Design Principles.

The three design principles we outline are not intended to be comprehensive. Instead, they should be seen as something akin to critical factors that, if ignored, may lead to sub-optimal outcomes.

Principle 1: Understand the values of all users. First, the study revealed the importance of understanding the values of all user groups who could benefit from the technology directly and indirectly. There was an increased attention to the integration of human values into the conception, design, and development of the emerging technology platform. 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 (Purao & Wu, 2013). 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.

Principle 2: (Re)design system and response protocols concurrently. Second, 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. Without this concurrency, we run the risk of following an implicit argument that privileges solving technological problems at the cost of engaging with the phenomenon that inherently requires a partnership between the caregivers and the technology platform.

Principle 3: Leverage both, caregiver and technology, capabilities. Third, it is important of understand the capabilities of the information systems and the capabilities of service providers and leverage the capabilities of both to redesign both the system and response protocols. In other words, the value-inspired redesign of the system and response protocol should leverage on the capabilities of IT and resources of prospective users. This ensures that the technological platform is not seen as one the 'directs' the caregivers' actions but rather, one that enables more effective delivery of services and more effective services from the caregivers. The redesign of the services, then, considers the potential resources that can be leveraged to achieve this goal. In the case of the SHINESeniors project, the strong volunteer support and clear communications among VWO team members were seen as 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.

7 Conclusion

The use of pervasive technologies to promote aging-in-place cannot be successful without strong support from caregivers. In many contemporary projects, the design of elderly-home monitoring system focuses on improving the security and safety of the elderly but neglects the requirements from caregivers. This focus on improving the technical accuracy and ensuring the safety of the elderly can have the unintended effect of overlooking the perspectives caregivers – who play an essential role in this context. Taking a value-inspired design perspective, the study followed a design-oriented research approach to redesign the system protocol and service protocol of an elderly-home monitoring project serving 50 older people. The redesign process leveraged the system capabilities and service providers' capabilities to reconcile the basic values that are valued by both, the elderly and their caregivers. The design principles that were developed and implemented were then reflected in the redesign, and effectively enhanced the project's outcome for both, the elderly and their caregivers. The contributions of our work include infusing a values-oriented perspective for the (re)design of an ensemble system (both the technological platform and the response protocol), and showing how design principles may

be extracted from such an effort. The method that we have implicitly outlined in the form of the three design principles can be further codified and subjected to scrutiny in other, similar settings. This remains on our research agenda.

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