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1 Short report

Deliverables that are of a nature other than written "reports", such as "prototypes", "demonstrators" or "others", should also be accompanied by a short report, so that the European Commission has a record of their existence.

Sustaining independent living of elderly is desired by citizens and a target for social policies. Substantial care interventions are provided to European citizens to support their independent living. This involves mainly human care provision. Robotics offers a large potential to answer the growing demand for this type of support. The functionality of such robots should be guided, even in the development stage, by the needs of users and their perspectives regarding what threatens independent living. This interaction between developers and potential users optimises the future applicability and acceptability of such robots. In this deliverable, we report the results of an inventory of problematic activities in independent living and of current care provisions supporting independent living in four European countries. These results, as well as subsequent user requirement studies in the project, are used to inform potential robot functionality.

Note: due to the nature of this deliverable, as a scoping study, it is supported by multiple publications.

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2 Current care guiding the development of a service robotic for independent living elderly

2.1 INTRODUCTION

In our society adults tend to live independently in their own homes. Individuals act upon their preferences regarding this independent living, adapting to their changing preferences over time. However, independent living is threatened by insufficient or decreasing ability to maintain such independence. For those who are not able to maintain their independence, societies seek solutions of different kinds to regain or sustain independence or alternatively offer an institutional arrangement for dependent living.

As they become increasingly old, citizens are faced with consequences of decreasing ability, which among others, threatens independent living. There are many everyday tasks persons need to be able to perform to maintain their independence and age-related changes of mental and physical abilities can make the performance of these everyday tasks difficult or challenging.

The proportion of older citizens in Europe and other developed countries is increasing significantly and expected to expand further over the course of the next decades. It is estimated that the percentage of the European population aged 65 years and over will grow from 16% in 2010 to 29,3% in 2060 [1]. A large part of this population will experience functional problems sooner or later, which is expected to cause an escalation of costs in the healthcare sector for the elderly. Short and long-term labour shortages are already experienced, especially in the healthcare sector. These are expected to become more acute in the twenties and thirties (see Fig. 1). Alternative ways of providing care to the elderly need to be investigated in order to lessen costs and meet the labour shortages whilst maintaining the quality of care at home for the elderly.

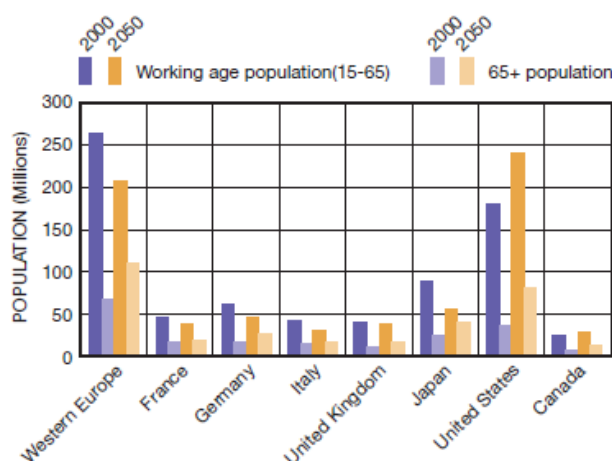


Figure 1. Demographic changes in Europe [2].

2.1.1 Role of robotics

Traditionally, care is provided by people either informally by those from the direct social environment (e.g. family) or more formally by professionals funded by either public or private means. Due to changing social structures (that result in family members being less inclined and/or able to provide care) and an increasing shortage of care staff [3] alternative solutions are given increased attention with technology as the alternative with the highest potential. Of course, technology is already used to support independence. Assistive technology (AT) such as wheelchairs, stairlifts, patient hoists, smart homes and in general accessibility adaptations of the home have come a long way in supporting individuals in their independence [4].

ICT technology and robotics in particular promise to support care and independence in many ways [5]. Although robotics application in care has been limited so far, substantial effort is underway to develop applications [6]. To date, these developments have been driven mainly by the technological possibilities. The envisioned role of robot in these developments, and the type of tasks the robot performs, are primarily guided by technical feasibility and to a lesser degree by the target users' needs [6].

Using robotics to support independence does not imply that robots will fully take over the execution of the task. Instead, AT in general and robotics in particular can be applied as physical support, cognitive support, social activity support or re-ablement / rehabilitation [7].

- A robot may provide physical support to take over the execution of those activities, the user cannot perform (robot vacuum cleaner). But user activity may also be supported by the robot. The user and the robot jointly perform the task where the robot provides the functionality the user cannot (for example exoskeletons or smart arm support).
- A robot providing cognitive support could monitor or coordinate activities. Typical example would be a reminder for medication or a fall detection system.
- A robot providing social activity could support and stimulate activities by enhancing the social aspects of an activity. Typical example would be a robot which provides and stimulates communication and activities between people.
- In the re-ablement or rehabilitation option the robot may train the user to perform activities that user can no longer perform, using a different or alternative way of doing the task. Typical example would be a rehabilitation robot for gait training at home.

Within any of these applications the robot could in principle offer a wide range of support. Over the past decades numerous projects have been developing a range of these functionalities, primarily guided by the technical feasibility. Nevertheless, only a small number of robotic systems have actually been brought to the market and are available to support care for individuals in their daily lives.

In the EU Accompany project [8] robot functionality will be developed to support older citizens to sustain independent living. To optimise the potential of this robot its functional capabilities will be selected after surveying the needs of future users and the types of care activities currently publically funded in Europe.

