

# Other Advanced Research Initiatives in Elderly Care and Fragility Prevention



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**Abstract** Based on the lessons learnt from the co-design, development and integration processes, the research findings and the outputs from the engagement with a network of stakeholders over the course of the EU funded initiatives, this chapter will aim to help sketching the future policies and research funding programmes for ageing well in Europe. The chapter presents the visions and the perspectives of the running projects in the frame of the H2020 Personalized Medicine-15 call.

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## 1 Introduction<sup>1</sup>

The Active Healthy Ageing is one of the main focus of European research among the recent calls in the Horizon 2020 Framework Programme, in the frame of the pillar Societal Challenge and its dedicated topic “Health, demographic change and well-being”, a specific action was dedicated to Personalized Medicine for people as they age. The overall strategic orientation for the ‘Health, Demographic Change and Well-being’ Work Programme 2016–2017 is ‘promoting healthy ageing and personalised healthcare’. Some insights about this demographic situation, the context, needs and challenges to be tackled by coming research initiatives are offered also in the next paragraphs by the single contributions.

This call (namely Personalised coaching for well-being and care of people as they age, TOPIC ID: SC1-PM-15-2017) supported a panel of project implementing new solutions for a personalised “virtual coach”, for empowering and motivating people in need of guidance and care due to age related conditions, in cooperation with their carers where relevant, and to help them improve and maintain their independence, functional capacity, health status as well as preserving their physical, cognitive, mental and social well-being.

The solutions have to be firstly designed and implemented by considering usability and ease of user interaction as essential design elements of the “coach”. This aspect has been integrated by intelligent ICT environments, access to relevant physiological and behavioural data, new forms of accessible interaction based on tangible user interaction concepts, open platforms and emotional computing.

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**Table 1** The projects funded under the H2020 PM-15 call

Project title	Project acronym	Grant agreement no.
Coach Assistant via Projected and Tangible Interface	CAPTAIN	769830
Council of Coaches	COUCH	769553
Empathic, Expressive, Advanced Virtual Coach to Improve Independent Healthy-Life-Years of the Elderly	EMPATHIC	769872
HOLOgrams for personalised virtual coaching and motivation in an ageing population with BALANCE disorders	HOLOBALANCE	769574
Novel Empowering Solutions and Technologies for Older people to Retain Everyday life activities	NESTORE	769643
Supporting Active Ageing through Multimodal coaching	SAAM	769661
Virtual Coaching Activities for Rehabilitation in Elderly	vCare	769807
Wellbeing and Health Virtual Coach	WellCO	769765

The “virtual coach” should provide personalised advice, guidance and follow-up for key age-related issues in daily life which impact the person’s ability to remain active and independent, for example diet, physical activity, risk avoidance, preventive measures, lifestyle and activity management, leisure, social participation and overall wellness. The goal should be to preserve physical, cognitive, mental and social well-being for as long as possible and to facilitate interaction with carers (where relevant).

The call funded the following proposals that, at the time of writing this chapter, are carrying out pilot studies to validate their approaches and solutions (Table 1).

If NESTORE project has been extensively discussed along the book a short summary of each project is here provided.

CAPTAIN aims to develop and validate useful and easy to use ICT tools for empowering and motivating people in need of guidance and care. It proposes a technology designed to turn the home of an older adult into a ubiquitous assistant introducing home augmented reality using interactive and tangible interfaces. CAPTAIN proposes a “transparent” technology designed to turn the home of the older adult into a ubiquitous assistant specifically designed to compensate for their physical and memory impairments during their daily living. To do so, it leverages on a few state of the art technologies, as follows: “Projected augmented reality” to project, through use of micro-projectors, contextualised (directly on walls, floor, tables, etc.) information and instructions on top of the real environment. To achieve this, CAPTAIN fosters a user-centered co-design methodology which is based on constant involvement of older adults (the Captain Stakeholders’ Community) in the design, development and testing stages. Older adults will benefit from the creation

of effective contextualised assistance in their home environment forming a virtual coach who is stimulating and enhancing elderly capabilities. This coach will act as a constant, vigilant and pleasant companion, ubiquitously present, that provides contextualised advice to help preserving elderly mental and physical, cognitive and social well-being. The participatory design process adopted in Captain harnesses the expertise of all levels of the stakeholder ecosystem in order to deliver an effective tool for people in need of guidance and care due to age related conditions.

COUCH introduces a radically new virtual coaching concept based on multiple autonomous, embodied virtual coaches. Together, they are a personal council that fulfills the needs of older adults in an integrated way. Each Coach has his own expertise, personality, and style of coaching; they might not always agree with each other, but they all share a single goal: to support the elderly across every aspect of well-being, including physical, social, cognitive and mental support. The Council members listen to the user, inform the user, help the user to set personal goals and inspire the user to take control of her/his health. Novel spoken dialogue interaction technologies will be provided as embodied conversational agents that will join in conversations with the user. The platform will not be confined to a constrained number of Coaches—rather it will enable developers and innovators to introduce new Coaches that provide additional know-how and services. Hence, COUCH will enable a new virtual coaching ecosystem, bringing together healthcare services providers with innovators to implement novel ideas.

EMPATHIC is based on a conceptual and ethical framework focused on the people rights and responsibilities, which is based on principles established by the United Nations: (a) Dignity, including privacy, obtrusiveness and equal access; (b) Autonomy, which requires respect for self-determination of people, recognition of the heterogeneity of people and respect to their preferences; (c) Participation. According to these principles EMPATHIC has designed a virtual coach to engage the healthy-senior user to enhance wellbeing through awareness of personal physical status, by improving diet and nutritional habits, by developing more physical exercise and by social activity. The developed methodology and tools are provided in open-source access in the software engineering process of implementing socially-centred ICT products.

Seniors will benefit from EMPATHIC-VC toward physical and mental health improvements: independent seniors are less likely to be socially excluded, show reduced risk factors for depression thus maintain their sense of value and importance to the society to which they contribute. Distinct needs and preferences of females are taken into consideration when designing and developing the coach, thus assuring a higher impact in elder women due to their longer life expectancy.

HOLOBALANCE focuses on balance disorders due to age related progressive loss of functioning of sensory information and the inability to control body movements because currently there is a total lack of personalized coaching solutions for people

with balance disorders to participate in balance and gait physiotherapy and activity promotion.

The overall objective of HOLOBALANCE is to develop and validate a new personalized hologram coach platform for virtual coaching, motivation and empowerment of the ageing population with balance disorders through augmented reality games, along with easy-to-use sensors that can be customized to implement and coach the user with specific, individualized exercises, offering new forms of accessible user interaction. HOLOBALANCE will engage the experts related to the management of people suffering from balance disorders, towards developing a multi-stakeholder user centered coaching ecosystem.

SAAM is specifically addressing the needs of elderly above the age of 60 in economically under-developed regions with low technological proficiencies, who are most vulnerable in terms of access to support services, economic deprivation and social isolation. Eight assessment and coaching domains, four being part of the basic system (Activity, Mobility, Sleep and Social Activity) and four as advanced system (Cardio-vascular health, Cognitive decline, Nutrition, and Language based emotional state) were selected. The project's progress beyond the state of the art is exemplified by three core innovations: an unobtrusive and fully ambient data collection mode that does not require user interaction, the use of cheap common hardware for sensing and coaching so as to allow widespread adoption of the system, and the use of primary user's social circles as part of a multi-modal coaching system. The user-side of the SAAM system consists of a set of affordable off-the-shelf devices connected together with the edge gateway that further connects them to the cloud-based part of the SAAM system. These devices include stationary components such as smart power meter, UWB localization sensors and an integrated ambient sensor that enable completely unobtrusive user activity monitoring. Activity monitoring can be further enhanced with optional wearable sensors or smartphones. Based on the sensing data the cloud-based part of the system performs coaching in four main domains of the user's life: mobility (ability to move), daily activity, sleep quality and social activity. The main innovation of the system is that the coaching actions are not rendered only directly to the user, but primarily through his or her social circle, thus positively affecting social interactions.

vCARE develops and investigates a Virtual Coaching solution encapsulating a set of coaching services for empowering and motivating people, helping them to proceed with a personalized rehabilitation by means of a virtual avatar. For this, vCare monitors the patients' daily activities, conditions, and habits to provide personalised feedback to recover the Quality of Life thanks to coaching programmes initialised by specialists in a well-elaborated clinical pathway as a tailored rehabilitation plan. According to this plan, vCare enables the personalization of the intensity and way of interaction and will trigger suitable exercises (serious games, cognitive training programs, etc.), suggestions and feedback driven by smart-home sensors (replacing the eyes of a human caregiver) or sensors for vital data, the avatar itself (replacing the

caregiver's face and interaction possibility) or the machine learning and reasoning (replacing the human's assessment abilities) but also based on patient preferences. The project mission is to utilize the virtual coach in terms of the virtual avatar as communication mean for the patient.

