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Abstract:

The deliverable *D2.2: Initial scenarios and use-cases* is one of two first content-deliverables for the eWall project. Together with *D2.1: Preliminary user and system requirements* these two deliverables form an initial overview of the requirements for the eWall system.

In this deliverable we first provide a detailed description of the primary- and secondary end-user groups targeted in the eWall project. We describe our methodology on requirements engineering explaining the process of developing *user profiles*, *personas*, *scenarios*, and *use cases*. These four topics cover the main contents of the deliverable and provide a solid basis for deriving detailed user- and system requirements in future Work Package 2 activities.

This deliverable defines the *user profiles* in which background information is given regarding the three primary end-user groups: *elderly with age related impairments* (ARI), *chronic obstructive pulmonary disease patients* (COPD) and *elderly suffering from mild dementia* (MD). In order to give a better understanding of these user groups we defined six personas for primary users and four for secondary end-users. Detailed story-like scenarios are created to describe the vision of the eWall system categorized into 13 application categories. From these 13 application categories, three are worked out into more detailed *use cases*.

Keyword list: older adults, age related impairments, chronic diseases, COPD, mild dementia, frailty, daily activity monitoring, daily functioning monitoring, health monitoring, remote health support, medication support, home sensor networks, body area networks, domotics, technology guided physical exercise, virtual biking, automated cognitive stimulation

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1 Executive Summary

The deliverable *D2.2: Initial scenarios and use-cases* is one of two first content-deliverables for the eWall project. Together with *D2.1: Preliminary user and system requirements* these two deliverables form an initial overview of the requirements for the eWall system.

In this deliverable we first provide a detailed description of the primary- and secondary end-user groups targeted in the eWall project (Section 2.1). Next, we describe our structured, literature based methodology on requirements engineering (Section 2.3) explaining the process of developing *user profiles*, *personas*, *scenarios* and finally *use cases*. These four topics cover the main contents of the deliverable and provide a solid basis for deriving detailed user- and system requirements in future Work Package 2 activities.

This deliverable starts with *user profiles* in Section 3 in which background information is given regarding the three primary end-user groups: *elderly with age related impairments* (ARI), *chronic obstructive pulmonary disease patients* (COPD) and *elderly suffering from mild dementia* (MD). In order to give a better understanding of these user groups we defined personas – fictitious descriptions of single end-users that are characteristic for the target group. Six of these personas are created for the primary end-user groups, two for each group. Furthermore, an initial set of four secondary end-user personas are created representing a *general practitioner*, *hospital nurse practitioner*, *visiting nurse*, and *informal caregiver*.

In Section 4 we created detailed scenarios, which are story-like descriptions of how the envisioned eWall system can support the defined personas. In order to increase readability we have divided the scenarios into 11 functional categories. For each of the six primary end-users, the use of these 11 functionalities is described. The functionalities have been discussed extensively within the consortium, and a preliminary categorization was made to define 13 application categories, which are defined in Table 6 (page 57).

From the list of 13 possible application categories, three were chosen and services from those categories are worked out in more detailed in the use cases in Section 6. These use cases describe detailed interactions between the user and the various envisioned interface devices of the eWall system.

As is clear from the title of this deliverable, the work described here is work in progress. As we go progressively into more detail from the personas to scenarios and to use cases, it should be noted that the details provided are not set in stone. Instead they now serve as an anchor point for discussion, indicating the important topics on which design decisions have to be made.

2 Introduction

As we get older, we have to cope with a decline of our physical and cognitive functions; the majority of the elderly has at least one chronic condition, limiting his/her functioning. With respect to physical conditions, this involves amongst others a decline in cardiopulmonary condition, weaker muscle functions and a declined neuromuscular control of movements. Consequences are a higher risk of fall and higher vulnerability for cardiovascular diseases. With respect to cognitive functions, this involves amongst others a decline of memory function, less ability to orientate and a declined ability to cope with complex situations.

An important wish of most elderly nowadays is to live independently in their home for as long as possible. This means that ways have to be found to cope with the decline of physical and cognitive functions. Next to the formal caregivers, family and other informal caregivers can play an important role to reach this wish. But their availability is limited which means that they become overloaded easily. In practice, a main reason to move to a care institute due to, for example progressing dementia, is the overload of the informal caregivers. Also the availability of formal caregivers is limited; some calculations show that when we want to continue to deliver the present care, in 2020 in e.g. The Netherlands every fourth person has to work in healthcare. It is clear that the present healthcare service is not sustainable.

It is the objective of eWall to support independent living, compensating for prevailing age- or disease-related physical and cognitive impairments. Overall, this should lead to a significant prolongation of the primary end-user's functional capacity, a delay in institutionalization, increased autonomy and, prolonged participation in our society. This will be done by creating a Caring Home environment, meaning an environment that "senses" intuitively the wishes and needs of the person that lives in this house, providing unobtrusive daily support, notifying informal and formal caregivers when necessary, and serving as a bridge to supportive services offered by the outside world.

2.1 The eWall target users

In order to develop a successful eWall system that can maximize potential societal impact, the system should be able to support a broad range of target users. However, due to the complexity and distinct implications of various chronic diseases, there is also a need for focus. As such, the design and the implementations of the first prototypes of the eWall system within the project will focus on the following primary end-user groups:

1. **Elderly users with age related impairments (ARI)**: users who are elderly, but otherwise considered healthy. Although they can have a low level of cognitive and/or physical impairment, their condition does not require specific assistance or therapy;

2. **Chronic Obstructive Pulmonary Disease patients (COPD)**: users diagnosed with COPD – GOLD stages 2 and 3 – a progressive, chronic condition that slowly decreases lung function over time. The restricted lung function, the lung infections and the fear of being breathless seriously limit physical functioning in daily life;

3. **Users suffering from Mild Dementia (MD)**: users suffering from cognitive impairments (e.g. short term memory, language, execution of complex or parallel tasks) beyond what can be

considered normal age-related symptoms, which can potentially progress to more severe conditions. These users are still able to live independently in their home environment, but when the disease progresses, they do need more and more functional support and supervision.

Figure 1 shows how these three end user groups relate in terms of cognitive and physical impairments. Age Related Impairment (ARI) users suffer from minor cognitive and physical impairments. The COPD and MD user groups should be seen as representatives of physical and cognitive related impairments, respectively. The boundaries between the conditions are not strict, with overlapping areas.

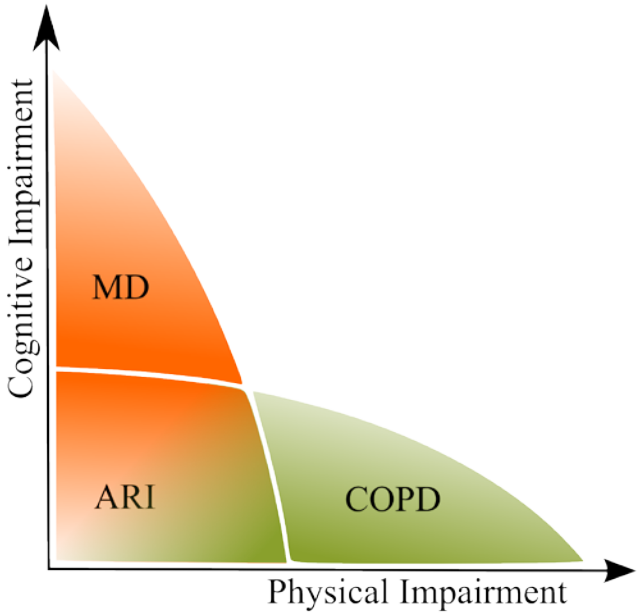


Figure 1: Broad overview of the primary end-user groups and related impairments. ARI users suffer from minor cognitive and physical impairments; COPD patients overlap this group but extend into more severe physical impairments; MD users extend into more severe cognitive impairments.

As the societal impact not only relates to the primary end users, the eWall project will also focus on the following secondary end-user groups:

1. **Professional caregivers**: including nurses, home care support professionals, medical doctors (general practitioners, lung physicians).
2. **Informal caregivers**: this user category contains the primary user's family, neighbors, friends and anyone else not from the professional healthcare field that provides any type of support, including social support, housekeeping, or more disease specific support.

2.2 Scope of this deliverable

The content of this deliverable contains four major parts. In Section 3 we provide a detailed understanding of who the target users are through the creation of User Profiles. This is done through a literature and background study that for each target group leads to *facts and figures* and a description of the *everyday life of the user*. For our two patient populations (COPD and mild dementia) we include a description of the *everyday life of the caregivers*. In Section 4 the detailed information from the facts and figures and descriptions of everyday life is used to create simple to understand *personas* that represent the majority of future eWall end users, each with common and distinct features. In Section 5 we define a number of scenarios, short stories that describe high level

typical interactions with a technology, in which the personas from the previous section are using the envisioned eWall system. In Section 0 the core interactions taken from the scenarios are worked out in more detail into *use cases* in order to guide the development of function requirements in Deliverable 2.1.

2.3 Objectives and methodologies

In order to come to a set of functional requirements that align with the targeted end-user population, several steps have been taken. These steps are in line with typical human-centered design approaches for (eHealth) technology, such as ISO 9241-210 [1] or user-centered design [2], and take the prospective primary end-user as a focal point during design. With these end-users in mind design is geared better towards the context and use and hence, a high degree of ease of use, usefulness and adoption can be expected. The four following products are developed in order to inform design: user profiles, personas, scenarios, and use cases.

2.3.1 User profiles

Once the target population of a specific technology has been decided upon, this population needs to be profiled and, if applicable, needs to be divided into homogeneous sub-segments [3]. These profiles need to be derived from existing research which is typically done via desk research or data mining of existing data (mostly in the case of large consumer databases). User profiles are important as they serve as the foundation for our understanding of the end-user. In this case, we have studied the current literature on the different target populations: elderly with age-related impairments, COPD and mild dementia patients. For each of these populations we include detailed facts and figures, as well as a “day in the life” section which serves as a “before-scenario” that can be compared to the technology enabled scenarios described afterwards.

2.3.2 Personas

Based on the user profiles, personas will be developed. Personas are fictitious descriptions of single end-users. Each end-user is representative for one end-user population or a sub-segment of this population. These personas are presented as short stories about the specific person in which the most important characteristics of the (sub-) population are included as personal traits. Personas are presented in this way because they can then be easily understood by all the people involved in system design. They are also very useful for informing system design, as they can function as focal point when designers need to make a decision during the design process. In this case they should not wonder whether or not they should include a specific feature or design an interface in a specific way. Rather, designers should ask themselves: What would Peter want? Would he like this feature? Would he appreciate this look and feel? This way, design decisions are taken from the end-users’ perspective. It should be noted that personas should not describe the interaction between user and the system which is to be developed.

In this project, user profiles were translated into personas as described by [4]. Basically, this means that each crucial attribute of the user profiles leads to a sentence in the persona. In the persona descriptions, three crucial attributes are discussed: persona demographics, the persona’s technology use and skills, and healthcare specifics (e.g., health literacy, attitude towards caregivers) [5]. For each primary end-user, a persona is created.

2.3.3 Scenarios

In the scenarios section, the “after-” scenarios are described that detail the interaction between the end-user (persona) and the technology to be developed. This way, it is described how the design team envisions the end-users to work with the system on an abstract level. As the “after” scenarios also include how the end-user works with the technology in his or her personal surroundings, the design team is also forced to think about the designated context of use, and to account for it in their design. From scenarios, functional requirements can be derived.

2.3.4 Use cases

Use cases, finally, will describe the envisioned functionalities of the technology by listing the different interactions between the end-user and system on a per-function basis. Use cases are especially important for describing how the front-end of the system supports the end-user in completing his or her tasks.

3 User Profiles

3.1 Elderly users with age-related impairments (ARI)

As people advance in age, the risk of contracting diseases and suffering from disabilities is higher. Preventing such risks is difficult due to the presence of age related impairments. This aspect is widely approached in European society and healthcare systems, as the European population is increasingly advancing in age.

3.1.1 Facts and Figures

Eurostat statistics show that the European population advanced in aged considerably over the last 10 years. This is shown by an increase in the European average age of population over a 10 year period.

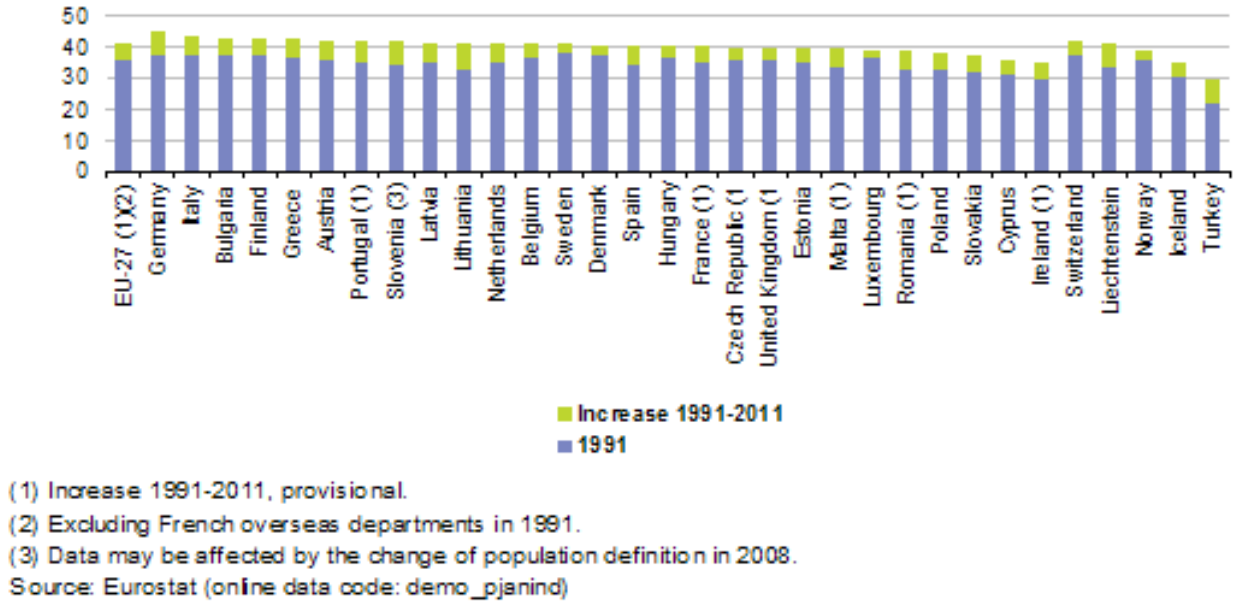


Figure 2: Average age difference between 1991 and 2011. [6].

"*In the past two decades, the share of the population aged less than 15 years in the EU-27 population decreased by 3.7 percentage points, while the share of the older population (65 years and above) increased by 3.6 percentage points; as a result, the top of the EU-27 age pyramid for 2011 widened.*

...

The median age increased from 35.4 years in 1991 to 41.2 years by 2011 (see Figure 2). Over the period from 1991 to 2011, the median age increased in all of the EU Member States, rising by at least six years in Lithuania, Portugal, Slovenia, Germany, Latvia, Spain, Austria, Malta, the Netherlands and Italy". [6].

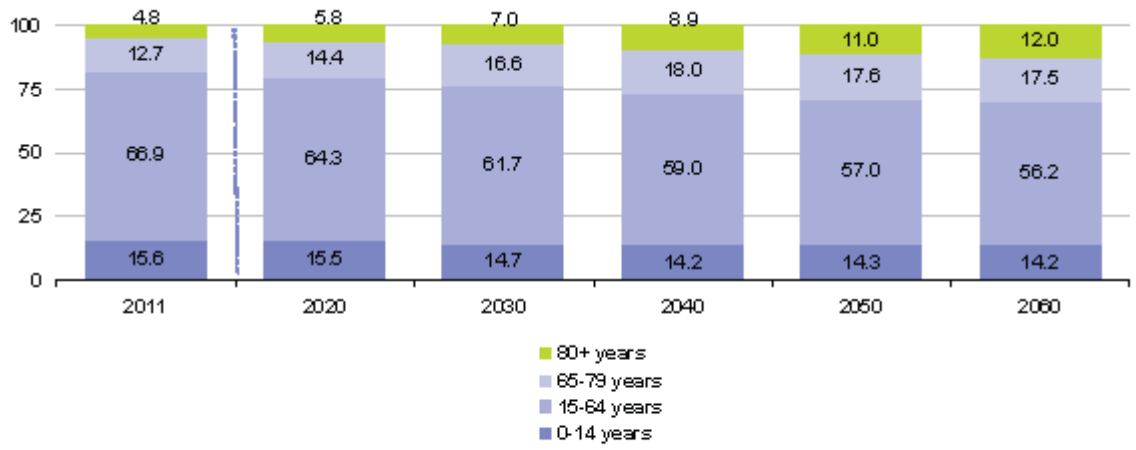
Eurostat also estimates future trends in population aging within the European member states.

"Eurostat's latest set of population projections (EUROPOP2010) were made covering the period from 2011 to 2060 – and show that population ageing is likely to affect all EU Member States over this period. The convergence scenario is one of several possible population change scenarios that

aim to provide information about the likely future size and structure of the population. According to this scenario, the EU-27's population will be slightly higher in 2060, while the age structure of the population will be much older than it is now. According to the convergence scenario of EUROPOP2010, the EU-27's population is projected to increase to 525 million by 2035, peaking at 526 million around 2040, and thereafter gradually declining to 517 million by 2060. During the same period, the median age of the EU-27's population is projected to rise to 47.6 years. The population of working age is expected to decline steadily, while older persons will likely account for an increasing share of the total population – those aged 65 years or over will account for 29.5 % of the EU-27's population by 2060 (17.5 % in 2011).

...

Another aspect of population ageing is the progressive ageing of the older population itself, as the relative importance of the very old is growing at a faster pace than any other age segment of the EU's population. The share of those aged 80 years or above in the EU-27's population is projected to almost triple between 2011 and 2060." [6].



(1) 2011, provisional; 2020-2060 data are projections (EUROPOP2010 convergence scenario).
Source: Eurostat (online data codes: demo_pjanind and proj_10c2150p)

Figure 3: Population structure by major age groups, EU-27, 2011-2060 [6].

3.1.2 Everyday Life of the Elderly with age-related impairments

The age related impairments occur due to changes on physiological cognitive level in the older adults.

Effects on cognitive level

Cognitive changes are associated with mental processes like sensation, perception, memory, intelligence, language, thoughts and problem-solving. One example is learning rate, which decreases in older adults as they advance in age. This is a direct consequence of slow encoding, storing, and retrieving information. This makes older adults to need frequent repetition of new information. Long term memory shows substantial changes with age, but short-term memory shows less age related decline. Therefore, language abilities remain strong, but remembering words that are not often used, may prove difficult. Creativity and wisdom are features that are present until the end of life.

Effects on physical level
Physical changes are more likely to occur in adults around the age of 65.

