An Ambient Assisted Living approach in designing domiciliary services combined with innovative technologies for patients with Alzheimer's disease: a case study

Abstract

Background: One of the most disabling diseases to affect large numbers of elderly people worldwide is Alzheimer's disease (AD). Because of the characteristics of this disease, AD patients require daily assistance from service providers both in nursing homes and at home. Domiciliary assistance has been demonstrated to be cost-effective and efficient in the first phase of the disease, helping to slow down the course of the illness, improve the quality of life and care, and extend independence for patients and caregivers. In this context, the aim of this work is to demonstrate the technical effectiveness and acceptability of an innovative domiciliary smart sensor system for providing domiciliary assistance to AD patients that has been developed with an Ambient Assisted Living (AAL) approach.

Methods: The design, development, testing and evaluation of the innovative technological solution were performed by a multidisciplinary team. Fifteen sociomedical operators and 14 AD patients were directly involved in defining the end-users' needs and requirements, identifying design principles with acceptability and usability features, and evaluating the technological solutions before and after the real experimentation.

Results: A modular technological system was produced to help caregivers monitor continuously the health status, safety, and daily activities of AD patients. During the experimentation, the acceptability, utility, usability, and efficacy of this system were evaluated as quite positive.

Conclusions: The experience described in this paper demonstrated that AAL technologies are feasible and effective nowadays, and can be actively used in assisting AD patients in their homes. The extensive involvement of caregivers in the experimentation allowed to assess that there is, through the use of the technological system, a proven improvement in care performance

and efficiency of care provision by both formal and informal caregivers, and consequently an increase in the quality of life of patients, their relatives, and their caregivers.

1. INTRODUCTION

1.1. *General background*

One of the most disabling diseases to affect large numbers of elderly people worldwide is Alzheimer's Disease (AD). Recently, statistics have estimated that worldwide there are about 30 million people suffering from AD [1], with more than 5.7 million in Europe [2] and 5.2 million in the U.S. alone [3]. The main features which characterize people suffering from AD are memory loss, difficulties in the production and comprehension of language, changes in personality, wandering, aggressive behavior, disorientation in time and space, loss of the ability to recognize what objects and their purposes are, an inability to carry out voluntary and purposeful movements, and an increased vulnerability to infection [2]. Currently, there is no cure for AD and some drug and nondrug treatments are provided only in order to attenuate the cognitive and behavioral symptoms.

Because of the characteristics of this pathology, Alzheimer's patients should be constantly assisted. This care can be provided at home by informal caregivers (relatives of the patients or persons engaged by families to assist the subjects) or in nursing homes by formal caregivers. Clinical experience has shown that specific domiciliary care of these patients provided in the initial stages of the disease can slow down the course of the illness [4]. However, assisting these patients is very complex and exhausting because caregivers are requested to assist them in activities of daily routine and medical care (commonly helping the person take drugs correctly), to monitor them in order to prevent unsafe situations, and to manage their behavioral changes [3]. All these activities demand time, physical work, and continuous attention, and often these conditions induce in caregivers severe psychological stress which has consequences for their quality of life and health status as well; many studies have verified the correlation between assisting a person suffering from Alzheimer's and the caregiver's physiological and psychological stress, which often causes depression and sometimes also induces rash gestures like suicide or homicide [5-9]. For this reason, patients suffering from AD are often institutionalized early in nursing homes with negative consequences both for the patients themselves, who are subjected to a more rapid degeneration, and for welfare costs, which are about three times higher in nursing homes than in domiciliary settings.

In this context, assistive technologies have the potential to prevent early institutionalizations and consequently slow down the course of the disease, improve the quality of life and care, and extend independence for patients and caregivers, and they can even help to slow the onset of symptoms by keeping patients cognitively active.

1.2. Ambient Assisted Living approach

Over the last few years, several projects have been funded and works have been published to demonstrate the effectiveness of assistive technologies that are integrated in end-users' domestic environments to increase the quality of domiciliary care and reduce the workload of caregivers [10-11] who assist patients with AD. Some works only dealt with specific technological issues, such as the assessment of localization and daily living activity in home environments [12-13]; others also involved a substantial number of patients and caregivers in a real nursing home setting [14, 15]; and others considered end-users' requirements as well from the beginning of the design phases [16] and provided usability validation [17]. Most of these studies demonstrated the feasibility of the user-centered design approach in technological solutions and consequential assessments of usability in nursing homes with real users.