This paper describes the survey process, which had two-steps and was guided by two questions:

1. Which problems in daily life most threaten the independence of elderly persons?
2. Which care interventions supporting the independent living of elderly persons are currently publically funded in European countries?

The first question was addressed by producing an inventory of activities that were reported, by elderly people and caregivers, as being critical for independent living. The second, by an inventory of publically funded care interventions in four European countries (the Netherlands, UK, France and Italy). Public funding was used partly as a measure of the perceived significance and effectiveness of support activities in these countries. On the basis of these inventories an analysis was made of the activities a robot should be able to perform or support to optimise supporting independent living of elderly persons.

2.2 METHOD

For this study two inventories were made. The first inventory concerns the activities that are problematic for elderly persons which might undermine their independent living. The second inventory concerns the care interventions now available in four European countries aiming to support independent living of elderly persons.

2.2.1 Problematic everyday activities threatening independent living

The inventory of threats to the independent living of elderly persons was made on the basis of desk research. This included a literature search in Google and Google SCHOLAR (until December 2011) to collect information about problematic activities of daily living (ADL) of elderly persons living independently. The search strategy used was: [problematic OR difficult] AND [activities of daily living OR ADL] AND elderly AND [independent living]. In addition, the website of the European commission [9] was searched for European robotic/ICT projects in which user needs assessments was a recurring work package. If no publications could be identified, the websites of the identified projects were searched for relevant scientific publications or relevant deliverables. For those projects identified as relevant and for which no publication could be found personal communication was used to retrieve relevant information about the identification of activities needing to be supported to sustain independent living of elderly persons.

2.2.2 Publically funded care interventions for independent living

Data for the inventory of publically funded care interventions was organised using a questionnaire (Appendix 1). The questionnaire was completed for four European countries represented in the Accompany consortium (the Netherlands, UK, France and Italy). The data collection was coordinated by the local consortium partners. Once the description based on the questionnaire were gathered, the results were validated by available national expertise to confirm appropriateness.

The questionnaire covered the range of care settings in each country, the types of care interventions provided in each of these settings, the availability of public funding for care interventions in these care settings, the criteria determining eligibility to care interventions and the use of AT in elderly care (Appendix 1).

The national descriptions of elderly care were then combined into an overview of types of accommodation and the various types of care interventions available in these by country.

2.3 RESULTS

2.3.1 Problematic activities of daily living of elderly

Humans perform a very wide range of activities, any of which could potentially become difficult for older people to perform thereby threatening independent living. To deal with the variety of pertinent activities the International Classification of Functioning (ICF) of the World Health Organization (WHO) was adopted. The ICF provides a structured taxonomy for the description of human functioning [10].

The process for user driven selection of care or service tasks supporting independent living of elderly is not well documented and only few publications could be found. This is surprising given the vast amount of funding invested in robot development in the last decade. Through the Cordis website the most relevant European (robotic) projects were identified (Movaid [11], SRS [12], Mobiserv [13], Cogniron [14], LIREC [15], CompanionAble [16], Ambience [17], HERMES [18], Florence [19], KSERA [20]). From this list, several projects were highlighted because of their focus on improving independent living of elderly persons.

SRS project – This project focused on the development of a semi-autonomous robot for a domestic environment to support elderly people in their independence at home. Tasks chosen for the scenarios of the robot are: fetch and carry, emergency help, situation monitoring and the preparation of food.

CompanionAble – The CompanionAble project aims at providing synergy of robotics and ambient intelligence technologies and their semantic integration to provide for a caregiver's assistive environment, mediated by a robotic companion working collaboratively with a smart home environment. This project was specifically aimed at dementia patients. Tasks chosen for this robot were: realisation of an intelligent day-time-management, content generation for cognitive stimulation and training and coherent delivery through multiple channels, reminder function for taking medications as well as analysis of acquired data regarding the health status of the care-recipient, efficient & natural social communication and care networking by means of audio-visual communication with relatives or care-givers.

HERMES – The aim of the HERMES project is to provide cognitive care for older persons. This project had no intention to develop a robot, instead an Assistive Technology (AT) was created to enhance the functional skills of an older person to reduce age-related decline of cognitive capabilities and assist the user where necessary. The tasks chosen for the HERMES robot scenarios are: facilitation of

episodic memory through the capture of content in audio and image including when/where/who/what/why of a moment, cognitive training through games, advanced activity reminding, conversation support and mobility support with cognitive support.

Florence – The project aimed to improve the well-being of the elderly as well as improving efficiency in care through ambient assisted living services supported by a general-purpose robot platform. The tasks chosen for the scenarios of the robot were: keeping in touch, home interface, fall handling, agenda reminder, lifestyle improvement, collaborative gaming and a logging system.

KSERA – The main aim of this project is to develop a socially assistive robot that helps elderly people, especially those with Chronic Obstructive Pulmonary Disease (COPD) with their daily activities, care needs and self-management of their disease. For this project utilised robotics in the following areas: a mobile assistant to support and interact with an older person, delivering useful communication and advise an older person or caregivers of anomalous or dangerous situations on the basis of health and behavioural monitoring.

There were, with the exception of the SRS project, very limited number of public documents available on user needs driven functionality selection without the a priori filtering for intended technical functionality for these projects. As a consequence, personal communication was adopted to retrieve data. As a consequence, personal communication was adopted to retrieve data. The efforts of this search led to two assessments of user needs driven functionality for robot development: the above mentioned SRS project and a non robot related study on problems in independent living elderly in the Netherlands.