WellCo provides a virtual coach supporting people to adopt healthier behaviour choices in physical activity, nutrition, mental status or social wellbeing. The solution proposed leverages data from sensors worn by the users, validated questionnaires and other information about users' daily life, preferences and context to provide recommendations that ensure the adoption of healthier behaviour choices by users. According to the behaviour change wheel model, the personalization of recommendations assesses the capability and opportunity of the user to perform the change and determines the best way to provide it in order to motivate the user in its follow-up through the WellCo Senior App. Other two applications will be available for WellCo: Informal Caregiver App, and the Expert Web App. WellCo incorporates a deep learning classifier aimed at catching the facial features indicating the emotion of the user. Through the affective module, the virtual coach is able to generate the most suitable dialogue and expressions in order to set emotional connection with the user. Then, the WellCo: Behaviour Change Recommender merges this data with those coming from sensors, Life Plan and validated questionnaires into four recommenders: wellbeing recommender (provides recommendations based on users' status and wellbeing expectations), emotion (recommendations to change the mood of the user), social (recommendations to foster social interaction) and general recommender (tips for wellbeing) that are automatically adapted to users' preferences. Personalization enables to provide recommendations adapted to the capabilities and opportunities of the user, favouring the motivation and adoption of them by the user.

In the following paragraphs, the visions and the experiences of these projects funded under the same call are shared and integrated so to contribute in building a common vision in this framework. All projects were stimulated in a wide reflection about challenges and opportunities by answering to the following questions:

- What are the challenges on Aging and Healthcare for Europe in 2030?
- What is the Vision of your project about Aging and Healthcare to tackle these challenges and transform them into opportunities?
- What are the main concepts of the project, the methodology, the developed tools, the outcomes?
- What is the expected impact of your project?
- Please describe the exploitation models and/or channels and/or opportunities.

## 2 Technology for Aging in Place: The CAPTAIN Solution as an Answer to Existing Challenges<sup>2</sup>

### 2.1 Challenges on Technology Supported Active and Healthy Ageing in Place

Technological advancements have provided the answers to most of the humanity challenges over the last years, including the support of older people to stay healthy, independent and active, able to remain at their home environment for as long as possible [1–3]. Although the benefits are nowadays well documented [4, 5], researchers and inventors are still struggling to create technologies that are easily adopted by older people with poor results in adherence and user experience [6]. Cho [7] argues that improved perceived ease of use becomes even more important for older adults, as they may have lower levels of digital competences and commonly they find difficulties in maneuver the navigation structure of apps and other software [8]. However, older adults are shown to be willing and interested to use new methods to manage their health and also value their privacy and control over their data [9, 10]. The issue is even more noticeable when technology usage requires more time and effort to solve a problem than before. Technology still fails to become a daily, trusted companion that supports ongoing activities, avoiding stealing time and being inappropriately intrusive. It becomes apparent that the challenge we have to overcome is to create technology that serves older people respecting their needs and habits and not the other way around, which is to convince them to adopt technology.

### 2.2 The CAPTAIN Vision and Solution

CAPTAIN's [11] vision is to bring improved well-being, safe and flexible independent life into the own homes of people in need. To achieve this, it tries to turn the homes of older adults into a gentle coach within an empowering space, providing intuitive interaction, guidance and help for independent living, whenever and wherever it is needed, leading to physical, cognitive, mental and social well-being.

CAPTAIN, aiming to win user's trust and avoid consuming too much of the user's time, is built on top of two main pillars:

- Spontaneous and organic interaction, eliminating the common interaction patterns where the user either has to launch a smartphone application or tap on a notification on her/his smartphone,

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<sup>2</sup>This paragraph has been authored by Evdokimos Konstantinidis, Despoina Petsani, Panagiotis Bamidis, Maria Nikolaidou, Michalis Timoleon, Nikos Athanasopoulos, Andoni Beristain, Roberto Álvarez Sánchez, Giuseppe Conti, Francesco Verrini, Valentina Conotter, Kiko Núñez, Unai Diaz-Orueta, Louise Hopper, Joanne Carroll, Maxim Kostin, Rosa Almeida, Raquel Losada, Wolfgang Kniejski, Angela Ivanova, Francesco Tessarolo from CAPTAIN project.

- The “right” moment and the “right” time of interaction, based on information from the user’s behavior and movement inside the house

To do so, CAPTAIN delivers “transparent”, state-of-the-art technology such as real-time 3D sensing technologies, speech analysis, non-invasive physiological and emotional data analysis, and intelligent comprehension of user’s behaviour and actions for the creation of an environment, which allows the coaching of adults towards leading a healthy and fulfilling lifestyle. CAPTAIN UI blends content with the environment by using micro-projectors, a camera for recognizing and monitoring the user as well as a microphone for voice interaction. In order to empower the users, the system is based on the I-Change model [12] that guides users to: (1) set goals, (2) achieve their goals, (3) get feedback for the process. This functionality is based on the creation of SMART goals from experts in the domain of health and wellbeing [13]. Following a plugin based architecture, any specialized organization can create an additional SMART goal that could be delivered by the system. The plugin describes the SMART goal that it is achieved and the schedule of interventions a user has to perform to achieve the goal.

CAPTAIN aims to address a broad range of older users and tries to achieve behavior change with brief interventions throughout the day. The technology blends in their home environment leaving it untouched when it is not needed.

### ***2.3 Design and Development Methodology***

To avoid the commonly made mistake of mismatch between the user needs and preferences and the ways that they are tackled by products [10, 14], CAPTAIN deployed an innovative, user-centered methodology. The design of the system was done following the Design Thinking, Lean Startup and Agile process [15]. During the first Design Thinking session, end-users were asked to consider the most important parts in which they need support in their everyday lives. The discussion was done based on personas representing the end-users to assist participants empathize and start talking about their experiences without revealing personal information [16]. 53 older adults and 38 informal and formal caregivers participated in the session across 5 European countries (Greece, Italy, Spain, Ireland and Cyprus). After the analysis of the qualitative data collected, the team noticed a strong will of the participants to be motivated and change their attitude towards a healthier life rather than strictly guide or patronize them. That validated the initial hypothesis that the system should be a coach rather than an assistant. Furthermore, CAPTAIN employed User interaction through voice and gestures as they are considered a more “natural” way of interacting with a system and requested by most of the participants in the Design thinking session.

During the Lean Startup and Agile process, three Minimum Viable Products (MVPs) were created. The initial MVP was a power point presentation using an ordinary projector. The presentation was controlled by a facilitator in order to create the perception that the system is interacting with the user. This prototype was tested by

75 older adults and 44 informal and formal caregivers. The most important feedback was about the simplicity of the UI appearance and the interaction flows. The second MVP was a computer-based application that detected the user and initiated a simple interaction flow of presenting some information after it gets some confirmation from the user. The goal was to receive feedback about the voice and gesture interaction and the automate generation of content using projections. The basic outcome was about when the system is initiated as the users would like to have some control on that and the approval of gesture and movement-based interaction.