In this context, the aim of this paper is to evaluate an Ambient Assisted Living (AAL) domiciliary service supported by technological solutions, including experimental setups in real domiciliary settings and using an AAL approach with the following aspects [18]:

- the technological solutions are conceived in combination with assistive services and caring organizations that are able to improve the management of sociomedical providers, the way in which caregivers work, and the quality and performance of the service itself for end-users;

- the use of technological solutions is conceived in a service dimension, so that technical, ethical, legal, clinical, economic, and organizational implications and challenges need to be considered at the same level;
- the design of technological solutions is achieved using a user-centered design approach, in which a multidisciplinary team composed of end-users, caregivers (also relatives), and sociomedical operators aids in the design phases of the innovative service with criteria of acceptability and usability, then actively participates in the experimentation, and finally contributes to the assessment of acceptability and usability parameters;
- the technological solutions are designed in order to be adequate to the end-users' needs, adaptive to the environments and end-users' behavior, not invasively embedded in the environments, appliances and furniture, easily wearable by end-users, proactive in an indoor and outdoor Ambient Intelligence (AmI) context, and highly usable with advanced human-machine interfaces.

According to these aspects, this work demonstrates the general feasibility, technical effectiveness, and acceptability of an innovative smart sensor system for providing domiciliary assistance to patients with AD that has been designed, developed, and tested in domiciliary cases with an AAL approach.

1.3. Background and motivations of the "Alzheimer Project"

This work is part of a wider project named "Alzheimer Project" that was coordinated by the municipality of Mantova, a city in the north of Italy, and funded by the Cariverona Foundation [19]. The project aimed to reorganize an innovative and more profitable domiciliary assistive service for elderly people in the first phases of AD in the city of Mantova. The strong impact of this project on the territory was due to the peculiar demographical trends registered in recent years and to the deficient social assistance provided to elderly people over 65: indeed, the city of Mantova was characterized by a population of about 50,000 citizens, of which about 15,000 were over 65 years old (30% of the total population), with about 4,000 of them living alone (8% of the total population) and about 1,000 with AD (6.67% of the elderly over 65). Several care organizations in Mantova participated in this project and one in particular, the “Azienda Servizi alla Persona e alla Famiglia” (ASPeF) [20], was involved in the experimentation of innovative services based on assistive technologies for domiciliary assistance and actively collaborated in all phases of design and experimentation.

2. METHODOLOGY

The development of the domiciliary assistance for patients with AD based on an innovative smart sensor system was conducted following a user-centered design approach by a multidisciplinary team consisting of clinicians, psychologists, therapists, and engineers who collaborated closely in all phases of the project in order to identify the real needs of patients and caregivers and to develop the most suitable and appropriate technological solutions. The developmental phases consisted of a precise sequence of work steps:

1. First, patients in the initial stages of Alzheimer's Disease who were assisted at home by the ASPeF were identified thanks to care workers who were in touch with them daily.
2. Second, the team interviewed the subjects and their informal caregivers in their homes to determine their life styles, habits, needs, and quality of life, and also to study the architectural structures and features of their houses. The information was noted on a form on which necessities, expected assistance scenarios, functions to carry out, and technological solutions were reported. For each case, a score based on the need for and the feasibility of the technological interventions was assigned by the team to prioritize the intervention (see Section 2.3).
3. Third, the technological solutions were designed and developed in a laboratory in order to produce smart home solutions.
4. Fourth, a specific validation protocol was conceived to verify both the single functions and the whole network in order to test the usability of the technological solutions and their effectiveness in relation to the characteristics and opinions of caregivers.
5. Fifth, the technological solutions were shown to clinicians and care workers who were asked to answer questions in order to identify possible weaknesses and improve the solutions before installation in patients' houses.
6. Sixth, the technological solutions and their control software interface were shown and taught to caregivers, highlighting the system's functionalities and interfaces.