2.3.1.1 SRS project

The European Multi-Role Shadow Robotic System for Independent Living (SRS) project [12] produced, on the basis of extensive user research (focus groups), a list of activities that make independent living challenging for the elderly. The overall goal of SRS project is to develop an innovative social service robot for assisting elderly people to live longer and independently in their own homes. The aim of the research was not therefore only to address the problematic ADL of elderly but also on the gathering of data on participants' attitudes towards personal service robots. The SRS user requirement study also included family caregivers and professionals (professional caregivers and health professionals) as these were regarded as indirect users of the personal service robot. Several activities were reported as difficulties in ADL for elderly by elderly and in the opinion of the family caregivers, professional caregivers and health professionals. These are presented in Table 1.

2.3.1.2 Crützen et al

A study into *The most recurring problems of independent living elderly, recommended assistive devices and solutions*. (translated from the Dutch title) as performed by Crutzen et al [21] focussed on the most common problems the elderly face when living independently. Data was collected using street interviews with the elderly, 1 on 1 interviews with the elderly and a literature review. This research resulted in a top 10, based on the frequency of a reported problematic ADL. It is important to note that no reference to any type of (robotic) solution was factored into the prioritisation process. The resulting list of activities is given in Table 1.

In both the research conducted by Crützen et al and the SRS project, mobility (d4), housekeeping (d6) and self care (d5) were all highlighted as particular problems. However, the ICF group self care (d5) was dropped as these problems concerning d510 – d560, were not ranked as high enough. The SRS project therefore continued with the problematic activities derived from the ICF groups mobility (d4) and housekeeping (d6).

In Table 1 the activities prioritised in both projects are combined. The table is structured according to the ICF classification. The shading of cells in the two right-hand columns shows if the activity was mentioned in either of the studies or both. The numbering used for Crützen et al shows the order of priority given to the selected activities.

No.	Activity	ICF number	Description	Crützen et al	SRS
1.	Changing basis body position	d410	Getting into and out of a body position and moving from one location to another, such as getting up out of a chair to lie down on a bed, and getting into and out of positions of kneeling or squatting.		
2.	Sitting and getting up	d4103	Getting into and out of a seated position and changing body position from sitting down to any other position, such as standing up or lying down.	6	
3.	Bending	d4105	Tilting the back downwards or to the side, at the torso, such as in bowing or reaching down for an object.	7	
4.	Reaching	d4452	Using the hands and arms to extend outwards and touch and grasp something, such as when reaching across a table or desk for a book.	10	
5.	Walking	d450	Moving along a surface on foot, step by step, so that one foot is always on the ground, such as when strolling, sauntering, walking forwards, backwards, or sideways.	1	
6.	Climbing	d4551	Moving the whole body upwards or downwards, over surfaces or objects, such as climbing steps, rocks, ladders or stairs, curbs or other objects.	2	
7.	Using transportation	d470	Using transportation to move around as a passenger, such as being driven in a car or on a bus or private or public taxi.		
8.	Washing	d510	Washing and drying one's whole body, or body parts, using water and appropriate cleaning and drying materials or methods, such as bathing, showering, washing hands and feet, face and hair, and drying with a towel	4	
9.	Toileting	d530	Planning and carrying out the elimination of human waste and cleaning oneself afterwards.		
10.	Dressing	d540	Carrying out the coordinated actions and tasks of putting on and taking off clothes and footwear in sequence and in keeping with climatic and social conditions, such as by putting on, adjusting and removing shirts, skirts, blouses, pants, undergarments, saris, kimono, tights, hats, gloves, coats, shoes, boots, sandals and slippers.	5	

11.	Eating	d550	Carrying out the coordinated tasks and actions of eating food that has been served, bringing it to the mouth and consuming it in culturally acceptable ways, cutting or breaking food into pieces, opening bottles and cans, using eating implements, having meals, feasting or dining.		
12.	Drinking	d560	Taking hold of a drink, bringing it to the mouth, and consuming the drink in culturally acceptable ways, mixing, stirring and pouring liquids for drinking, opening bottles and cans, drinking through a straw or drinking running water such as from a tap or a spring.		
13.	Acquisition of goods and services	d620	Selecting, procuring and transporting all goods and services required for daily living, such as selecting, procuring, transporting and storing food, drink, clothing, cleaning materials, fuel, household items, utensils, cooking ware, domestic appliances and tools; procuring utilities and other household services.	8	
14.	Preparing meals	d630	Planning, organizing, cooking and serving simple and complex meals for oneself and others, such as by making a menu, selecting edible food and drink, getting together ingredients for preparing meals, cooking with heat and preparing cold foods and drinks, and serving the food.	9	
15.	Housekeeping	d640	Managing a household by cleaning the house, washing clothes, using household appliances, storing food and disposing of garbage, such as by sweeping, mopping, washing counters, walls and other surfaces; collecting and disposing of household garbage; tidying rooms, closets and drawers; collecting, washing, drying, folding and ironing clothes; cleaning footwear; using brooms, brushes and vacuum cleaners; using washing machines, driers and irons.	3	

Table 1 : List of problematic tasks for elderly based on the literature search, unified and labelled by ICF.

2.3.2 Publically funded care interventions for independent living

In European countries costs of care are rapidly increasing and this prompts governments to carefully consider the type of care interventions that are publically funded. Therefore, in addition to the individual based prioritizing of problematic activities, the societal perspective is also of relevance as any technological intervention will have to be adopted and funded by these care systems in the future.

