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ADDED VALUE OF STAKEHOLDERS' INVOLVEMENT IN DESIGNING FOR INFORMAL CAREGIVERS

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ABSTRACT

Informal caregivers, who are usually family members or friends of care recipients, provide unpaid assistances to help care recipients remain in their homes. However, they may be prone to depression, grief, fatigue and changes in social relationships. This paper presents the development process of a Product Service System (PSS) which is able to offer a respite to informal caregivers. Based on the Community-Based Co-Design (CBCD) method and the Service, Technology, Organization and Finance (STOF) framework, various qualitative research and design methods were combined in the development process in order to: 1) establish the requirements of the PSS; 2) study the feasibility of the PSS and 3) validate the added value of involving stakeholders in the development process. The development process can be divided into to two parts: First, requirements of the PSS were generated using the CBCD method. Then, in total 8 steps were carried out in the designing process following the STOF framework. In each step, discoveries, insights and/or feedback from different stakeholders were iteratively fed back to requirements of the PSS. Among those steps, a role-play study, which was executed in Step 4, gave a new perspective regarding engaging stakeholders in the design process. The outcomes of the presented research verified the feasibility of the PSS and proved the added value of engaging different stakeholders in the development process. Limitations of the PSS and innovation barriers identified in the development process are discussed as well.

KEYWORDS

Informal caregivers, CBCD, STOF, role-play, product service system, socio-technical system

1. INTRODUCTION

The ageing societies of many countries are facing financial, practical and social problems [1-4]. With the rising number of people with chronic diseases, it is necessary to develop innovative Product Service Systems (PSS) [5-7] that empower informal caregivers, to safeguard or even enhance quality of care while keeping the healthcare system affordable. One of the solutions is to develop assistive technology [8, 9] for informal caregivers to reduce their workload and relieve part of their burden. However, literature survey [10-15] indicates that currently, most technology-based support systems target at care recipients or healthcare professionals, and the wishes of the informal caregivers are not always addressed. A few case studies can be identified in this field. For instance, Sara et al [16] provided a solution for informal caregivers based on assistive technologies. However, they concluded that further research should be conducted to investigate i) the effectiveness and efficiency in monitoring care recipients' activities and ii) the benefits of such a system in both social and economic aspects.

As one means to address this challenge, together with Epposi Think Tank [17], an innovation in healthcare project was setup in Delft University of Technology to explore the added value of engaging stakeholders in developing healthcare PSS. This paper presents the

development process of an example of such PSS, with the emphasis on exploring the added value of involving different stakeholders in each step of the development. The rest of this paper is arranged as follows: First, the objectives of the research and the approach used in the development process are presented in Section 2. Using the CBCD method, Section 3 presents the framework of the PSS and summarizes requirements of the PSS. With requirements of the PSS, the design activities are carried out by 8 steps following the STOF framework. Choices, intermediates outcomes and the added value in each step are explained from Section 4 to Section 11, corresponding to the 8 steps approach, respectively. Section 12 presents a discussion on the added value of PSS and the methods used in the development process. Section 13 concludes this paper.

2. THE OBJECTIVES AND THE APPROACH

The proposed research aims at i) Establishing the requirements of a PSS framework to support Informal Caregivers; ii) Studying the feasibility of the PSS and iii) Exploring the added value of engaging stakeholders in the embodiment design of the PSS. To develop a PSS for informal caregivers, the requirements was generated based on an approach named *Community-Based Co-Design* (CBCD) [18]. With the requirements of the PSS, many qualitative research and design methods were combined in the development of the PSS, the validation of its estimated added value to target users, and the estimation of its feasibility of the PSS. This process was formulated based on the *Service, Technology, Organization and Finance* (STOF) framework. The STOF framework was developed by Faber and de Vos [19], and it is often used in the design of Information and Communication Technology (ICT) related products.

Four distinct parts are often engaged in the STOF frame as: service, technology, the organizational issues and the financial issues. Using these four parts as design goals, the design activities were structured using the user-centred design cycle as defined by van der Peijl et al [20]. Figure 1 presents an overview of the approach and activities in the development process. In the figure, the first row represents the generation of requirements for the PSS and activities in the designing process; the second row indicates the contributions of those activities to requirements; the third row explains outcomes in each step; the final row indicates where four design goals were reached within 8 steps, respectively.