The third CAPTAIN MVP is based on a new hardware device and an initial casing design. Furthermore, the device was tested in a real house by an end-user in order to investigate any problems with the size, the cables and the projection brightness and quality. The device was tested by an older adult with the presence of a facilitator. An informal discussion followed in order to get the appropriate feedback. Currently, CAPTAIN is in the stage of installation in real homes in order to assess the user acceptance and usability.

## ***2.4 Envisaged Impact***

The envisaged impact of CAPTAIN project is summarized in the following pillars:

- Serve the needs of older adults in an unobtrusive, non-invasive way in order to achieve improved quality of life and empowerment of setting goals;
- Improve effectiveness of the care processes through more effective coaching processes involving older adults in care homes or home scenarios;
- Enhance home care prevention, in order to delay cognitive and physical impairment of older adults; and
- Support more independent living and improve quality of life and dignity of cognitively impaired aging users by helping them be more independent and for longer time.

## ***2.5 Towards Business Exploitation of CAPTAIN***

This coaching technology is essential for significant commercial use based on different use cases, related business schemes and scenarios. CAPTAIN consortium strongly believes in the impact of CAPTAIN in the community and the establishment of a CAPTAIN spin-off company is a milestone for the project. This spin-off will allow heavily building upon CAPTAIN success stories and leveraging the business models implemented in the project pilots as use cases into international markets. It will also maintain the CAPTAIN vision and commercialize the CAPTAIN project results.

### 3 Council of Coaches promotes elderly health<sup>3</sup>

#### 3.1 *Engagement with Supporting Technologies Is the Challenge for Healthy Ageing e-Coaches*

From the perspective of Council of Coaches, we see many great technology solutions being developed to tackle the problem of aging and healthcare. However, we fear that too many people that are not used to or not interested in using these technologies will not be able to benefit from the support that is available through such technologies. There are many important societal and healthcare challenges to be tackled as mentioned by our fellow projects: independent living, loneliness, risk of falling, and safe home environments to name a few. But the main challenge for us is how to make the many technological solutions to these problems inclusive for older adults. How do we keep older adults, but also younger audiences (when it comes to preventative services) engaged with the technologies, so they can benefit from the smart coaching and support they provide?

#### 3.2 *A Vision of Collaborative Coaches*

Council of Coaches aims to tackle the challenge of how to keep older adults engaged with a coaching solution that focuses on the broader domain of health and wellbeing in various domains. We introduce a radically new concept of virtual coaching, called the “Council of Coaches”. The council consists of a number of virtual characters—each specialized in their own domain—that interact with each other and with the user to inform, motivate and discuss about health and well-being related issues (e.g., physical, cognitive, mental and social well-being). The individual coaches will listen to the user, ask questions, inform users, discuss between themselves, jointly set personal goals and inspire the user to take control of his health. Any combination of specialized council members collaboratively covers a wide spectrum of lifestyle interventions, with a substantial likelihood of positive impact on outcomes related to chronic disease or prevention. By introducing the concept of a group of virtual coaches, many opportunities arise for creating fun and engaging interactions around the topic of the user’s health. Users that are not immediately willing to engage with the application (the coaches) can sit back and listen to the virtual coaches as they discuss between themselves what lifestyle advice would work for them [17].

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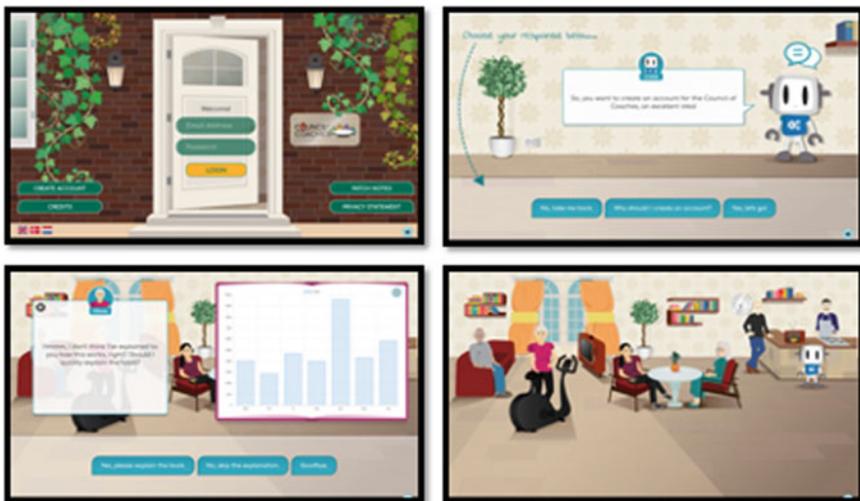
<sup>3</sup>This paragraph has been authored by Harm op den Akker on behalf of COUCH consortium.

### 3.3 The COUCH Web Application Design

In Council of Coaches, a total of four iterations of technical- and functional demonstrators have been developed, based on user input, and evaluated with end-users. Early in the project, a vision on Responsible Research and Innovation (RRI) was established in how the Council of Coaches project handles ethical issues and how to develop a coaching application within ethical, legal and societal boundaries. The main outcomes of the project are its two core demonstrators—one “Functional Demonstrator”, that served to demonstrate the proof of concept of the Council of Coaches concept, and a second “Technical Demonstrator” that served to push the boundaries of state-of-the-art embodied conversational agent systems.

The Functional Demonstrator (Fig. 1) is a stable, highly scalable web application. This application underwent several design cycles, in which the focus was on aesthetics, user interface, content and robustness (speed and reliability). The end-result is an easy-to-use application that runs on any device with a web-browser, in which the core ideas of a Council of virtual coaches were demonstrated with 92 end-users for a period of 5-9 weeks.

The second main outcome is the project’s “Technical Demonstrator”, a software platform in which various state of the art components are integrated, allowing content creators to develop their own applications that employ multiple embodied conversational agents. Various end-user studies have been performed using the technical demonstrator, gathering evidence on e.g. user-interaction paradigms, and fundamental questions of vicarious persuasion. Released as a fully open-source platform



**Fig. 1** Screenshots of the Council of Coaches “Functional Demonstrator”, used to demonstrate the core concept of having multiple virtual coaches for lifestyle support

under the name “Agents United”, the platform is fully available to the public on GitHub.<sup>4</sup>

### ***3.4 The Envisaged Impact of COUCH Solution***

From the onset, we believed strongly that the simple idea of putting multiple virtual coaches in the room would create great opportunities for engaging users, not only in the healthcare domain, but in any situation that calls for a fun, and personalized way of providing information to users (e.g., eLearning). Primarily, the project has demonstrated, through a series of studies, that the core concepts indeed work. For example, does vicarious persuasion indeed work better than direct persuasion? A study by Kantharaju et al. [18] suggests that it does. As the project’s results are finding its way in scientific journals and proceedings, we hope to have set a solid foundation for further research in this topic.

The desire to spin off future research in this area, and to entice people to start exploring opportunities using multiple embodied conversational agents to promote health, or for any other application domain has always been the main driver for the project. As such, there has been a great focus on developing open-source tools and to create communities of developers and innovators around those tools. The Agents United platform mentioned earlier is an example of an open-source platform that resulted from the Council of Coaches project, which allows developers to create state-of-the-art 3D embodied conversational agent systems that include high levels of automation in terms of verbal and non-verbal behaviours. But for those professionals and companies that need a lower barrier for entry in the virtual coaching domain, the project has also released the WOOL Platform: a fully open-source platform that is designed to allow domain experts with little technical skills to author engaging, personalized dialogue. The platform, released under the MIT license, provides the tools and software libraries to easily embed those dialogues into web- or mobile applications.<sup>5</sup>

### ***3.5 Exploitation Strategies for COUCH***

Council of Coaches identified two distinct exploitable outcomes that are currently being pursued. The first is the “Council of Coaches as a Product”, and it is tied directly to the functional demonstrator that is depicted in Fig. 1. The demonstrator is a highly scalable, robust solution that contains many hours of coaching content on various domains. This demonstrator forms the basis for efforts to develop digital

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<sup>4</sup>For more information see: [www.agents-united.org](http://www.agents-united.org).