Based on the four national descriptions of the care system for independent elderly citizens, an overview was produced summarizing the systems and comparing their contents regarding type of care interventions currently supported.

When looking at the Netherlands, the United Kingdom (UK), France and Italy two different health care models were distinguished. This is in accordance with a general trend across Europe [22]:

- The medical model: in this model an impairment of a person is directly linked to a disability. A disability can therefore be seen as a problem that needs to be faced by the disabled person individually.
- The social model: in this model the impairment of a person is not necessarily linked to a disability. Instead, a disability is caused by the response of the society if the needs of a person with an impairment are not met;

The Netherlands – The care system in the Netherlands is based on a combination of the social model and the medical model. A distinction can be made between three different support systems which are used for different purposes; health insurance, AWBZ (Exceptional Medical Expenses Act) and WMO (Social Support Act). All Dutch residents are legally required to have health insurance, which means that all citizens have access to a basic level of healthcare. Everybody can request support from the AWBZ and WMO. The need for provision of (human) care is established by an independent authority; the Centre for Need Assessment (CIZ) that fulfils the role of indicating the individual level of care needed and the level of the allowance when applying for AWBZ. In order to receive provision to support independence and social participation of people through the provision of technology or services (WMO) a request needs to be made in their municipality. The municipal authority decides if the application is accepted and the level of the applicants allowance.

The United Kingdom – The care system in the UK is similar to the care system of the Netherlands as it is a combination of the medical model and the social model. Care in the UK is mainly provided by the National Health Service (NHS) that provides healthcare to all permanent residents of the UK, paid for from general taxation. When the need for help is linked to a specific medical condition, it is regarded as responding to a medical need and therefore provided free. There is no overarching legislation for providing financial support for social care. Services are means-tested. Older people can ask their local authority for an assessment. Budget constraints mean that local authorities cannot provide all the support requested. Recent policy developments have supported the move towards 'personalisation' in which older people are supported through a process of self assessment and have a budget allocated (direct payments) to allow them to buy their own care package (note: direct payments may not be used to pay for the services of a person who is a spouse or a close relative of, and living under the same roof as, the service-user). Also any assistive technology that meets the assessed needs can potentially be financed through the direct payments schemes. Another means of receiving provision for assistive technology is to apply for a Disabled Facilities Grant from the local council. This grant is also means-tested. The public system dominates the healthcare provision, though private care is available for those willing to pay.

France – The French healthcare system is based on a combination of the medical and social model, both of which can be seen at the level of its funding and its implementation. At the funding level, the National Health Insurance (*Caisse Nationale d'Assurance Maladie*) is in charge of the reimbursement of healthcare expenses. The National Pension Fund (*Caisse Nationale d'Assurance Vieillesse*, or CNAV) at the national level, and at the decentralised level the departmental councils (*Conseil Général*), are the main funding bodies for the provision of assistance to the elderly in their daily life. Based on the medical assessment of the capacity of the elderly to live independently (their level of impairment and

disability), the AGGIR grid is the French national assessment table used for allocating allowances [23]. The grid consists of 6 different categories (IRGs) where IRG 1 corresponds to the most dependent people and IRG 6 to the most independent. The elderly in groups IRG 1 – 4 are eligible to claim the APA managed by the departmental councils, and the elderly in groups IRG 5-6 are eligible to claim in particular the PAP of the National Pension Fund. The APA is a universal benefit, although income is taken into account in the calculation of the amount granted and the beneficiary is asked to make a contribution known as “co-payment”. The PAP is a discretionary benefit provided by the National Pension Fund calculated according to income and involving a financial contribution from the beneficiary. At the implementation level, the support is provided through medical and social teams which are in charge of adapting the services to the needs and the way of life of the elderly. The social model is therefore much more present at the implementation stage of the services.

Italy – The Italian health care system is mainly based on the medical model. People can receive money from the Italian National Health Service (NHS). The NHS is organised at two levels: national (central) and regional. At national level the Italian National Security Institute (INPS) allocates cash transfers to frail elderly and disabled, but only in case of 100% inability to perform ADL without guidance and when being hosted without charge in a nursing home or hospital. Each region autonomously manages and provides care services, but the NHS defines the guidelines (example: in the south of Italy people receive by their municipalities one-third of the financial support for social and health assistance services received by those living in the north-east of Italy [24]. In order to apply for an NHS allowance people need to have an assessment. Due to the reported complexity of the application, elderly care is often financed by private money.

Data obtained from World Health Organisation statistics on 2010 presents the difference in between governmental expenditure on health, as well as differences on private expenditure as well as uncompensated private expenditure as shown by Table 2.