3. REQUIREMENTS OF THE PSS

The CBCD method, which is used to generate requirements for the PSS, is built up based on the Open Innovation 2.0 model [21]. It has two interconnected parts: *co-design* and *community*. The *co-design* approach [22] asks for cooperation of different types of stakeholders across different stages

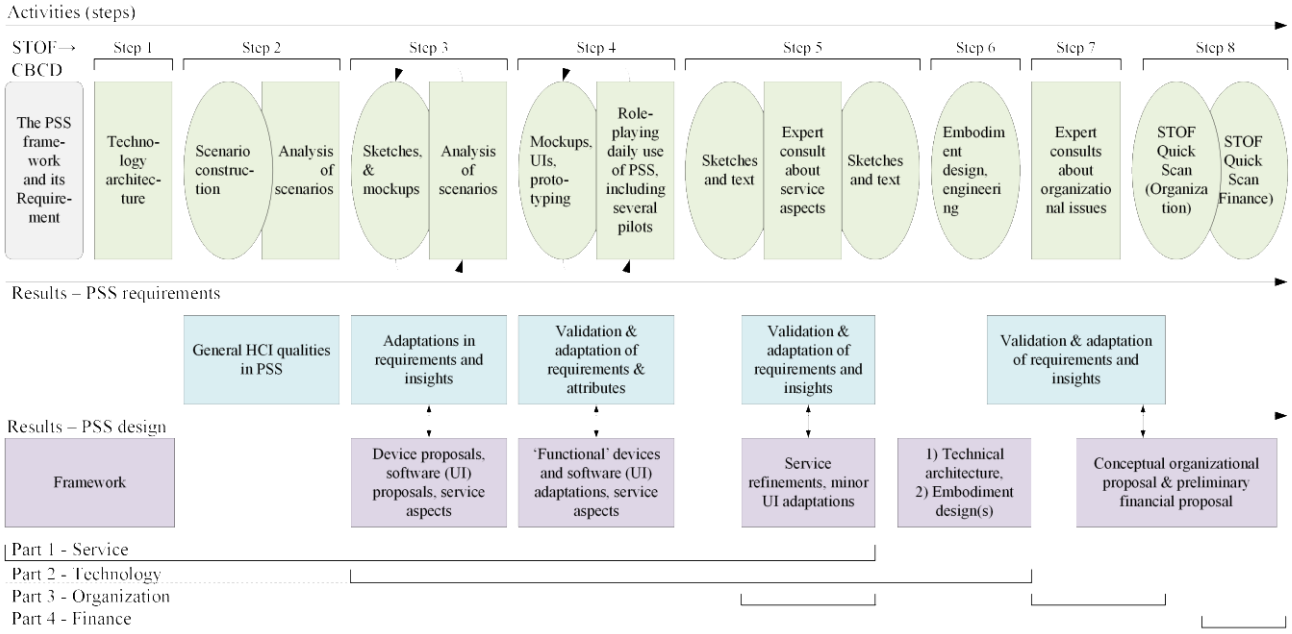


Figure 1 The approach and activities in the development process

of the development process. In many co-design sessions, the local stakeholders are often closely engaged. For instance, in this research, local stakeholders, especially the informal caregivers, they are identified and provided by the *community*.

In order to develop a PSS to support informal caregivers, two large co-design session were held using the CBCD approach [23]. The outcomes of the discussions forms the basis of requirements. Together with advices of experts, those requirements were refined to 76 detail requirements in three main categories as:

- Requirements related to the information (notifications and alerts) about the care recipient that should be sent to the caregiver;
- Requirements related to the communication between the caregiver and the care recipient, as well as communication between the caregiver and the backups and
- Requirements related to implementation and distribution of the system.

In the co-design sessions, the occurrences of each requirement in the meeting notes was counted. Three variables were defined as follows:

- $n_{i,IC}$, which is the number of informal caregivers that mentioned requirement *i*;
- $n_{i,exp}$ is the number of experts that mentioned requirement *i* and;
- $n_{meeting}$ is the number of times that requirement *i* was mentioned in group discussions.

To rank the priorities of those requirements, based on the assumption that frequently mentioned requirements were likely to be more important, the importance of each PSS requirement was estimated by:

$$G_i = (n_{i,IC} + n_{i,exp} + 1)(n_{meeting} + 1),$$

where G_i is an indicative value of the estimated priority of requirement *i*. Using the G_i value, the complete list of requirements was split into three lists: 1. high priority PSS requirements; 2. medium priority PSS requirements and 3. low priority PSS requirements. Among the 76 requirements, 30 of them have high priority, 19 have medium priority, and 27 had low priority. Space limitations prevent the complete list of those requirements. We list 9 typical requirements in Table 1, they corresponds to three categories and three levels of priorities, respectively.

Requirement nature	High priority (G ≥ 11)	Medium priority (11 > G ≥ 4)	Low priority (G > 4)
Information	"I want to know my partner's indoor location"	"I want to be alerted when my partner is close to the gas stove"	"I want to know my partner's blood pressure"
Communication	"Care recipient shouldn't have to push a button to answer a phone call"	"Embed a protocol for informal caregiver/volunteer in case of emergencies"	"Provide a contextual button for care recipient to indicate he is unable to speak"
Implementation and distribution	"Design nice-looking bracelet(s)"	"Tailor volunteer network size based on care case in intake session"	"There should be a reward mechanism for volunteering"

Table 1 Examples of requirements with different priority levels in each category.