Mild hearing impairments are often occurrences to adults in this age group, 48 percent of men and 37 percent of women over the age of 75 experience hearing difficulties. Loss of hearing is the third leading chronic condition that affects adults over 75 years old. Hearing impairments are defined as a loss of sensitivity of the hearing apparatus, or increase in the level of loudness. A mild hearing impairment makes the person hear sounds with a minimum intensity within the interval of 20 Db – 40Db. A moderate impairment requires 40Db – 55Db sound. Severe hearing impairments allow persons to hear sounds with a minimum intensity ranging between 70Db-90Db.
People who do not hear sounds with an intensity greater then 90db are considered profoundly deaf. (Sensory changes, Pamela Z. Cacchione, PhD, RN, BCGNP -Hartford Institute for Geriatric Nursing).

Changes in vision have a major impact also on the elderly. Such frail vision includes slower reading speeds, difficulties seeing in dim lighted environments, locating objects, etc. The amount of time for detecting and reacting to changes in the environment is typically slower in older adults [7].

Loss of elasticity and thickening of the eye lens could be the main cause of vision problems in older adults. This results in change of the eye lens shape and the loss of focus on near objects, such as small printed text and a weaker ability to adapt to light. This change has an impact on the elderly's safety by reducing the ability to properly read medication labels, increase difficulty with driving, and crossing streets, and an increased risk for falling. Reduced vision also impacts quality of life by reducing the ability to maintain an independent lifestyle, difficulty of inability in getting daily information, by reading newspapers with fine print. [8]

Cardiovascular changes associated with age manifest themselves in forms of: arterial wall thickening and stiffening, causing elevated blood pressure in elderly; left ventricular and atrial hypertrophy leading to sclerosis of atrial and mitral valves; strong arterial pulse and diminished peripheral pulse are causing cold extremities. These physical changes in the circulatory system lead to a decrease of maximal heart rate, under physical stress, e.g.: when the older adult is making physical exercises. This condition leads to fatigue and a delayed recovery to normal heart beet rate, once the physical stress stops. [9].

The decline in muscle mass and strength, associated with aging results in a higher weakness and poorer exercise tolerance in the elderly. A replacement of muscle tissue by fat and a redistribution pattern of fat is evident. This is coupled with the decrease in ligament and tendon strength, intervertebral disk degeneration, articular cartilage erosion resulting in changes in structure (curved back) and height reduction. Implications of this physical change include: increased risk of disability, loss of balance and frequent falls, unstable gait, joint instability, risk of osteopenia, osteoporosis and osteoarthritis. [9].

3.2 Chronic Obstructive Pulmonary Disease (COPD)

Chronic obstructive pulmonary disease (COPD) is a progressive condition that slowly decreases lung function over time. The term COPD includes emphysema and chronic bronchitis. When a COPD diagnosis is made, a physician will classify it in stages (mild, moderate, severe, or very

severe) according to a person's symptoms and overall lung function. At any stage of COPD, it is important to quit smoking and avoid inhaling pollutants like second-hand smoke or anything that may further damage the lungs [14].

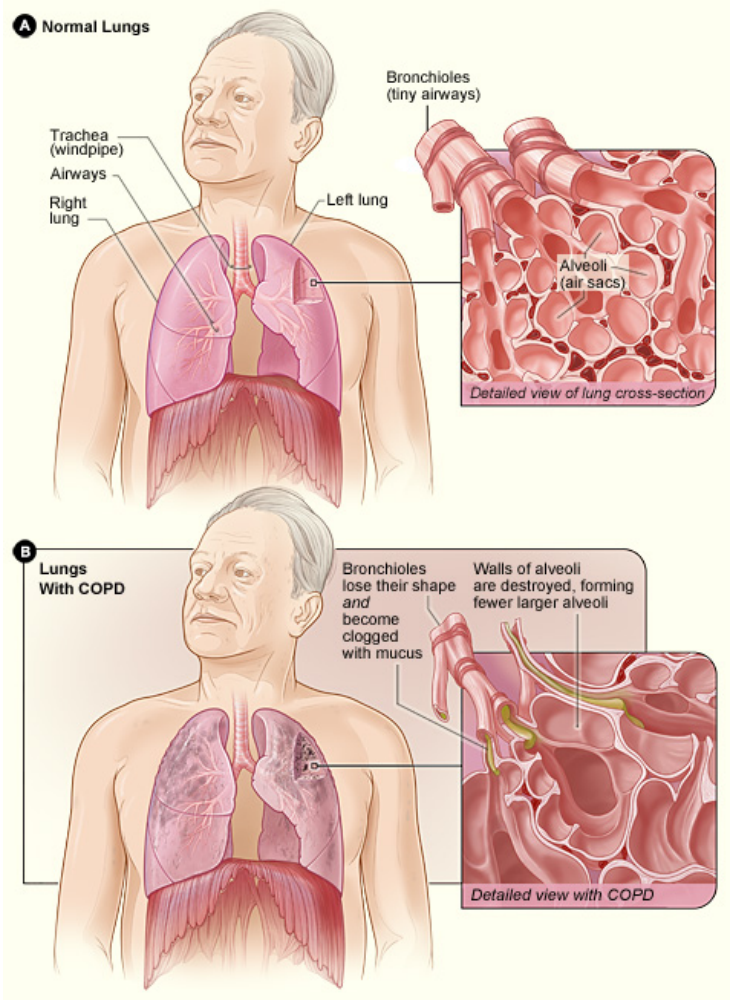


Figure 4: Healthy and COPD lung comparison. Section A shows the location of the lungs and airways in the body. The inset image shows a detailed cross-section of the bronchioles and alveoli. Section B shows lungs damaged by COPD. The inset image shows a detailed cross-section of the damaged bronchioles and alveolar walls [13].

3.2.1 Facts and Figures

Doctors may use a variety of diagnostic tests to determine the severity of COPD. These tests include: spirometry (lung function test), chest X-rays, CT scans, and blood tests. In some cases, the cells in mucus or sputum are analyzed to help determine if bacteria are present, or if the cells are abnormal or cancerous. Doctors classify COPD in stages according to its severity. The following values reflect recent changes in the universal COPD treatment guidelines set forth by the Global Initiative for Chronic Obstructive Lung Disease (GOLD).

COPD Stage I / Mild. People with Stage I COPD are typically unaware that they are suffering from a lung disease. Their symptoms of coughing and mucus are frequent, but not chronic. They are not short of breath and usually continue to exercise normally. Their FEV1 numbers (Forced Expiratory Volume in 1 second) are less than 80 percent of normal lung function (FEV1/FVC<80%). Treatment for Stage I COPD is usually a short-acting bronchodilator to be used as needed to open up restricted airways.

COPD Stage II / Moderate. People with Stage II COPD may experience shortness of breath while exercising, especially when climbing stairs. Most people become aware of COPD at this stage because coughing and mucus production becomes too excessive to be ignored. As in Stage I, treatment for Stage II COPD can be both a short-acting bronchodilator to be used as needed as well as one or more long-acting bronchodilator medications. Patients with moderate COPD are also urged to exercise their lungs by keeping active and undergoing pulmonary rehabilitation to maintain lung function. Stage II FEV1 numbers reveal between 50 and 79 percent of normal lung function (FEV1/FVC (50-79%)).

COPD Stage III / Severe. Stage III COPD can have a serious impact on a person's daily life activities. Increased shortness of breath is experienced during exercise, even when it is moderate. Flare-ups or exacerbations are more frequent, as is coughing and mucus production. In addition to treating Stage III COPD with one or more bronchodilators and pulmonary rehabilitation, physicians will often add inhaled corticosteroids for periods of exacerbation. Stage III COPD patients also should be vaccinated for pneumonia and seasonal influenza. Stage III FEV1 numbers reveal between 49 and 30 percent of normal lung function (FEV1/FVC<49-30%).

COPD Stage IV / Very Severe. Stage IV COPD is the most serious stage of the disease. Symptoms worsen, coughing and mucus production are even more frequent, and any activity, even eating, can be a challenge. Stage IV COPD sufferers often rely on oxygen therapy, but flare-ups from the disease are increasingly serious, even deadly. In addition to a variety of bronchodilators and inhaled corticosteroids, oxygen therapy, vaccinations and antibiotics, treatment may also include surgery to remove damaged lung tissue. Stage IV FEV1 numbers reveal less than 30 percent of normal lung function (FEV1/FVC<30%) [14].

Because of the severity of Stage IV COPD and the fact that Stage I COPD often remains undiagnosed, the focus within the eWall project will be on the Moderate and Severe (Stage II and III) cases of COPD.

Epidemiology, Economic and Social Impact of COPD

Predictions from the World Health Organization put COPD as the third leading cause of death in 2030. An observed increase in tobacco use contributed to this statistic. Several European countries participated to WHO's survey and provided information regarding amongst others economic and social impact. The statistical data is derived from official sources and public information.

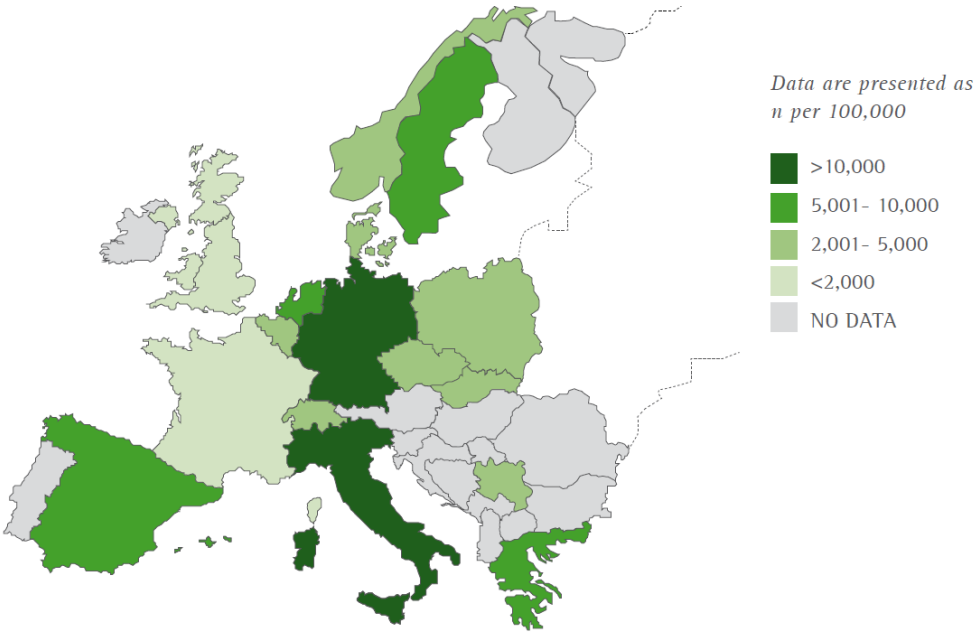


Figure 5: Incidence of COPD in Europe according to the Organization for Economic Co-operation and Development [15].

The EFA survey shows a variation of the incidence of COPD between 2% (in the Netherlands) and more than 10% (in Austria and Germany). This variation is due to the environmental, social and economic differences across Europe. As COPD diagnosis methods vary within the European countries, many cases do not appear in the official statistics. Other misclassifications may appear due to underdiagnosing young people and over-diagnosing elderly, as well as wrongly quantifying real disease dimensions.

Table 1: Incidence of COPD in Europe [15].

Country	COPD Incidence	Reference Population	Data Source	Year
Austria	10.7%	Adult population (over 40 years old)	Statistik Austria	2007
Belgium	5.3%	Middle-aged population	Ministry of Health. Health for All Database	2004
Czech Republic	2.4%	Adult population	Institute for Health Information and Statistics	2007
Finland	Over 5% of the population suffers from COPD; a further 5% suffer for latent COPD	Total population	The National Finnish COPD Programme	2007
France	Between 6% and 8%	Adult population	Ministere de la Sante et des Solidarites	2005
Germany	13.2%	Adult population	Geldmacher et al.	2008
Ireland	7.3%	Adult population	The Irish Thoracic Society	2008
Italy	4.5%	Total population	ISTAT	2007
Netherlands	2%	Estimated	The National Institute for Public Health and Environment	2006
Portugal	4.6%	Adult population	National Observatory of Respiratory Disease	2008
Serbia	6.0%	Adult population	Institute of Public Health of Belgrade	2007
UK	1.5%	Population >40 years	Stang et al.	2000

According to EFA, the total annual financial burden of lung disease in Europe is around €102 billion. COPD costs cover almost one half of this figure. The total social costs for managing COPD

patients revolve around €3.538 in Spain to 1024 in the Netherlands. The costs of health care systems per patient, due to exacerbations and subsequent hospitalizations range from €530 in France, €614 in the Netherlands to €3.238 in Spain. Table 2 shows the direct and indirect COPD costs as proved by the EFA survey.

Table 2: Direct and indirect COPD costs in European countries.

Country	Direct Costs Euro	Reference	Indirect Costs Euro	Reference
Austria	69,545,445	Ministry of Health	163,000,000	Institut für Pharmaekonomische Forschung
Belgium	5,600/patient	Centre federal d'expertise des soins de santé	no data	no data
Finland	108,000,000	Tynkkynen et al. Finnish Medical Journal 23/2009	194,000,000	Tynkkynen et al. Finnish Medical Journal 23/2009
France	530/patient	Piperno et al.	1078/patient	Piperno et al.
Ireland	437,000,000	Inhale Report, 2nd Edition	387,100,000	Inhale Report, 2nd Edition
Italy	2,724/patient	Social Costs of Asthma and COPD in Italy	216.84/patient	Social Costs of Asthma and COPD in Italy
Netherlands	280,000,000	The National Institute for Public Health and the Environment	no data	no data
UK	597810500 (GBP 500,000,000)	National Institute of Clinical Evidence	no data	no data

The social impacts of COPD can be tightly correlated with the evolution of the disease. Table 1 and Table 2

Depression and anxiety are frequently associated with COPD. Often patients suffer from anxiety of recurrent exacerbations. Depression slowly evolves with the patient gradually degrading ability to function in society, due to reduced physical capabilities, increase in the fear of exacerbation occurrence and lowered self-esteem [15].

3.2.2 Everyday Life of the COPD Patient

Effects on cognitive level

Persons suffering from chronic obstructive pulmonary disease often experience some form of cognitive decline during the disease progression. Cognitive decline can manifest itself in the form of memory loss, delayed reflexes or depression. According to [16], neuroimaging investigations show that adults with severe COPD may develop alteration in brain perfusion as a consequence of hypoxemia. Their study showed that COPD may cause or exacerbate diseases that are characteristic to cognitive impairment such as Alzheimer disease and vascular dementia. Also, due to the chronic nature of the disease and the progressively reduced physical capabilities, coupled by social pressure, COPD persons are highly predisposed to depression and low self-esteem.

Effects on physical level

Living with COPD can be a challenge. The disease strongly impacts the everyday life of the patient. At a physical level, COPD progressively affects the patient's ability to perform sports, physical work or everyday physical activities that may seem easy for the healthy: walking for long distances, climbing stairs, cycling, etc.

As breathing becomes progressively difficult, patients tend to avoid physical exercise and this leads to a decrease in peripheral muscle functions and in the overall muscle force. This leads also to COPD patients getting tired progressively faster when doing everyday activities.

According to the type of affection that causes COPD, patients tend to undergo changes in their body mass. Usually, but not always, patients with chronic bronchitis suffer an increase in their body mass, due to the fact that it is generally harder for them to breathe and this leads to a less physically active lifestyle. A rapid decrease in body mass can be experienced by patients with decreased lung tissue elasticity such as those with chronic emphysema. This derives from the fact that a decrease in lung tissue elasticity leads to more difficulties in exhaling. This makes eating difficult, as a discomfort in swallowing makes the patience eat less and have less appetite.

The persons suffering from COPD often suffer from cardiovascular abnormalities such as coronary artery disease or high blood pressure. It is highly recommended for the patients with advanced stages of the disease to be medically monitored and their cardiac risk to be assessed. Training duration, intensity and frequency should be individualized in order to obtain the best results and build the patient's self-confidence. Scaling shortness of breath can be used to monitor the patient's exercise intensity. Shortness of breath alone will not limit the exercise intensity. Intermediate exercises usually permit a higher intensity of training. [17].

Living with COPD also involves some adaptation to a new life style that is focused on minimizing the influence of home environment factors. Smoking or being subjected to secondhand smoke can be very harmful for a person suffering from COPD. Avoiding exposure to these hazards is advised. Aerosol products are also dangerous when used within the home environment. They can emit chemicals that are harmful to the respiratory system. Mold constitutes a danger to respiratory health and to prevent it, kitchens and bathrooms must be kept well ventilated and the indoor humidity level should be between 30% and 60%. A well ventilated house will avoid exposure to smoke and other harmful air pollutants. It is recommended to avoid using indoor fireplaces that are purely ventilated. Some air purifiers can provide up to 99% particle-free air.

Overall effect on behavior

Persons with COPD face physical as well as cognitive challenges. As a result, they change their behavior in order to cope with the disease characteristics. [16] discusses the overall effects of COPD on cognitive impairments and executive functions that require greater cognitive ability. It is demonstrated that COPD influences an increase in cognitive decline and actions such as handling money and medicine.

The disease strongly impacts the patients on a physical level, making everyday life tasks a challenge for them. Coupled with a cognitive decline and social pressure, COPD may be the cause of depression. Due to these difficulties in functioning, patients tend to exclude themselves from an active social life and this completes a vicious cycle of degradation in the physical and mental functions of the COPD patient. Often, the persons with COPD have trouble sleeping and relaxing.

Coping strategies

The most common way of improving the quality of life for a person that suffers from COPD is to undertake a carefully personalized exercise program that is designed to work their heart and lungs. These exercises are designed to improve how the body uses the oxygen, improve the breathing,

strengthen the heart, reduce blood pressure and improve the blood circulation. As a consequence to an active physical life, persons will enhance their emotional outlook.

The suggested exercises for COPD patients are:

- Stretching exercises that lengthen the muscles and increase flexibility. Stretching also helps in preparing the muscles for other type of exercises.
- Aerobic exercises use various muscle groups to move in a rhythmic pace. They work the heart and lungs and improve endurance of the respiratory muscles, resulting in improved oxygen use and better breathing. Using a stationary bike, walking or performing other types of activities of daily living (ADLs) is a good choice of aerobic exercise for persons with COPD.
- Strengthening exercises targeting the upper body will increase the strength of the breathing muscles.
- Breathing exercises for COPD result in stronger breathing muscles, getting more oxygen and breathing with less effort. The most common exercises are pursed lip breathing and diaphragmatic breathing.

Exercises must be well balanced with rest, lowering and increasing difficulty levels. Exercise programs are highly personal and should be designed by a doctor or a health care provider after a thorough consult and evaluation of the disease and overall physical condition of the patient. Heavy lifting, pushing, sit-ups or isometric exercises that involve pushing against immovable objects, walking up steep hills, outdoor exercises in bad weather conditions are to be avoided.