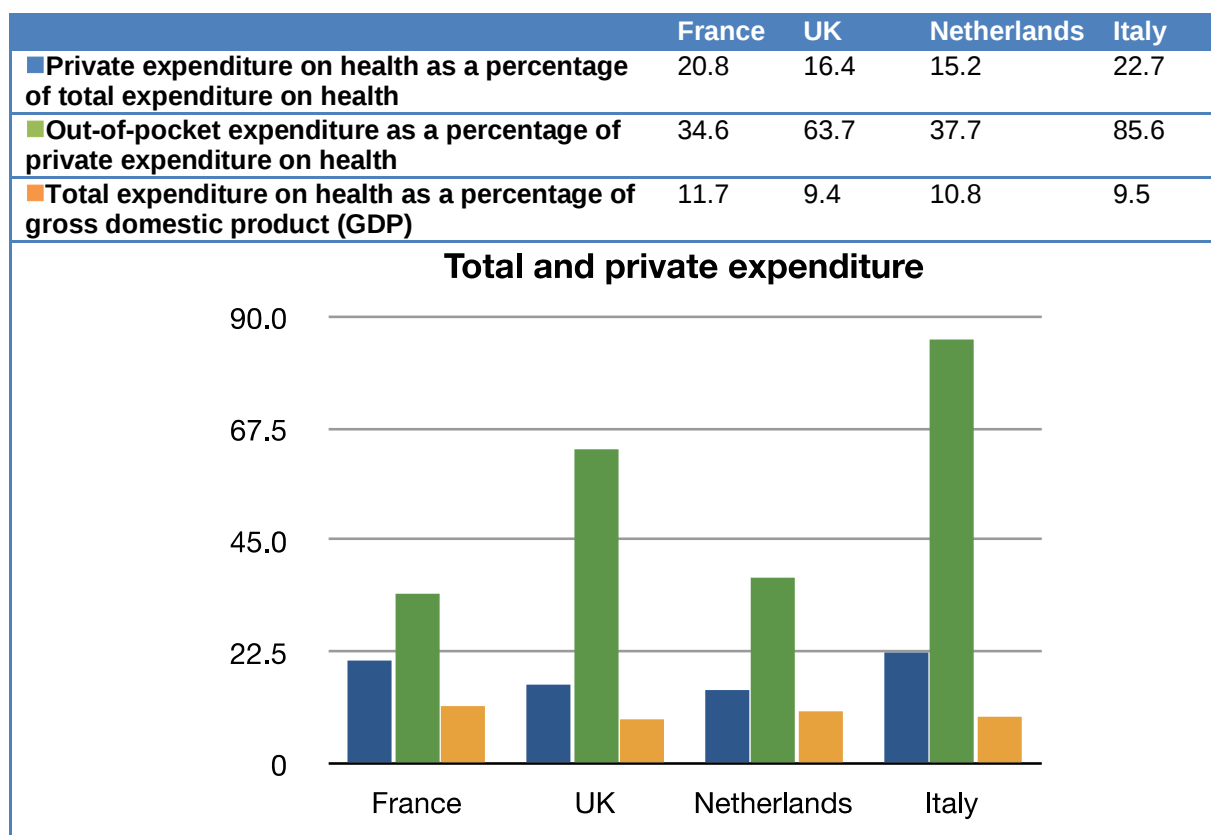


Table 2. Comparing public and private expenditure on health [25]

2.3.3 Important dimensions of care systems

Elderly people facing difficulties in remaining independent have a variety of residential care arrangements ranging from extramural (at home) to receiving up to 24 hour nursing in an intramural setting (nursing home). When looking at the Netherlands, the UK, France and Italy, four types of settings or accommodations can be distinguished:

1. The extramural setting is the person's own home. Elderly people still live in their own home and if they need care, they can receive homecare.
2. A semi extramural setting such as an assisted living community. Elderly people living here are still independent, and when needed (care) services are available. There are roughly two different types; sheltered housing and housing with care. The difference between these two lies in the services provided.
3. Intramural setting in a residential home. When the client can no longer remain in their own home or assisted living community housing, due to extensive care requirements, the care providing environment shifts to the third type: institutional care. In this setting only formal care is funded.

4. Intramural setting in a nursing home. This setting provides all services available in a residential home as well as additional nursing. Similar to a residential home informal care is not funded.

In addition to the indicated human care in all four settings AT can be provided. Table 3 provides an overview of all activities for which supporting care interventions are provided.

No.	Activity	ICF number	Description
1.	Planning daily routine	d230	Planning simple or complex and coordinated actions in order to plan, manage and complete the requirements of day-to-day procedures or duties, such as budgeting time and making plans for separate activities throughout the day.
2.	Changing basis body position	d410	Getting into and out of a body position and moving from one location to another, such as getting up out of a chair to lie down on a bed, and getting into and out of positions of kneeling or squatting
3.	Walking	d450	Moving along a surface on foot, step by step, so that one foot is always on the ground, such as when strolling, sauntering, walking forwards, backwards, or sideways.
4.	Using transportation	d470	Using transportation to move around as a passenger, such as being driven in a car or on a bus, or in a private or public taxi.
5.	Washing	d510	Washing and drying one's whole body, or body parts, using water and appropriate cleaning and drying materials or methods, such as bathing, showering, washing hands and feet, face and hair, and drying with a towel
6.	Toileting	d530	Planning and carrying out the elimination of human waste and cleaning oneself afterwards.
7.	Dressing	d540	Carrying out the coordinated actions and tasks of putting on and taking off clothes and footwear in sequence and in keeping with climatic and social conditions, such as by putting on, adjusting and removing shirts, skirts, blouses, pants, undergarments, tights, hats, gloves, coats, shoes, boots, sandals and slippers.
8.	Eating	d550	Carrying out the coordinated tasks and actions of eating food that has been served, bringing it to the mouth and consuming it in culturally acceptable ways, cutting or breaking food into pieces, opening bottles and cans, using eating implements, having meals, feasting or dining.
9.	Drinking	d560	Taking hold of a drink, bringing it to the mouth, and consuming the drink in culturally acceptable ways, mixing, stirring and pouring liquids for drinking, opening bottles and cans, drinking through a straw.
10.	Acquiring a place to live	d610	Buying, renting, furnishing and arranging a house, apartment or other dwelling.
11.	Acquisition of goods and services	d620	Selecting, procuring and transporting all goods and services required for daily living, such as selecting, procuring, transporting and storing food, drink, clothing, cleaning materials, fuel, household items, utensils, cooking ware, domestic appliances and tools; procuring utilities and other household services.