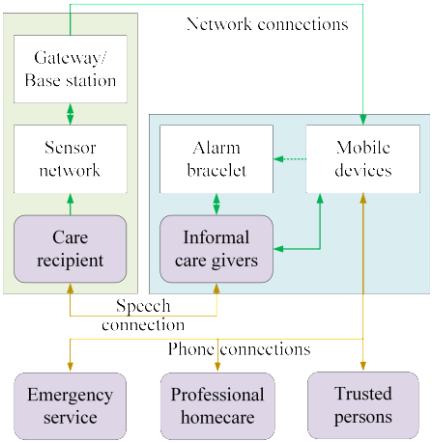


Figure 2 The framework of the PSS

Using high priority requirements as basic requirements, medium and lower priority requirements as wishes, the PSS framework was developed as Figure 2. It consists of monitoring (green lines) and alarming functions (yellow lines). In the framework, a Wireless Sensor Network (WSN) registers the actions of the care recipient when the informal caregiver is not available on site. Information regarding the care recipient is shared with the informal caregiver through a mobile device. This is done upon the informal caregiver's request, or

automatically in the case of critical situations. An alarm bracelet, which acts as a double-redundant system, is added to decrease the risk that the informal caregiver may miss an alarm. Using the mobile device, the informal caregiver can directly contact his/her partner to assess the situation at home. In the case of critical situations and the caregiver is not able to help or react instantly, the caregiver may decide to call emergency services, professionals, or a volunteer (e.g. neighbour) nearby to handle the situation.

The PSS serves the scenario that the caregiver lives either together with or close-by to the care recipient in a non-institutionalized care setting (e.g. home). For instance, an informal caregiver cares his/her partner who suffers from consequences of stroke [24]. It was also found that many of these target users are aged 50 years and above [25].

4. STEP 1 - DESIGNING TECHNICAL ARCHITECTURE

Based on requirements and the framework of the PSS, a technical architecture is generated as the first step in executing the STOF framework. This architecture is a generic technical platform for homecare. It features affordability, scalability and compatibility. In particular, it was designed to emphasis: i) realizing technical requirements of the PSS; ii) using off-the-shelf components, as to keep the price down, and to minimize the needs for technology that is unfamiliar to end-users; iii) offering alternatives to end-users regarding existing equipment in the house; and iv) keeping the architecture as simple as possible in order to improve safety and privacy of the system, and bring down costs and obtrusiveness.

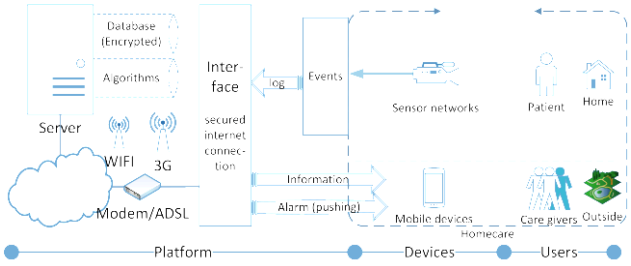


Figure 3 Technical architecture of the proposed PSS

Figure 3 presents the technical architecture of the proposed PSS. It consists of a platform and different types of devices. The platform is constructed based on a server located in the cloud. Using encrypted databases and algorithms, the platform is able to offer different types of web-services, e.g., registering the events from sensor networks. Different types of devices, for instance, sensor networks, mobile devices etc., can be plugged into the platform via ADSL, WiFi or 3G. In a usage scenario, information regarding the care recipient can be registered in the database and be retrieved by the caregiver via applications of the mobile device. In the case of critical situations, the platform will "push" messages to the mobile device. Space limitations prevents the full description of technical details regarding the architecture. It will be presented in the authors' future papers.

5. STEP 2 - CONSTRUCTION AND ANALYSIS OF USAGE SCENARIOS

Informal caregivers use the mobile device and the sensor network to monitor the care recipient. To create appropriate Human Computer Interactions (HCI) of the mobile device, a concise set of requirements was formulated by exploring daily usage that might occur with the PSS. For this, fictional end-users and related scenarios were created based on the outcomes of CBCD and available literatures [24, 25]. Figure 4 illustrates an example of those scenarios. In the figure, simple sketches are used to describe three possible locations of the informal caregiver when he/she leaves the care recipient for a short while: i) at the lockers of a supermarket, ii) queuing, and iii) walking on the street.