Medication plays an important factor in reducing the breathing difficulties and keeping the lung tissue from degrading further. According to the type of COPD and specifics of the breathing apparatus affection, doctors may recommend: bronchodilators - for shortness of breath, corticosteroid pills - to prevent and treat flare-ups, antibiotics - to treat infections that cause the flare-ups, flu and pneumonia vaccinations - to prevent some viral infections, supplemental oxygen - to boost the inhaled oxygen level.

3.3 Mild Dementia (MD)

3.3.1 Facts and figures

Dementia is a group of syndromes associated with a loss of memory and other cognitive abilities that are serious enough to interfere with daily task performance. The risk for exhibiting symptoms of dementia increase with age and doubles about every 5 years after the age of 60. The change of suffering from dementia is 1 in 50 for age 65 and 1 in 5 for those above 80. Mild Cognitive Impairment (MCI) is closely related to dementia and is often viewed as a precursor to developing dementia, as its symptoms are similar but less severe. We will describe both MCI and dementia in this section as both stages of memory deficits are relevant for eWall, as explained in paragraph 2.1.

MCI relates to a decline of cognitive abilities, often involving a deficit in memory, greater than age-expected but that does not significantly impact daily functioning. Patients diagnosed with MCI are supposed to be able to function independently but find some difficulties in their day-to-day life such as increased time necessary to perform daily tasks. The diagnosis cannot be compatible with dementia. MCI can be classified as amnestic (involving memory loss) or non-amnestic (involving another cognitive impairment than memory). From now on we will only consider amnestic MCI due

to the higher rates of progression to dementia (15% in case of amnestic and 2% in case of non-amnestic MCI).

Currently, there is no generally accepted diagnosis for MCI. The final decision for diagnosis is made by the doctor based on physical and cognitive examinations and on information provided by the patient and relatives. At this point, family members and loved ones (i.e. informal caregivers) assume a critical role. They are commonly the first ones to notice and keep track of the evolution of symptoms. The list of symptoms include memory deficit showing decline over time, and mental status showing mild level of impairment for respective age and education level. The mental performance is often assessed with the Mini-Mental State Examination (MMSE). Additionally neurological and imaging tests can be performed under physician's criteria in order to evaluate other possible origins of the memory problem (e.g. Parkinson's disease and brain tumor).

There has been an increased interest in MCI during the last decade (Peterson et al. 2009). However, there is not a commonly accepted definition of MCI. The condition was recently incorporated in the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders 5 (DSM-V) under the name "mild neurocognitive disorder". In any case, MCI is placed between expected cognitive decline associated to normal ageing and dementia (Table 3).

Table 3: Cognitive and Functional decline in normal aging, MCI and Dementia.

	Normal Ageing	**Mild Cognitive Impairment**	**Dementia**
Cognitive Decline: Deficitis of some areas of cognition over age-expected	NO	YES	YES
Functional Decline: Need support for daily functioning	NO	NO	YES

Although literature suggests that a significant amount of MCI diagnosis evolve into dementia (Figure 6), this progress is not straightforward. Actually, people with MCI can remain stable for years or even find improvements in their memory capacity. Due to its association with an increased risk of developing dementia, it seems critical to find strategies to cope with this neurocognitive condition.

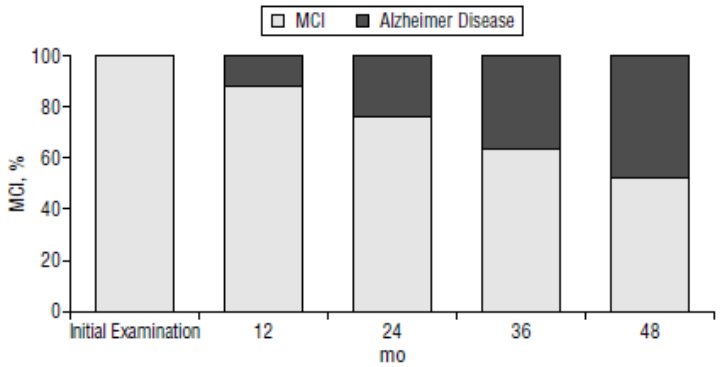


Figure 6: Annual rates of conversion from MCI to dementia over 48 months. (Peterson et al. 2009).

Currently, there is no standard treatment to MCI. It is recommended to adopt a healthy lifestyle, as well as to perform memory training. In the same way, there are no medications approved for use for

MCI. However, it is recommended to control disease that can directly affect the brain such as hypertension, depression, and sleep apnea.

Epidemiology, Economic and Social Impact of MCI

Reviews analyzing the prevalence of MCI present inconsistent data mainly due to different diagnostic criteria. One of the commonly accepted diagnosis criteria is the absence of impairment in daily functioning. What constitutes impairment of daily functioning is specific to each individual and considerable judgment is necessary from the physician/researcher to evaluate which impairments are normal age-related and which ones can be associated to a medical condition. This subjective judgment, combined with the difficulty in setting defined thresholds between normal aging, MCI and dementia, leads to substantial differences in the results of epidemiologic studies. For example, Peterson et al. (2009) performed a review of the evolution of interest in MCI in the years from 2000 to 2010 including reviews evaluating the prevalence of MCI in different parts of the world finding prevalence rates varying from 3% to 25%. Factors contributing to the bias include, but are not limited to, geographical location, sample size, and different inclusion criteria (e.g. age). Focused on Europe, the systematic review performed by [18] identified a prevalence range between 3% and 50% in elderly (over 65 years old) depending on the diagnostic criteria applied.

The incidence of MCI seems to be slightly higher for men than women and also higher in people with less education [12]. Actually, recent studies report a decrease in the prevalence of MCI in Europe and it is suggested that this fact is due to the overall increase education level of the European population during the last decades.

The evaluation of the economic impact of MCI is relatively sparse. “Patient dependence” is pointed as one predictor of costs associated to MCI. The decrease of productivity of both informal and formal caregiver is another indicator (Lin & Neumann, 2013). Costs associated with MCI can include the expansion of existing programs for elderly in early stages of dementia to those with MCI such as support groups for both, patients and informal caregivers, as well as memory training programs.

3.3.2 Everyday Life of the Mild Dementia patient

Effects on cognitive level

At a cognitive level, the memory deficit is reflected in many aspects of daily living such as forgetting simple and routine tasks of daily life, forgetting names of people recently met, having troubles remembering the flow of a conversation and misplacing things. Simple tasks as cooking or gardening can induce serious safety risks for those living with MCI. The previous aspects can lead to mental conditions as depression, anxiety, irritability and apathy. Depression should be carefully followed up as literature suggests a correlation between depression in MCI patients and the risk of developing Alzheimer Disease (Modrego & Ferrandéz, 2004; Richard et al. 2013). The person with MCI gets upset, angry and worried more easily.

Effects on physical level

MCI does not affect the physical level directly. However, the secondary effects such as depression can lower the normal physical activity level of the patient.

Overall effect on behavior

Although MCI does not cause changes in daily functioning, it comprises several constraints to the day-to-day life of the patient. These challenges are significantly increased when the patient lives alone. The combination between the physical and cognitive effects of MCI commonly leads to social withdrawal or even exclusion and consequently fasten of disease progress. Therefore, it is necessary to find strategies to motivate people to leave their houses and continue being proactive even after the disease diagnosis.

Coping strategies

An early diagnosis of MCI allows people to develop coping strategies to prevent the progress to a dementia state. Due to the differences in diagnosis and non-consensus in disease definition, there is no widely accepted professional guideline for MCI treatment. As for other diseases, it is also important to adopt healthy lifestyles, including smoke and alcohol cessation.

Increasing daily levels of physical activity has assumed an important role in coping with MCI since observational studies have reported its effect in the prevention of cognitive decline (Geda et al. 2010).

On the nutritional field, a diet low in fat and rich in fruits and vegetables is recommended.

Intellectual stimulation and memory training should be included in the routine of every patient suffering from MCI. Playing games and performing leisure time activities such as reading can help sharpening the memory. Patients with MCI are also encouraged to learn a new skill. As it is an age-related disease, most of the patients are retired and have more time to relax. This can be good but also a boost for depression and loneliness. Finding a new hobby can be very beneficial.

In any case, it is important to maintain social interactions and avoid exclusion. Activities such as volunteering in the local school or health care center can benefit both mind and body. It is also advised to enhance the contact with family members and friends. Other day-to-day tips pass through the use of memory tools such as to-do lists and big calendars, as well as, placing the most used objects of daily day (e.g. wallet, glasses, and keys) always in the same place. Making a clear daily routine can also be beneficial. Apart from that, talking therapies in communities of people suffering from the same condition are also advised as way to share experiences. It is also advised to keep brain stimulation activities such as reading and playing board games. Finally, it is important to keep a close contact with the physician in order to regularly monitor memory skills. And most of all, it is important to know when to call for help.

4 Personas

Personas are fictitious descriptions of single end-users. Each end-user is representative for one end-user population or a sub-segment of this population. These personas are presented as short stories about the specific person in which the most important characteristics of the (sub-) population are included as personal traits.

This section is divided into two subsections. First we describe the primary end-user personas in Section 4.1, then the secondary end-users are described in Section 4.2.

4.1 Primary end-user personas

Sections 0 through 4.1.6 below describe the 6 primary end-user personas, starting with 2 personas for *elderly users with age-related impairments*: Michael (4.1.1) and Simone (4.1.2). Then two personas are defined for *chronic obstructive pulmonary disease*: Petra (4.1.3) and Bob (0). Finally two personas suffering from *mild dementia*: Jane (4.1.5) and Phillip (4.1.6).

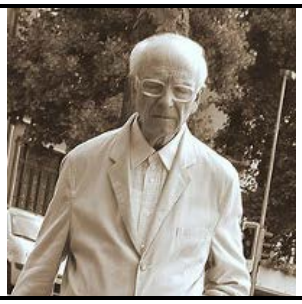
These personas are later used in the development of scenarios (Section 5) and referenced by name. As a summary and reference of these names, the personas and their friends/family mentioned in the descriptions are given in Table 4.

Table 4: Reference table of names of primary end-user personas and their friends/family.

Persona	*Summary*	*Ref*
Michael	67 year old male, suffering from ARI.	**(4.1.1)**
| Maria	Michael's wife.	
Simone	72 year old female, suffering from ARI.	**(4.1.2)**
| John	Simone's son.	
| Joanna	An old friend of Simone.	
Petra	43 year old female, diagnosed COPD Gold Stage II.	**(4.1.3)**
| Michelle	Petra's older daughter.	
| Alice	Petra's younger daughter.	
Bob	65 year old male, diagnosed COPD Gold Stage III.	**(0)**
Jane	74 year old female, suffering from Mild Dementia.	**(4.1.5)**
| Sarah	Jane's daughter.	
Phillip	66 year old male, suffering from Mild Dementia.	**(4.1.6)**
| Theresa	Phillip's younger sister (living together).	

4.1.1 ARI persona "Michael"

Persona:	Michael (67 years, male)
Domestic situation:	Living at home with wife (Maria) in a big city
Characteristics:	Hypertension, Forgetfulness, Social Anxiety, Lack of Motivation, Social Isolation, Experience with modern technology



Michael is a 67-year-old former business consultant who lives with his wife, Maria, in an urban center. Michael retired two years ago and Maria, who is expecting to retire in a year from now, has a job as a social assistant in the community center of their neighborhood.

As a business consultant, Michael had a very active life. He often travelled between the several departments of the company and met new people almost every day. During his last year as an employee, Michael started noticing difficulties in memorizing the names of the people he met. Keeping in mind the importance that social interaction has in his job, these lapses of memory often led to frustration. Michael thought this was only the result of a life of hard working and everything would come back to normal after retirement, by adopting a more relaxed lifestyle.

Actually, the situation only got worse. Michael started forgetting the birthdays of his friends, and he often failed to remember to take the medication for hypertension, a condition he was diagnosed of decades ago. Michael knows the importance of this medication and feels frustrated that Maria has to remind him all the time.

Maria encourages her husband to go for a walk in the central park of the city while she is at work but Michael does not want to do that. He used to enjoy the busy characteristics of the big city and feel excited about the crowded metro during the early mornings or the chaos in the main cross-roads. Now Michael is afraid of leaving the house alone. He feels disturbed in overcrowded places and, to find a calmer place, Michael has to go to the outskirts of the city. But in general he prefers to stay at home. Maria suspects that Michael spends most of the time on the couch, contrarily to what is recommended by the cardiologist, and she would like to be able to see how active her husband was during the day. She feels he needs a push to continue an active life.

To stimulate Michael's memory, Maria proposes playing games very often but Michael is not enthusiastic about the idea. She tried everything from Sudoku to Tic-tac-toe or word-games in the newspaper. In fact Michael shows a lack of enthusiasm in almost everything his wife proposes. Michael knows that Maria is trying to help him in all possible ways but he does not feel capable to cooperate. He feels frustrated and closes himself in his own world.

4.1.2 ARI persona "Simone"

Persona:	Simone (72 years, female)
Domestic situation:	Lives alone, son lives far away
Characteristics:	Reduced mobility, Social isolation, Hypertension, High cholesterol, No experience with modern technology

Simone is a 72 year old woman with reduced mobility due to balance problems. Simone is afraid of falling and prefers to support herself while walking by holding the wall, the furniture or handles placed specifically for this purpose by her son John. Her fear of falling also made her prefer to walk using her walking stick whenever possible. She doesn't go outside without it. Simone was never a very active person and the mobility impairment works as an excuse to spend her days sitting on the couch watching TV, ending up isolated in her home environment. As a result of her lack of self-initiative for almost any activity, Simone ends up eating much more than necessary. John is worried about the continuous weight gain of his mother, especially because she should follow a healthy diet due to her diagnosed hypertension and high level cholesterol, two common conditions at her age. Every time they talk on the phone, John asks if Simone cooked and what she ate during the day. Sometimes Simone avoids answering and John gets worried about her health. John believes his mother is totally capable of living independently at the cognitive level, but if her physical condition does not improve he will suggest a home care facility.

Due to her mobility issues, Simone was advised to do physiotherapy twice a week. However, to reach the clinic, Simone has to take two buses and she does not feel confident to do that by herself anymore. It is not possible for John to join his mother every week and Simone withdrew after the first month. Simone would benefit from a system that would allow her to do the exercises at home.

Simone's social life was encumbered by the mobility limitations. Simone used to go to the market every Saturday morning with her old friend Joanna, enjoying the time spent with the two of them. But now she feels ashamed of her walking pace and she tends to find excuses to skip the meetings week after week.

4.1.3 COPD persona "Petra"

Persona:	Petra (43 years, female)
Domestic situation:	Married, two children, lives with husband and one daughter
Characteristics:	COPD Stage 2, Overweight, Heavy smoker, Can't commit to physical rehabilitation programs, Experience with modern technology

Petra is a 43 year old woman, diagnosed with COPD GOLD Stage II. She has a part-time office job, preventing her from being physically active during the day. This has caused her obesity as well as her bad physical condition. She has a husband and 2 daughters. Her oldest daughter Michelle is a student at a university in the city, 150 kilometers from her house, and her youngest daughter Alice studies in the local high school. Petra is suffering from moderate dyspnea (short lasting and with medium recurring frequency), but she became more and more fatigued due to progressive gain in weight.

Alice, her youngest daughter, usually invites her friends to her house and sometimes Petra feels that her home environment suddenly becomes too crowded causing Petra's stress. In these situations, Petra usually prefers to interact as little as possible with the teenagers, as she is afraid they will not understand her condition. As her stress level rises, Petra risks manifesting some forms of dyspnea. She usually sneaks out on the balcony and smokes. She feels less stressed after a smoke break. Petra and her husband are long time smokers; they tried to stop on multiple occasions, but never managed to succeed.

Once per month, the oldest daughter, Michelle, comes to visit and it is a family tradition for all members to spend the evening together. It is important for Petra to be socially integrated and to maintain a healthy and active social life involving group activities. She justifies her lack of physical activity by not having enough time between her job and her taking care of the family. In reality, her social life revolves around her daughters and she makes little time for meeting friends and not-immediate family members.

One year has passed since Petra's last medical visit targeting her COPD. She decides to see a lung physician. Her evaluation showed that her COPD has worsened. Petra is advised to increase her daily medicine intake and is reminded by the doctor that it is critical to undertake a physical activity program. Due to her obesity, she also suffers from heart and circulatory problems and high cholesterol. This also contributes to her fatigue in her daily life physical activity (like walking to work, standing up for long periods of time, climbing stairs). She accepts to attend the physical activity program and starts with 2 months of guided exercises by a physiotherapist at the physical rehabilitation center in her town. After the 2 months, Petra starts feeling better and she gets a higher confidence in herself. Her physiotherapist makes a daily exercise plan that Petra is supposed to follow at home. She follows the plan for 2 months, but she slowly decreases the amount of exercises she performs, gradually loses her motivation and reverts to her old habits of physical inactivity.

4.1.4 COPD persona “Bob”

Persona:	Bob (65 years, male)
Domestic situation:	Lives alone
Characteristics:	COPD Stage 3, Ex-Smoker, Underweight, Hearing problems, Has trouble sleeping, No experience with modern technology

Bob is a 65 year old male and lives in the rural area of Enschede, the Netherlands. He was diagnosed with COPD almost ten years ago, and despite the fact he quit smoking, his disease is getting worse. Bob is a furniture maker, but due to his disease he stopped working. His dyspnea became severe, he became more and more fatigued, became progressively underweight, was coughing a lot, and he felt increasingly limited in his physical capabilities – the intense scent and dusty work environment made him feel even worse. He has difficulties in hearing and this makes communication extra difficult for him. The consequence is that his self-confidence substantially decreased. Moreover, he felt uncomfortable around his colleagues, who did not really understand his problems. He decided to stop working; he is at home a lot. He lives alone and one year ago, he decided to get a dog. Bob really enjoys the fresh air and walking with the dog in the forest.

During a visit to his general practitioner he was referred to the lung physician at the local hospital, since he was now in GOLD stage III, and from now on the lung physician would monitor him. He visits the hospital twice a year: once for an appointment with the lung physician and once with the nurse practitioner. They tell him that it is very important to stay active and strong: a lack of movement causes his physical condition to decrease rapidly, increasing his symptoms, and a vicious cycle will ensue. When his body is in a better condition and shape, Bob is able to do more with the same lung function. Therefore, Bob has to participate in a COPD physiotherapy programme, but he rarely goes since he finds it too far from his house, and he finds it boring to do exercises there.

But Bob’s situation is getting worse. This year Bob was even admitted to the hospital twice, due to exacerbations. Bob also lost 2 kilos of weight. The doctor again explains to Bob that exercise is really important to break the vicious circle and that nutrition provides his energy to breathe.