<sup>5</sup>For more information see: [www.woolplatform.eu](http://www.woolplatform.eu).

therapeutics services between two of the consortium's SMEs (Roessingh Research and Development, and Innovation Sprint).

The second exploitation pathway has been touched upon before, and relates to the two open-source platforms that were released as outcomes of the project: The Agents United platform and the WOOL Platform. By providing these platforms to the community, the project's partners hope to create traction and be in the forefront of innovation on virtual coaching in the exciting years to come.

## **4 The Empathic Promotion of a Satisfying and Independent Lifestyle<sup>6</sup>**

### ***4.1 Social Challenges and Innovation Opportunities to Support Elderly Independency and Wellbeing***

Population ageing is one of the social challenges of the 21st century that directly concerns Europe as well as other developed communities. The decline of the fertility rates along with the increase in life duration result in a fast raise of the percentage of the population above 65. In Europe, this percentage is expected to grow from 16% in 2010 to 29% in 2060 [19]. Moreover, this population segment expected to be predominantly female and includes a growing number of elder persons above 80. In this context, social challenges to be addressed are, among others:

- A high demand of infrastructures and services targeting the elderly needs and wishes. In particular, the extended preference of ageing at home has to be fulfilled while taking into consideration specific cultural facts as well as the diversity of societies.
- A cross-cutting approach covering different sectors such as health, housing, low-income persons and adequate living conditions in cities and rural areas.
- Support healthy older people to remain productive and have an independent life in their community as long as possible. To this end, a wide range products and services need to be conceived to assist a certain standard of living and wellbeing as people age. Furthermore, technology is in the core of most of nowadays innovative products and services.

Currently there is a huge demand for autonomous systems able to assist people on several needs in their aging. Provisions of support have been made either through the monitoring and detection of changes in the physical, and/or cognitive, and/or social daily functional activities, as well as in offering therapeutic interventions [20]. These

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<sup>6</sup>This paragraph has been authored by M. Inés Torres, J. Tenorio, G. Cordasco, E. González-Fraile, A. Esposito, M. S. Kornes, G. Chollet, B. Fernández-Ruinova.

systems have targeted vulnerable elder people who face complex and stressed interactional exchanges. In this context, strong emotional behaviors arouse, having as consequences discomforts, loss of control, anxiety, stress, depression, misplaced conducts. These behaviors are furtherly affected by several factors including personality, individual traits, social and cultural information [21–23]. Having an EMPATHIC coach for facing such daily facets would be desired. To do so there is a need to develop “experimental and theoretical models of behaviors for implementing computational paradigms that should produce ICT interfaces equipped with a human level of automaton intelligence” [22, p. 48]. Their design has to take into account the user involvement and interests. Users must judge the developed technology acceptable and useful in their context of use. Text, voices, or nonverbal communication must be appropriately exploited to generate feedback messages but also capture user’s acceptance and trustworthiness.

## ***4.2 Vision of the EMPATHIC Project***

As a consequence of the previous context, there is a need to follow a novel user centered approach focused on making the interaction personalized to the prospective users, accounting of their age, gender, culture, preferences, personality, role, occupation, and responses to the system’s strategies. The interactions and feedback messages must be tailored to the knowledge the system has about that specific user at that specific interactional instant, with system’s reactions attuned by the knowledge gained during previous interactional turns, and the whole history of users-device interactions.

The EMPATHIC Research and Innovation project researches, innovates and validates new paradigms, laying the foundation for future generations of Personalised Virtual Coaches to help elderly people to live independently. The wellness coaching advice promotes healthy habits and behaviors, by challenging each user to transform their personal goals and needs into actions. The EMPATHIC Virtual Coach engages the healthy-senior user to take care of potential chronic diseases, maintain a healthy diet, have adequate physical activity as well as encourage social engagement, thus contributing to the older adults’ ability to maintain a satisfying and independent lifestyle. The EMPATHIC Agent motivates the user through a friendly virtual coach to reach pre-set benefits, whose achievement are measured through project-defined metrics. Our ambition was to create a personal, friendly and familiar environment for the users, avoiding the threatening effects of unfamiliar new gadgets or an excessive focus on medical supervision. The project looks beyond the basic medical and physical needs of a person, to the link between body and emotional well-being. The EMPATHIC Agent is designed to be capable of perceiving the emotional and social state of a person, in the learned context of the senior users’ expectations and requirements, and their personal history, and responds adaptively to his/her needs.

### **4.3 Main Concepts and Outcomes of EMPATHIC Project**

The EMPATHIC project implements the concept of coaching through a virtual conversation agent. Nevertheless, the aspiration is not to conceive and put into practice a coach who provides personalized nutritional advice or recommendations for physical and social activities adapted to the particular conditions of the user. In contrast, the project proposes coaching strategies aimed to get behavioral changes on the user. Coaching dialogs are logical structures based on question-answer model with the objective to understand needs, restrictions and goals of the user [24, 25]. The goals need to be accepted by the user. Therefore, coaching dialogs will promote the user's self-awareness and guide the user through realistic and healthy goals. Each dialog follows a sequential structure based on the GROW (Goal, Reality, Options and will of action plan) which was proposed by professionals of health coaching.

In this framework, EMPATHIC project (a) Provides automatic personalised advice guidance (through the coach) having a direct impact in empowering elder users into a wide of advanced ICT keeping improving their quality of life and level their independent independency living status of the people as the age [26]; (b) Identifies non-intrusive technologies to detect the individual's emotional and health status of the person through non-intrusive technologies [27]; (c) Implements health-coach goals and actions through an intelligent computational system, intelligent coach and spoken dialogue system [28] adapted to users' intentions [29], emotions and context (d) Provide the virtual coach with a natural, empathic, personalised and expressive communication model [24, 29, 30].

In addition the main technological goals carried out are: (a) the development of a simulated virtual coach allowing to develop coaching conversations between professionals and end-users, which enables the project to acquire a corpus of dialogues as well as engage the end-users on the design decisions as well as evaluate the progress (b) the integration a proof-of-concept of the technology running on different devices and (c) the validation through field trials performed in three different countries (Spain, Norway and France) with three distinct languages and cultures (plus English for research and development) of the proposed methods, approaches and solutions.

### **4.4 Expected Impact of EMPATHIC Project**

Nowadays, at the beginning of the 21st century, most elderly people may experience barriers to access to some philological or coaching-based interventions. Those barriers are related to mobility, accessibility, economical or even lack of awareness. Those type of interventions may be especially relevant for those suffering a decrease of their well-being (e.g. suffering social isolation, sadness, depression or anxiety).

The use of information and communication technologies (ICTs) is becoming a cost-effective way to overcome those barriers mentioned above. Moreover, ICTs enable in an accessible and scalable way the promotion of health, prevention, active

aging and even early diagnose. Thus, ICT based therapies can reach thousands or millions of people simultaneously.

Speaking about ICT based therapies and important concept raises. Low intensity interventions refer to brief therapies, group treatments, self-help approaches, such as bibliotherapy and computerized treatments. Low intensity interventions represent a new paradigm in evidence-based practice and the delivery of health and well-being services to promote healthy habits and to increase access (availability, utilization and equity) to them. In that sense, EMPATHIC project, is a clear example of low intensity intervention promising and providing impact as described below:

- New model of psychological/health care that limits specialist time or used this time in a highly cost-effective manner.
- The development of new services which can be more efficient as well as effective.
- Key element in a stepped and collaborative care model. The low intensity intervention represents an initial step before referring to a human professional.
- New ways of working and new workforces that provide more rapid and flexible access to early intervention and preventive programs. People can access to short weekly sessions of about 10–20 min, depending on persons time availability.
- New ways of training new and skills.
- New ways of assessment, monitoring and evaluation of variables and key elements related with well-being and health.
- New ways of increase adherence and engagement to e-coach through more attractive, relevant and interesting.
- New communication tool with our target population to deliver coaching.
- New ways to disseminate services in a massive scale to sparse populations located in remote communities, e.g. providing recommendations based on personal desires, needs or interest.
- Intervening in a way that the patients' choices are respected (anonymity, time slots....)
- Tailored intervention with best matching between program contents and idiosyncratic patient's needs.