Figure 4 An example of usage scenarios

After scenario construction, action steps in each scenario were analysed regarding different types of users. Although all stakeholders were taken into account, extra attentions were paid to the informal caregiver and the feasibility of HCI. Key events (e.g. important actions, interactions, thoughts, or feelings) in different scenarios were marked and categorized. These categories were translated to adjectives that served as requirements for the HCI in the PSS.

Insights were gained from the analysis of usage scenarios. For example, the caregiver is anxious

regarding leaving the partner alone, thus extra stress will be introduced in the operation of the mobile device. In summary the following requirements of HCI in the requirements of the PSS were setup to ease the emotion of the user and assure the rightness of the operation:

1. Clear/straightforward - The easier it is for informal caregivers to understand and use the system, the better it will support them in effective risk handling;
2. Reassuring (in every step) - The caregiver should feel as much as possible that the situation is safe, or everything is going according to the plan;
3. Tailored/personalized - User preferences (e.g. how to contact other parties) should be incorporated as far as possible into interactions. This should be balanced with the ease of use (e.g. only a few clicks);
4. Unobtrusive - The HCI should be subordinate to the context of usage, such as comforting the care recipient.

6. STEP 3 – INTERMEDIATE UI EVALUATION

Using the outcomes of Step 2, the preferences of target user group from CBCD and recommendations of literatures [26, 27], we visualized the concept by sketches and preliminary prototypes. Figure 5(a) presents a conceptual image of the monitoring system inside a house where a WSN is applied. In Figure 5(b) and (c), a visual impression of the mobile device is presented. Figure 5(d) shows the preliminary prototype of the User Interface (UI).

To gain insights into usability of preliminary UIs and acquire recommendations of the service of the PSS,

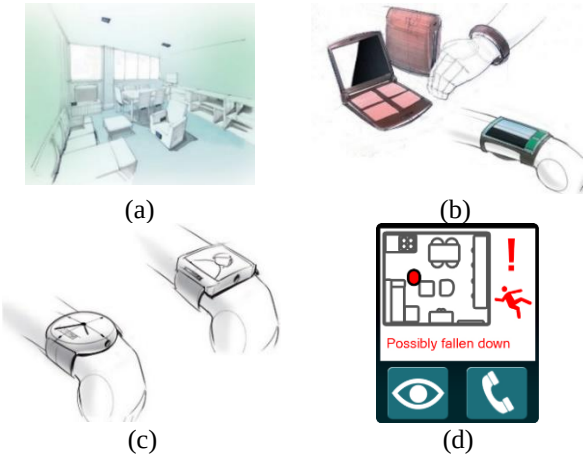


Figure 5 Preliminary prototype (devices & UI)

four target users (n = 4, 2 female and 2 male users, $\mu = 73$ years and $\sigma = 12$ years) were asked to evaluate the prototype. The sketches and prototypes were shown to participants, and they were asked open-ended questions, such as: "What do think about this proposal? Which variant would you prefer? What would you change about this proposal, if anything?"

Subsequently, participants were asked to perform several tasks on a mock-up model of the caregiver's carried device. This model was deliberately made 'sketchy' looking, in order to emphasize its preliminary nature and to facilitate free discussion in participants. In the process, participants were asked questions like: "To what extent was this task easy to you? What do you think caused this? What would you change about this interface, if anything?"

In the final part of this evaluation, some general questions about service aspects of the PSS were asked, such as: "If this were a paid service, how much would you be willing to pay for it as a monthly fee? How would you like to be informed about this service? Who would you like to teach you how to use the service?"

The preliminary evaluation of the first PSS design delivered several insights. Knowledge was gained about the service in general (e.g. where to get first information about the service). Next to this, insights were gained about acceptability of technology. An interesting discovery is that placing sensors and/or cameras in the home was acceptable to caregivers, but generally unacceptable by care recipients. In one case a care recipient insisted that he would not agree with any sensors or cameras placed in his home. The outcome of this research indicates that the physical scale of the sensor network should not be noticeable for some care recipients.

The preferences of types of UIs for caregivers varied among participants. For instance, the use of visual icons seemed confusing and those icons should be replaced by simple text labels on buttons. In later sessions, a seemingly 'natural' use of device was mostly observed, even for elderly participants who claimed to be unskilled with modern technology. In these sessions, recommendations were increasingly about minor (but important) details of the interface, such as the way of notifications. For instance, one participant said "the message 'John has made a sudden movement' instead of 'John might have fallen down' might lead to less stress to the informal caregiver upon receiving such an alarm. Considering

the visual acuity of elderly [28], the text on the button should be as large as possible. However, considering the weight and the cost, the mobile device should be as small as possible. To solve this dilemma, efforts were made towards two sides of this problem: i) a relative large screen mobile device is needed; ii) articles and other unnecessary words are removed from the text.