7. Seventh, the systems were installed and tested in the domestic environments.
8. Finally, the sociomedical operators were asked to judge the use of technological systems.

2.1. Ethical issues

Even if the technological solution presented in this paper is a prototype, the previous described research and developmental phases were conducted considering the ethical principles and guidelines for gerontechnology research & development for persons with Alzheimer's disease and their caregivers, presented by D. F. Mahoney et al. in [21]. The following ethical issues were considered and implemented in the developmental and experimental phase: (1) Respect, (2) Autonomy & Informed Consent, (3) Beneficence (Do Good), (4) Justice & Distributional fairness, (5) Non-Abandonment, (6) Non-malfeasance (Do no Harm) and (7) Privacy & Confidentiality.

High respect was maintained for users and family caregivers by minimizing the intrusiveness of the installed technological solutions and of the presence of researchers in their home and by preserving safety for all participants. Particularly, the experience and multidisciplinary expertise of the entire team were crucial to foster technologies that realistically match the targeted needs of AD patients in order to interact carefully with people with AD and avoid upsetting them when installing the technology, especially on them or in their home. The AD patients' capacity for decision making was appropriately assessed by the sociomedical operators in order to ask informed consent from them or their relatives. Furthermore the multidisciplinary team paid attention to avoid frustrating users due to upkeep needs of the technology or its complexity, such as frequent battery changes to enable the components, daily resetting of the system, or other burdensome demands requiring active involvement on the part of patients, caregivers, or family members. The developed technological solution was composed of components already available on the market and selected without any particular commercial preference and anyway the entire system was conceived to be affordable to all who can benefit from it. Patients and families were informed from the beginning that the tested technology was a prototype of a feasibility study, which would not have been available for continued use upon the study. Finally privacy and confidentiality was preserved in different aspects. During the end-user needs' analysis, data about the health status and private life of users were collected and anonymously treated during the entire project. During the experimental phase, also data and behavioral patterns, collected by monitoring the patients with the technological solution (i.e. activities done during the day at home, outdoor localization, met people, etc.), were anonymously used after approval from the person with dementia, his/her family and professional caregivers. Additionally, since the technological solution was based on a wireless sensor network, security measures to safeguard access to data were taken by installing simple security keys, in order to avoid any abuse from external persons.

2.2. Recruitment

The subjects involved were recruited by the ASPeF sociomedical operators, who selected them from among those people they were assisting with domiciliary services. The recruitment process consisted of two phases: firstly, ASPeF sociomedical operators selected those subjects who were in the first and second clinical stage of AD, lived alone or with a caregiver, were partially autonomous, and needed support in some of the activities of daily life (ADLs). In this phase 80 subjects were identified, providing a Mini Mental State test. Then these subjects and their relatives were asked to participate actively in the experimentation and 14 of them accepted (10 women (age 84±5.31), 4 men (age 83.5±5.8), 5 Living Alone, 3 Living with spouse, 6 living with care worker).

2.3. Definition and design of the technological interventions

The definition and design of the technological interventions were carried out following the Human Activity Assistive Technology (HAAT) model, which allowed the performance of a profitable and exhaustive analysis of the different requirements of end-users, focusing on patients and caregivers (Human), their daily activities within a context (Activity), and the Assistive Technology they used [22]. The technological interventions and solutions conceived through adopting this approach resulted in assistive technology more acceptable and usable for end-users' needs that could easily be integrated in the environment where they lived and organized and provided as a territorial assistive service.

In particular, sociomedical workers and engineers met the selected AD patients and their caregivers at their homes to obtain information about the conditions of each subject, his/her necessities, where he/she lives and how the environment is structured (i.e., whether there were conditions potentially dangerous for the person), his/her habits, the support he/she receives from the caregiver and from the ASPeF domiciliary services, and the condition and needs of the caregiver. Then the team elaborated this information to identify and analyze the needs of each user, the relative scenario, which functions and tasks were associated with the needs, and finally, the hypothesis regarding technological solutions that could totally or partially solve the problems encountered by the user. The results of this analysis were synthesized in a specific scheme as shown in Table 1. The final results of this process are summarized in Table 2.