The dyspnea remains very severe and Bob is afraid to experience extreme dyspnea. He rarely walks the dog anymore. He likes to watch television, especially soccer and avoids physical activities and situations that might cause an attack of dyspnea again. His grandchildren say they sent him lots of emails, but he never reads them, because he doesn't know how this modern technology works.

His lack of movement causes his physical condition to decreases rapidly and he has trouble sleeping, caused by the low oxygen levels in his blood and the coughing. He also feels depressed, since he is less socially active. Therefore, Bob participated in the rehabilitation program for 3 months. Within these 3 months Bob trained with other COPD patients which he enjoyed and he improved his physical condition. However, 2 months later, he reclined to his original low activity levels, since he was not motivated to be this active by himself.

4.1.5 Mild Dementia persona "Jane"

Persona:	Jane (74 years, female)
Domestic situation:	Lives alone
Characteristics:	Cognitive decline, Memory deficits, Sleeping problems, Anxiety, Avoid social contact, No experience with modern technology

Jane is a 74 year-old-woman who has been living alone since her husband passed away ten years ago. Her only child Sarah lives 200 km away and tries to visit her mother once a month. In recent years, Jane has noticed some deficits in her memory capacity. In the beginning she would forget small routine appointments such as the weekly visit to the butcher. More recently she began losing track of things around the house. The pots appeared in the wrong place, and she couldn't find her favorite earrings.

Jane experiences some sleeping problems related to the work shifts she used to do during her nursery job in the local hospital. Jane was accustomed to uncommon sleep-wake patterns but after a point she would wake up during the night to go to the toilet and suddenly forgot what she was doing.

Jane used to be a very active outdoor person. Now she does not feel able to do much physical activity but she would never give up on her daily walks through the neighborhood. These walks made her feel calm. It was when she found herself lost in her own neighborhood that she felt the urge to visit her General Practitioner. After several tests Jane was diagnosed with Mild Dementia. Jane's GP set a plan including both physical and cognitive stimulation. Jane was advised to keep active by doing her daily walks and keep leisure activities as reading or playing games with friends. The GP also wants to arrange more frequent meetings with Jane but he is very restricted in his available time. Jane is advised to keep a journal to write what she does during the day, what she cooked, etc. Jane finds it funny because it reminds her of her diaries during childhood.

Recently Jane tried to go for a walk a few times but was too afraid of getting lost. She ended up walking around her house and going back home after a couple of minutes. She knows this is not enough to elevate her heart rate but cannot fight the fear. Jane also thought of doing some exercises at home but she does not know what to do. And she cannot find the motivation to do it.

One of Jane's weekly routines used to be the reading club. These meetings encouraged Jane to read and also supported the contact with old time friends. However, lately Jane has found it more difficult to follow the flow of the discussions. She was afraid that other people would notice her difficulties and progressively withdrew from the meetings. Actually, Jane started to avoid every kind of social contact. And the more social interaction Jane avoids the lonelier and depressed she feels.

After the diagnosis, Sarah calls more often. She is worried about the fact of her mother living alone without regular assistance. She wishes she could have an insight on Jane's daily routine and be more present in her life, but she can't visit more often due to the distance separating the cities.

4.1.6 Mild Dementia persona "Phillip"

Persona:	Phillip (66 years, male)
Domestic situation:	Live with his younger sister (Theresa)
Characteristics:	Suffered a stroke, Vision problems, Gaps in working memory, Social isolation, Low physical activity, Experience with modern technology

Phillip is a grocery store owner who lives with his younger sister Theresa in a rural area. Two years ago, at age 64, during a normal working day, Phillip suffered a stroke. A few months after the incident, Phillip was feeling physically recovered. Theresa suspected however that his cognitive capacity had been affected. Phillip frequently seemed disoriented and his mental calculations as cashier were not as fast as they used to be. Theresa also noticed occasional changes in the mood of her brother. Phillip was always a relaxed person but suddenly started showing irritability at minor things and even some aggressiveness. As he advanced in age, Philip's eye site got worse. After the stroke, he noticed that it is very difficult for him to recognize objects further than 5 meters away.

The serious concerns started one day when Theresa arrived home from work and found the stove on and Phillip relaxed in the living room watching TV. When asked about the incident, Phillip answered that he did not have any memory of turning the gas on. At this moment, Theresa started fearing for her brother's safety. After this episode Theresa registered all events of forgetfulness on her notebook. When she thought she had collected a substantial number of events, Theresa confronted Phillip and, although reluctant, he was convinced to visit the General Practitioner. Phillip answered a couple of standardized questionnaires and talked to the physician about the events of the last months. Theresa's notebook played a crucial role. Finally Phillip and Theresa got the diagnosis that Phillip suffers from Mild Dementia.

After the diagnosis Theresa started searching for information on how to help her brother. Books, Internet, special issues of magazines. It was in the community group for caregivers of persons diagnosed with Mild Dementia that she found the biggest support. She found out that Phillip should keep performing activities that challenge him both physically and mentally. This could be difficult, considering that Phillip feels fearful and suspicious about almost everything and everyone.

Phillip's cognitive decline is clear to everyone. He used to deal with a lot of people during the day in this grocery store but lately he often asks Theresa to replace him at the cashier, preferring other back-up tasks such as stock checking or replacement. It became hard for Phillip to follow a conversation. He often has troubles finding the words he wants to say and keeping track of the conversations. For that reason, Phillip also withdrew from the weekly hiking meetings with some of his oldest friends. Instead of meeting his friends, Phillip started going outside alone. This is a big concern for Theresa considering that for three times Phillip got disoriented and could not find his way home, even when doing well-known paths. He was only able to get back home because an acquaintance was passing by. Against Theresa's advice, Phillip does not give up on his walks in the surroundings.

4.2 Secondary end-user personas

Sections 4.2.1 through 4.2.4 below describe an initial set of 4 secondary end-user personas, including the *general practitioner* Karen (4.2.1), a *hospital nurse practitioner* Lars (4.2.2), a *visiting nurse* Helen (4.2.3) and the *informal caregiver* Maria (4.2.4).

Section 0 provides also an initial set of scenarios describing some of the ways in which the eWall system can support these secondary-personas. In these scenarios, also the secondary personas are referenced by name. As a summary and reference of these names, the personas are shortly summarized in Table 5.

Table 5: Reference table of names of secondary end-user personas.

Persona	*Summary*	*Ref*
Karen	General practitioner (GP)	**(4.2.1)**
Lars	Hospital nurse practitioner	**(4.2.2)**
Helen	Visiting nurse	**(4.2.3)**
Maria	Informal caregiver to Michael (4.1.1)	**(4.2.4)**

4.2.1 General Practitioner persona "Karen"

Secondary persona: Karen (General Practitioner)
Tasks: Consultation hours for patients, medication prescriptions, house visits to house-bound patients

Karen is a general practitioner in the Enschede area. She starts her work day at 07:45 by logging into her computer and browsing through her e-mail and through the out-of-hours faxes, in case any of her patients need to be contacted for a follow-up. She then highlights the diagnosis of all 12 electronic letters and writes them into her patient log as entry notes. Then she pours a cup of coffee and says hello to her colleagues, before the opening hour starts at 08:00. Between 08:00 and 10:00 she sees around 10 patients. Today she consulted a patient with chest pain who needed an ECG, another had seen a cardiologist and required a major medication change; an elderly lady had her bi-annual check-up regarding her cognitive decline and needed a change in her medication along with a new diet.

After the consults, Karen takes part in the daily clinical meeting, a 30 minutes review where doctors share information about their concerns for patients and hear the nurse's presentation of patients requiring doctor's inputs. She is warned that a previously aggressive patient is scheduled to come later in the morning. She has 5 more patients booked after 10:30 that include the potentially aggressive person, who turned out to be kind and thankful this time. Karen grabs another coffee and goes on seeing the urgent patients; she has time to check her new messages, writes 2 referral letters for physiotherapy and arranges several blood tests.

At noon she receives a call from a physiotherapist reporting on one of her patients. Then she goes through her the phone messages collected by the receptionist during the morning and makes some calls back to her patients with answers to their questions. This reduces the need to make extra appointments. Twenty minutes later, she checks her patient's hospital results on her computer. She uses them to update medications. At 12:45, she has read all her electronic messages and she is ready to collect her 'real paper' in-tray. This contains minutes from the practice meetings, several letters from pharmaceutical companies and various insurance forms for completion.

By 13:00 she is ready for the dispensary. The 'query' clip contains prescription counterfoils where patients have requested 'expired' medications (i.e. they were scheduled for review) or medications that do not appear to be on their repeat list. This takes 10 minutes to sort out, and then she collects around 120 prescriptions for checking and signing.

An urgent call comes through to visit one of the very poorly, house-bound patients, and it can't wait. Karen gets back to the hospital at 14:15 and finds a patient has arrived early for surgery. Then she quickly goes through 8 electronic letters that have just come in. She signs the letters and prepares for the afternoon consults. She sees 18 patients in the afternoon. At 18:00 she checks her messages again. There are 4 messages from which one is for a visit, which she schedules for the next day. She dictates a few more letters and finishes the work day at 18:30.

4.2.2 Hospital Nurse Practitioner persona “Lars”

Secondary persona: Lars (Hospital Nurse Practitioner)
Tasks: Arranges medication for admitted patients, performs standardized tests and assessments, admits patients to the hospital

Nursing is a process and nurses from every field of medicine need to have a process based thinking, by constantly assessing the needs of the patients, identifying (or diagnosing) problems, planning how the needs and problems are addressed, implementing the plans and evaluating the outcomes.

Lars starts his work day at 7:00 in the morning with a meeting to which both nurses and doctors attend. They discuss the state of the patients already admitted in the hospital unit. This meeting usually lasts no longer than 30 minutes. Then, Lars goes through his work e-mails and faxes, replies to the queries that he can and checks his list of patients scheduled for tests during the day. He also makes the premed orders (medications that patients need to take for the procedures).

At 8:00 he sets up his equipment for lung assessment and gets ready for his first patient scheduled at 8:15. This patient required a basic lung assessment and a spirometry test. Lars will write the results of the assessment and test on the patient’s entry document while the doctor performs the consult.

His next patient is a COPD patient and this is his first of the 2 annual assessment meetings. Since this is not his first COPD assessment, Lars will perform the consult without the need to involve a doctor. After the standard pulmonary assessment procedure, Lars has a discussion with the patient using a COPD state evaluation questionnaire. The information in this questionnaire plays a very important role in getting as much information as possible about how the patient is dealing with the disease, what are the characteristics that changed since the last consult and having a clear idea on the patient evolution. This is both time consuming and, due to the reduced frequency of the consults, they provide limited insight. Based on this questionnaire, after the consult, Lars has to extract relevant knowledge about the evolution of the disease and fill in the patient record. During his workday, he will perform around 3 more of such assessments. They each vary from 30 to 50 minutes.

It is 10:30 and Lars, gets a message about a new critical patient arrival with severe exacerbation. He will meet the patient and arrange his admission to the hospital.

4.2.3 Visiting Nurse persona "Helen"

Secondary persona: Helen (Visiting Nurse)
Tasks: Visits patients at home, treats wounds, gives medication

Helen is a visiting nurse in the eastern Aalborg area in Denmark. She starts her workday at 07:00, as she is part of the day shift. She meets with her colleagues at the office and drinks a cup of coffee while discussing the tasks of the day. The office planner hands out the routes of the day. Helen has her first visit at 7:30, and she is therefore out the door and on her way again quite quickly.

Her first visit is with Frank. Frank is 77 years old, has diabetes and suffers a lot from diabetic ulcers. Helen treats the ulcer and gives Frank his medication. After the visit Helen jumps in her car and drives to the next visit. Helen does 15 visits throughout the morning. Her last visit is with Bob who has severe COPD. Bob has a lot of trouble breathing and a bit more mucus than usually. Helen chooses to give Bob cortisone and hopes that it will decrease his symptoms.

After her last visit, Helen drives back to the office. She is back at 12:45 – just in time to have lunch with some of her colleagues. She then finishes her day doing paperwork. She also has some questions regarding today's visits that she needs to address to the patients' general practitioners. She calls three different general practitioners because the citizens' are not assigned to the same GP clinic. Helen finishes her day at 3:00.

4.2.4 Informal Caregiver persona "Maria"

Secondary persona: Maria (Informal Caregiver)
Tasks: Helps Michael (her husband) with: eating, hygiene and daily planning. Motivates Michael to be active socially and physically

Maria starts her day by getting up at 7:00. Every morning she needs to get up earlier than Michael, because she will have to prepare breakfast and help her husband with his morning hygiene routine, then prepare herself for going to work. Michael's doctor suggested that Michael should be engaged in various activities during the day, such as, getting his daily newspaper from the city center, going for a walk in the central park of the city, and solving crossword puzzles. As Michael usually wakes up between 8:00 and 9:00, Maria also has time to read and revise Michael's day planning.

Michael does not always follow his morning routine; instead he just sits on his bed. In these moments, he loses track of time and can sit in this position for half an hour. The doctor instructed Maria, that in such moments she need to approach him gently. Maria takes a seat facing Michael and tells him: "Good morning Michael! Please come for your shower." She talks calmly. She knows that Michael understands and responds to short and simple sentences and longer explanations may confuse him. At the moment, Michael is still able to shower, brush his teeth and change into his day clothes alone, but sometimes he needs some guidance from Maria. She lets him do as much as possible alone and helps him whenever he looks confused or upset.

At 8:30 Maria and Michael meet at the dining table. Maria always makes sure that she and Michael have breakfast together. As he needs as much engagement as possible, Michael is in charge of setting up the table, according to Maria's suggestions. At 9:00 it is time for Michael to take his medicine and so, he goes to his pill organizer box, which was carefully labeled by Maria and takes his pills from the correct container. This action has to be carefully observed by Maria and she usually follows and observes him throughout this process.

At 9:15 Maria shows the day plan (which is written on a paper on the refrigerator door) and goes to work. At 13:30, Maria calls home, from her office. She reminds Michael that his lunch is in the Tupperware in the refrigerator. She also tells him that he can call for food delivery, if he prefers to eat something else and that he can find a menu with the phone number, on the refrigerator door, next to his day plan.

At 18:00, Maria arrives home and asks Michael if he managed to follow his day plan and if she can help him with something. She also tries to engage Michael in as much physical activity as possible and suggests starting their daily exercise routine. She will do the exercises alongside Michael while carefully guiding him when needed. The training session lasts for at least 30 minutes. At 20:00 Maria prepares dinner and she also checks Michael's pill box and refills it with missing pills when necessary.

As Michael goes to sleep usually no later than 21:30, Maria will take some time for herself and watch her favorite TV shows until 23:00.

5 Scenarios

The scenarios described here show how the envisioned eWall system can support the various personas (Section 4) in their day-to-day life.

Scenarios are a perfect means to create a common view on the services we want to create. The eWall system is described as a series of functionalities, for each persona. Each one of these functionalities could correspond to a module of the eWall system. Modules should be loosely coupled and as less codependent as possible. Communication between modules can be done via middleware and data and knowledge repositories. Module output will be transformed into knowledge that will form the user profile. The user profile describes in depth the profile of the person for which the eWall home installation is being used, from a therapeutic perspective.

5.1 Scenarios for primary end-users

5.1.1 eWall supporting Michael (ARI)

1. Physical exercise.
Since Michael is suggested daily exercise, eWall can contain a home exercise installation such as a stationary bike with sensors, or a treadmill, an abdominal machine with sensors and/or a video based system that constantly measures his performance. For extra motivation, eWall can combine and contextualize the home exercise program using immersive media technologies, augmented and/or virtual reality technology and gamification techniques.

Michael will follow eWall personalized training program that consists of two main parts: cardiovascular exercises and overall muscle strength maintenance exercises. Since Michael is no longer an active person and his goal is to increase his mobility and get in shape, he is able to perform a pre-training muscle warm-up, which will engage his full body and also elevate his heart rate. This warm-up consists of few breathing exercises and stretching exercises. eWall will assist Michael, by detecting his body posture and reading his heart beat frequency by using the data provided by the Body Area Network (sensor belt or sensor wristband) correlated, when possible, with sensor installations within the Home Area Network (i.e. close proximity 3D sensors, video sensing) and provide him with appropriate rhythm incentives, like music and exercise repetition count (audio and visually represented).

Next comes the treadmill. This is part of his cardiovascular training and, based on his heart rate and oxygen saturation, eWall will show and/or tell Michael motivating messages. Muscle tonus and strength will be increased by using elastic band exercises. These types of exercises engage most of the body and eWall will be able to detect the type and correctness of the exercise execution using HAN sensor data. As a feedback, eWall will show and tell motivating and or correcting messages and provide rhythm appropriate incentives (i.e. music and exercise repetition count).

All the exercises are followed by an appropriate resting period. The eWall also shows his performance compared to friends and family, so he gets additionally motivated to make physical exercise as often as possible. All sensor data captured by this module will be automatically analyzed and reasoned upon. The eWall system will generate relevant knowledge of the status of Michael's

health and his ability to follow the training program. This knowledge will update Michael's user profile.

2. Daily Activity Monitoring.
Besides the exercise planning, Michael also benefits from the wearable sensor he carries around during the day to encourage a more active lifestyle. The eWall system provides personalized and contextual feedback as well as suggestions on ways to become more active. For example, when it is sunny outside, eWall provides gentle motivation cues encouraging a walk in the park after a period of inactivity.

The eWall system also provides daily activity goals. These goals follow Michael's progress and are adaptable to his routine. After dinner, Michael checks his daily progress and, when below the goal, he does some gardening in order to meet his goal. After eWall, Michael is more aware that small steps can increase his general level of activity and consequently, become physically and mentally healthier. Even his mood changed; Maria noticed a significant increase in his level of self-initiative. The eWall system also gives the chance to share his achievements with his friends.

3. Calendar/agenda.
When Michael wakes up, he can see displayed on the eWall screen the birthdays of his friends and relatives, as well as the most important appointments of the day.

4. Memory book.
Michael was advised by his GP to keep track of all the events that happened during the day. With eWall, he can choose between doing it in a form of a diary, in which he can write about the event, or just upload pictures and add small descriptions. Every time Michael wants to remember something he only has to search on his memory book. He can also configure which events are private and which ones she wants to share.

5. Cognitive stimulation.
Michael knows the importance of keeping cognitive training. The eWall provides weekly recommendation of books and movies according to his profile and also based on the list of items already seen/read. Also, the eWall prompts periodical messages advising small games aiming cognitive training. Other cognitive training provided by eWall is the memory game using the pictures from his memory book where the objective is to find all the matching pairs of pictures.