12.	Preparing meals	d630	Planning, organizing, cooking and serving simple and complex meals for oneself and others, such as by making a menu, selecting edible food and drink, getting together ingredients for preparing meals, cooking with heat and preparing cold foods and drinks, and serving the food.
13.	Housekeeping	d640	Managing a household by cleaning the house, washing clothes, using household appliances, storing food and disposing of garbage, such as by sweeping, mopping, washing counters, walls and other surfaces; collecting and disposing of household garbage; tidying rooms, closets and drawers; collecting, washing, drying, folding and ironing clothes; cleaning footwear; using brooms, brushes and vacuum cleaners; using washing machines, driers and irons.
14.	Recreation and leisure	d920	Engaging in any form of play, recreational or leisure activity, such as informal or organized play and sports, programmes of physical fitness, relaxation, amusement or diversion, going to art galleries, museums, cinemas or theatres; engaging in crafts or hobbies, reading for enjoyment, playing musical instruments; sightseeing, tourism and travelling for pleasure.
15.	Monitoring	X	Observing the activities of elderly people.
16.	Nursing care	X	Paramedical activities (e.g. medication, compression therapy or wound care).
17.	Therapeutic intervention	X	Therapy focused on the maintenance/improvement of activities.

Table 3: List of activities for which supporting care is provided, unified and labelled by ICF.

A table was compiled to combine the care settings and the care interventions, indicating which care interventions are funded in the four countries as distributed over the care settings (see Table 4). The numbers in the cells of this table refer to the activities of Table 3.

Note: when an elderly person has no assessment for a care intervention, the care intervention is always paid by private money.

ACCOMPANY

<March 23, 2012>

Contract number: 287624

Dissemination Level: CO

		Extramural			Semi-extramural		Intramural			
		Living at home			Assisted living accommodation		Residential home		Nursing home	
		Assistive technology	Informal care	Formal care	Assistive technology	Formal care	Assistive technology	Formal care	Assistive technology	Formal care
The Netherlands	Funded	1-2-3-5-6-7-8-9-10-11-12-13-15-16-17	1-2-4-5-6-7-8-9-11-12-13-15-16-17	1-2-4-5-6-7-8-9-11-12-13-14-15-16-17	1-2-3-5-6-7-8-9-10-11-12-13-15-16-17	1-2-4-5-6-7-8-9-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17
	Private money	4-14	3-10-14	3-10	4-14	3-10		10		
The UK	Funded	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17
	Private money									
France	Funded	1-2-3-4-15	1-2-3-4-5-6-7-8-9-11-12-13-15-16-17	1-2-4-5-6-7-8-9-12-13-14-15-16-17	1-2-3-5-6-7-8-9-10-11-12-13-15-16-17	1-2-4-5-6-7-8-9-10-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-4-5-6-7-8-9-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17
	Private money	6-7-8-9-10-11-12-13-14-16-17	1-3-4-8-9-10-11-12-13-14	1-4-8-9-12-13-14	6-7-8-9-10-11-12-13-14-16-17	1-4-8-9-12-13-14		1-4-8-9-12-13-14		1-4-8-9-12-13-14

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Italy	Funded	1-2-3-4-6-9-15		1-2-3-4-5-6-7-8-9-11-12-13-14-15-16-17	* 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	† 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	† 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	† 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	† 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	† 1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17
	Private money	4-5-7-8-10-11-14-15-17	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17	4-10-14-16		† 3-4-12-14-16-17		† 1-2-3-4-5-6-7-8-9-11-12-13-14-15-16-17		† 1-2-3-4-5-6-7-8-9-11-12-13-14-15-16-17

Table 4: Overview of funded care interventions distributed over the care settings.

* Public residential home
† Private residential home

2.4 DISCUSSIONS

For the development of a service robot intended to support independent living activities were identified by ACCOMPANY that are considered problematic by the intended user population. Activities were also assessed that are currently being supported through care interventions funded by public money in four European countries. The purpose of this is to narrow down the number and kind of activities that a service robot should be designed to support. The functional capabilities of a robot intended to support independence of older persons should be aimed at the interface between the two collections of activities; otherwise there is danger that the resulting robot is able to solve non-existing problems and/or perform tasks which are not considered worth funding.

There is substantial overlap between the lists derived from both studies of activities threatening independent living. But there is also obvious overlap between the list of problematic activities and the activities supported by public funding (see Table 5 for the overview of the activities of both lists in a single table). On the basis of this, the quest for user needs driven selection of robot functionality can be narrowed down.