INSERT TABLE 1 AROUND HERE

INSERT TABLE 2 AROUND HERE

2.4. Validation protocol and evaluation

The validation protocol used to evaluate the technological interventions drew inspiration from a previous study pursued to assess rigorously the acceptability of assistive technologies [23]. The evaluation was characterized by two steps: a preliminary validation carried out after the development of the first prototypes of the technological interventions, and another one after their experimentation with patients and caregivers in real domestic environments. These two evaluation steps were mainly performed together with sociomedical operators because they were actually the first users of the technological devices and had the overall vision of the requirements and social/logistic situation. End-users just took advantage of using these technologies, and their judgments were not always reliable because of their dementia. The parameters considered in the validation protocol were acceptability, utility, obtrusiveness, patient consciousness, usability, and efficacy (Table 3). Each subject tested only technological tools he/she needed and the duration of the experiment was not fixed but related to his/her availability.

INSERT TABLE 3 AROUND HERE

Fifteen sociomedical operators were involved in the technology evaluation by means of two interviews, one before and one after the experimentation phase. After the end-user need analysis and development of the first prototypes, the wireless sensor network and its modules were shown to the sociomedical operators and the first questionnaire was provided to investigate the initial advice about the utility, acceptability, obtrusiveness, and patient consciousness of these technologies. The operators involved filled out the questionnaires with not only the 14 users involved in the previous phases of the project in mind but all end-users they followed (a total of 45 end-users) in order to evaluate the potential impact of these technologies for all of their patients. Firstly, operators were informed and instructed about which technologies could be used to deal with end-user needs and how they could be used in specific situations. Then the following questions were asked by means of a 5-point scale questionnaire (with 1 as the most negative judgment and 5 as the most positive one):

1. How useful do you think technological interventions are for addressing end-users' needs?
2. How obtrusive do you think technological interventions are for end-users?

3. How acceptable do you think being monitored and supported with these technologies is for end-users?
4. How conscious do you think elderly people with dementia are of their need for support using technologies?

After that, the technological interventions were designed and developed, and then they were tested in real selected cases thanks to the support of the operators involved. After using the systems, the operators were asked to evaluate the utility, acceptability, obtrusiveness, usability, and efficacy of the technologies. The previous questions were asked again in addition to the following ones that were answerable only after the experimentation:

5. How usable do you think technological interventions are for caregivers?
6. How efficacious do you think the technological interventions are in addressing end-users' needs?

3. INSTRUMENTATIONS

The list of end-user needs was grouped in the following technological categories [10]:

- Functional monitoring, emergency detection and alerting
- Safety and security monitoring and assistance
- Social interaction and support
- Cognitive and sensory support

After a feasibility analysis with the clinical staff, it was decided to consider and test only some of the end-user needs. This choice was basically made by considering the most demanding needs (Table 2), the availability of users and relatives in the experimentation, and the level of pathology of the users. On the basis of this choice, a smart sensor network based on ZigBee wireless technology [24] and made of modular components customizable according to user needs and requests was designed.

The proposed system was conceived as an instrument for caregivers and clinicians to monitor the subjects remotely and at every moment of the day in order to gain a view of their physical health, their daily activities, and the occurrence of events potentially dangerous for them [10].

This smart network acquired sensor information about the patient and the domestic environment and processed these data in order to recognize the patient's behavior and identify risky occurrences. The result of this process was accessible to the caregiver through specific software control interfaces consultable on a computer and through alert signals sent to the caregiver's mobile phone. The combination of the systems network with technological aids and periodical domiciliary social assistance rendered the house a safe environment in which the person suffering from AD could live more independently and safely because he/she was monitored more effectively and assisted all day long.

The tasks performed by the ZigBee system network were the result of in-depth study about the characteristics and necessities in the activities of daily life of persons suffering from Dementia or Alzheimer's Disease. In particular, the network was able to carry out the following functions:

- monitoring and analysis of patient posture and movement;
- monitoring of the presence of the patient in the domestic environment and recognition of his/her leaving the house when he/she is alone;
- patient localization outside the house;
- cognitive stimulation of the patient with multimedia contents;
- reminding the patient to take his/her drugs in the right doses;
- facilitating the communication of the patient with other persons who are not in the house (i.e., members of his/her family, friends, and health workers);
- alerting the caregiver or health workers about potentially dangerous events for the patient;
- improving the accessibility and safety of the house.