6. Outdoor guidance.
Living in a big city, it is not easy to avoid overcrowded places. Before leaving the house, Michael checks on eWall what are the most crowded places and chooses his destination in the predefined options. The PTD monitors his deviation from the desired route forming a virtual geo-fence. The eWall system will display gentle notifications on the PTD, when Michael's detected geographical position exceeds the tolerance threshold, offering him guidance to the desired destination. Together with Maria, Michael can set new routes and add optional buttons. Maria can also keep track of Michael's geographical position.

7. Medication support.
Michael knows the importance of taking his medication for hypertension. However, when Maria is not at home, he forgets to do it almost every time. It changed with eWall. Michael gets gentle reminders to take his medication at the desired times. When Michael is not responding appropriate

additional reminders are given, using an agreed escalation scheme. The eWall system will keep track of the frequency of Michael's failures to respond.

8. Social integration.
Michael was always very competitive. Now with eWall, he can keep track of his friend's scores on the cognitive games. This stimulates him to play regularly. Michael can also video-call his friends and keep a closer contact. As part of the social integration module, eWall will suggest outside activities, based on Michael's user profile. For example: eWall could suggest Michael to pick-up playing golf. Once Michael agrees, eWall will suggest adapting the Physical exercise module to target specific muscle training for golf players.

9. Data security.
Michael has a fully protected digital identity associated with eWall and he has access to his data at all times. He can view all his data by accessing eWall data aggregation services after providing a username and password in the login phase. He may only view his personal data and data adjacent to his eWall digital identity (the social integration configuration, the identity and contact information of the qualified medical personnel that can view her data and edit configuration on her eWall installation).

10. Healthcare support.
Michael has access to phone and video call service through eWall main screen and the handheld device, in order to get in touch primarily with his therapist, GP, medically trained caretaker. The eWall system will use a gentle reminder with a previously agreed upon escalation scheme to tell Michael when he has to take part in such a (video) call.

During the (video) call, the trained medical person is able to share with Michael, via an easy to understand interface, an aggregation of Michael's recorded data and any other digital references (written text, additional media) needed during the session. This will help Michael in understanding his disease state and inform him about future therapy steps.

During the (video) call, eWall can be remotely configured by the trained medical person, once agreed upon by Michael, for enabling, disabling, modifying modules within eWall's functionality.

11. Technical support.
The eWall system is a self-sustainable computational system. It can detect internal malfunctions and it is able to send detailed feedback about the occurring errors or non-responsive modules, to a technical administration team, while not compromising in any way Michael's confidentiality privileges.

Michael agrees to notify any malfunction that may occur throughout eWall's runtime. He agrees on allowing medical trained professionals, namely: his therapist and his home caretaker to have access to both: his personal medical data recorded by eWall and his eWall installation configuration and functions. As he has lower than average technical skills, he has access to a part of the maintenance functions of eWall (he is able to get in contact with a technical help service operator by phone and/or video call; he has access to follow troubleshooting steps, in case eWall detects unresponsive or malfunctioning connections and modules with a easy to follow through interface; he is able to perform a system reset, when eWall has a malfunction and specifically notifies Michael to take this action).

5.1.2 eWall supporting Simone (ARI)

1. Physical exercise.
Her home exercise equipment consists of: a wearable sensor belt or bracelet, a stationary bike, a series of elastic bands (the home exercise is set within 2 meters from the eWall main screen), free weights, ankle and wrist weights. Simone will follow eWall personalized training program that consists of 3 main parts: cardiovascular exercises, overall muscle strength maintenance and specific balance exercises. Since Simone is old aged and her goal is to lose weight, get in shape and improve her mobility, she is able to perform a pre-training muscle warm-up, which will engage her full body, elevate her heart rate and also require the body to get more oxygen into the blood. This warm-up consists of few breathing exercises and stretching exercises. eWall will assist Simone, by detecting her body posture and reading her heart beat frequency by using the data provided by the Body Area Network (sensor belt or sensor wristband) correlated, when possible, with sensor installations within the Home Area Network (i.e. close proximity 3D sensors, video sensing) and provide her with appropriate rhythm incentives, like music and exercise repetition count.

Next comes the stationary bike. This is part of her cardiovascular training and, based on her performance and heart rate, eWall will show and/or tell Simone her performance and provide her with motivating messages. EWall offers also additional functions: she is able to invite family and friends to join the biking in a virtual environment. EWall is able to compensate for differences in capacity, so the relative effort is equal for all persons. Muscle tonus and strength will be increased by using elastic band exercises. These types of exercises engage most of the body and eWall will be able to detect the type and correctness of the exercise execution using HAN sensor data. As a feedback, eWall will show and tell motivating and or correcting messages and provide rhythm appropriate incentives (i.e. music and exercise repetition count).

All the exercises are followed by an appropriate resting period. Specific balance exercises require the use of exercise equipment for body support (e.g. chair, standing support, and walking stick) and the on body sensor belt. Repetitions will be tracked by eWall in a similar way, with the previously mentioned feedback mechanism. All sensor data captured by this module will be automatically analyzed and reasoned upon. The eWall system will generate relevant knowledge of the status of Simone's health and her ability to follow the training program. This knowledge will update Simone's user profile.

2. Daily Activity Monitoring.
Since her situation worsened, Simone has used her mobility impairment as an excuse to justify inactiveness. The distance that separates her bedroom from the living room is the longest performed inside the house. However, that changed after eWall. The wearable sensor measuring activity that she carries around during the day motivates her to become more active. Being aware of Simone's condition, eWall provides attainable goals for her mobility limitations. The eWall system also provides personalized feedback and motivational cues regarding her condition. Now she forces herself to walk around and do the house duties feasible concerning her limitations. The eWall system keeps track of the frequency of Simone's failures to respond the motivation cues.

After eWall, Simone is more aware that small steps can increase her general level of activity and consequently, become physically and mentally healthier. The eWall system also gives the chance to share her achievements with her friends.

3. Daily Functioning Monitoring.
John is afraid his mother does not cook as often as desired and eats more pre-prepared food. eWall is designed to monitor the daily functioning of the targeted person, such as sleep quality and quantity, eating habits, use of household appliances, daily or periodic habits such as: home entertainment (watching movies, inviting family and friends), cleaning the house. This functionality will "read" all sensor data that is relevant within the context of daily functioning, excluding the situational sensor data, such as: physical exercise correctness data. The monitored information will be transformed into knowledge that contributes to the primary user's profile. Based on this profile, eWall will adapt its decision making mechanisms for a better interaction and communication with its user.

4. Nutritional coach.
The eWall system has a nutrition coaching service that can suggest diets and compatible food recipes and local food providers with compatible menus. The eWall system will provide Simone with appropriate descriptions of what she can eat in order to maximize her physical exercise results and overall wellbeing, in the context of her health state. The eWall system will send gentle reminders about eating time, using an agreed upon escalation scale.

This service is controlled and configured by her medical caregiver or nutritionist and therefore can be tuned during (video) call sessions, home visits or by Simone herself. The service will be configured to trigger gentle reminders, using an agreed upon escalation scale that tells Simone when and what to eat, with respect to her physical exercise scheduling and her day planning.

5. Social integration.
Whenever Simone wants to go to the supermarket, she checks the map displayed on eWall where she can see if any of her friends have already shown intention to take the same route during that day. If not she prompts a message: *does anyone want to go to the supermarket this afternoon?* Simone checks this map every time she wants to leave the house. This is a good way to see her friends while making her walks more pleasant.

With eWall, Simone found out that there are more people with mobility impairments and they organize walks all together. There is no reason to be ashamed of her walking pace.

6. Healthcare support.
Simone has access to phone and video call service through eWall main screen and the handheld device, in order to get in touch primarily with her close family, therapist, GP, medically trained caretaker. The eWall system will use a gentle reminder with a previously agreed upon escalation scheme to tell Simone when she has to take part in such a (video) call.

During the (video) call, the trained medical person is able to share with Simone, via an easy to understand interface, an aggregation of Simone's recorded data and any other digital references (written text, additional media) needed during the session. This will help Simone in understanding her health state and inform her about future therapy steps (if needed).

During the (video) call, eWall can be remotely configured by the trained medical person, once agreed upon by Simone, for enabling, disabling, modifying modules within eWall's functionality.

7. Data security.
Simone has a fully protected digital identity associated with eWall and she has access to his data at all times. She can view all her data by accessing eWall data aggregation services after providing a username and password in the login phase. She may only view her personal data and data adjacent to her eWall digital identity (the social integration configuration, the identity and contact information of the qualified medical personnel that can view her data and edit configuration on her eWall installation).

8. Technical support.
The eWall system is a self-sustainable computational system. It can detect internal malfunctions and it is able to send detailed feedback about the occurring errors or non-responsive modules, to a technical administration team, while not compromising in any way Simone's confidentiality privileges.

Simone agrees to notify any malfunction that may occur throughout eWall's runtime. She agrees on allowing medical trained professionals, namely: her therapist and her home caretaker to have access to both: her personal medical data recorded by eWall and her eWall installation configuration and functions. As she has lower than average technical skills, she has access to a part of the maintenance functions of eWall (he is able to get in contact with a technical help service operator by phone and/or video call; she has access to follow troubleshooting steps, in case eWall detects unresponsive or malfunctioning connections and modules with a easy to follow through interface; she is able to perform a system reset, when eWall has a malfunction and specifically notifies Simone to take this action).

5.1.3 eWall supporting Petra (COPD)

Petra has above average knowledge about the use of modern consumer technology, like PC's, Internet, tablets and smartphones. Knowing that her condition has worsened, she searches for information on the internet and finds the eWall project website which contains detailed statistical analysis and demonstrated results of the eWall support for COPD patients. She is interested in getting a professional opinion and mentions eWall to her doctor. They both decide that eWall is worth trying and are optimistic about future results.

1. Physical exercise.
Since Petra is suggested daily exercise, eWall can contain a home exercise installation such as a stationary bike with sensors or a treadmill, an abdominal machine with sensors. For extra motivation, eWall can combine and contextualize the home exercise program using immersive media technologies, augmented and/or virtual reality technology and gamification techniques. The eWall system will provide a progressive disclosure user experience, where the exercise routine is divided in steps and the exercises are grouped by the effect they target (i.e. cardio exercises, muscle strength exercises, etc.).

Her home exercise equipment consists of: a wearable sensor belt or bracelet, a treadmill, a series of elastic bands (the home exercise is set within 2 meters from the eWall main screen). Petra will follow eWall personalized training program that consists of 3 main parts: cardiovascular exercises, overall muscle strength maintenance and specific breathing exercises. Since Petra is middle aged and her goal is to lose weight and get in shape, while keeping her COPD under control, she is able to perform a pre-training muscle warm-up, which will engage her full body, elevate her heart beat and also require the body to get more oxygen into the blood. This warm-up consists of breathing exercises and stretching exercises. eWall will assist Petra, by detecting her body posture and heart beat frequency provided by the Body Area Network (sensor belt or sensor wristband) correlated, when possible, with sensor installations within the Home Area Network (i.e. close proximity 3D sensors, video sensing) and provide her with appropriate rhythm incentives, like music and exercise repetition count.

Next comes the treadmill. This is part of her cardiovascular training and, based on her heart rate and oxygen saturation, eWall will show and/or tell Petra motivating messages.
Muscle tonus and strength will be increased by using elastic band exercises. These types of exercises engage most of the body and eWall will be able to detect the type and correctness of the exercise execution using HAN sensor data. As a feedback, eWall will show and tell motivating and or correcting messages and provide rhythm appropriate incentives (i.e. music and exercise repetition count).

All the exercises are followed by an appropriate resting period. Specific breathing exercises do not require the use of exercise equipment, other the on body sensor belt. Repetitions will be tracked by eWall in a similar way, with the previously mentioned feedback mechanism. All sensor data captured by this module will be automatically analyzed and reasoned upon. The eWall system will generate relevant knowledge of the status of Petra's health and her ability to follow the training program. This knowledge will update Petra's user profile.

2. Daily Activity Monitoring.
This module monitors Petra's daily activity both inside and outside her house through a wearable sensor. Using a questionnaire based mobile application, eWall will get knowledge about Petra's daily activity habits and updates her user profile. Based on the user profile, eWall provides Petra

with a personalized and contextualized feedback during the day, with moving tips to increase her activity. During the day, she gets feedback using the smart-phone or tablet. She is comfortable using this technology as she has experience with handling such devices for her work.

The eWall records inactivity and appropriate additional reminders are given, using an agreed escalation scheme. The eWall system will keep track of the frequency of Petra's failures to respond, update her user profile and adapt its motivational feedback.

Parts of Petra's activities are linked to cleaning the house and for this, eWall offers support for a better, healthier home environment. Since dust and air quality are very important, eWall constantly monitor home air humidity and chemistry using dedicated sensors. The eWall system contains and controls and air purifier and an air dehumidifier. Petra can configure eWall's rules of activation/deactivation of these devices.

3. Daily Functioning Monitoring.
eWall is designed to monitor the daily functioning of the targeted person, such as sleep quality and quantity, eating habits, use of household appliances, daily or periodic habits such as: home entertainment (watching movies, inviting family and friends), cleaning the house. This functionality will "read" all sensor data that is relevant within the context of daily functioning, excluding the situational sensor data, such as: physical exercise correctness data. The monitored information will be transformed into knowledge that contributes to the primary user's profile. Based on this profile, eWall will adapt its decision making mechanisms for a better interaction and communication with its user.

4. Daily functioning monitoring (socializing).
When multiple persons are present inside the home and Petra does not want eWall to post messages on the main screen, a question will be displayed on all devices, asking for Petra's approval for switching to a "private mode". This means that, if Petra agrees, eWall sends its notifications only to the handheld device (Petra's phone and/or smart watch). These notifications trigger also vibrations of the hand held devices, when set as such. The private mode setup will postpone or cancel physical exercise sessions and personal coaching sessions according to Petra's requests. This means that, in case such sessions are scheduled to start, Petra will be notified and asked for either a reschedule time, or a cancellation of the coaching (or therapy) session.

Medicine reminders will be displayed on the handheld device to avoid social embarrassment.

5. Nutritional coach.
The eWall system has a nutrition coaching service that can suggest diets and compatible food recipes and local food providers with compatible menus. The eWall system will provide Petra with appropriate descriptions of what she can eat in order to maximize her physical exercise results and overall wellbeing, in the context of her disease state. The eWall system will send gentle reminders about eating time, using an agreed upon escalation scale.

This service is controlled and configured by her medical caregiver or nutritionist and therefore can be tuned during (video) call sessions, home visits or by Petra herself. The service will be configured to trigger gentle reminders, using an agreed upon escalation scale that tells Petra when and what to eat, with respect to her physical exercise scheduling and her day planning.

6. Medication support.
Petra gets gentle reminders when she forgets to take her medicine at the prescribed time. When Petra is not responding appropriate additional reminders are given, using an agreed escalation scheme. The eWall system will keep track of the frequency of Petra's failures to respond. When Petra will have her periodic medical visit, her lung physician will be reminded to gently ask her the reason behind not taking her medicine at the prescribed times. Petra's eWall user profile will record, via this module, her medication history, starting since the eWall was installed in her home.

7. Social integration.
The eWall system suggests Petra activities that she can do together with friends and family and also engage her physically and socially, such as inviting friends for out-door bike rides, trekking, camping, dancing and bowling. Petra could schedule a meeting place and organize a path (when the type of activity allows it) and send invitations to her friends and family via social networks, e-mail, SMS. The eWall would record her activity via the wearable sensors and the sensors on the bike (when possible), but also track her position via GPS for safety reasons.

8. Healthcare support (Teleconferencing).
With eWall, Petra is able to schedule (video) calls with caregivers and friends, family in a conference like fashion. In this way, Petra's family members can take part in her therapy and/or consult sessions and get awareness about Petra's disease state.

Through these (video) consults between Petra and medically trained specialists, Petra can receive an accurate, expert assessment of her disease. The family members or friends can take part in helping Petra as informal caregivers, part of their training can happen during these (video) conference calls. Petra has access to teleconferencing service through eWall main screen and the hand held devices, in order to get in touch primarily with her lung physician, GP, medically trained caretaker. The eWall system will use a gentle reminder with a previously agreed upon escalation scheme to tell Petra when she has to take part in such a (video) call.

During the (video) call, the trained medical person is able to share with Petra, via an easy to understand interface, an aggregation of Petra's recorded data and any other digital references (written text, additional media) needed during the session. This will help Petra understand her disease state and inform her about future therapy steps.

During the (video) call, eWall can be remotely configured by the trained medical person, once agreed upon by Petra, for enabling, disabling, modifying modules within eWall's functionality.

9. Health monitoring (exacerbations monitoring).
Her daily pattern is monitored and especially symptoms related to exacerbations (coughing, fever, oxygen saturation, being less active). Petra is asked for how she feels, using a (portable) tangible device. This information is compared with information gathered during the past days to reason about Petra's present health status and to conclude what advices should be given and/or whether a physician or an informal caregiver should be warned. Feedback to Petra is given via voice and/or the screen.

The eWall system is connected to fast intervention units (ambulance service, fire fighter service) and provides Petra the possibility of calling for help in case of an extreme exacerbation or other incidents.

Petra gets as well seasonal disease information like a flu infection map and a pollen map of her current geographical area. The eWall system shows this information on the main screen and also on her portable tangible device (smartphone/tablet).

All questionnaire data captured by this module will be automatically analyzed and reasoned upon. The eWall system will generate relevant knowledge of the status of Petra's general health and the frequency of her exacerbation. This knowledge will update Petra's user profile.

10. Data security.

Petra has a fully protected digital identity associated with eWall and she has access to her data at all times. She can view all her data by accessing eWall data aggregation services after providing a username and password in the login phase. She may only view her personal data and data adjacent to her eWall digital identity (the social integration configuration, the identity and contact information of the qualified medical personnel that can view her data and edit configuration on her eWall installation).

11. Technical support.

The eWall system is a self-sustainable computational system. It can detect internal malfunctions and it is able to send detailed feedback about the occurring errors or non-responsive modules, to a technical administration team, while not compromising in any way Petra's confidentiality privileges. The eWall system can be remotely configured by the trained medical person, once agreed upon by Petra, for enabling, disabling, modifying modules within eWall's functionality.

Petra agrees to notify any malfunction that may occur throughout eWall's runtime. She agrees on allowing medical trained professionals, namely: her lung doctor and her home caretaker to have access to both: her personal medical data recorded by eWall and her eWall installation configuration and functions. As she has higher than average technical skills, she has access to a part of the maintenance functions of eWall (she is able to follow troubleshooting steps, in case eWall detects unresponsive or malfunctioning connections and modules; she is able to perform a system reset, when eWall has a malfunction; she is able to understand and reconnect to the internet when needed/possible).