In conclusion, low intensity can be a great solution to a stepped support service model where the intensity of the coaching can be adjusted depending on the situation. The elderly population is highly heterogeneous, and they may need from different types of solutions, e.g. professional support, activities recommendations, awareness of the local offer etc.

#### ***4.5 Exploitation of the Results and Concluding Remarks***

We are living in a longevity revolution. The numbers are clear, the 20% of the population in western countries is over 65 years and this percentage is growing. However, the old age does not depend on the age but with the dependency. Even though, senior population is highly heterogeneous, there is a main profile of active person, consumer and committed with the community. We are speaking about retired

people with a lot of active years to enjoy. People that expect quality of life, contribute to the community and postpone the old age.

Considering this reality, there is a need to accommodate current products and services to this new demography [31]. In other words, adapt the current market to the senior qualities (not necessarily create new offer). Therefore, there are a lot of efforts, from different entities, to centralize and “silverize” the current offer. Regarding active aging, especially relevant the offer related to culture, leisure, physical activity and healthy nutrition. This offer can be (and will be soon) centralized and adapted through different platforms age friendly. Most probably, through public-private collaborations. Those initiatives will open new spaces for virtual advisors and coaches.

This type of solutions is a very suitable environment to integrate and exploit a virtual coach such EMPATHIC. We are speaking about a virtual coach capable to understand (in an automatized way) the needs of each user (as a unique individual). In that sense, EMPATHIC is trained to understand needs related 4 main areas: Leisure and culture, social relations, physical activity and nutrition. Those areas are key for a suitable active aging. Moreover, EMPATHIC is engaging and motivating the users to take actions.

Therefore, connecting EMPATHIC with the local offer, especially the silver offer, provides a huge potential for both public and private entities. First, it can provide a real sensor of the senior needs and desires from a specific area. Second, connects the local offer with the seniors’ interests. The local offer can be public or private, but the strengths rely on the personal suggestions linked with the local offer. Imagine somebody that feels a bit blue and through EMPATHIC ends up buying a ticket for the local theatre.

On that scenario, the exploitation model relies on both the public and the private sector. The public contribution would help the implementation and an initial maintenance. The expected source would be local entities which aim to both provide response to the demographic challenge and stimulate the local economy. After the implementation and the market penetration, the maintenance would come from the private offer, as a percentage of the sales coming from an EMPATHIC recommendation.

## **5 The Solutions of HOLOBALANCE to Manage Equilibrium Disorders<sup>7</sup>**

### ***5.1 Challenges in Active and Healthy Ageing***

One of the challenges the older Europeans face is falls. Function and flexibility deteriorate as people age and along with dizziness which can be caused from several

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<sup>7</sup>This paragraph has been authored by Dimitrios Gatsios and Dimitrios I. Fotiadis on behalf of the HOLOBALANCE consortium.

inner-ear, vestibular nerve and central nervous system diseases, lead to balance disorders and, sooner or later, to falls. Hospitalizations due to fractures caused by falls and the resulting limited functionality when elders return at home are associated with high healthcare costs and caregiving burden that affect the society more widely.

Current guidelines lack information on specific balance components to be included in falls interventions and more specific evidence-based guidelines are required. Current falls interventions provide some benefit, but due to lack of training, insufficient number of clinicians and cost many older adults receive no or sub-optimal falls interventions.

## ***5.2 The HOLOBALANCE Vision in Ageing and Healthcare***

HOLOBALANCE aims to become a state-of-the-art system providing an evidence-based, gradually progressive, multifactorial, individualized falls intervention, through cutting-edge technology and improving clinical practice. HOLOBALANCE essentially aims to provide balance rehabilitation at patients' home, remotely supervised by expert physiotherapists.

## ***5.3 The Proposed Solution for AHA by HOLOBALANCE***

For people without dizziness problems, exercises such as bending over and head movements, aiming to stimulate and retrain the vestibular system and eventually stabilize gaze, improve gait etc. Personalized balance rehabilitation programs are considered more effective than non-specific exercises in improving symptoms.

The long-term maintenance of the effects of the developed home-based program, requires the lasting adoption of a healthier and more active lifestyle from community-dwelling older adults. To promote such behavioral change HOLOBALANCE has adopted the COM-B ('capability', 'opportunity', 'motivation' and 'behaviour') model and the whole interaction with the older adults is designed accordingly.

HOLOBALANCE includes three types of coaching:

1. Balance rehabilitation exercises provided by the holographic coach which interacts with the patients or in the form of Augmented reality exergames, and Internet of Things devices that capture and evaluate the performance of the exercises and enable the interactions. Two holographic interfaces have been developed: a projector-based which requires a  $2 \times 2 \times 2$  box and a head mounted device equipped with a smartphone.
2. Cognitive Training provided with Augmented Reality Games designed and developed to stimulate cognitive skills (attention, memory, psychomotor abilities). Cognitive training is combined with auditory tasks that aim to improve speech in noise perception and auditory memory.

3. Multilevel motivation and physical activity promotion with a dedicated mobile app enabling activity planning and monitoring with an activity tracker, as well as offering networking and competition functionalities.

#### ***5.4 The Expected Impact for HOLOBALANCE Project***

In the short term, HOLOBALANCE will provide a platform facilitating multi-directional sharing of information between HOLOBALANCE actors and stakeholders. In the mid-term, HOLOBALANCE will transform healthcare for patients at risk of falling by: providing individualized input with a strong motivational component to improve adherence and services accessible to a wider population; requiring low-level expertise to administer the intervention; supporting self-management and promoting sustainable behavior change; reducing reliance on the health care system. In the long term, HOLOBALANCE will create value for: service providers by pinpointing intervention strategies and enhancing outcomes; the scientific community with the evidence produced; policy makers by determining health service provision priorities.

#### ***5.5 The Proposed Exploitation Model for HOLOBALANCE Solutions***

HOLOBALANCE can be exploited as a Service offered by balance physiotherapists with the support of a company constituted by the members of the consortium involved in the design and development of the platform. The supervised training can be implemented in the healthcare facility with the projector-based box or at patients' home with the head mounted device. Currently both are being pilot tested and evaluated in a proof-of-concept study aiming to recruit up to 80 patients in the HOLOBALANCE intervention and 80 controls.

### **6 The Multimodal Coaching of SAAM Project<sup>8</sup>**

#### ***6.1 What Are the Challenges on Aging and Healthcare for Europe in 2030?***

Europe faces an on-going crisis in caring for its ageing population. The ageing process creates many daily difficulties increasing over time: financial, social, and physical insecurity, loneliness, medical problems, management issues, and many

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<sup>8</sup>This paragraph has been authored by Vera Veleva, Martin Žnidaršič, Bernard Ženko, Aljaž Osojnik and Richard Wheeler on behalf of SAAM Consortium.

others. Social care and assisted living services struggle as the population ages, and older citizens are under increasing pressure to live at home, often alone, for as long as possible. This is further complicated by the increased mobility of younger generations that contributes to increasing levels of isolation. On the other hand, access to health and social services for the elderly is often limited in lower-income countries or in resource-poor settings around the world. Thus, there is a clear need for formulating more sustainable models for health and care delivery, especially considering the ageing population.

### ***6.2 What Is the Vision of Your Project About Aging and Healthcare to Tackle These Challenges and Transform Them into Opportunities?***

SAAM is focused on a single goal: *providing new methods supporting Europe's ageing population to remain active and live independently for as long as possible*. SAAM does this by employing a holistic approach, contributing to physical, mental and social well-being, in particular by focusing on continuing participation in social, economic, cultural, spiritual and civic affairs, and not just the ability to be physically active or to participate in the labour force.

