Co-design and engineering of user requirements for a novel ICT healthcare solution in Murcia, Spain

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Abstract. This contribution summarizes the co-design and user requirements engineering work carried out in the framework of the Pharaon Large Scale Pilot project, in Pilot to be deployed in the Region of Murcia (Spain). During the co-design phase, authors defined the methodology for the co-design and representation of user requirements as goal models, use case scenarios, and user stories. The methodology entailed several up-to-date co-design methods for user requirements' elicitation. ISO 9241-210 standards were followed. The original plan for eliciting and representing user requirements was modified due to the Covid-19 outbreak. The methodology designed and used is explained to serve as inspiration for similar approaches for smart healthcare, Ambient Assisted Living, or smart environments.

Keywords: AAL, healthcare, co-design, user requirements, goal models, use cases

1 Introduction

The Pharaon[1] Large Scale Pilot project aims to design and implement a European healthcare – ecosystem – in which people, software and hardware interact with each other in a smart, non-intrusive and dynamic way, that is, a novel Information and Communication Technology (ICT)-based healthcare solution. The Pharaon ecosystem is composed of a great variety of Ambient Assisted Living (AAL) technological solutions organized in clusters – Large Scale Pilots – to be deployed in 6 different sites: Murcia and Andalusia (Spain), Portugal, The Netherlands, Slovenia and Italy (see Figure 1). Each Pilot will be designed to perform a set of scenarios and use cases, while a Large-scale Pilot, under the Pharaon ecosystem umbrella, will orchestrate a subset of technologies deployed on each Pilot and data gathered, to perform novel and collaborative crossed-Pilot scenarios and services.

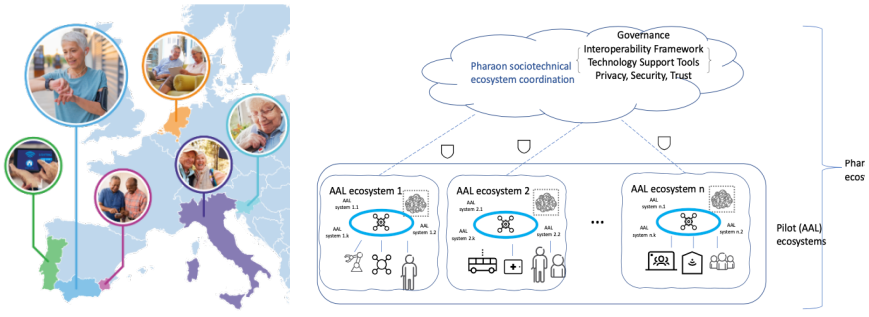
[1] Pilots for Healthy and Active Ageing. Project ID: 857188, funded under the H2020 topic DT-TDS-01-2019 - Smart and healthy living at home. https//www.pharaon.eu

Pharaon project can be categorized as a human-service project, since its final goal consists of promoting and improving the healthy life of ageing people. In fact, Pharaon project follows a human-centric design (HCD) approach. In this context, co-design is seen as a critical phase to success [1]. Co-design helps people involved in the project development to articulate more precisely and realistically the needs of the service's customers or users and for the organizations involved. The benefits of co-design are related to improving the creative process, the service, project management, or longer-term effects. The phases of co-design are mainly twofold: (1) to identify the goals of the service design project and (2) to align their co-design activities and the associated benefits with these goals. The co-design output feeds the engineering user requirements, mandatory step for finding the technical requirements, and consequently, for the design, development, implementation and testing of the technical solution.

This contribution summarizes the co-design and user requirements engineering work carried out in the framework of the Pharaon project, in the Murcia Pilot (Spain), serving as inspiration for similar approaches in the field of ICT for healthcare, AAL or smart environments, among others.