In short, the outcomes of Step 3 can be summarized as: i) Sensors should be unnoticeable for the care recipients; ii) Large button with fewer text in the UI and iii) Natural use of devices. These outcomes directly reflected on the prototype of the mobile device as Figure 6. In the design, an Samsung® Android® smart phone was chosen due to i) it is an off-the-shelf option; ii) low price; iii) light and iv) relatively large screen to accommodate "text" buttons.



Figure 6 The prototype of the mobile device based on an Android® smart phone

7. STEP 4 – ELABORATE EVALUATION: ROLE- PLAY OF PSS DAILY USE

To gain feedback from target users on the latest PSS iteration, an elaborate evaluation study was carried out in this step. Specifically, this evaluation was conducted in order to i) acquire more detailed and realistic insights about and target user's opinion of the daily HCI; ii) verify indications made by caregivers and experts in earlier steps; iii) obtain additional target user recommendations of the service of the PSS. For this, a role-play (partly) scenario with (ex) informal caregivers was introduced. The role-play was conducted using a Wizard-of-Oz prototype [29], in which some PSS functions were carried out by one of the assistants at the background.

Role-play setup

Figure 7 presents the basic setup of the role-play. In a simulated living room, the care recipient (an actor) was monitored by an IP camera and the caregiver carried "care recipient bracelet" (Figure 6) as the mobile device. In the role-play, the assistant simulated part of the technical functionalities (video control and alarm generations) as well as the back-up network in the PSS (a volunteer or emergency services). Three highest priority alarms were embedded in this prototype: 1) Care recipient is moving close to gas stove; 2) Care recipient is opening the front door; 3) Care recipient has made a sudden movement (meaning he/she might have fallen down).

Role-play study procedure

Preparation: To prepare assistants in the research team for the role-play study, technical pilots with a preliminary prototype and research protocol were conducted with assistants alone (2 pilots without participants), as well as caregivers (4 pilots with participants; $n_{participants}$ = 2, both were male, μ_{age} = ~73 years, σ_{age} = ~3 years, care recipient conditions of their partners included advanced dementia and mild stroke). Based on feedbacks of technical pilots, to further improve the prototype in Figure 6, a new mobile holder was made. In the prototyping process, to guarantee the best fit between the mobile phone and the holder, we digitized the shape of smart phone by a 3D scanner (Figure 8(a)). The mobile phone holder was modelled as the negative print of the shape of the digitized smart phone. Then it was manufactured by rapid prototyping technology. Comparing to the cupboard prototype, the new smart phone holder is lighter, stronger and more comfort.

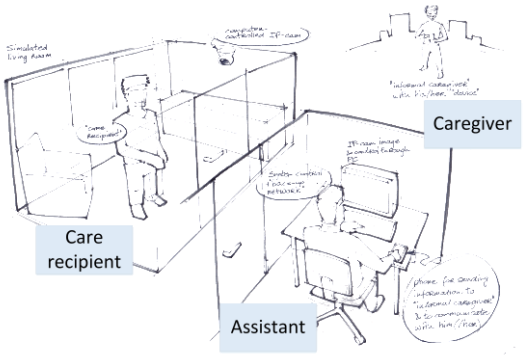


Figure 7 Setup of the role-play

Informal caregiver: After the pilots, two rounds of role-play studies were held. The first round was conducted in a simulated living room inside the Faculty of Industrial Design Engineering (IDE) at Delft University of Technology ($n_{participants}$= 4, 3 of them were female, μ_{age} = ~67 years, σ_{age} = ~8 years, care recipient conditions of their partners included mild and advanced dementia, stroke, and neck stenosis). The second round was conducted at the Living Lab in a community center in Delft ($n_{participants}$ = 5, 4 of them were male, μ_{age} = ~76 years, σ_{age} = ~4

years, care recipient conditions included mild and advanced dementia as well as stroke).

Procedure: After a general introduction and the participant signing an informed consent form, the PSS framework was first discussed with participants who were new to the study, or that had forgotten (part of) the PSS framework.

Subsequently, participants were given an explanation of the prototype and role-play setup, as well as a role-play demonstration by the research team. After this demonstration, participants were given room to provide feedbacks on the role-play. If necessary, the team could adjust scenarios for the remaining session based on those feedbacks.

The participant was then instructed when the role-play was about to start, he/she was required to 'go for a short trip outside the house' with the device. He or she was told to prepare for the trip, and to actually leave the simulated living room. He/she was told that 'anything might happen' while the participant was away, and the participant should decide how to respond to each situation. Upon leaving the room, participants were instructed to go to one of two locations, one location with good internet connection and another location with poor signal (participants did not know about the differences). Two role-play tests were performed with each participant, testing both 'locations' in a randomly determined order.