These tasks were strictly related to the activities of daily life of elderly persons and to the necessities of these subjects. Thanks to these functions, it was possible to guarantee and to preserve the wellness of the patient from physical and psychological points of view both in an indoor environment and outdoors.

INSERT FIGURE 1 AROUND HERE

3.1. Bed and easy chair monitoring systems

The bed and easy chair monitoring systems (Figure 1a) were placed under the mattress of beds and under the cushions of chairs, and used to detect the presence of a patient on his/her bed or easy chair in order to monitor his/her activity and alert caregivers to physical support when he/she is trying to stand up. It was produced with fireproof materials consisting of two parallel metallic nettings separated with a punched polyurethane foam layer and inserted in a cushiony casing. Each of these sensorized cushions was connected to a ZigBee module that transferred information about cushion status to the wireless sensor network. The two metallic nettings work as a switch, so that when the patient goes to bed or sits down, they touch each other and generate the closure of the switch. As soon as the switch is closed, a ZigBee message is sent through the network to the coordinator, which acts according to the functionality.

3.2. Door monitoring system

The door monitoring system (Figure 1b) was used to detect the exit of the patient from his/her house or possible intrusions by unknown people. It was composed of a ZigBee module to share data through the wireless network and a magnetic contact switch that is able to detect two states: when the magnets are lined up the door is closed and when they are not lined up the door is open. In correspondence with a change of door status, the system sends a message through the wireless network to the remote computer, which elaborates the data and makes actions to alert the caregiver.

3.3. Personal localization system

The personal localization system was particularly useful in allowing caregivers to monitor the outdoor location of patients with reduced memory and cognitive capabilities who often have moments of bewilderment which induce them to lose a sense of their location and consequently suffer panic attacks.

The system was composed of a portable device worn or used by the patient when he/she is outdoors, and a remote computer used by the caregiver to visualize the position of the patient (Figure 1c). The portable device included a compact Global Position System (GPS) to acquire the geographical position (latitude and longitude) and a Global System for Mobile Communications (GSM) module to communicate with the remote computer. The remote computer is used by means of a graphical interface designed in C# language in Microsoft Visual Studio which allowed caregivers to localize patients' locations in outdoor environments simply by clicking one button on the interface. Using the GSM network, this interface requests the geographical coordinate to the GPS-GSM module worn by the patient and, with an internet connection, is able to display on the Google Map panel the exact position of the patient. Thanks to the present systems network, caregivers and relatives can always know the location of patients both at home and outside.

3.4. Personal posture

The analysis of the posture and movement of a person is an important task because Alzheimer's Disease induces the degeneration of the patient's self-perception in space and his/her ability to move correctly and safely in the environment [25-27]. The continuous monitoring of posture and motion allow the caregiver and relatives of the patient to control the patient's locomotion capabilities and intervene at the right time in case of necessity (i.e., when the patient falls down). Moreover, continuous monitoring inside the house allows the caregiver to understand better the patient's habits and how much he/she stays active. This function is useful for evaluating the daily activities of a patient. The developed system integrated an inertial sensor with a ZigBee module that enables the localization of the user in the house while at the same time monitoring his/her posture. The system was designed to be worn by the user at the waist (Figure 1d).

3.5. Cognitive stimulation

Furthermore, this systems network is design to carry out a kind of multimedia therapy. Many studies in this field have showed that patients recover serenity and memories of details of their lives when exposed periodically to particular stimuli (music, art, pets, photos, and movies related to his/her past and present life) [28-33]. The systems network is conceived to provide this kind of therapy to patients, using music, pictures, and videos related to the past of the patients. The system provided these stimuli through the television and was activated by caregivers according to the status of the user.