The authors defined a methodology for the co-design and representation of user requirements as goal models, use case scenarios, and user stories. The methodology entailed several up-to-date co-design methods for user requirements' elicitation, such as the DO-BE-FEEL method, the HOW-NOW-WOW method and empathy maps, gathering the data from interviews and surveys, and also other trending goal-based approaches for representing user requirements. ISO 9241-210 standard [2] is followed for co-design and requirements elicitation, which provides a framework for human centred-design (HCD) activities. The original plan for eliciting and representing user requirements was modified due to the Covid-19 outbreak in March 20. This is explained in depth in subsection 3.1.

The rest of the paper is organized as follows: Section 2 introduces the general methodology for engineering user requirements. Section 3 explains in depth the co-design engineering and user requirements performed in the Murcia Pilot. Finally, section 4 summarizes the conclusions.



(a) **(b)**

Fig. 1. Pharaon Large Scale Pilot. (a) Deployment sites. (b) Collaborative vision

2 General methodology for engineering user requirements

The methodology for co-design and user requirements elicitation to be applied in the Pharaon project should enable iterative co-design with the stakeholders - in particular with older adults. Iterative co-design means that the requirements are iteratively validated and elaborated through user experience design and prototyping until the stage is reached. Then, more detailed requirements for the actual implementation of the prototyped solutions can be specified. (see Figure 2).

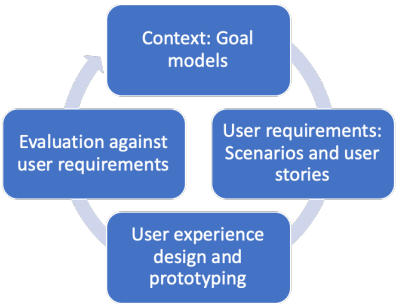


Fig. 2. Iterative co-design of the Pharaon ecosystem.

In the Pharaon project, user requirements were elicited by co-design workshops, managed by each pilot, with format of motivational goal modelling [3]. After that, the results of each co-design workshops must be represented in a uniform way, so that it would be possible to identify the commonalities of the co-design results by different pilots and integrate country-wide pilots into a European Large-Scale Pilot, which is a clear expectation by the European Commission (EC).

Co-design workshops involved older adults and other stakeholders in the elicitation process, such as healthcare professionals, formal and informal caregivers, and service providers. The requirements elicitation methods used by the pilot sites were interviews by phone and electronic means, in-person interviews conducted by formal caregivers trained for this purpose, web surveys, and, in some cases, virtual co-design workshops.

The useful data gathered from these workshops were basically an understanding of what activities by older adults and other stakeholders should be supported by the overall sociotechnical system to be designed, and what are the quality and emotional aspects of the activities to be supported [4]. In other words, an understanding of who should be able to perform what activities, which quality aspects should be considered in performing these activities and how should the actors feel when performing these activities. In short, workshops and other means produced the following four lists:

- **Do** (functional goals): e.g. communicate (be in touch); sustain wellbeing; call for help.
- **Be** (quality goals): e.g. easy-to-use; secure; scalable; quick response; helpful; proactive; accessible; reliable; mobile.

- **Feel** (emotional goals): e.g. helpful; purposeful; fun; engaging; positive; empowering; secure; feeling cared about; feeling independent; feeling assured; feeling in control.
- **Who** (stakeholder roles): e.g. older adults; caregivers including formal caregivers and informal caregivers; healthcare professionals including nurses and physicians.

To obtain a holistic overview of the solution to be designed, the four lists should be represented in a structured way as a single page diagram – goal model. Goal model can be considered as a container of four components (Figure 3): functional goals, quality goals, emotional goals and stakeholder roles [5, 6, 7]. The skeleton of a goal model is a hierarchy of functional goals drawn as a tree. The hierarchical structure is to show that the subcomponent is an aspect of the top-level component. The root of the tree sits at the top of the page and represents the overall goal of the system. An example of goal model for the wellbeing support system designed for older adults is shown in Figure 4. It reflects, the overall goal of the system is to support wellbeing, divided into "Being in touch" and "Calling for help". "Being in touch" has, in turn, been elaborated into "Communicating", "Confirming" and "Acknowledging". The roles, quality goals and emotional goals are placed at an appropriate level in the hierarchy, whereby each of them applies to the functional goal they are attached to and all the functional goals below that goal in the goal hierarchy.