SAAM is flexible enough to provide assistance to most seniors but focuses on one of the most under-served segments of the population—those above the age of 60 in economically under-developed regions with very low technological proficiencies. These are also more likely to live in an area with poorly developed social housing and support services, and more likely to suffer from economic deprivation and social isolation later in life.

To tackle these challenges, we need to have in mind that ageing takes place within the context of friends, neighbours, family members, community, and support and care services. We see these as important supporting and enabling elements of active ageing, and SAAM system is designed to provide feedback to and involve these social circles of ageing users, and to support them in helping the elderly to live independently.

### ***6.3 What Are the Main Concepts of the Project, the Methodology, the Developed Tools, the Outcomes?***

The core concept of SAAM is based on a seamless and highly autonomous modular active ageing coaching system that supports seniors to continue living independently and increase their overall well-being. SAAM uses technology-enabled approaches with a novel and practical emphasis on ambient sensing and learning user needs and preferences, and effective coaching by leveraging the user's social support networks.

User-centred design is a priority for SAAM, and it is grounded on experience of four care organisations acting as project partners. Technical development is supported by two extensive user surveys conducted during the project—one at the beginning of the project, eliciting user needs and requirements, and one towards the end of the project involving pilot testing with end users from Austria, Slovenia and Bulgaria. Care organisations were also actively involved in development of situation assessment, coaching and rendering models.

SAAM system aims at supporting seniors in maintaining themselves in personal homeostasis with respect to wellbeing by balancing between available individual resources and challenges [32]. The basic assumption is that supporting the homeostasis (resources—challenges balance) of the senior in single domain-specific situations contributes to supporting their overall wellbeing.

SAAM core intervention domains are sleep, mobility, activity, and social activity and they are pilot tested with real end-users. SAAM is also developing advanced system components for intervention in other domains, but these are tested primarily in laboratory settings.

As an ICT system SAAM consists of fixed and wearable sensors, edge computing and communication devices, cloud infrastructure, all linked together with custom software. Users interact with the system through a multimodal interface as well as more standard mobile and web application.

SAAM system is devised in a way that takes into account and adapts to users’ personal needs, preferences, living environment, and their social connections. Adaptive coaching of this kind is done in SAAM by a series of hardware and software components that are dedicated to various coaching domains and are denoted as coaching pipelines. A coaching pipeline consists of sensor data processing components, reasoning models for selection of a suitable coaching action and components for personalization of outputs that are communicated to the users (Fig. 2 Coaching pipeline architecture).

Sensing is performed by the hardware components, while actuation refers to rendering coaching actions to the user through various interfaces. The steps in between are completely invisible to the users. Sensing is done as unobtrusively as possible.

SAAM is designed to keep the users active primarily by enhancing interactions with their social circles. It introduces specific user roles: primary user (PU), secondary user (SU), coach and caregiver. Coaching rendering is done via text or light + audio messages, while the actuation uses several persuasive strategies (suggestion, self-monitoring and commitment bias) and is tailored to PU’s preferences. The timing for coaching actions from different pipelines is combined not to overwhelm the users. For PUs unwilling or incapable of using the SAAM system rendering is done through

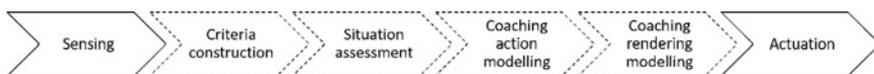


Fig. 2 Coaching pipeline architecture in SAAM project

SUs—a countermeasure to boredom and technology rejection by PUs. In this way, PUs who are not technologically apt can also benefit from SAAM coaching through their SUs. Thus, coaching is as unobtrusive as possible.

#### ***6.4 What Is the Expected Impact of Your Project?***

One of the expected project impacts is creating a low-cost, extensible and inclusive coaching system providing support for users of varying language, physical, and technological capabilities. SAAM is a scalable coach providing for flexible user interactions, including ambient data collection and an “invisible helper”. For users unable or unwilling to interact with technologies, the system’s novel “social circles” capability engages the user’s social networks to act as coaches to support healthy independent living.

Diversity of data streams and decision support methods sensitive to the needs and preferences of individual users provides a more useful and practical system, offering better and less intrusive, personalised coaching recommendations.

#### ***6.5 Please Describe the Exploitation Models and/or Channels and/or Opportunities***

The final product development for low-end markets such as Bulgaria focuses on the low cost components: core system with a smart power meter, Wi-Fi router, and (optionally) an inexpensive mobile phone. In this configuration that we call “basic SAAM”, we likely have the strongest product with the most benefit for local authorities. Also in this case, it is important to provide maximum impact with minimum user interaction in line with the latest research and developments in the field. This approach allows for machine learning for user behavioural nudging that is context independent. This concept is worth considering as the SAAM basic product, as it is coherent with the abilities of our original elderly user cohort (low ICT familiarity, likely unable to use a mobile phone, unlikely to welcome gadgets, likely to have a strong emotional attachment to their home). In this way “SAAM makes your (smart) home caring”.

A promising concept in the long run is to partner with external smart meter companies producing smart home kit infrastructure that is then offered as a package to electricity companies’ end-users to “enable a smart home and smart energy usage infrastructure”. In this configuration, SAAM product would include back-end software, intelligence, and workflow architectures for their hardware to turn a “smart home” into a “caring home”.

## 7 Virtual Coaching for Telerehabilitation: Insight to the European vCare-Project<sup>9</sup>

### 7.1 Project Context Introduction

The vCare project designs a Virtual Coach (VC) that supports the rehabilitation phase after the occurrence of the particular Non-communicable diseases (NCDs) stroke, PD, and heart failures/ischemic heart disease. Such pathologies represent a major public health challenge globally in the 21st century diminishing quality of life (QoL) [33]. The efficient implementation of the secondary prevention measures through adequate rehabilitation is essential in this regard. However, given that the institutionalized rehabilitation programs usually last only for a definite period the continuity of care is often interrupted after the transition from the institutionalized rehabilitation to the home self-rehabilitation environment. Within vCare, the patients' home rehabilitation is amended by advice for a healthy behavior and monitoring and motivating the execution of distinct (physical) exercises such as serious games. This way, also the VC tries to compensate the absence of a human caregiver and enrich the traditional care schemata of more or less defined check-ups by doctors and therapists. The VC motivates patients to perform therapy and prevention measures and personalize its recommendation to the behavior, preferences and habits of the patient.

In particular, by utilizing the VC in the vCare-project, we aim to enhance the QoL of patients by helping them to adhere to the care plan that consisted of personalized healthy recommendations for daily activities. The permanent coaching shall lead to a continuous reduction of risk factors that are related to the probability of a relapse of the disease, the manifestation of disabilities, or the decline of (mental) health (see Fig. 3).

### 7.2 Principle Project Approach and Methodology

The vCare project focuses on building a VC solution for the rehabilitation in the home environment that integrates existing technical solutions in order to provide a holistic user experience, that works on defined care pathways which are personalized continuously, and that provides a verifiable clinical evaluation in terms of patient's engagement, medical recovery and QoL (TRL 7). Therefore, vCare is deploying a twofold joint medical and technical implementation and testing phase for the validation studies in order to assess the VC system's appropriateness gradually concerning the project progress (see Fig. 4). This allows to collect real-time feedback from the user perspective (patients, therapists, and physicians). The project evaluation should demonstrate in particular how the specific challenge of empowering and motivating

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<sup>9</sup>This paragraph has been authored by Kai Gand, Hannes Schlieter, Sofoklis Kyriazakos, Massimo Caprino, Luc Nicolas, and Johannes Kropf on behalf of the vCare consortium.