(a)



(b)



(c)

Figure 8 The prototype and an impression of the role-play

Upon an unspecified amount of time after the participant leaving the house (but within a couple of minutes), the 'care recipient' would do something potentially 'dangerous', such as turning on a (mock-up) gas stove. In such cases, alarm messages (such as "the care recipient is close to the gas stove") would be sent to the participant. Each role-play session was ended upon the informal caregiver reaching the front door again.

Figure 8(b) (c) presents an impression of the first and the second role-play sessions, respectively. In between the two role-play sessions, an intermediate evaluation of the first session was held with each participant. It was discussed that how the session went, and what stood out to the participant and assistants. Before conducting the second role-play, minor protocol adaptations were made according to the interim feedbacks.

Evaluation: An evaluation were conducted at the end of each session. The first part of this evaluation was a general interview. Participants were asked open-ended questions such as: "How was the experience? What stood out for you? How would you summarize the experience? In your view, what went good and what went less good? What do you think caused this?" Next, participants were asked to mark up to five adjectives that best described the PSS and the prototype he/she had just used in a list of adjectives (Figure 9) [30]. Subsequently, participants were asked to explain his/her choice. The purpose of these was to estimate that to what extent the participant's experience matched the target HCI which was designed in Step 2.



(a) Original Dutch list

Reckless	Private	Busy	Easy
Gloomy	Friendly	Reassuring	Smart
Cheerful	Easy	Naturally	Stable

(b) Translations

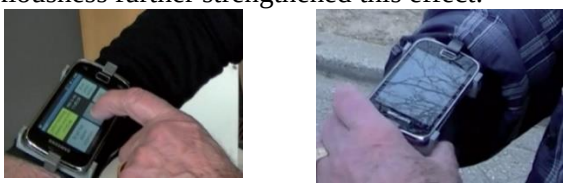
Figure 9 A sample adjectives list, marked by the participants

The evaluation was ended with some specific questions, as far as they had not been answered by participants yet (serving to reach goals ii and iii of Step 4). For each round, all sessions were first processed separately, following thematic analysis as described in the example given by Silverman [31].

Summarization of role-plays

Overall, there were differences and similarities in how participants managed alarms, depending on arrangements with the volunteer, video signal quality, types of alarms, and ways of processing those alarms. Video was often watched, but it also

took too much attentions of participants, which distracted him/her from tasks ahead. Participant anxiousness further strengthened this effect.



(a) (b)

Figure 10 An example of technical problems regarding the glossy screen

In the role-play, technical problems regarding the visibility of the interface were also identified. For instance, Figure 10(a) presents the menu of the mobile phone in an indoor environment. However, in the outdoor environment, the menu is not always readable due to strong ambient lights (Figure 10(b)).

Other aspects related to human behavior and interaction were also observed. In general, interactions between a participant and the care recipient seemed calm, relaxed, and friendly, especially when leaving the house, and also when calling the care recipient. The same applied to interactions between a participant and the backup network. However, besides these 'normal' or natural interactions, some observed interactions might be unwanted. For example, most participants discussed the care recipient's state with the 'volunteer' in the same room with the care recipient. In another case, after the care recipient had fallen down, a participant focused on arranging assistance through the system other than comforting her 'partner' first. However, participants did not feel that the system was too obtrusive, or that it would influence the partner relationship.

Regarding the perceived functionalities of the system and its perceived added value, for monitoring the care recipient, the system was "useful" due to the combination of speech and video, and for the use of a backup network. In general, participants liked that the caregiver is in control and he/she had additional options, for instance "to check the situation when I want to with video, and to check it in case of an alarm." As such, several participants felt that "it would make many caregivers feel more or less secure to leave the house."

Many participants felt the system would be (or have been) added value directly in their daily life: "people can leave home longer with this." Some participants were quite enthusiastic about the application potential: "Seen as an alarm button without the actual button, this system can be used for many care situations." However, it was also said that "there will always be limitations to this system. In some cases, such as severe dementia, it simply will not work."

Insights were gained about the implementation of the PSS. The trust of the system seemed to be the most important issue in this respect. According to participants, the trust should be built on i) using familiar technology; ii) the caregiver's knowledge of the care recipient; and iii) prolonged and frequent usages "with guidance by an expert in the first months." With respect to introduction and guidance, one participant (he is also a homecare professional for dementia) figured that "a case manager might inform a couple about it, an ergo therapist might provide initial guidance, and a technician of education level 3 can take it from there. But he or she has to be empathic towards the end-users as well."

Finally, participants made practical recommendations about the system and carried devices. For instance, one participant advised to "combine this system with simple appliances in the home, for example a digital lock." It was recommended to market the system (partially) through care organizations "because the system fits nicely into existing health procedures." Participants were willing to pay between €10 and €25 per month for the system, but felt it should be free of charge for the first two months, "to get used to it without obligations."