Fig. 3. Notation for goal models

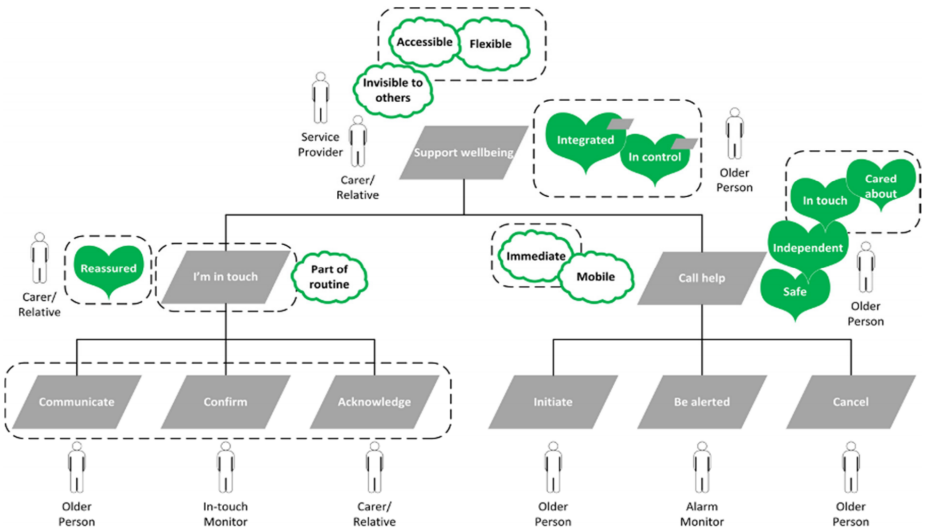


Fig. 4. The goal model of supporting wellbeing of an older adult [6].

3 Co-design and engineering of user requirements in Murcia Pilot

The Region of Murcia is one of the 17 autonomous communities of Spain. It is located in the southeast of the state, on the Mediterranean coast. It has more than 1.5M inhabitants, being the 7th most populated province in Spain. One third of the population lives in the capital and its surroundings with the 16% of it is 65 years old and above. The Murcia pilot aims to deploy a new line of virtual assistance that will transform the current model of health and care service based on the patients to notice when they need help. The pilot is focused on older patients with chronic heart failure (CHF). The new telecare model would allow patients to stay in their preferred environment and provide a more intense, effective, proactive and less intrusive care and observation service. Such novel model is based on:

- **Tele-assistance:** Integrating technologies like sensors, wearables, Internet of Things (IoT) or robotics.
- **Proactivity and Prevention:** Since the demographic change and the increased longevity are changing the profile of the user of the health and care services, moving from passive patient receiving treatments to active consumers of health and care that must participate in the process from the data perspective, not only in critical situations but also paying a lot of attention in prevention.
- **Users and their environment:** Because one of the main problems now is that care and health facilities are being used as care homes, being more expensive than keeping them at home as much as possible and only using institutional health facilities when intensive care is needed.

Murcia pilot defines two target scenarios for addressing two Pharaon challenges: PCH2 (Health status definition and its progress over time, focused on hearth failure) and PCH3 (Non-intrusive monitoring and alarm triggering, focused on energy consumption patterns). These scenarios are called Angel of Health and Care@Home. The definition of these scenarios includes goals, roles involved, Key Performance Indicators (KPI), quality goals, emotional goals, technologies involved and ethical concerns. Table 1 and 2 summarizes some of these features.