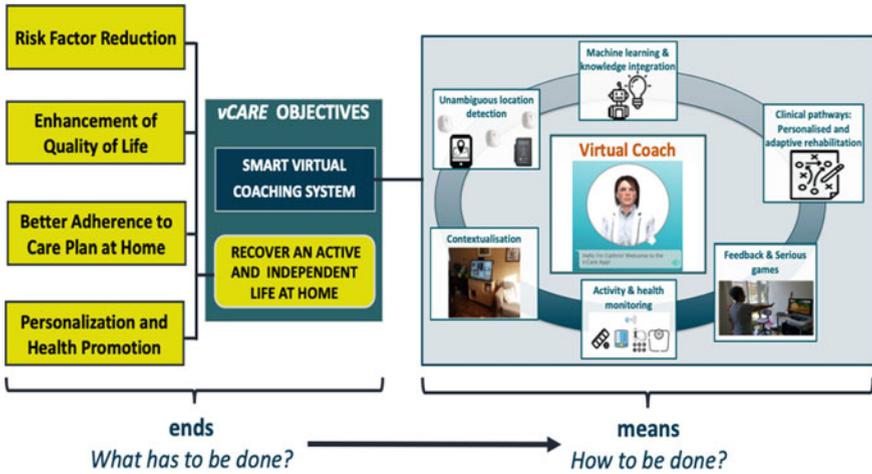


Fig. 3 Overview of vCare’s objectives (What has to be done?) and implementation measures (How to be done?)

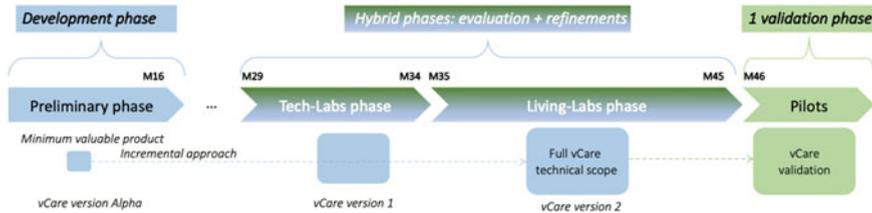


Fig. 4 Overall implementation plan

via a VC works in a clinical setting. For building the VC the clinical expertise is used, on the one hand, to derive the basic rehabilitation needs as well as the necessary clinical pathways. On the other hand, the technicians ensure that the VC solution properly works and is adapted to the patients’ needs and pathways. To in turn ensure this overall ambition, an iterative, tripartite testing strategy is in place: First, within the TechLab phase the sole functioning of the technical components and their interplay have been tested having the therapists substituting the patient behaviors. Second, the Living Lab simulates the homes by research apartments providing a protected environment and support for the patients trying out the VC solution. Third, within the Pilot phase the patients use the solution in their real home setting.

The overall aim of the pilot study is to refine and test the use of the vCare coaching system to find out if it is useful in motivating and empowering patients with various functional impairments and comorbidities to engage actively in performing personalized rehabilitation activities in order to be independent and to improve their QoL.

The continuous technological progress is changing the impact of the user on the approach to a VC as health professional. A good interaction between the user and the VC can ensure a trusty relationship. Thus, looking at secondary prevention of chronic diseases, vCare might particularly impact medication adherence and extend existing rehabilitation programmes, providing a great opportunity to guarantee the continuity of care between hospital and home. vCare will show that is possible to deal with complex clinical situations.

### *7.3 The vCare Project's Perspective on the Future of Ageing*

The vCare system is a persuasive and non-obtrusive technology that helps people change their habits and improve their home-based rehabilitation. Therefore, they can become healthier and gain more healthy time of living. In general, when broadly looking on the VC literature an increased diffusion of technologies with strong interaction with human beings in the world of health and medicine can be confirmed [34]. In the future, this relationship might even be strengthened in the medical sector fostering patients' engagement toward a process of self-awareness and self-confidence in health management. According to the lessons learned from the vCare project [35] and the current trends in the scene, we predict the following directions for the future of aging combined with the use of VC:

**Ubiquity of the VC:** Advanced modes of presence will lead to ubiquity of the VC in daily life and allow further interaction modes. Broadened augmentation in terms of a further integration of VC into the reality might in turn broaden its abilities to guide the user and therefore increase the literacy of the suggested actions.

**Advanced sensory capabilities:** Advanced sensing and acting levels will allow seamless adaptation in relation to the people's conditions.

**Multiple Coaches:** Multiple linked coaches and other assistant systems could allow an even monitoring and guidance of the user.

**AI grounded treatment knowledge:** Advanced AI may also infer novel treatment and well-being strategies grounded on common health data ecosystem. It is very likely that such changes could improve the management of increasingly complex clinical situations, especially for cases of chronic diseases and disabilities (as one needs to expect a further increase of case counts here).

**Converging Wellbeing and Health Care enhancing Quality of Life:** In the future, both healthy as well as frail or sick, younger and ageing people could be supported by VC. Results from the primary prevention or even well-being could be more easily transferred to the more complicated and specific one of secondary prevention. When assuming also a broader evidence of the (perceived) usefulness and advantageousness it might become possible to transfer the VC's support modes to a broad range of use cases for preserving physical, cognitive, mental, and social well-being for as long as possible. More specifically, the VC will educate and finally

empower patients to increase their adherence to drug therapy and to pursue physical and cognitive rehabilitation programs to regain independence with a healthier lifestyle and a better quality of life.

**Desired commercialization path and formalities:** In order to reach the directions listed above, it is important to address the challenges of the regulatory framework to operate eHealth or Digital Therapeutic (DTx) solutions. The vCare project has identified this challenge and is already investigating pathways to address potential barriers. Already today, elements of vCare are classified as Medical Devices with CE mark and the project is further developing a commercialization strategy for the post-project period.

## 8 WellCO Recommends Healthier Behaviour Change<sup>10</sup>

### 8.1 Ageing Challenges for 2030: The WellCo Perspective

Important challenges arise in Europe with regards to healthcare and ageing due to it will be up to all of us to ensure that social welfare and healthcare systems are made more resilient for the next generation [36].

On the one hand, it is expected that people remain working till older ages in the next decades. The reason is that this is one of the more realistic solutions to ensure the sustainability of resources to finance the higher healthcare costs associated with population ageing.

On the other hand, the digitalization of the healthcare sector and the advances in artificial intelligence and big data offer an opportunity to reduce the gap between the demand and the quantity and quality of the supply of healthcare. In this sense, the COVID-19 pandemic seems to have accelerated the adoption of digital solutions, especially the use of telehealth, with virtual consultations and remote patient monitoring [37].

Finally, a sustainable, efficient and cost-effective future for health also requires a population health management approach with special attention to prevention policies. This culture will permeate all areas of society, so it is expected that in the near future: unhealthy behaviours are taxed, companies award to those employees that have healthier habits (e.g. paying if cycling instead of using the car [38]) and that the demand of digital applications for healthcare experiences a tremendous growth in the coming years.

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<sup>10</sup>This paragraph has been authored by Inmaculada Luengo and Paloma Jimeno on behalf of the WellCO consortium.

## 8.2 WellCo Supports Elderly Empowerment

WellCo vision is to empower elderly people and general population on the importance of the prevention through the acquisition of healthier behaviours. It is crucial for an ageing population to reduce the risk of developing preventable chronic conditions which are accounted mainly from unhealthy behaviour like physical inactivity, smoking, poor diet, etc. Although currently just after developing any disease the population pay attention and try to change their behaviour, it is important to raise awareness about this disease prevention and how the ICT could help us on an easy and comfortable way with a solution like WellCo, a personalised wellbeing coach (Fig. 5).

In the current pandemic times, ICT solutions has raised a special importance, due to the limitations on presence attendance and follow up by the health professionals. Also, it seems that people incrementally are raising awareness on the importance of being healthy and improving their wellbeing habits.

Thanks to the holistic approach of WellCo, it is possible to guide people on the different key age-related issues like diet, physical activity, risk avoidance, preventive measures, lifestyle, activity management, leisure, social participation and overall wellness. So, the possibilities and opportunities allow WellCo to act as a holistic coach or as domain specific one just focalizing the monitoring and recommendations in that domain.