4. EXPERIMENTAL RESULTS

INSERT FIGURE 2 AROUND HERE

The results of the interviews to the sociomedical operators revealed interesting situations (Figure 2). Before the experimentation, the consciousness of technological possibilities was a little low, demonstrating that either end-users or caregivers were unaware of the potential of technology to help them in daily lives, and also that their attitude toward using it was not appropriate. For this reason, caregivers and also end-users should be trained and frequently instructed on the evolution of technology and its relative potentiality. This situation was also confirmed by the fact that the perception of the acceptability and utility of technological interventions at the beginning of the experimentation ($T_{initial}$) was not positive: indeed, caregivers were not able to understand the potential usefulness of those devices and were afraid that elderly end-users would never accept the use of some devices. However, once they used the technological devices, they perceived that they were not intrusive in terms of size and feeling. Indeed, effort was made from the beginning to design and produce devices that are as small as possible and do not change the aspect of the home.

During the experimentation, caregivers had the opportunity to test technologies actively, and they effectively understood the usefulness of the devices and the fact that elderly people are not so adverse to technology. Therefore, at the end of the test (T_{final}) the values of acceptability and utility increased respectively by about 50% and 30%. Obtrusiveness, on the other hand, increased little, confirming the good design of the devices. After the experimentation, aspects related to usability and efficacy were also investigated. The values for both of them were quite positive and confirmed that the use of technology could really improve the quality of care for end-users.

Beyond the questionnaire results, after the experimentation the operators and caregivers involved expressed freely their appreciation of the technological systems developed because they perceived that these technologies were effective and reliable for monitoring AD patients in a more profitable way and were not complex to use; this result was confirmed by the requests received to use the tools beyond the experimentation. Furthermore, operators also provided suggestions for improving the systems. In particular, they recommended the improvement of the modules for localizing the user and for monitoring the posture and motor activity of the user, suggesting that their dimensions be reduced in order to increase wearability and “invisibility,” and that battery duration be increased in order to reduce the frequency of recharges.

5. DISCUSSIONS AND CONCLUSIONS

This paper presents the implementation and validation of an AAL system that integrates technology in order to maintain and even enhance functional health, security, safety and quality of life of AD patients. As for smart home [10], the implemented system aimed to enable non-obtrusive monitoring of residents and involved different levels of technological sophistication, ranging from wearable devices to smart environments that continuously monitor residents' activities and physical status and adapt to residents' needs, often providing proactive measures.

The experience described in this paper demonstrated that AAL technologies are nowadays feasible and effective and can actively be used in assisting AD patients in their homes. The extensive involvement of caregivers in the experimentation allowed the assessment that there is, through the use of the technological system, a proven improvement in care performance and efficiency of care provision by both formal and informal caregivers and consequently an increase in the quality of life of patients, their relatives, and their caregivers.

However, this experience also demonstrated that the introduction of AAL technologies in the public and private system of social care services was not easy because of the mistrust of caregivers regarding these new strategies of care based on technologies that will change their professional role. Particularly moving forward in bringing AAL technologies to the home required dialogue between academia, service providers and patients and their family [34]. For this reason, the training activities for caregivers focused on the existence of AAL technologies and their use was fundamental to demonstrate to them that AAL technologies can help them in their work without reducing their importance and role in assisting AD patients.

The question of acceptability and usability was another important issue that was addressed to avoid possible stigmatization of AAL technologies associated with their use and to prevent proliferating of marketplaces littered with products that failed to address this key issue [11]. During the experimentation, not only professional caregivers, but also patients and their relatives were sometimes skeptical about accepting the installation and use of these technologies in their daily lives and homes. At the beginning, some of them did not understand the potential of AAL technologies to improve their lives and did not accept these technologies, above all because of their poor attitude toward using technology and their lack of acceptance and perception of the disease. However, making them conscious of and directly involved in the design of these new AAL services was fundamental for stimulating them to be involved in the experimentation.

Moreover, from the technical point of view, the investigation of the usability and acceptability aspects of AAL technologies was fundamental to guarantee the suitability of these solutions in real daily contexts. During the Alzheimer Project these factors were investigated in depth and the design of the system was significantly influenced by them. The environmental modules of the sensor network were judged positively by caregivers involved in the project because they look tiny enough and are almost "invisible" so as to be easily integrated in the houses of elderly people. With regard to the control interfaces, the sociomedical workers appreciated the simplicity of these software control tools both for the outdoor localization of elderly people and for the sensor network and event control.