3.1 Planned methodology and contingency plan

The methodology for engineering user and pilot requirements in the Murcia pilot was planned is depicted in Figure 5. Three workshops were planned to be carried out during one month. The attendees of the workshops were 1-2 representatives of the target collectives: primary care doctor, cardiologist, internist, primary care/hospital nurse, Emergency (hospital & PC), pharmacy, rehabilitation, psychologist, social workers, patient, relative/caregiver, technology provider and/or representatives of health and care authorities.

Table 1. Target scenario in Murcia Pilot: Angel of Health

Angel of health: user's information gathering, response, alarm setting and management.
Goals: improve health and care services and follow up to patients with CHF; decrease older adult´s dependency; involve patients in the health and care process from the data perspective; help relieve health-care centres and their workers of workload pressure; improve health care prevention/reaction in emergency/alarm status.
Roles involved: patients, caretakers, health professionals (primary care doctors, cardiologists, primary care nurses), call emergency centre staff, platform and solution providers.
Quality goals and KPI: reduced number of visits of patients to health centres; reduced number of visits of health professionals to patients' homes; reduced health complications and the related number of hospitalizations; increased satisfaction of patients, caregivers and health professionals; reduced time response in emergency status (alarms); increased years of independent living; increased of the Social Return of Investment (SROI) ratio.
Emotional goals: independent; empowered; safe; healthy; proactive; reactive; satisfied.
Technologies: Onesait Healthcare Data Homecare (OHC)[2] platform as a communication tool, for tracking vital signs, for registering clinical information and setting alarms; other technologies, such as wearables, accelerometers, presence sensors, pill reminders, etc.

Table 2. Target scenario in Murcia Pilot: Care@Home

Care@Home
Goals: reduce the older adult's dependency; early detection of emergency situations.
Roles involved: older adults; relatives/informal caregivers; neighbors; emergency services staff (nurses and medical doctors).
Quality goals and KPI: reduction of response time in an emergency situation; reduction of severity of emergency situations. reduction of complications due to emergency situations and related hospitalizations.
Emotional goals: safety level perceived by older adults and relatives.
Technologies: MIW+ Platform[3] as a comprehensive platform that connects individuals with their total energy consumption data at their homes; uGRID[4], energy management software; OHC platform; other technologies, such as wearables, accelerometers, and presence sensors.

[2] https://onesaitplatform.atlassian.net/

[3] https://www.miwenergia.com/plataforma-miw/

[4] https://ugrid.miwenergia.com

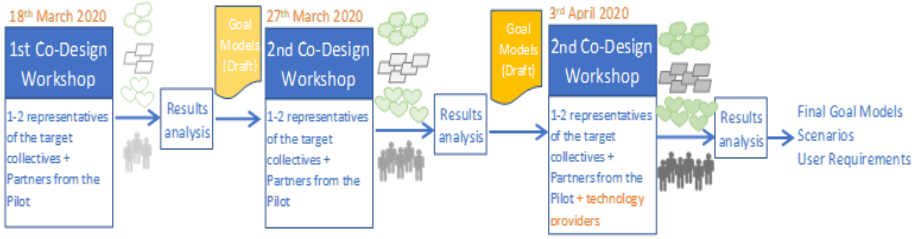


Fig. 5. The methodology planned for engineering user and pilot requirements in the Murcia pilot.

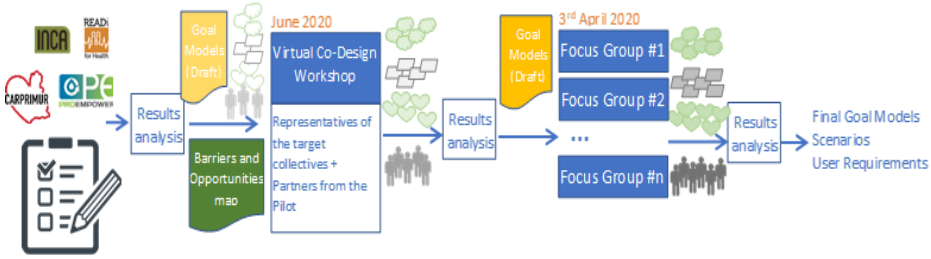


Fig. 6. The contingency methodology for engineering user and pilot requirements in the Murcia pilot.