Here are some possible robotics interventions by type of care tasks earlier identified:

- | | |
|--------------------------|---|
| <i>Physical support</i> | <ol style="list-style-type: none"> 1. In the provision of care, robot functioning should aim for substitution of task execution as far as the user is not capable him/herself. Only those tasks a user nominates should be taken over as people prefer to perform activities independently and it is preferable that people remain active as long as possible. In addition, only care tasks that are currently funded should be considered. 2. A robot functioning as compensation for the loss of activities of elderly, should support activities as far as the user requires, for – in the case of substitution – it is preferable that people remain active for as long as possible. The robot therefore will only provide the functionality the user cannot perform and the robot will not execute tasks without help of the user. The user needs to teach the robots which and how support is required. Only care tasks that are currently funded should be considered. |
| <i>Cognitive support</i> | Cognitive support is currently funded in the form of assistive technologies or as a by-product of delivered care services in an extramural situation. A service robot, providing cognitive support when people perform different activities, could combine these two aspects. For this role it is important that the focus of the cognitive support is on providing support for the problematic activities as well as for funded care tasks. |
| <i>Social activity</i> | A robot providing social activity in an extramural setting is unlikely to be funded by public money as social activities are not funded at home. However this does not imply this role should be ignored as a robot could be capable of supporting the elderly with activities through enhancing social activity. |

Re-ablement

Currently re-ablement interventions are not applied preventively. Intensive coaching or training of persons at risks is currently not being funded. Due to the required staff to coach reablement, this is also not feasible. Similarly out-patient rehabilitation programs are not extended to the patients' homes because to do so would require an extensive increase in staffing levels. This however does not impact on the feasibility of robotic interventions. Application of a robot could open new possibilities for extending training programmes that could be highly beneficial for older persons living at home e.g. rehabilitation robots for post stroke patients training at home.

Regarding the *type of tasks* the robot should be designed to undertake, the analysis of activities that require support and tasks that are open to funding show that physical task support should be considered. For cognitive tasks and social tasks there is no urgent need reported, there is almost no funding available for these types of tasks and it is even questionable whether a robot is essential in supporting them. This is in contrast with the functionality developed in many service robot projects, as the main focus of most projects, as measured by the reported results, is based on cognitive and/or social tasks. This is probably the result of using a technology driven method for the task development of the robot, instead of user demand driven one. Physical support is probably also the most challenging type of tasks from the perspective of technical development.

Currently in homecare there is only funding for support of physical tasks, although care staff claims that their presence in homes allows them to support cognitive functioning whilst executing the physical tasks. Obviously the social nature of humans will introduce social aspects to the visit of care staff to the client's home. There is assistive technology available to support cognitive (medicine dispensers, cognitive orthoses etc) and social functioning and it is unlikely that a robot system could improve significantly on these.

Regarding the differences between the activities supported in the different *types of accommodation* a robot system should be aiming to support extramural care; there seems no big difference in the available support for clients in their own home and that available in assisted living accommodations. In intramural care more activities are supported but given the fact that the residents have more severe problems in these facilities the requirements for a robot system supporting these patients will be much more challenging.

Not all care related activities that are considered critical in sustaining independence and that are considered important enough to justify public funding are amenable to a robotic support system. In general a number of constraints to application of robotics should be considered.

- Robots are a complex technical solution and are therefore expensive. Where these are available, cheaper low-tech solutions which provide the same functionality, should be preferred. From a commercial perspective, developing a robot as a replacement for cheaper low tech available functionality should therefore be avoided.

- Robots are characterized by their distinct functionality, they are complex ICT devices that in addition are mobile and/or exert forces/produce movement of some kind. Application of robots then seems most sensible in situations where these capabilities are specifically required.
- There is obviously a big difference between human care and robot mediated care. Depending on the application a robot may bring major disadvantages (e.g. regarding social interaction and “de-humanizing care”). But in other application the robots’ machine-like character could be an advantage (e.g. regarding social embarrassment and privacy). Also human intellect is still considered as a relative safe means of dealing with unexpected, potentially dangerous situations, while robots may be more dependable as they are not restricted by working hours, fatigue, impatience or wages.

2.5 CONCLUSION

In conclusion, the reported analysis advocates for the development of functionality for a service robot to support elderly persons to live independently. A selection of tasks from the following list with recommendations can be made.

No.	Activity	ICF number	Recommendation
1.	Planning daily routine	d230	A robot is not required when it comes to planning daily routine of elderly people, as mobility and movement have probably no added value. Also several cheaper AT solutions are already available.
2.	Changing basic body position	d410 (including d4103 and d4105)	The support of clients during in home difficult movements such as transfers can be supported by a robot system. For many home dwelling elderly this support could mean providing the sense of safety, some guidance or a third hand in order for easy transfers.
3.	Reaching	d4452	Fetching items is of course not a specific task for care staff but it is a problematic, very frequently recurring obstacle. For a human it is an unrealistic care task, but for a machine it is a very realistic task.
4.	Walking	d450	Walking is an activity that exceeds the need for mobility. There are many AT solutions to overcome the need for mobility. But walking activates people cognitively and physically. A system supporting walking should not be a <i>walker</i> type of system but a system evoking natural walking (including supporting ones’ own weight and maintaining balance) and providing motivation to walk as an type of exercise.
5.	Climbing	d4551	For climbing stairs there are effective AT solutions available, such as stairlifts, platform lifts and even ceiling hoists. However, although a technical challenge, a robot could be used as well to support elderly in walking stairs where existing solutions run short.
6.	Using transportation	d470	It does not seem to make sense to develop a robot system providing transport in order to be able to make use of other transportation.
7.	Washing	d510	For washing or bathing, a location based, daily, highly repetitive activity for which privacy may be preferred, a robotic solution is an interesting option.