Leveraging state-of-the-art artificial intelligent technologies, WellCo implements algorithms capable of reasoning, extracting knowledge and adapt to personal needs, emotional and behavioural patterns with the purpose of getting enough information about the environment surrounding the user. The access to this information enables the system to have information about the areas of wellbeing where the user requires

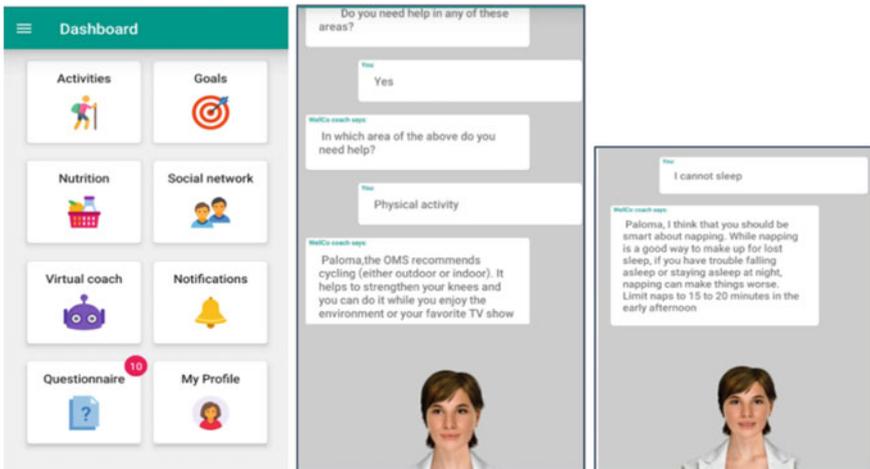


Fig. 5 Dashboard and Affective-Aware Coach in WellCo system

to improve. This information together with the capabilities and opportunities of the user are utilized to offer the user motivational recommendations to change his/her habits and ensure that healthier behaviours are adopted and maintained in the long term.

### 8.3 *The WellCO Approach*

The WellCo concept is developed from the Behavioural Change Wheel [39], a new method that characterises and designs behaviour change actions through three essential conditions: capability, opportunity and motivation to perform the change action (“COM-B” system). Taking this as baseline and considering that behaviour change interventions focused on fear and warning are not enough, the methodology that WellCo adopts to deal with behaviour change is as follows:

- WellCo leverages **wearable sensors and AI-based algorithms** that process the emotional and wellbeing status of the user with the aim of **knowing the context surrounding the user**;
- Contextual information is used by the different **recommender systems** implemented in WellCo to provide **personalized recommendations** that ensure the adoption, follow-up and maintenance of the proposed behaviour change actions for as long as possible.
- To address the **motivational dimension** of the user during this process of change of habits, WellCo offers:

**Social Incentives** that generate a sense of belonging to WellCo. “Goals” are the main element around which social incentives emerge.

**Immediate Rewards** that increase the positive experience of the action, with important outcomes for motivation and persistence.

**Progress Monitoring and Continuous Support.** The user has a clear roadmap for personalised guidance and follow-up. These elements are:

- **Affective-Aware Coach** that provides recommendations to the user and offers support in case of needed. The coach leverages information of the user available in the database to personalize interactions. Also, information derived from the emotional status of the user is used with the purpose of showing empathy. The coach implements:
  - (a) **Tips** shared by experts in each of the different wellbeing areas: physical activity, nutrition, mental and general wellbeing.
  - (b) **Video-call events** arranged by coordinators or GPs about the main topics of interest or areas of behaviour in WellCo.
  - (c) **Validation of recommendations** by experts providing the observers outcomes and feedback loop into the system.

## ***8.4 The Expected Impact of the WellCO Affective-Aware Coach***

The foreseen impact of the system proposed by WellCO project is at three levels:

- **Societal Impact**

Proper dissemination and exploitation actions have been performed during and after the project with the purpose of transferring to general population the results derived from WellCo. The more important societal impact expected for WellCo is the contribution to the improvement of well-being on population thanks to WellCo virtual coach and the awareness raised on prevention through ICT technologies promoting behaviour change towards well-being.

- **Economic Impact**

WellCo training will allow individual users to self-manage their own health, so the consequence of WellCo could be the delivery of an approach that help to spread the culture of health prevention and population health management (PMH). This culture will have significant impact on the sustainable future of healthcare in Europe.

- **Scientific Impact**

Proper dissemination actions will be essential to ensure that the knowledge gained in WellCo is transferred to the scientific community. In quantitative terms: 8 scientific papers have been published in conferences and 2 as an article in scientific journal. Being 3 of these papers provided for open access in OpenAire. In addition, the project has brought possibilities to 2 Ph.D. students that were involved along since the project beginning till the end.

## ***8.5 Exploitation Model for WellCo Coaching System***

WellCo allows multiple exploitation models, through the individual exploitation of their modules as well as through the whole exploitation of the business solution.

Individual models developed along WellCo are mostly related with the monitoring of users' behaviour and how this behaviour could be modified. On this area we have developments like mental health assessment, activity monitoring, risk estimation, bite counting, energy expenditure, social interaction assessment, etc. Moreover, inside the project other exploitation assets like emotional assessment via visual and speech analysis have been developed as well as recommendations engines. All these developments have been based on innovative technologies like IoT, big data, machine learning and deep learning technologies. Being all of them important exploitable outcomes of the project.

Finally, WellCo as a complete application, has established a minimum viable product to be used in the initial exploitation steps on the prevention domain, focusing on public health, private health and insurance companies, all of them mostly motivated, after pandemic, on health prevention through ICT technologies.

## 9 Conclusions

A European community of project dedicated to the design and test of solutions for Active and Healthy Ageing, have been built around the PM-15 H2020 call. This is important because a common research framework is being shared and joint initiatives support the construction of a common vision, interoperable tools and mutual development to encourage a true exploitation of research outcomes. Only through such initiatives, research findings and innovative technological solutions could land among citizens. All projects recognize the importance of the elderly empowerment through the leverage of existing mobile and ICT tools as basic and key strategy. The digital acquaintance and “stability” are crucial for this category of subjects. Thus, the innovation should stay “behind the curtain” of the existing object by increasing their intelligence and the capability to support, to remind, to stimulate elderly in activities aimed at keeping or improving their health status. In this perspective, the perceived importance of the new solutions and related applications, stays in the “how better I feel” but with minor (apparently) and incremental changes in my habits.

This also represents the reward that is necessary to support the motivational dimension of people. All projects also recognize the importance of such actions both at short-time and local level, with immediate rewards through local stakeholder and policy makers (community, town, ...) like social incentives small economic revenues in the form of discounts for certain products (for healthcare, food and nutrition, ...), and in the long-term by increasing the level of the intervention at a wider community (regional, national, European). The rewards represent the strategic tools for perceiving the positive experience of the action so that motivation and persistence is continuously maintained.

The expected exploitation is envisioned in the frame of eHealth or Digital Therapeutic solutions. Their recent introduction and the possibility to be included in the welfare systems at national level could represent the key point for the actual deployment of these solution in the healthcare sector.

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For further details and information please visit the projects’ websites:

- CAPTAIN—Coach Assistant via Projected and Tangible Interface, G.A. No. 769830, <https://www.captain-eu.org/>.
- COUCH—Council of Coaches, G.A. No. 769553, <https://www.council-of-coaches.eu/>.
- EMPATHIC—Empathic, Expressive, Advanced Virtual Coach to Improve Independent Healthy-Life-Years of the Elderly, G.A. No. 769872, <http://www.empathic-project.eu/>.

- HOLOBALANCE—HOLOgrams for personalised virtual coaching and motivation in an ageing population with BALANCE disorders, G.A. No.769574, <https://holobalance.eu/>.
- SAAM—Supporting Active Ageing through Multimodal coaching, G.A. No. 769661, <https://saam2020.eu/>.
- vCare—Virtual Coaching Activities for Rehabilitation in Elderly, G.A. No.769807, <https://vcare-project.eu/>.
- WellCO—Wellbeing and Health Virtual Coach, G.A. No.769765, <http://wellco-project.eu/>.
- NESTORE—Novel Empowering Solutions and Technologies for Older people to Retain Everyday life activities, G.A. No. 769643, <https://nestore-coach.eu/home>.

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