Due to the constraints imposed by Covid-19, a contingency methodology was designed (see Figure 6), based on three main phases:

- *Desk work phase*. Desk research on co-design workshops, data and results obtained in previous initiatives carried out by the public healthcare in Murcia framed in similar contexts than Pharaon, like ProEmpower[5], ReadiForHealth[6], INC3CA[7] and CARPRIMUR[8]. The functional, quality and emotional goals identified during this desk research phase are presented in Figure 7. This initial phase provided a global overview of potential requirements of the stakeholders.
- *Requirement analysis phase*. The design, dissemination of a questionnaire for all the involved groups and analysis of results. The feedback received was used to further identify potential participants from the different target collectives and to complete the initial goals framework. It also helped to build a map of barriers and opportunities for the assistance of CHF in the whole region and appoint the most suitable repre-

[5] Procuring innovative ICT for patient empowerment and self-management for type 2 diabetes mellitus. Grant Agreement nº 727409. H2020 topic SC1-PM-12-2016 - PCP - eHealth innovation in empowering the patient. https://proempower-pcp.eu/

[6] Regional Digital Agendas for Healthcare. Grant Agreement nº 320021. Funded under the FP7 topic REGIONS-2012-2013-1 - Transnational cooperation between regional research-driven clusters.

[7] INclusive INtroduction of INtegrated CAre. Grant Agreement nº 621006. Funded under the topic CIP-ICT-PSP.2013.3.1b. www.in3ca.eu

[8] Institutional Project from the SMS aiming at transferring knowledge between cardiologists and primary health doctors for improving the attendance of patients with Chronic Heart Failure. https://carprimur.com/proyecto/

sentatives from each collective. 50 responses were gathered (56% were patients, relatives or caretakers and 44% health and care professionals). Two thirds of the respondents showed interest in participating in the working groups planned for the next phase. The main conclusions of the questionnaire were:

- All focus groups agreed on the need of providing access to a personalized online and user-friendly care plan that enhances patient self-management of the heart failure disease.
- A lack of heart failure knowledge on the part of patients and caregivers has been identified that can be compensated for by mixed training (face-to-face + online).
- The disparity in heart failure-related metrics and measurements opens the door to the development of a unified monitoring plan for the disease. Need to create face-to-face communities as a link among focus groups to empower and motivate patients and families.
- It is advisable to find new flexible communication channels that adapt to the needs of the focus groups, such as WhatsApp messages, emails, Skype or notifications from mobile apps.

Fig. 7. Quality (blue), Functional (pink) and Emotional (green) goals and goal models (purple) identified in the desk research stage.

- *Virtual co-design phase*. To arrange a virtual co-design workshop with the selected representatives of each collective, selected in the previous step, and pilot partners for the introduction of the work framework, and create different focus groups with representatives of each collective that, through several teleconference meetings, in order to define and discuss the goals and their models. The selected participants were grouped in 6 different collectives: patients, family and caregivers, hospital physicians (cardiologists and internists), primary care physicians, nurses, and mixed practitioners (one psychologist, two social workers, one pharmacist, one rehabilitation specialist physician, one physical therapist and a nurse). Approximately fifty people involved in the six focus groups attended a webinar, organized as a workshop where partners involved in the Murcia Pilot explained the objectives and methodology of the Pharaon project, provided details about the pilot to be carried out in the region and the framework for the focus groups.

3.2 Identification and design of goal models

The analysis of the results obtained from the abovementioned activities performed during the contingency methodology resulted in the identification of quality, functional and emotional goals. The main three goal models identified to be designed were: "Get involved in the health and care process", "Improve patient care" and "Detect emergency situations". The design of these goal models is represented in Figure 8, 9 and 10, respectively.