5.1.4 eWall supporting Bob (COPD)

Since Bob has limited knowledge about how to use modern technology, his nurse introduces Bob to eWall and its components. The eWall system interface is able to show Bob information according to the state in which Bob is with his daily training program. The eWall system interface and interaction pattern is also tailored to fit Bob's knowledge about technology usage and his current perception abilities. The interfaces and interaction patterns are consistent throughout its various modules. Appropriate information and feedback are given according to the situation. After a small training session, Bob is able to understand and use eWall's basic functions.

1. Physical exercise.
Since Bob needs daily exercise, eWall will contain a home exercise installation, such as a stationary bike with sensors, or a treadmill with sensors, an abdominal machine with sensors. For extra motivation, eWall can combine and contextualize the home exercise program using immersive media technologies, augmented and/or virtual reality technology and gamification techniques. The eWall system will provide a progressive disclosure user experience, where the exercise routine is divided in steps and exercises are grouped by the effect they target (i.e. cardio exercises, muscle strength exercises, etc.).

Unlike Petra's routine, Bob will undertake a low intensity and low difficulty physical activity routine. The goal of the exercise is to maintain overall muscle strength, to increase respiratory muscle strength, optimize breathing and promote an increase in Bob's appetite. He is underweight and one goal of the therapy is to gradually increase Bob's muscle mass and mobility. His home exercise equipment consists of a stationary bike, a set of elastic bands and free weights. The home exercise is set within 2 meters from the eWall main screen.

An exercise routine will always begin by a warm up session. Bob will be monitored by eWall using the on body sensor belt that measures his heart beat rate, body gait and oxygen saturation and a set of HAN sensors (i.e. close proximity 3D sensors, video sensing) that can detect and track the accuracy of exercise execution, when possible.

After a proper warm-up, Bob will have to undertake elastic resistance exercises and free weight exercises, designed to reduce body fat and increase muscle strength and size. This set of exercises is detected and tracked by eWall using sensor data from both BAN and HAN. In a similar way with Petra's routine, eWall will track and detect the accuracy of Bob's exercise execution, give guidance and motivational feedback. The eWall system will detect Bob's rhythm and his present physical capabilities and will adapt its feedback in order to avoid Bob's over-exercise or under-exercise.

The cardio exercise enables a simulated bike ride through a virtual representation of a track (i.e. virtual biking through a forest, virtual biking through London (Immersive Media - Demos)). Since this is not a precision exercise, eWall will recognize this type of exercise as one that does not require additional body motion and posture tracking using HAN sensors and will decide that the body sensor data is sufficient. In order to strengthen motivation, virtual biking with a group of other people at their home is offered. Appointments can be made via eWall and then biking in a group in the same environment is offered. Social interaction is possible via speech and differences in capacity are automatically compensated for, so everybody has a similar relative performance. The eWall system measures oxygen saturation constantly and will warn Bob in time to decrease his efforts so he will not experience a serious lack of air.

The last part of Bob's training consists of specific breathing exercises. These exercises do not require the use of exercise equipment, other the on body sensor belt. Repetitions will be tracked by eWall in a similar way, with the previously mentioned feedback mechanism.

All sensor data captured by this module will be automatically analyzed and reasoned upon. The eWall system will generate relevant knowledge of the status of Bob's health and his ability to follow the training program. This knowledge will update Bob's user profile.

2. Daily Activity Monitoring.
This module monitors Bob's daily activity both inside and outside his house. It uses primarily wearable sensors. Using a questionnaire based mobile application, eWall will get knowledge about Bob's daily activity habits and updates his user profile. Based on the user profile, eWall provides Bob with a personalized and contextualized feedback during the day, with moving tips to increase his activity. During the day, he gets feedback using the smart-phone or tablet. He is comfortable using this technology as the user experience of the technology is designed to adapt to Bob's characteristics, extracted from his user profile.

The eWall records inactivity and appropriate additional reminders are given, using an agreed escalation scheme. The eWall system will keep track of the frequency of Bob's failures to respond, update his user profile and adapt its motivational feedback.

Part of Bob's activities is linked to cleaning the house and for this, eWall offers support for a better, healthier home environment. Since dust and air quality are very important, eWall constantly monitor home air humidity and chemistry using dedicated sensors. The eWall system contains and controls and air purifier and an air dehumidifier. Bob can configure eWall's rules of activation/deactivation of these devices.

3. Daily Functioning Monitoring.
eWall is designed to monitor the daily functioning of the targeted person, such as sleep quality and quantity, eating habits, use of household appliances, daily or periodic habits such as: home entertainment (watching movies, inviting family and friends), cleaning the house. This functionality will "read" all sensor data that is relevant within the context of daily functioning, excluding the situational sensor data, such as: physical exercise correctness data. The monitored information will be transformed into knowledge that contributes to the primary user's profile. Based on this profile, eWall will adapt its decision making mechanisms for a better interaction and communication with its user.

4. Daily functioning monitoring (socializing).
When multiple persons are present inside the home and Bob does not want eWall to post messages on the main screen, a question will be displayed on all devices, asking for Bob's approval for switching to a "private mode". This means that, if Bob agrees, eWall sends its notification only to the handheld device (Bob's phone and/or smart watch). These notifications also trigger vibrations of the hand held devices, when set as such. The private mode setup will postpone or cancel physical exercise sessions and personal coaching sessions according to Bob's requests. This means that, in case such sessions are scheduled to start, Bob will be notified and asked for either a reschedule time, or a cancellation of the coaching (or therapy) session. Medicine reminders will be displayed on the handheld device.

5. Nutritional coach.
The eWall system has a nutrition coaching service that can suggest diets and compatible food recipes and local food providers with compatible menus. The eWall system will provide Bob with appropriate descriptions of what he should eat in order to maximize his physical exercise results and overall wellbeing, in the context of his disease state. The eWall system will send gentle reminders about eating time, using an agreed upon escalation scale.

This service is controlled and configured by Bob himself or his medical caregiver of nutritionist during (video) call sessions or home visits, with Bob's approval. The service can be configured to trigger gentle reminders, using an agreed upon escalation scale, that suggests Bob when and what to eat, with respect to his physical exercise scheduling and his day planning.

6. Safety.
The eWall system is connected to fast intervention units (ambulance service, fire fighter service) and provides Bob the possibility of calling for help in case of an extreme exacerbation or other incidents. The eWall system is designed with a "panic button" type mechanism that will help Bob reach for help in case of an emergency. The interaction with this module is designed to ease the reach of specific fast intervention units such as: ambulance, firefighters, police, etc.

7. Medication support.
Bob gets gentle reminders when he forgets to take his medicine at the prescribed time. Bob will get a detailed description of the type and quantity of medicine he will need to take. The description is part of the remainder and is displayed directly on both the handheld device and the main screen. When Bob is not responding, appropriate additional reminders are given, using an agreed escalation scheme. The eWall system will keep track of the frequency of Bob's failures to respond.

When Bob will have his periodic medical visit, his lung physician will be reminded to gently ask him the reason behind not taking his medicine at the prescribed times. Bob's eWall user profile will record, via this module, his medication history, starting since the eWall was installed in her home.

8. Social integration.
The eWall system suggests Bob activities that he can do together with friends and family and also engage him physically and socially, such as inviting friends for out-door bike rides, dog walking, going fishing, going bowling, etc. Bob could schedule a meeting place and organize a path (when the type of activity allows it) and send invitations to his friends and family via an aggregation system to social networks, e-mail, SMS. The eWall will record his activity via the wearable sensors and the sensors on the bike, but also track his position via GPS for safety reasons.

9. Health monitoring (exacerbations monitoring).
His daily pattern is monitored, especially symptoms related to exacerbations (coughing, fever, oxygen saturation, being less active). Bob is also asked for how he feels, via voice and/or the screen using a tangible device. This information is compared with information gathered during the past days to reason about Bob's present health status and cognitive state and to conclude what advices should be given and/or whether a physician or an informal caregiver should be warned.

During the day, he gets feedback using a handheld device. At home, he gets his feedback automatically on the eWall main screen.

Bob gets as well seasonal disease information like a flu infection map and a pollen map of his current geographical area. The eWall system shows this information on the main screen and also on his portable tangible device (smartphone/tablet).

All questionnaire data captured by this module will be automatically analyzed and reasoned upon. The eWall system will generate relevant knowledge of the status of Bob's general health and the frequency of his exacerbation. This knowledge will update Bob's user profile.

10. Healthcare support.
Bob has access to phone, teleconferencing and video call service through eWall main screen and the hand held devices, in order to get in touch primarily with his lung physician, GP, medically trained caretaker. The eWall system will use a gentle reminder with a previously agreed upon escalation scheme to tell Bob when he has to take part in such a (video) call.

Through these (video) consults between Bob and medically trained specialists, Bob can receive an accurate, expert assessment of his disease. The family members or friends can take part in helping Bob as informal caregivers, part of their training can happen during these (video) conference calls.

During the (video) call, the trained medical person is able to share with Bob, via an easy to understand interface, an aggregation of Bob's recorded data and any other digital references (written text, additional media) needed during the session. This will help Bob understand his disease state and inform him about future therapy steps.

During the (video) call, eWall can be remotely configured by the trained medical person, once agreed upon by Bob, for enabling, disabling, modifying modules within eWall's functionality.

11. Data security.
Bob has a fully protected digital identity associated with eWall and he has access to his data at all times. He can view all his data by accessing eWall data aggregation services after providing a username and password in the login phase. He may only view his personal data and data adjacent to his eWall digital identity (the social integration configuration, the identity and contact information of the qualified medical personnel that can view his data and edit configuration on his eWall installation).

12. Technical support.
The eWall system is a self-sustainable computational system. It can detect internal malfunctions and it is able to send detailed feedback about the occurring errors or non-responsive modules, to a technical administration team, while not compromising in any way Bob's confidentiality privileges.

Bob agrees to notify any malfunction that may occur throughout eWall's runtime. He agrees on allowing medical trained professionals, namely: his lung doctor and his home caretaker to have access to both: his personal medical data recorded by eWall and his eWall installation configuration and functions. As his has lower than average technical skills, he has access to a part of the maintenance functions of eWall (he is able to get in contact with a technical help service operator by phone and/or video call; he has access to follow troubleshooting steps, in case eWall detects unresponsive or malfunctioning connections and modules with an easy to follow through interface; he is able to perform a system reset, when eWall has a malfunction and specifically notifies Bob to do this action).

5.1.5 eWall supporting Jane (MD)

1. Physical exercise.
Since Jane is suggested daily exercise, eWall can contain a home exercise installation such as a stationary bike with sensors, or a treadmill, an abdominal machine with sensors and/or a video based system that constantly measures her performance. For extra motivation, eWall can combine and contextualize the home exercise program using immersive media technologies, augmented and/or virtual reality technology and gamification techniques.

The coaching program provides her a personalized and contextualized feedback during the day, with moving tips to increase her activity. At home, she gets her feedback automatically on the eWall main screen. The eWall also shows her performance compared to friends and family, so she gets additionally motivated to make physical exercise as often as possible. As this eWall module is not of primary importance in Jane's case, its configuration allows for disabling the gentle reminding mechanism.

2. Daily Activity Monitoring.
Jane was encouraged to adopt a more active lifestyle. This refers not only to programed exercise but also to the small tasks of the daily life. With that in mind, Jane carries around a wearable sensor that helps to monitor her activity level during the day and also provides personalized and contextual feedback as well as suggestions on ways to become more active. For example, Jane is advised to visit the bookstore of her neighborhood every time a new book of her interest is released. The eWall records inactivity and appropriate additional reminders are given, using an agreed escalation scheme. The eWall system will keep track of the frequency of Jane's failures to respond, update her user profile and adapt its motivational feedback.

3. Daily Functioning Monitoring.
eWall is designed to monitor the daily functioning of the targeted person, such as sleep quality and quantity, eating habits, use of household appliances, daily or periodic habits such as: home entertainment (watching movies, inviting family and friends), cleaning the house. This functionality will "read" all sensor data that is relevant within the context of daily functioning, excluding the situational sensor data, such as: physical exercise correctness data. The monitored information will be transformed into knowledge that contributes to the primary user's profile. Based on this profile, eWall will adapt its decision making mechanisms for a better interaction and communication with its user. Maria can access the reports at any time and intercede whenever she finds necessary.

The eWall monitors different parameters of daily functioning and sends a concise daily report to Jane's daughter. In this way, Sarah keeps a daily update of her mother's life and can intercede whenever she finds necessary. One of the parameters assessed is the anxiety level. Whenever a high level of anxiety is detected, Jane is prompted with relaxation advices.

4. Nutritional coach.
The eWall system has a nutrition coaching service that can suggest diets and compatible food recipes and local food providers with compatible menus. The eWall system will provide Jane with appropriate descriptions of what she should eat in order to maximize her physical exercise results and overall wellbeing, in the context of her health state. The eWall system will send gentle reminders about eating time, using an agreed upon escalation scale.

This service is controlled and configured by Jane and her medical caregiver or nutritionist during (video) call sessions or home visits, with Jane's approval. The service can be configured to trigger

gentle reminders, using an agreed upon escalation scale, that suggests Jane when and what to eat, with respect to her physical exercise scheduling and her day planning.

5. Social integration.
Displayed on the eWall, Jane can see in real-time which of her friends are interested to go for a walk and establish the contact automatically. This is a great way to meet her daily physical activity goals at the same time that she keeps in touch with her friends. Jane also made new friends on virtual communities of Mild Dementia patients. The eWall also enhances the contact with Sarah. Jane likes to see her daughters face on the big screen of eWall whenever they talk.

6. Healthcare support.
Jane has access to phone and video call service through eWall main screen and the handheld device, in order to get in touch primarily with her therapist, GP, medically trained caretaker. The eWall system will use a gentle reminder with a previously agreed upon escalation scheme to tell Jane when she has to take part in such a (video) call.

Through these (video) consults between Jane and medically trained specialists, Jane can receive an accurate, expert assessment of her disease. The family members or friends can take part in helping Jane as informal caregivers, part of their training can happen during these (video) conference calls.

During the (video) call, the trained medical person is able to share with Jane, via an easy to understand interface, an aggregation of Jane's recorded data and any other digital references (written text, additional media) needed during the session. This will help Jane understanding her disease state and inform her about future therapy steps. Also during the (video) call, eWall can be remotely configured by the trained medical person, once agreed upon by Jane, for enabling, disabling, modifying modules within eWall's functionality.

7. Calendar/agenda.
To help Jane remembering her appointments, eWall can sustain a digital agenda and through a feedback system, can provide an aggregated data interface that display her agenda entries and can trigger gentle reminders for upcoming tasks. As well, eWall offers Jane the possibility to manage data in the agenda and reference her entries with semantically relevant (enriched) media data from the Internet.

8. Cognitive stimulation.
Jane knows the importance of keeping cognitive training. The eWall provides weekly recommendation of books and movies according to her profile and also based on the list of books that Jane has already read. Also, the eWall prompts periodical messages advising small games aiming cognitive training. Whenever she is bored, Jane plays one of these games. And at the end she can share the results with her friends.

9. Domotics (Guidance in home).
The eWall detects via its wireless heterogeneous sensor system that Jane is getting up, guides Jane to the toilet by switching on the lights in the proper sequence. When Jane gets stuck in the living room, the Caring Home recognizes this state and guides Jane to her bedroom using lighting patterns.

10. Outside guidance.
The eWall brought back to Jane the feeling of security when walking around her neighborhood. Whenever Jane wants to leave the house, she chooses one of the destination options displayed on her Portable Tangible Device and it monitors her deviation from the desired route forming a virtual geo-fence. The eWall system will display gentle notifications on the PTD, when Jane's detected geographical position exceeds the tolerance threshold, offering Jane guidance to her desired destination. Together with Sarah, Jane can set new routes and add optional buttons. Every time Jane feels lost, the PTD gives subtle but clear advices on how to find the destination. Jane feels much more confident to go around the neighborhood and she is not afraid of getting lost anymore.

11. Memory book.
Jane was advised by the GP to keep a diary where she could report her daily life. However, Jane kept losing it inside the house. With eWall it is simpler. Jane writes about every events of her day: food, visits, conversations or even thoughts. She can also associate pictures of people and places to each entry. As a book lover, Jane finds this journal very engaging. Every time Jane wants to remember something she searches through the memory book. She can also configure which events are private and which ones she wants to share. Jane's doctor can keep track of the shared events in real-time and is aware of the progress of the memory impairment.

12. Data security.
Jane has a fully protected digital identity associated with eWall and she has access to her data at all times. She can view all her data by accessing eWall data aggregation services after providing a username and password in the login phase. She may only view her personal data and data corresponding to her eWall digital identity (the social integration configuration, the identity and contact information of the qualified medical personnel that can view her data and edit configuration on her eWall installation).

13. Technical support.
The eWall system is a self-sustainable computational system. It can detect internal malfunctions and it is able to send detailed feedback about the occurring errors or non-responsive modules, to a technical administration team, while not compromising in any way Jane's confidentiality privileges.

Jane agrees to notify any malfunction that may occur throughout eWall's runtime. She agrees on allowing medical trained professionals, namely: her therapist and her home caretaker to have access to both: her personal medical data recorded by eWall and her eWall installation configuration and functions. As she has lower than average technical skills, she has access to a part of the maintenance functions of eWall (she is able to get in contact with a technical help service operator by phone and/or video call; she has access to follow troubleshooting steps, in case eWall detects unresponsive or malfunctioning connections and modules with a easy to follow through interface; she is able to perform a system reset, when eWall has a malfunction and specifically notifies Jane to take this action).

5.1.6 eWall supporting Phillip (MD)

1. Physical exercise.
Since Phillip needs exercise 3 times/week, eWall will contain a home exercise installation, such as a stationary bike with sensors, or a treadmill with sensors, an abdominal machine with sensors. For extra motivation, eWall can combine and contextualize the home exercise program using immersive media technologies, augmented and/or virtual reality technology and gamification techniques. As his vision is bad, eWall's notifications come in the form of voice messages and text messages. The eWall system will provide a progressive disclosure user experience, where the exercise routine is divided in steps and exercises are grouped by the effect they target (i.e. cardio exercises, muscle strength exercises, etc.).

Due to his previous stroke, Phillip will undertake a low intensity and low difficulty physical activity routine. The goal of the exercise is to maintain overall muscle strength, to increase mobility of his neck, arms and legs and decrease his cholesterol level. His home exercise equipment consists of a treadmill, a set of elastic bands and free weights, and a set of knee and arm weights. The home exercises are set within 2 meters from the eWall main screen.

An exercise routine will always begin by a warm up session. Philip will be monitored by eWall using the on body sensor belt that measures his heart beat rate, body gait and oxygen saturation and a set of HAN sensors (i.e. close proximity 3D sensors, video sensing) that can detect and track the accuracy of exercise execution, when possible.

After a proper warm-up, Phillip will have to undertake elastic resistance exercises and free weight exercises, designed to reduce body fat and increase muscle strength and size. This set of exercises is detected and tracked by eWall using sensor data from both BAN and HAN. The eWall system will track and detect the accuracy of Phillip's exercise execution, give guidance and motivational feedback. The eWall system will detect Phillip's rhythm and his present physical capabilities and will adapt its feedback in order to avoid Phillip's over-exercise or under-exercise.