Outcomes of role-plays

From the adjectives that participants chose for the system in role-plays, 83% of them matched the HCI qualities defined in Step 2. About 87% of adjectives selected were positive in general (such as 'private'). Negative adjectives chosen were used to further improve the safety of the PSS design. Besides, with the results from the role-play sessions, several adaptations were made to the UI as i) Rearrange some menu sequences, e.g., simplify the volunteer arrangement menu; ii) A 'timestamp' was added to alarms, and a time display was added to the bracelet; and iii) A button was added for watching the video.

8. STEP 5 – FINAL SERVICE ADDITIONS

Based on the outcomes of Step 4, a professional homecare expert was consulted regarding the PSS. The homecare expert was positive about the overall service part of the PSS. She did note that "it will depend on both caregiver and care recipient whether this will work. Chances might be increased by

introducing it very early, and by offering very basic functionality." She added that next to managing alarms, "the caregiver probably wants to keep the partner calm." Furthermore, she addressed the importance of the initial discussion with participants of the PSS. As for system realization and reaching more people, the expert thought "word of mouth" might work best. "You could initially target technically educated elderly, for instance people that retired from the technical university. They'll master the system more quickly, and can explain it to others." Considering those results, the supportive value to the user, which is one of the goals of the design, is fulfilled.

9. STEP 6 - TECHNICAL DESIGN

With outcomes of previous steps, the technical details of the PSS were added on in this step. First, a WSN (Figure 11(a)) [32] and an IP camera were added to the system to detect the care recipient's activities. Equipped with motion and thermo sensors, the WSN is able to collect activities of the care recipients and register those activities in the database of the PSS.



(a) The WSN (b) The bracelet

Figure 11 Technical designs

The mobile device is built based on a smart phone, and an app was developed with the functions and UIs described before. As a doubly redundant backup, a bracelet will be provided as an option to ensure the alarms "pushed" by the server can be received. Based on PSS specifications, the bracelet had to i) generate loud sound and vibration after an alarm on the main carried device, through wireless communication and ii) look nice, unobtrusive, and personal. Figure 11(b) presents the CAD model of a "female" variant of the bracelet and its exploded view. In the figure, Part 1 is the electronics component; Part 2 is a single plastic shell in which the electronics are embedded; Part 3 is a plastic cap which is used to seal the electronics; Part 4 is a reset button; and Part 5 is a rubber wrist strap.

10. STEP 7 – CONSTRUCTING AN ORGANIZATIONAL MODEL

To further explore critical aspects regarding PSS implementation and organization, two experts on organizational matters about the PSS were interviewed. The discussions focused on the experts' perception of implementation and diffusion of supportive technology, and the organizational issues associated with such processes. With the outcomes of previous steps, 15 stakeholders were identified and they are organized around the service provider as Figure 12.

In the figure, the service provider is positioned at the top right corner of this figure. The blue lines indicate connections between stakeholders which are needed for the realization of the PSS. The horizontal axis indicates the duration of the involvement of a stakeholder. The vertical axis denotes "degrees of influence" of stakeholders on the PSS. Based on this model and current insights, the most important stakeholders are: i) (Inter)national funding organizations and think tanks; ii) Legal authorities, such as the Inspection of Healthcare and the College for Protection or Personal Data; iii) A professional authority on homecare/elderly/dementia and/or caregiver's organization – who may promote PSS towards both customers and end-users and iv) Healthcare insurers, who may finance the PSS.

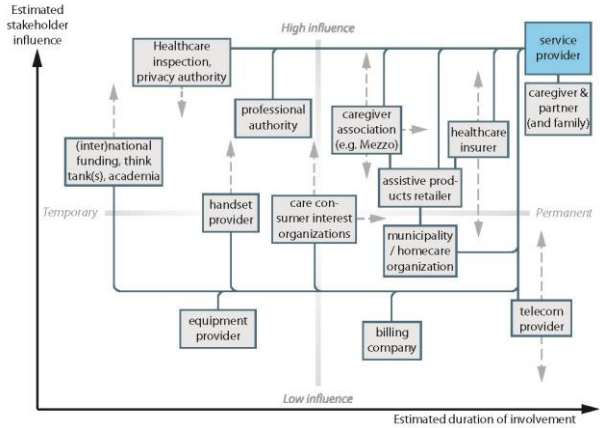


Figure 12 The organizational model

11. STEP 8 – THE FINANCIAL MODEL

In this step, using the QuickScan method from the STOF framework [19], we calculated the cost, the revenue and the societal profit regarding the proposed PSS. Space limitations prevents details of the calculation, here we only present calculation results.