8.	Toileting	d530	For similar reasons as mentioned under 7 a robotic support system for toileting is an interesting option.
9.	Dressing	d540	A system able to support dressing and undressing could be preferred. Again this is a location-based task requiring specific support that could start at the level of lending a third hand. In any case it will create independence from the timetable of home care staff.
10.	Eating and drinking	d550 and d560	For eating and drinking effective AT and robotic solutions are available.
11.	Acquiring a place to live	d610	Acquiring a place to live is not a task for a robot.
12.	Acquisition of goods and services	d620	For supporting the coordination of these tasks a robot does not seem to be able to offer much support, however, for the physical support of transportation of objects, e.g. groceries, a robot could be suitable.
13.	Preparing meals	d630	For the preparation of meals there are already excellent types of support available. Microwave meals as well as meal services are available to support any problem with preparing meals. A robotic solution does not make sense, as a robot does not have added value compared to the types of support available.
14.	Housekeeping	d640	Robotic systems and other smart machines are already available compensating for inability to perform specific household tasks. Extension of the functionality might lead to an increase of the number of devices needed as a wide range of specific functionalities is required.
15.	Recreation and leisure	d920	It is not useful to develop a robot just for recreation and social activities, as there are cheaper low-tech solutions available. However recreation and leisure could play a role in supporting other activities.
16.	Monitoring	X	Despite the presence of several AT systems, monitoring is an activity a robot could perform well. However it is unclear if a robot can perform on a higher level than a cheaper low-tech solution.
17.	Nursing care	X	Providing care is specific and requires human intervention. A robot could be used as support for the nurse, but a robot cannot replace the nurse.
18.	Therapeutic intervention	X	Therapeutic interventions require, similar to nursing care, human interaction. However, in case of prevention, a robot can be used to monitor elderly people and to provide exercises at home.

Table 5: Recommendations for a robotic solution for (problematic) activities.

Following this table, all activities with a positive recommendation were combined with the different roles of the robot in order to create examples of different tasks the robot could perform (see Table 6).

The column *physical support* in Table 6 requires physical contact between a human and a robot. It is known that this contact is challenging with regards to safety, adequacy and reliability. This certainly holds for the relative fragile population considered in this research. The more vulnerable and dependant the target population is, the more extensive physical contact is required to take care of them. However, for now this issue is regarded as a safety issue and not a requirement.

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	Physical support	Cognitive support [‡]	Social activity	Re-ablement [§]	Co-learner
Changing basis body position	Lifting person from sitting position into standing position.	Fall detection			
Reaching	Fetching items from the top shelf or picking up items from the ground.	Reminding people where items are.			
Walking	Function as rollator or walker during walking.	Reminding people to go walking.	Create elderly walking club.		
Climbing	Helping a person to balance or giving support for walking stairs.				
Washing	Helping a person to get in and out bath / shower or washing person.	Reminding people to go and have a shower / bath.			
Toileting	Supporting person when sitting down, lifting person up from sitting position or helping with clothes.	Reminding people to go to the toilet.			
Dressing	Dress / undress a person or helping to open / close buttons.	Reminding people to go and get dressed / changed.			
Eating and drinking	Assist person with eating / drinking.	Reminding people to have a meal / drink.	Having lunch / dinner with friends / family.		
Acquisition of goods and services	Carrying groceries or putting them away.	Reminding people when new groceries must be purchased.	Doing grocery shopping together.		Grocery list support (e.g. what to eat in combination with a diet).

[‡] For all activities: Monitoring activities.

[§] For all activities: Monitoring activities and training person how to improve own capabilities/flexibility/movement.

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Housekeeping	Vacuum cleaning or dusting the house.	Coordinate / scheduling housekeeping activities.			Performing housekeeping tasks together.
Recreation and leisure	Playing game together.	Reminding people of social agenda.	Reminder for birthday of family / friends or create social group around game.	Training the capabilities of person through game.	Exercise / play game together.
Monitoring	Providing help in case of an emergency (e.g. fall detection).	Coordinate / scheduling activities.	Remind people to visit friends.		
Therapeutic intervention	Supporting a person with revalidation exercises.	Monitoring activity and reminding people a person to do revalidation exercises.	Create social group around revalidation exercises.		Exercise / play game together in order to improve the capabilities of person.

Table 6: Examples of different tasks a service robot could perform combining the recommended activities with the different roles of a robot.

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2.7 APPENDIX 1 – QUESTIONNAIRE

1. There are different stages of care to be distinguished in each country, if we assume a continuum starting from living completely independently extramural (no care issues) to 24 hr nursing in intramural setting (nursing home or hospital). Name these and provide description.
2. Provide a description of the financing of these care settings (who pays, is it public money, private money or combinations). If possible distinguished for the various settings.
3. Provide a description for the criteria that are used for assigning an individual to these settings for care (i.e. the French AGGIR system).
4. What types of support can be provided in these settings where people live in their own home (extramural) and what not (i.e. self care, housekeeping, social support etc)?
5. Provide a description of experiments in progress or technologies already developed and commercialized for the elderly living at home
6. Which settings are considered suitable for Care-o-bot application and why (on functional level)?
7. What is the situation /the conditions for such applications from financial perspective/ reimbursement potential?
8. Is there a distinction in these settings between the provision of technology and the provision of care? Could there be a partial substitution within the current way things are organized?
9. Provide a description of current public policies or the strategies of complementary health funds for the prevention of the dependency of the elderly

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