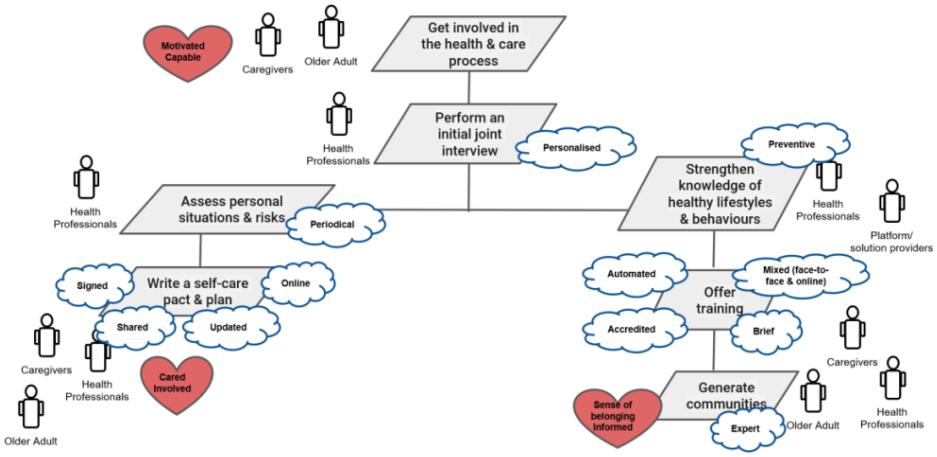


Fig. 8. Representation of the goal model "Get involved in the health and care process"

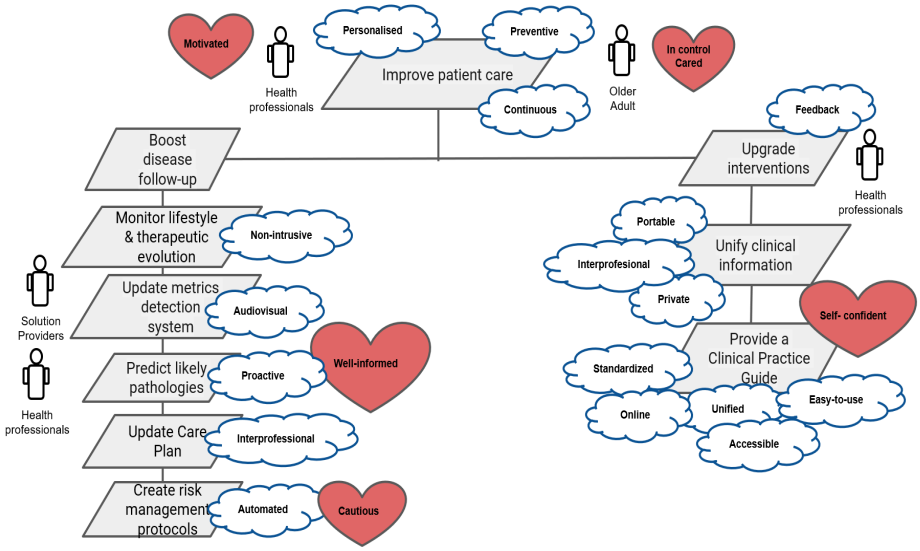


Fig. 9. Representation of the goal model "Improve patient care"