In the calculation, costs were split into investment sources and capital, as well as fixed (startup) costs. Investments include additional development cost of products and software, notary arrangements, etc. The total investments were estimated to be around €183.575 (between €115.900 and €251.250). Variable costs were estimated per 'end-user' (i.e. an elderly couple) per month. Important parts of costs include i) service provider management; ii) monthly support and maintenance; and iii) 3G network subscriptions. Variable costs were also included to estimate equipment write-off, based on assumed duration of usages. As such, monthly variable costs were estimated to be around €62 (between €46 and €79) per end-user.

Same as the cost, variable societal revenues were estimated per elderly couple per month. Based on literature [33], the main revenues were estimated based on: i) A duration of time that placement in a nursing home can be postponed (about 3 to 12 months); ii) A decrease in the time needed for professional healthcare services to visit the home (about 1 hour per month), and iii) An additional decrease in occupation of homecare nurses since in the proposed PSS, alarm management is done by the caregiver. Considering all the revenue sources, monthly revenues per elderly couple were estimated to be around €324 (between €170 and €478).

The results of the calculation is promising. However, for most revenues it is hard to identify the actual benefited stakeholder (municipalities, homecare organizations, or others). Consolidating the actual benefited stakeholder(s) will be an important part in the future research.

12. DISCUSSION

In this section, based on outcomes of the development process, the design is reflected regarding the following three aspects: the value of the design, the barriers in the innovation and the design methodology.

Assessment of the supportive value of the PSS

The first goal in this research is to estimate the supportive value of the PSS to target users' daily lives. In the development process, target users showed their enthusiasm about the PSS across different stages of the development process. Remarks such as "this has to be brought to market" were given by nearly all participants, including those who were not involved before. Furthermore, the experts involved in the role-play shared the enthusiasm from their professional perspective as well.

Assessing feasibility of the PSS – Innovation barriers present and taken

The second goal was to estimate the feasibility of the PSS throughout the development process. This was done by analysing innovation barriers that may exist at various levels [34]. Some barriers can be foreseen, for instance, the usability problems. Through user-friendly interfaces, and by offering multiple options for several parts of the PSS, target users mostly accepted a smart phone-based design.

New barriers were also found in the development. For instance, if such a device is categorised as a medical device, the Medical Device Directives (MDD) [35] suggests it is a Class IIA device since it will process the data collected from the care recipient. In addition, Data Protection Directives [36] has strict regulations on the storage and transmission of patients' data. Currently, it is suggested to design and categorize the propose PSS in the "life style" product category.

Reflection on methodology

The first argument of CBCD is to gain deeper insights into contextual end-users' needs, leading to increased service value. From this research, it seems that insights into contextual end-users' needs gained during Step 4 were very rich, as the role-play research enabled an evaluation in a context which is more realistic than that was used in a normal usability test (e.g. Step 3). As a proof, insights from Step 4 added greatly to service value, as most additional PSS requirements were found in this step.

Next to this, CBCD aims at a more efficient design process. In the overall process, most efforts was spent on Step 4 –role-play. It took much time to develop the prototype and study protocols, and to find participants and assistants. Still, given (amongst others) valuable results of Step 4 as discussed before, it was certainly worth the effort.

Treating people (in a community) as equal partners is the third aim of CBCD. From this perspective, multiple participants in Steps 3 and 4 stated that had the feeling of being "taken seriously" as they shared their opinions and ideas. Some participants found this "quite nice". In addition, serious engagements were developed when the participants' advices were addressed and reflected in the development process.

This is also relevant regarding the fourth aim of CBCD – to achieve reciprocity, in both the process and/or the final results [19]. This aim is also observed in the current process, particularly in the role-play research. Most participants in this step found the research "a fun experience". One participant added: "It's nice that I can share my story again." Another participant confessed that: "It even provided my daily dose of exercise!"

Role-play [37] and drama workshops were used in medical innovation studies [38]. However, most of application fields of role-play are in healthcare professional educations [39] [40]. In the presented research, it is proved that role-play can be an important addition to the CBCD approach. It offers a communicative advantage over traditional methods, supports designers dealing with complex technology, feeds the designer's imagination and triggers end-user's empathy. Comparing with other methods from different steps presented in this paper, role-play is a worthwhile investment. In short, for innovations in homecare, role-play may facilitate meaningful end-user involvements in early stages of development.

13. CONCLUSION

This paper presents the development process of a PSS that supports informal caregivers. The approach used in the development is based on the CBCD method and the STOF framework, and stakeholders were engaged in every step of the development process. The feasibility of and the supportive values of PSS are verified through an 8 steps approach, where the role-play plays an important role in the development process. It is also concluded that the CBCD method is able to converge different interests of stakeholders together to create added values in the development of the PSS.

The presented research is the first iteration of the complete PSS development process. Current research is directed towards further development of the PSS. More functions of the PSS will be added based on the CBCD method. In addition, the financial model will be consolidated in the future research. It is also expected that this realization process may reveal valuable insights for academic researchers and innovation policy makers.

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