Regarding the wearable tool, the sociomedical operators evaluated the prototype as suitable for use by elderly subjects in the early stages of dementia, but not by patients with severe AD because of their behavioral alteration and lack of willingness to wear such devices. For this reason, the operators suggested that we go beyond this prototype suited for persons with slight dementia and study another smaller solution embeddable in some personal belongings of the users (i.e., a belt or purse). Concerning the portable device for outdoor personal tracking, the decision how to use GPS was made at the time of diagnosis jointly by the person with dementia, his/her family and professional caregivers, according to the recommendations proposed in [35].

Finally, the key point of this study was working as a multidisciplinary team with engineers, social scientists, psychologists, and sociomedical workers who shared practical information on patients' and caregivers' needs, characteristics of the disease, and technological opportunities, as well as their own professional experience.

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Table 1. Example of analysis of user needs and possible technological solutions

Name and surname of the patient: User No.1	
Need	Monitoring AD patient at home when she goes out/comes in.
Scenario	The user usually goes out to mass in the afternoon and when she comes back home, she is usually calls relatives by phone to reassure them. Sometimes she forgets to do that and this situation generates anxiety in relatives. When the user goes out or comes back home, the caregivers want to receive on their mobile phones a short message that communicates that the user has gone out or come back.
Functions	• The system is able to identify entrance to and exit from the home. • The system is able to send a message to advise relatives or caregivers.
Solution	• A magnetic sensor is used on the main door of the apartment to sense the opening and closing of the door. • A wearable sensor is used to sense if the user is at home. • Both sensors are included in a smart sensor network, which is connected to a central server able to collect data from them and extrapolate context awareness. • The central server also includes a GSM module that is able to send appropriate alerts to caregivers.

Table 2. Results of the analysis of user needs carried out on 14 elderly volunteers with AD

FUNCTIONALITIES	**USERS**														**PERCENTAGE OF SERVICE REQUEST**
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	
Exit/entrance monitoring and alerting	X		X								X	X		X	**36%**
Support and adaptations of the home			X	X	X	X						X			**36%**
Multimedia cognitive stimulation		X				X			X			X			**29%**
Support in taking drugs	X			X		X		X							**29%**
Automatic lighting at night		X			X	X	X								**29%**
Recognition of rising from bed and alerting		X					X						X		**21%**
Recognition of fall and alerting				X				X				X			**21%**
Support in outdoor localization							X					X			**14%**
Control of gas and water electron valve							X			X					**14%**
Control of access to cabinets and lockers				X						X					**14%**
Support in using phone	X														**7%**
Support if night agitation		X													**7%**
Multimedia communication								X							**7%**
TOTAL SERVICES FOR EACH USER	**3**	**4**	**2**	**4**	**2**	**4**	**4**	**3**	**1**	**2**	**1**	**5**	**1**	**1**	

Table 3. Brief description of parameters considered during the evaluation

ASPECTS	DEFINITION
Acceptability	The degree of primary users’ predisposition to carry out daily activities using the intended device as the result of their diverse perceptions on the following set of characteristics.
Utility	The degree to which users believe that using a particular system would enhance their job performance.
Obtrusiveness	The degree of device encumbrance perceived by users on themselves and in the work environment.
Consciousness	The degree of users’ awareness that technology could help them.
Usability	The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of users.
Efficacy	The capability of users to effectively complete tasks and achieve goals with the devices.