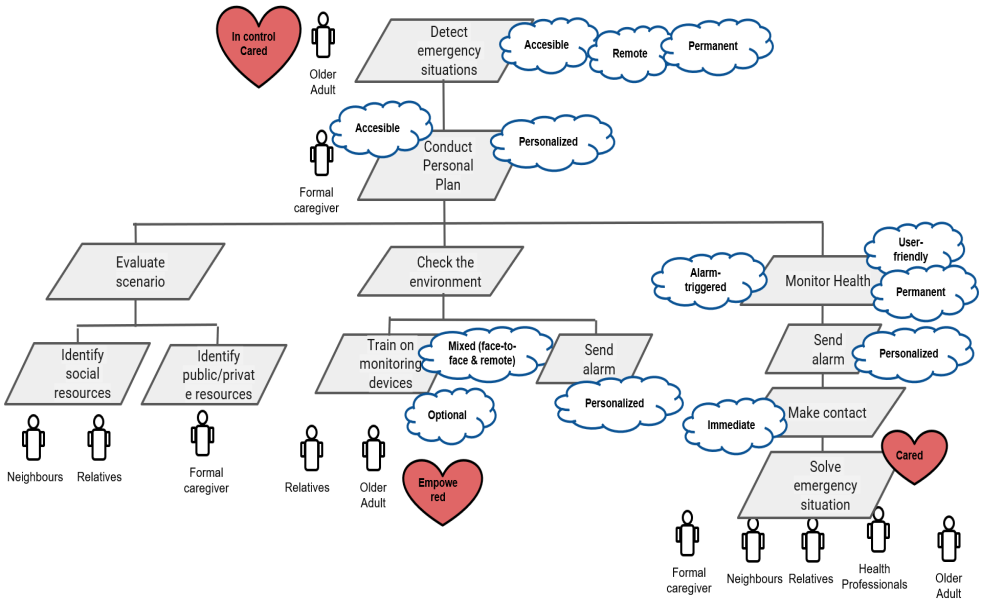


Fig. 10. Representation of the goal model "Detect emergency situations"

3.3 Use case scenarios

From the goals models and main scenarios described above, the methodology of use cases was used to identify, clarify and organize the system requirements in the Murcia Pilot. Seven use cases were defined:

- Get involved in the health & care process
- Asses personal situations and risks
- Strengthen Knowledge of Healthy Lifestyles & Behaviors
- Improve patient care
- Boost disease follow-up
- Upgrade interventions
- Detect emergency situations

The fields of the use cases descriptions have been designed to describe all requirements needed as input in the next Pilot deployment phase: to decide the technologies to be used in the use case scenarios, and how to use them as building blocks of the Pharaon ecosystem. Some of these technologies are already designed as building blocks, to be accessed by Application Programming Interfaces (API). Others need and extra software development for its integration as new building blocks. Then, the user requirements should be represented in even a more detailed manner as user stories.

Tables from 3 to 5 show a set of the use cases defined, as example of the work performed. Note that the field Potential technology enumerates those offered by the Technical and platform providers in the Pharaon consortium.

Table 3. Description/requirements of use case "Scenario for Strengthen Knowledge of Healthy Lifestyles & Behaviors"

Goal	Strengthen Knowledge of Healthy Lifestyles & Behaviors	
Initiator	Health Professionals and Platform/Solution Providers	
Trigger	Action by the Health Professional	
Description/Outline	Learning/ training process for older adults to increase their knowledge of his/her illness and have it under control.	
Expected Innovation	This scenario allows the patient to participate in the health and care process from the data perspective not only when intensive care is needed with the aim of paying attention in prevention.	
Condition	**Interleaved**	
Step	1	2
Activity	Training sessions and tools are made available to older adults and relatives	Generate specific communities for patients and caregivers with similar profiles and geographic proximity.
Roles involved	Health professionals, platform/solution providers	Caregivers, older adults, health professionals, platform/solution providers
Quality goals	Personalised, preventive, automated, accredited, mixed, brief	Personalised, preventive, automated, accredited, mixed, brief, expert
Emotional goals	Motivated, capable	Motivated, capable, sense of belonging, informed
Potential technology	OHC platform	OHC platform, Sentab TV platform[9]; IoTool[10] and IoChat[11]; eHealth Platform[12]

Table 4. Description/requirements of use case "Scenario for upgrade interventions"

Goal	Upgrade Interventions

[9] www.sentab.com
[10] www.iotool.io
[11] www.iochat.io
[12] http://www.rrd.nl/en/