The cardio exercise is limited to a simulated jogging or rapid walking through a virtual representation of a track (i.e. virtual biking through a forest, virtual biking through London (Immersive Media - Demos)). Since this is not a precision exercise, eWall will recognize this type of exercise as one that does not require additional body motion and posture tracking using HAN sensors and will decide that the body sensor data is sufficient.

The last part of Phillip's training consists of specific breathing and balance exercises that target a post stroke rehabilitation. These exercises do not require the use of exercise equipment, other than the on-body sensor belt. Repetitions will be tracked by eWall in a similar way, with the previously mentioned feedback mechanism.

All sensor data captured by this module will be automatically analyzed and reasoned upon. The eWall system will generate relevant knowledge of the status of Phillip's health and his ability to follow the training program. This knowledge will update Phillip's user profile.

2. Daily Activity Monitoring.
Phillip was always a very active person but after the stroke he was advised to calm down his routine. The wearable sensor he carries around during the day, keeps track of his active level and also of his heart rate. Phillip is advised to calm down taking a short break every time his heart rate goes above a certain threshold. Phillip found out with short breaks he is now able to do longer

walks. The eWall system also provides daily activity goals and gives the chance to share Phillip's achievements.

3. Daily Functioning Monitoring.
eWall is designed to monitor the daily functioning of the targeted person, such as sleep quality and quantity, eating habits, use of household appliances, daily or periodic habits such as: home entertainment (watching movies, inviting family and friends), cleaning the house. This functionality will "read" all sensor data that is relevant within the context of daily functioning, excluding the situational sensor data, such as: physical exercise correctness data. The monitored information will be transformed into knowledge that contributes to the primary user's profile. Based on this profile, eWall will adapt its decision making mechanisms for a better interaction and communication with its user.

The eWall monitors different parameters of daily functioning and sends a concise daily report to Philip's sister Theresa. In this way, Theresa keeps a daily update of her brother's life and can intercede whenever she finds necessary. One of the parameters assessed is the stress level. Whenever a high level of stress is detected, Philip is prompted with relaxation advices. As his vision is bad, eWall's notifications come in the form of voice messages and adapted displayed messages.

4. Nutritional coach.
The eWall system has a nutrition coaching service that can suggest diets and compatible food recipes and local food providers with compatible menus. The eWall system will provide Philip with appropriate descriptions of what he should eat in order to maximize his physical exercise results and overall wellbeing, in the context of his health state. The eWall system will send gentle reminders about eating time, using an agreed upon escalation scale. As his vision is bad, eWall's notifications come in the form of voice messages and adapted displayed messages.

This service is controlled and configured by Phillip himself or his medical caregiver of nutritionist during (video) call sessions or home visits, with Phillip's approval. The service can be configured to trigger gentle reminders, using an agreed upon escalation scale, that suggests Philip when and what to eat, with respect to his physical exercise scheduling and his day planning.

5. Social integration.
Displayed on the eWall, Philip can see in real-time which of his friends are interested to go for a walk and establish the contact automatically. This is a great way to meet his daily physical activity goals at the same time that he keeps in touch with his friends. Philip also made new friends on virtual communities of Mild Dementia patients.

6. Social integration (Information about Mild Dementia and communities).
The eWall provides an up-to-date database where Philip and Theresa can choose between a lay approach and a more academic database of information. All the information provided was submitted to a reliability test approval. It also gave Philip the opportunity to meet more people and make new friends.

7. Healthcare support.
Philip has access to phone and video call service through eWall main screen and the handheld device, in order to get in touch primarily with his therapist, GP, medically trained caretaker. The

eWall system will use a gentle reminder with a previously agreed upon escalation scheme to tell Philip when he has to take part in such a (video) call.

During the (video) call, the trained medical person is able to share with Philip, via an easy to understand interface, an aggregation of Philip's recorded data and any other digital references (written text, additional media) needed during the session. This will help Philip understanding his health state and inform him about future therapy steps.

During the (video) call, eWall can be remotely configured by the trained medical person, once agreed upon by Philip, for enabling, disabling, modifying modules within eWall's functionality.

8. Calendar/agenda.
To help Philip remembering his appointments, eWall can sustain a digital agenda and through a feedback system, can provide an aggregated data interface that display her agenda entries and can trigger gentle reminders for upcoming tasks. As well, eWall offers Philip the possibility to manage data in the agenda and reference her entries with semantically relevant (enriched) media data from the Internet.

8. Memory book.
Phillip was advised to keep a diary reporting his daily life in order to monitor is cognitive level. Phillip was never the type of person who would sit behind a desk and in fact he finds it difficult to understand the value of this therapy. The eWall gives him the perfect solution. Phillip takes pictures of what he does during the day and automatically uploads to the Memory Book. Each picture is tagged with a reference to time and local. Sometimes Phillip also adds small descriptions. He can choose which pictures are private and which ones are shared with his friends.

9. Domotics (Guidance in home).
The eWall detects via its wireless heterogeneous sensor system that Philip is getting up, guides Philip to the toilet by switching on the lights in the proper sequence. When Philip gets stuck in the living room, the Caring Home recognizes this state and guides Philip to his bedroom using lighting patterns.

10. Outside guidance.
The eWall brought back to Philip the feeling of security when walking around her neighborhood. Whenever Philip wants to leave the house, he chooses one of the destination options displayed on his Portable Tangible Device and it monitors his deviation from the desired route forming a virtual geo-fence. The eWall system will display gentle notifications on the PTD, when Philip's detected geographical position exceeds the tolerance threshold, offering Philip guidance to his desired destination. Together with Theresa, Philip can set new routes and add optional buttons. Every time Philip feels lost, he looks at the PTD which gives subtle but clear advices on how to find the destination. As his vision is bad, eWall's notifications come in the form of voice messages and adapted displayed messages. Philip feels much more confident to go around the neighborhood and he is not afraid of getting lost anymore.

11. Data security.
Philip has a fully protected digital identity associated with eWall and he has access to his data at all times. He can view all his data by accessing eWall data aggregation services after providing a username and password in the login phase. He may only view his personal data and data adjacent to his eWall digital identity (the social integration configuration, the identity and contact information

of the qualified medical personnel that can view her data and edit configuration on her eWall installation).

12. Technical support.

The eWall system is a self-sustainable computational system. It can detect internal malfunctions and it is able to send detailed feedback about the occurring errors or non-responsive modules, to a technical administration team, while not compromising in any way Philip's confidentiality privileges.

Philip agrees to notify any malfunction that may occur throughout eWall's runtime. He agrees on allowing medical trained professionals, namely: his therapist and his home caretaker to have access to both: his personal medical data recorded by eWall and his eWall installation configuration and functions. As he has lower than average technical skills, he has access to a part of the maintenance functions of eWall (he is able to get in contact with a technical help service operator by phone and/or video call; he has access to follow troubleshooting steps, in case eWall detects unresponsive or malfunctioning connections and modules with a easy to follow through interface; he is able to perform a system reset, when eWall has a malfunction and specifically notifies Philip to take this action).

5.2 Scenarios for secondary end-users

5.2.1 eWall supporting the general practitioner “Karen”

1. Sharing of Information.
Karen uses the eWall service for medical professionals that allow her to extract monitoring data from her patients that have eWall home installations. Data is aggregated into easy to understand information visualization figures and charts. It is very easy for Karen to see her patient’s evolution and the effects of the therapy, by simply making a meaningful query.

The eWall system contributes to helping Karen make accurate diagnostics and treat more efficient her patience. Accessing the patients’ medical data also helps Karen cooperating with other sectors of the health care system. If a visiting nurse calls Karen to discuss the treatment of a patient, they can both access the same data, which promotes their communication. Karen can decide a course of treatment quickly and confidently based on the medical data she receives from eWall.

2. Teleconferencing.
The eWall system allows Karen to save time and connect to her patience with home eWall installations through the eWall service for medical practitioners. She can schedule video appointments with these patients and also send them, during the video call, information notifications, that may help Karen with her explanations, such as explaining patient evolution through monitored data and helping her patient understand his/her health status.

The eWall system helps Karen save time and stress, by giving Karen the consult her patients remotely. She will not spend time on organizing her agenda and she will have a better work mobility, as she can guide consults over the internet. The remote consults also saves Karen a few home visits as she can consult patients who are unable to come to the clinic using the video system.

5.2.2 eWall supporting the hospital nurse caregiver “Lars”

1. Sharing of information.
Lars uses the eWall service for medical professionals that allows him to extract monitoring data from his patients that have eWall home installations. Before meeting patients for their annual assessment meetings Lars logs in to the eWall service for medical professionals and see the medical data. Charts and figures visualize the information, which makes it easy for Lars to get an overview of the development in both the COPD and the patients handling of the COPD. Lars no longer uses the COPD state evaluation questionnaire, as he saves time and gets a better insight using the eWall data. Lars can now use the limited time with the patient more constructively. Firstly because the patient does not have to fill out the questionnaire and secondly because Lars and the patient have a common starting point to start their discussion from being the eWall data.

Lars often uses the data actively during the assessment meetings. He views the data with the patients and has a dialog with the patient based on these.

5.2.3 eWall supporting the visiting nurse “Helen”

1. Health monitoring.
Helen uses the eWall service for medical professionals that allows her to extract monitoring data from her patients who have the eWall home installations. She logs in to the system twice a week and monitors all the patients within her area, who have the eWall home installations. Charts and

figures visualize the information, which makes it easy for Helen to get an overview of all data for each patient. The system's visual design helps Helen see if some of the data is outside the patient's normal values. If that is the case, Helen reacts by either:

- Contacting the patient's GP or other relevant health care professionals.
- Discussing the concerning data with the colleague who is scheduled to do the next visit to the patient.
- Arranging an extra visit to the patient.
- Initiating a remote consultation with the patient.

The data she needs to react to determines Helen's choice of action. If Helen chooses to contact another health care professional, eWall assists both of them, as they are able to see the same data and therefrom discuss the treatment strategy.

When Helen visits the patients, who have the eWall home installations she feels much better prepared. She has a better insight into each patient's situation, because she has seen the data, and she can have a talk with the patient about changes in the patient's activity behavior, comment on specific data and so on.

2. Healthcare support.
Helen often uses the option of remote consult. Sometimes the patients' book a consult and sometimes Helen initiates the consult herself. Of course, Helen needs to be physically present for many tasks, but she can do some of her tasks remotely, which spares her a few visits. She often initiates the remote consults when she sees some of a patient's data deviate from normal. Thereby the patient is sometimes able to explain what causes the deviation and Helen can plan a plan of action in collaboration with the patient.

6 Use cases

Use cases are generally written as part of detailed product requirement documentation. They capture the goal of an action, the trigger event that starts a process, and then describe each step of the process, including e.g. inputs, outputs, errors and exceptions. Use cases are often written in the form of an actor or user performing an action followed by the expected system response and alternative outcomes. They provide human-centered anchors to guide design and development by providing tangible faces, names and stories for how the technology will be used. In this document, the use cases provided below are preliminary and are meant to provide as much as possible anchor points for discussing the details of interaction with the eWall system.

The scenarios in Section 5 describe in a story-like fashion how the life of the personas (Section 3) is envisioned while using the eWall system. The scenarios resulted in a large number of possible applications that each provides useful functionalities for one or more of the end-user groups. After in-depth discussion within the consortium, these applications were grouped in the application categories as defined in Table 6.

Table 6: List of the 13 preliminary application categories.

#	***application category***
1	Physical Exercise
2	Daily Activity Monitoring
3	Daily Functioning Monitoring
4	Nutritional Coach
5	Safety
6	Medication Support
7	Social Integration
8	Healthcare Support
9	Calendar
10	Cognitive Stimulation
11	Domotics
12	Outdoor Guidance
13	Health Monitoring

Each of these application categories contains several possible applications, which have to be prioritized and defined in further detail. In the subsections below we define detailed use cases for applications from three of the core eWall application categories: **Daily Activity Monitoring**, **Daily Functioning Monitoring**, and **Healthcare Support**. The chosen application categories are representative to the scope of research and describe key aspects of the proposed technology: implementing mechanisms for self-therapy within the home eWall installation of the primary user, monitoring the primary user's state of health and functioning capabilities within his/her home environment and enabling means of communication with informal and formal caregivers. The use-cases mentioned in this section should be seen as representatives of work-in-progress, and, therefore, must be continuously reviewed during the development phase of the project. New use-cases should also be created whenever necessary.

The **Daily Activity Monitoring** application category describes a set of applications that monitor and guide the primary user towards a more active and consequently healthier lifestyle. These applications use on-body sensors, possibly combined with home installed sensors, and target functionalities inside and outside the eWall home installation.

The **Daily Functioning Monitoring** application category describes a set of applications that detect, monitor and guide the primary user when executing daily tasks inside the living area. These tasks refer to personal hygiene, sleeping behavior, eating behavior, household activities, etc. The applications use primarily sensor data from the home installation.

The **Healthcare Support** application category describes a set of applications that allows communication between the primary user and multiple persons, form which at least one is a medically trained caregiver, such as a general practitioner, or a medical nurse. The communication is always oriented within the scope of therapy. Through the services provided by this set of applications, both formal and informal care givers can assess remotely particularities of the state of health of the primary user.

Many applications interact with other applications in various ways. For example, the **Eating Monitor** application use-case describes the ability for an informal caregiver to contact the primary end-user about some detected anomaly. The details regarding the ways in which this contact occurs are left out of the use cases, as they can be defined in more detail in the relevant application category (in this case e.g. **Healthcare Support**).

The *users* that are described in the use cases below are the personas described in Section 3 or their friends/family. For quick reference, Table 7 gives an overview of the names of these personas with short descriptions, in order of appearance in the use cases.

Table 7: Short overview of personas used in the use cases below, in order of appearance.

Persona	***Description***
Michael	67 year old male, suffering from ARI (primary end-user)
Joanna	An old friend of Simone.
Simone	72 year old female, suffering from ARI (primary end-user)
John	Simone’s son.
Theresa	Phillip’s younger sister (living with him together).
Phillip	66 year old male, suffering from Mild Dementia (primary end-user)
Alice	Petra’s younger daughter.
Petra	43 year old female, diagnosed COPD Gold Stage II (primary end-user)
Sarah	Jane’s daughter.
Jane	74 year old female, suffering from Mild Dementia (primary end-user)

6.1 Application category: Daily Activity Monitoring

6.1.1 Application: "Daily Activity Monitoring" – recognizing activities

Context:	Michael went for a cycling tour in the quiet surroundings, away from the busy city. Before leaving home, Michael confirms that he carries his activity tracker with him. When Michael arrives back home, he goes to the eWall screen to be sure he does not forget to save this route. It was such a nice route that is worth to be repeated in the future.
System:	The eWall screen shows a new entry in the *Daily Activity Monitoring* application.
User:	Presses the button of this application.
System:	Shows a message congratulating Michael for his cycling tour: "*Congratulations Michael! You are in a good way to become more active!*". After that, the eWall prompts the question: "*Do you want to see detailed information regarding this activity?*"
User:	Selects "*Yes*".
System:	Shows a map where is indicated the distance that Michael travelled with the car to the outskirts of the city and the distance travelled by bike. On the right side of the screen is displayed the duration of bicycle ride, calories expenditure, distance travelled and the contribution for his daily goal as a percentage value. A blinking icon shows "*Save route*" and other one "*See suggestions*".
User:	Selects "*Save route*".
System:	The eWall system adds this route to the list of cycling tours already saved.
User:	Selects "*See suggestions*".
System:	On the top of the screen shows the message: "*We have a list of similar routes to the one you performed today. Do you want to see it?*"
User:	Says "*Yes*".
System:	Shows a list of routes with similar effort (in terms of distance and time) and a list of interesting points in the path of those routes.
User:	Checks information regarding the different tours.
User:	Selects a route that passes through a historical village he wanted to visit since a while ago.
System:	Shows the message: "*Do you want to schedule the bicycle tour Getting to know the historical village of Zaanse Schans by bike?*"
User:	Says Yes.
System:	Shows a calendar.
User:	Chooses the upcoming Friday at 10.00.
System:	Shows the message "*Bicycle tour Getting to know the historical village of Zaanse Schans by bike added to your agenda next Friday at 10.00.*"

6.1.2 Application: "Daily Activity Monitoring" – motivation and coaching

Context:	Phillip has been sitting in the sofa for the last two hours.
System:	The eWall smartphone application blinks a message from the application *Daily Activity Monitoring*.
User:	Selects Read message.
System:	Shows the message: "*You have been sitting in the sofa during the last two hours! It is sunny outside and the temperature is ideal for a walking in the surroundings.*"
User:	Glances at his wrist worn bracelet.
System:	The activity sensing bracelet softly lights up and blinks 2 out of the 10 LED lights.
User:	Realizes he has already achieved approximately only 20% of his daily activity goal.
User:	In order to see if any of his friends is willing to go for a walk during the same period, goes towards the eWall screen and selects the *Daily Activity Monitoring* icon.
System:	Shows a circular graphic that is partly colored in and the daily and weekly goal.
User:	Selects the option *View detailed information*.
System:	Shows a graphic with the amount of activity Phillip did per hour since the beginning of the day.
User:	Selects the option *Find a friend!*
System:	Shows a list of the users and respective desired activity and duration. In front of each person there is the button *Contact user*.
User:	Realizes that a friend that lives nearby is looking for someone to go for a walk during the afternoon. Selects *Contact user*.
System:	Makes the connection to Phillip's friends.
User:	Arrange a meeting and go for the walk.

6.1.3 Application: "Daily Activity Monitoring" – personalized goals

Context:	Jane achieves her weekly goal.
System:	The *Daily Activity Monitoring* smartphone application prompts a message "*Congratulations Jane! You achieved your weekly goal for physical activity. We suggest a new goal for you. Connect to the eWall screen if you want to see detailed information and perform changes.*"
User:	Establishes connection with the eWall screen and starts the *Daily Activity Monitoring* application.
System:	An animated image fulfills the whole screen: "*Congratulations Jane!*". This animated image disappears automatically and a new message appears: "*You are on your way to becoming more active. The eWall system suggests an increase of 70 minutes walking in your weekly goal (this roughly corresponds to an increase of 10 minutes per day).*"; followed by three options *Accept new goal*, *View more information* and *Change goal later*.
User:	Chooses the second option.
System:	Shows an overview of the activity performed by Simone in each one of the days of the last week. The "information icon" next to Wednesday's activity blinks.
User:	Sees that she achieved her daily goal on each day of the last week except on Wednesday. Jane selects the blinking icon.
System:	Shows the message: "*On Wednesdays you go to the reading club and as a result you haven't achieved your daily goal. Do you want to decrease the goal on this day?*"
User:	Says Yes.
System:	Shows an option to increase/decrease the goal.
User:	Chooses to reduce the Wednesday goal on 15 minutes walking.
System:	Shows a confirmation message: "*New goal set for Wednesdays.*" followed by another message "*Do you want to accept the suggestion of increasing your weekly goal by 70 minutes?*"
User:	Says Yes.
System:	Shows message: "*New weekly goal set. Keep motivated and don't forget our list of tips on how to become more active.*"

6.1.4 Application: "Daily Activity Monitoring" – competition system

Context:	Jane is very competitive and makes sure she always stands on the top-three most active persons of the reading club.
User:	The user walks towards the eWall main screen.
System:	Screen switches on with the main menu showing the different applications.
User:	Selects *Daily Activity Monitoring* application.
System:	The right side bar of the screen shows a ranking of the most active persons of her different groups, including the "*Reading club group*". Jane is in second place and her friend Patricia in first.
User:	Goes for a walk. She is decided to beat Patricia this week.