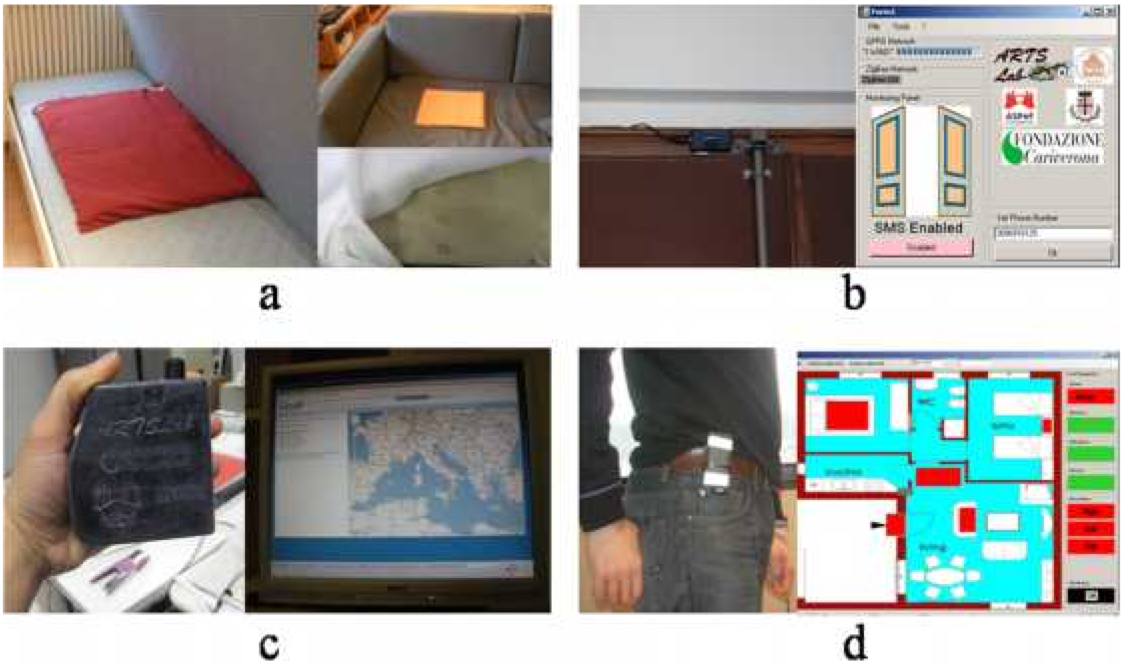

Figure 1. Systems developed and tested with AD subjects: a) bed and easy chair monitoring systems; b) door monitoring tool; c) personal localization system; d) personal posture monitoring system.

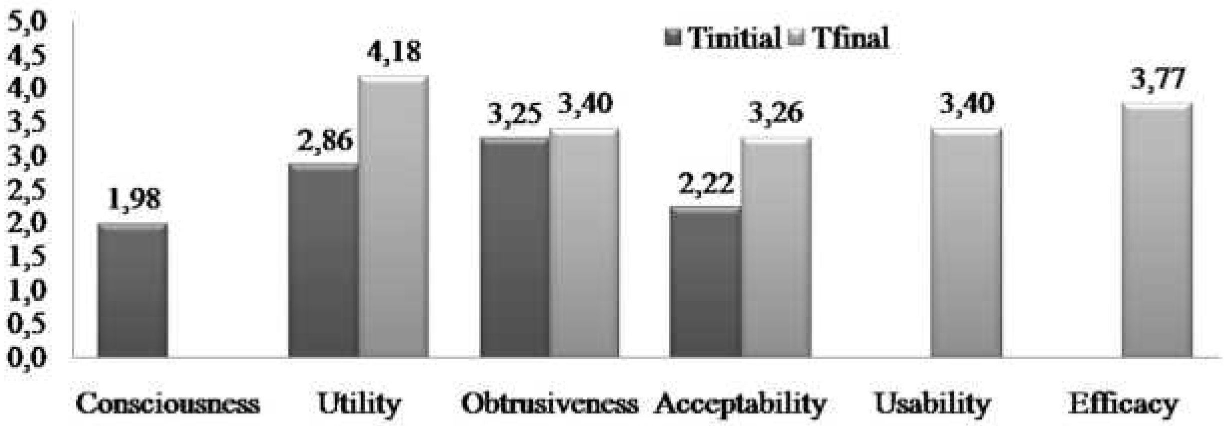

Figure 2. Mean values of results obtained in the preliminary validation ($T_{initial}$ data: dark grey column) and after the experimentation (T_{final} data: light grey column).