Initiator	Health professionals	
Trigger	Action by the Health professional	
Description/ Outline	Upgrade interventions, unify clinical information, provide clinical practice guide.	
Expected Innovation	It will allow to unify clinical information of the same patient to ensure their safety, continuity of care and portability in other Spanish Autonomous Communities. This will also facilitate communication among professionals (alert to Primary Care after discharge, fast communication among professionals, shared spaces among professionals), as well as the systematic use of a single Clinical Practical Regional Guide for decisions on care of patients with CHF, applied in all areas of health and care level.	
Condition	**Sequence**	
Step	1	2
Activity	Unify Clinical Intervention	Provide a Clinical Practice Guide
Roles Involved	Health professionals, Older adults	
Quality Goals	Personalised, Preventive, Continuous, Portable, Interprofessional, Private	Personalised, Preventive, Continuous, Portable, Interprofessional, Private, Standardized, Unified, Online, Accessible, Easy-to-use
Emotional Goals	Motivated, In Control, Cared	
Potential Technology	OHC platform	

Table 5. Description/requirements of use case: “Scenario for detect emergency situations”

Goal	Detect Emergency Situations
Initiator	Older Adult/Caregiver
Trigger	Action by the Older Adult/Caregiver
Description/ Outline	To prevent emergency situations in older adults and improve their attendance in case they happen.
Expected innovation	It will demonstrate the feasibility of the energy domain to detect and predict emergency situations with the support of sensors and AAL devices

	and the definition of energy consumption patterns according to the user routines			
Condition	**Sequence**	**Interleaved**		
Step	1	2	3	4
Activity	A customized plan on the most relevant risks of the older adult is conducted	The scenario of each older adult is evaluated, considering those social, public and private resources available.	The living environment is checked and triggers alarms in case of possible emergencies (requires caregivers/older adults to have specific skills)	The older adult´s health is monitored according to his/her vital signs and emergency alarms are triggered if needed
Roles involved	Older adult, formal caregiver	Older adult, formal and informal caregivers, neighbors	Older adult, formal and informal caregivers, relatives, technology/ platform provider	Older adult, formal and informal caregivers, neighbors, health professionals
Quality goals	Accessible, remote, permanent, personalized			Accessible, remote, permanent, personalized, alarm-triggered, user-friendly, immediate
Emotional goals	In control, cared	In control, cared, empowered.		In control, cared
Potential technology	OHC platform; Asistae[13]; Amicare[14] [8]; MIW+; Aladin[15]; IoTool, IoChat; Sentab TV platform; eHealth Platform, eWall Platform[16]		IoTool; MIW+; Amicare; Asistae; RB-Base2[17]; Aladin; eWall Platform; SmartHabits [9]	Discovery[18] ; Sentab TV platform; MOX[19]; eHealth Platform; eWall Platform

[13] http://asistae.fama.es/

[14] http://www.cetem.es/en/projects/i/934/321/amicare-project-completed

[15] https://www.domalys.com/en/pro

[16] https://cordis.europa.eu/project/rcn/110560_it.html

[17] https://www.robotnik.eu/mobile-robots/rb-1-base/

[18] https://alfred.eu.

[19] www.accelerometry.eu

4 Conclusions

This work has introduced the co-design and user requirements engineering work carried out in the Pharaon Large Scale Pilot project, focused on the Pilot in the Murcia Region (Spain). The work has been conducted by a co-design phase, where the authors had to define the methodology for the co-design and representation of user requirements as goal models, use case scenarios, and user stories. The methodology entailed several up-to-date co-design methods for user requirements' elicitation. The result of this work will feed the next step in the Pilot deployment, deciding the technologies to be used in the use case scenarios, and how to use them as building blocks of the Pharaon ecosystem. In most cases, such building blocks already exist and can be accessed by the appropriate APIs. However, whenever needed, new building blocks or wrappers to the legacy building blocks will be developed. For such cases demanding development of new software, user requirements should be represented in even a more detailed manner as user stories. This contribution can serve as inspiration for similar approaches in the field of ICT for healthcare, AAL or smart environments, among others.

Acknowledgments

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