6.1.5 Application: "Daily Activity Monitoring" – rewards system

Context:	Petra is walking back home from the supermarket when she gets a message from the eWall smartphone application.
System:	Application *Daily Activity Monitoring* shows a message "*Congratulations Petra! You have walked 1.000 minutes since you started using the activity tracker. The eWall system has a reward for you. Connect to the eWall screen to see more information*".
User:	When Petra arrives home she goes towards eWall.
System:	Shows the same message given by the smartphone application and prompts a question: "*Do you want to see more information?*"
User:	Says Yes.
System:	Shows a list of vouchers that she can "buy" with the points she obtained by achieving the mark "1.000 minutes walking". The vouchers regard cultural, sportive and beauty activities.
User:	Chooses a voucher of one hour free swimming in the local swimming pool.

6.2 Application category: Daily Functioning Monitoring

6.2.1 Application: "Sleeping Monitor"

Context:	Michael has experienced some problems falling asleep during the last few days. He wants to know if this is somehow related to his hypertension condition.
User:	Selects the *Daily Functioning* option on the main menu of the eWall screen.
System:	The eWall screen provides the menu: *Sleep, Eat*, *Self-Care*, *Household, Social* and *Mood*.
User:	Select option *Sleep*.
System:	The eWall screen displays a short summary of Michael's sleeping patterns during the last seven days.
User:	Selects: *View detailed information*.
System:	Displays a plot detailing the sleeping cycles and stages of the last evening. On the top of the screen there is a tab bar that allows the user to select the different days. On the right side of the screen there is a menu with small icons that allow the integration of data from different sources (e.g. respiratory rate, heart rate, humidity level).
User:	Selects the icon that represents a blood droplet.
System:	Prompts a question: "*You have showed intention to add Heart Rate information to the Sleep application. Do you want to continue?*"
User:	Says: "*Yes*".
System:	Shows a plot with both sleeping stages and heart rate data in the same plot.

6.2.2 Application: "Eating Monitor"

Context:	**(single anomaly event case)** Joanna spends the day at Simone's and they decide to order food instead of cooking.
User:	Simone does not cook during the whole day even though other services detect her presence in the house.
System:	The eWall screen shows a multiple-choice question: *The "Daily Functioning" application did not detect any cooking-related activity during the day. Please complete the sentence in the most appropriate way:* "*I didn't cook today because...*" • I ate food cooked somewhere else (e.g. ordered, take-away, friends brought food over) • I didn't feel appetite • Other reason The third option allows manual logging of information.
User:	Simone chooses the first option.
System:	The eWall saves the answer of the questionnaire for future analysis.

Context:	**(multiple anomaly event case)** Simone has not been cooking during the last three days and when questioned about the reasons for that she either answers that she ordered food or that she did not feel appetite.
System:	The eWall sends an alarm message to John reporting the event. The eWall portable application for informal caregivers launches automatically and shows a warning icon.
User:	John presses the *See warning* button.
System:	Shows a message saying that his mother has not cooked during the last days. Two buttons are displayed on the screen: *View detailed information* and *Contact*.
User:	Selects option *Contact*.
System:	The system shows an option list for ways to contact Simone: *Call*, *Video Call*, and *Leave a Message*.
User:	Selects *Video Call*.

6.2.3 Application: "Self-care Monitor"

Context:	Theresa is afraid that Phillip has not been taking regular care of his personal hygiene.
User:	Theresa starts the eWall smartphone application for informal caregivers.
System:	Smartphone application launches with the main menu.
User:	Selects the *Daily Functioning* option.
System:	The system shows the *Daily Functioning* menu: *Sleep*, *Eat*, *Self-care*, *Household*, *Social* and *Mood*. The *Self-care* button is highlighted with a warning icon.
User:	Selects *Self-care*.
System:	Application shows self-care overview screen where a warning message is displayed: "*Inadequate showering behavior*".
User:	Selects the *Showering* icon.
System:	Shows a detailed overview of showering behavior per day part (morning, afternoon, evening), which indicates that during the last four days there was no use of the shower.
User:	Theresa is worried about these events and selects the option to send this data to the **Healthcare Support** application to inform the former caregiver.

6.2.4 Application: "Social Monitor"

Context:	**(detecting unregistered person)** Alice, Petra's daughter, invites a friend to her house to do a group work. It is the first time that this friend goes to her house after eWall's installation.
System:	The eWall identifies multiple persons in Petra's house that are not registered in the system. A question appears on the screen "*New person identified. Do you want to add this person to eWall database?*"
User:	Says "*Yes, please*".
System:	Prompts a menu with the option to create profile.
User:	Writes the name "*Maria Smith*" using the touchscreen of eWall and does not add any other information.
System:	Prompts new question: "*To which category do you want to add Maria? Friends, Family, Daughters' friends, Colleagues, Others, or add a new category?*"
User:	Says "*Daughters' friends*".
System:	New question: "*Do you want to keep track of Maria's visits?*"
User:	Says "*No*".

Context:	**(detecting healthcare professional)** Physiotherapist visits Simone to add new exercises to her physical training plan and assist her doing these new exercises for the first time.
System:	Application *Socializing* recognizes the physiotherapist. Prompts a message: "*Do you want to see the physiotherapy record?*"
User:	Says "*Yes*".
System:	The screen displays the list of physical exercises previously recommended to Simone as well as her performance evaluation. On the same screen there is a button *Add new exercises*. A tab allows the possibility to also check information regarding daily physical activity.
User:	Presses the button *Add new exercise*.
System:	Prompts a list of categories of exercises including: *Strength, Cardio,* and *Balance*.
User:	Presses the button *Balance*.
System:	Shows a list of videos on the screen each one regarding a different exercise.
User:	Selects *Exercise 3*.
System:	Shows the video.
User:	Assists Simone performing the exercise.
System:	Automatically saves this face-to-face appointment as well as the changes performed in the configuration.

6.2.5 Application: "Household Monitor"

Context:	Sarah goes on vacation for a week and wants to see if her mother Jane has been taking care of her house.
User:	Sarah starts the eWall smartphone application for informal caregivers.
System:	Smartphone application launches with the main menu.
User:	Selects the *Daily Functioning* option.
System:	The system shows the *Daily Functioning* menu: *Sleep*, *Eat*, *Self-care*, *Household*, *Socialization* and *Mood*.
User:	Selects *Household*. Although there is no warning message, Sarah wants to get detailed information of her mother's household activities during the last week.
System:	Shows detailed information including the amount of times, days and hours when her mother vacuum clean, mopped and tidied the house.
User:	After checking the information, Sarah switches off the application.

6.3 Application category: Healthcare Support

6.3.1 Application: "Teleconferencing"

Context:	Teleconferencing between 2 or more persons from which one is a medically trained professional. This service is meant for all types of primary users and it does not itself present disease specific actions. Teleconferencing members are assigned different roles. Roles are described as follows: 1. ***Primary user*** *is the eWall user towards the therapy is intended. Benefits primarily from the eWall applications and is the principal person that interacts with the eWall home installation.* 2. ***Medical caregiver*** *is the eWall user that is medically trained and offers professional healthcare services to the primary user.* 3. ***Informal caregiver*** *is the eWall user that offers support and non-professional health care services to the primary user.* Michael, an eWall primary user, has a scheduled teleconferencing with his general practitioner Karen. Maria, Michael's wife and informal caregiver has the option to join the teleconference.
System:	Michael is being notified by eWall about the teleconference. As he is the primary user, the teleconferencing application assigns him the role of *primary user* for this teleconference.
System:	Karen is being notified by the eWall about the teleconference. As she is the medical caregiver, eWall will assign her the role of *medical caregiver* for this teleconference.
System:	Maria is being notified by eWall about the teleconferencing. The eWall system will assign Maria the role of *informal caregiver*.
User:	Michael joins the teleconference from his home, using his eWall home installation. He needs to tap the *join* button, inside the notification, displayed on the eWall

	primary display.
User:	Karen is in her office and will join the teleconference by pressing the *join* button, inside the notification, in her eWall software installation on her work computer.
System:	The teleconferencing service sustains communication between the two users allowing video, audio and text exchange in real-time.
System:	All other notified users will get an updated interface of the teleconference notification, indicating that the teleconference has started and they have the option to join this discussion any time by tapping/clicking on the *join* button.
User:	Maria observes that the meeting has started and decides to join the teleconferencing.
User:	Since the discussion is oriented towards therapy improvement, Karen has the possibility to launch the *Sharing Information* Application and explain to Michael and Maria aspects of Michael's health monitoring.
System:	When Karen selects the *Sharing Information* Application, eWall notifies her what part of the shared information is displayed on the teleconference participants' screens.
User:	Karen has also the option to use the *Configuration* Application during the teleconferencing.
System:	The teleconferencing app notifies all teleconferencing participants that Karen is now using the *Configuration* Application.
User:	Karen configures and explains in natural language the changes she has made on Michael's eWall configuration.
System:	Once she is done making the configuration, eWall prompts Michael (as a primary eWall user) and Maria (as an informal caregiver) a detailed description of the changes that Karen did to Michael's eWall home installation configuration and how will the new configuration affect Michael and Maria's interaction with eWall (if relevant). This detailed description is in the form of a video tutorial accompanied by clearly written text.

6.3.2 Application: "Sharing of information"

Context:	This application allows sharing eWall information between two or more eWall users in accordance to their roles, within the scope of medical therapy. These roles are described as follows: 1. ***Primary user*** *is the eWall user towards whom the therapy is intended. Benefits primarily from the eWall applications and is the principal person that interacts with the eWall home installation.* 2. ***Medical caregiver*** *is the eWall user that is medically trained and offers professional healthcare services to the primary user.* 3. ***Informal caregiver*** *is the eWall user that offers support and non-professional health care services to the primary user.* Michael, an eWall primary user, has a scheduled appointment with his general practitioner Karen, an eWall medical caregiver.
User:	Michael enters Karen's consultation room.

User:	Karen selects the *Sharing of Information* application and presses the "*request for sharing information*" button.
System:	Karen's eWall office installation displays a list of users from which Karen can select to whom she will send the request for sharing information.
User:	Karen selects Michael.
System:	The eWall system sends Michael a *request for sharing information* notification, on his mobile phone with the following message: "*Dr. Karen requests for sharing information. Do you agree? Yes /No*".
User:	Michael taps the "*Yes*" button from this notification.
System:	The eWall system displays on Michael's phone a list of all information he can share with Karen.
User:	Karen asks Michael to share his health monitoring data with her.
User:	Michael selects the health monitoring data item in the list and slides it to the sharing are of his phone application interface.
System:	The eWall system will display on Karen's screen a detailed dashboard like information aggregation of Michael's health monitoring data.
User:	Having understood the displayed information, Karen explains Michael his health monitoring data.

Context:	Michael, a primary eWall primary, has scheduled a teleconference with his general practitioner Karen. Maria, Michael's wife and informal caregiver also joins the teleconference from her office, using her office computer and the web-based eWall application. Michael attends the teleconference from his home, using eWall's primary display. Karen attends the teleconference from her office, using her office computer and the web-based eWall application. **Note:** All participants use screens with diagonals higher than 13 inches.
User:	During the teleconference, Karen selects the *Sharing of Information* Application.
User:	Karen presses the *request for sharing information* button.
System:	Karen's eWall office installation displays a list of users from which Karen can select to whom she will send the request for sharing information.
User:	Karen selects Michael.
System:	The eWall system sends Michael a *request for sharing information* notification, on his main eWall screen with the following message: "*Dr. Karen requests for sharing information. Do you agree? Yes /No*".
User:	Michael taps the "*Yes*" button from this notification.
System:	The eWall system sends Michael a second notification with the following message: "*Maria is also attending this teleconference. Do you allow her to see your shared information? Yes/No*".
User:	Michael taps the "*Yes*" button from this notification.

System:	The eWall displays, on Michael's primary display, a list of all information he can share with Karen and Maria.
User:	Karen asks Michael to share his health monitoring data.
User:	Michael selects the health monitoring data item in the list and slides it to the sharing are of his primary display application interface.
System:	The eWall will display on Karen's, Michael's and Maria's screens, a detailed dashboard like information aggregation of Michael's health monitoring data.
User:	Having understood the displayed information, Karen explains Michael and Maria, his health monitoring data and tells them her professional opinions. She uses a digital marker tool to underline information on the shared dashboard.

6.3.3 Application: "Configuration"

Context:	Enables the configuration of the eWall home installation by an informal caregiver or a medically trained health care giver. Configurations can be made also remotely. Bob, a primary eWall user, has a scheduled appointment with his general practitioner Karen, an eWall medical caregiver.
User:	Bob is in Karen's consultation room after having undergone the routine check-up.
User:	Karen's new evaluation of Bob's health state results in the need of configuring some of eWall's applications, to better fit Bob's current condition.
User:	Karen accesses the *Configuration* application.
System:	The eWall application displays a list of patients (primary users of eWall) for which Karen can configure their home eWall installation.
User:	Karen selects Bob.
System:	The eWall system displays a notification on Bob's mobile phone with the message: "*Dr. Karen would like to configure eWall. Do you agree? Yes/No*".
User:	Bob taps the "*Yes*" button.
System:	The eWall system displays a detailed interface on Karen's display with configuration options classified by application groups.
User:	Karen inputs her new configuration choices.
System:	Bob's eWall mobile app displays a notification: "*A new configuration has been made. Please check the main display in your home, for more details.*"
System:	Bob's eWall home installation will offer Bob an easy to understand tutorial, shown on the primary display explaining the new change in configuration.

Context:	Jane, an eWall primary user, has a scheduled teleconference with her general practitioner Karen, an eWall medical caregiver. Jane attends from her home, while Karen attends from her office.
User:	During the teleconference, Karen chooses to re-configure some of Jane's eWall applications. Karen accesses the *Configuration* application.
System:	The system shows Karen a list of patients (primary users of eWall) for which Karen can configure their home eWall installation. The first one on the list is Jane, because the system detects there is a teleconferencing with Jane as a primary user.
User:	Karen selects Jane.
System:	eWall prompts Jane a notification on the primary display: "*Dr. Karen would like to configure eWall. Do you agree? Yes/No*".
User:	Jane taps "*Yes*".
System:	eWall displays a detailed interface on Karen's display with configuration options classified by application groups.
User:	Karen inputs her new configuration choices.
System:	Jane's eWall primary display shows a notification: "*A new configuration has been made. Please check the main display in your home, for more details.*" Jane's eWall home installation will offer Jane an easy to understand tutorial, shown on the primary display explaining the new change in configuration.

6.3.4 Application: "Log-Book"

Context:	Enables medical trained care givers and informal caregivers to log observed patient characteristics, during the tele-conferencing. Logs are recorded by audio and/or written text. Bob, an eWall primary user, has a scheduled appointment with his general practitioner Karen, an eWall medical caregiver. During the consult, Karen can note her remarks on the log book. Throughout this use case, Karen's office eWall installation is referred to as the system (S).
User:	Karen accesses the *Log-Book* application on her office computer eWall installation.
System:	Displays a list of Karen's eWall primary patients.
User:	Karen selects Bob.
System:	Displays the main interface composed of: 1) a timeline interface containing Karen's logs from previous consults and teleconferences with Bob; 2) an interface in which Karen can type logs, or record audio logs. Each entry has an automated time stamp. Entries are saved automatically after creation.
User:	Karen selects a previous log text entry, relevant for the present consult.
System:	Displays a detailed version of the selected log entry. This is a text entry; therefore all

	the text is displayed.
User:	Karen closes the entry.
System:	Displays the main *Log-Book* interface.
User:	Karen clicks on the "*record a new log entry*" button.
System:	Launches a combined text editor and audio recorder.
User:	Karen presses the "*record*" button and speaks her log entry, the presses the "*stop*" button.
System:	Registers a new audio entry on the log timeline with the current timestamp.
User:	Karen wants to enter a new log, so she presses the "*record a new log entry*" button.
System:	Launches a combined text editor and audio recorder.
User:	Karen types her log entry in the text editor.
System:	Registers a new text entry on the log timeline with the current timestamp.

Context:	Michael, an eWall primary user, is assisted throughout the day by Maria, his wife and informal caregiver. Maria can note her remarks on the log book mobile app. Throughout this use case, Maria's mobile phone eWall installation is referred to as the system (S).
User:	Maria accesses the *Log-Book* Application.
System:	Displays the main interface composed of: 1) a timeline interface containing Maria's logs; 2) an interface in which Maria can type logs, or record audio logs. Each entry has an automated time stamp. Entries are saved automatically after creation.
User:	Maria selects a previous log text entry, relevant for the present consult.
System:	Displays a detailed version of the selected log entry. This is a text entry; therefore all the text is displayed.
User:	Maria closes the entry.
System:	Displays the main *Log-Book* interface.
User:	Maria clicks on the "*record a new log entry*" button.
System:	Launches a combined text editor and audio recorder.
User:	Maria presses the "*record*" button and speaks her log entry, the presses the "*stop*" button.
System:	Registers a new audio entry on the log timeline with the current timestamp.
User:	Maria wants to enter a new log, so she presses the "*record a new log entry*" button.
System:	Launches a combined text editor and audio recorder.
User:	Maria types her log entry in the text editor.
System:	Registers a new text entry on the log timeline with the current timestamp.

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Abbreviations

Abbrev.	*Description*
AD	Alzheimer Disease
ADL	Activities of Daily Living
ARI	Age Related Impairments
BAN	Body Area Network
COPD	Chronic Obstructive Pulmonary Disease
CT scan	Computed Tomography scan
FEV1	Forced Expiratory Volume in 1 second
GOLD	Global Initiative for Chronic Obstructive Lung Disease
GP	General Practitioner
HAN	Home Area Network
ISO	International Organization of Standardization
MCI	Mild Cognitive Impairments
MD	Mild Dementia
PTD	Portable Tangible Device, or Portable Touch-enabled Device