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Current aspects regarding "smart homes"/ ambient assisted living (AAL) including rehabilitation specific devices, for people with disabilities/ special needs

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Abstract

Introduction: The population life expectancy has increased ("over half the EU's population predicted to be over-65 by 2070"), according to recent prevalence studies, being a result of the advancement of technology and medical science. This aging population has implications for society because there is increased number of older people requiring better quality of life.

Materials and Methods: AAL represents the systems that may support completely the living area of a person and has the potential to facilitate the elderly to live longer and more safety in their family environments, allowing them to continue their current activities, facilitating participation in more activities at home and in the community and improving the cost-effectiveness, the quality of health and social services. A practical use of technology is the introduction of home networks, which involve notions such as: "smart homes ", "tele-health / tele-care" and even, possibly, "tele-medicine" to allow people with serious illnesses / conditions / and special needs to maintain an appropriate quality of life (QOL) at home.

Discussions and Conclusions: AAL can contribute to an increased autonomy, self-confidence and mobility in people whose activity is limited to home environment, such as "the oldest olds" and/ or those with severe neuro-/ loco-motors disabilities, and so to reduce the risk of institutionalization, enhance security, prevent social isolation, thus allowing "older adults to age in place". An important role in achieving this goal is representing by working in a multidisciplinary team (experts in the field of health - rehabilitation, gerontology -, social experts, technical/ informatics experts, engineering and robotics experts).

Keywords: *ambient assistive living, quality of life, special needs, tele-medicine, rehabilitation,*

Introduction

Current demographical data regarding life expectancy in EU population

The population life expectancy has increased ("over half the EU's population predicted to be over-65 by 2070"), according to recent prevalence studies, being a result of the advancement of technology and medical science (1). This ageing population has implications on the society, because there is increased number of older people requiring better quality of life (1).

Demographic works showed the average life expectancy of people in the European Union (EU) countries has enhanced over the last decades (specifically – at birth, since 1980 – by around 0.2 years annually and seems more than likely it will continue to increase)" (2).

Yet, "Chronic disease, frailty and disability tend to become more prevalent at older ages, so that a population with a higher life expectancy may not be healthier" (3).

Chronic diseases represent the major share of the burden of disease in Europe (4) and are responsible for 80% of all deaths (5) in the region. Chronic diseases affect more than 80% of people aged over 65 in Europe. Moreover, in patients over 65, the presence of multiple conditions or co-morbidities has a multiplier effect on the burden of disease and on management costs. This is particularly significant as current forecasts indicate that in the EU, the population aged 65 and above will rise from 87.5 million in 2010 to 152.6 million in 2060. The number of people aged 80 years and above is projected to almost triple: from 23.7 million in 2010 to 62.4 million in 2060 (6).

As it is known, individuals with one or more chronic conditions – especially serious: with life threatening or impairment(s)/ disability(es), have to face (much) more problems than the healthy ones, just to cope with the current daily living. To denominate such a "diverse group" (7) there is frequently used the term: "(people/ persons) with special (health care – and not only) needs. Therefore, this term refers to a wide spectrum of "needing" situations, in relation to specific problems/ conditions, that may range from neurological evolutive diseases to (consequent)7 "severe mental and physical disorders". Their levels of disability may vary from speech disorders to quadriplegia" (7); the neurologically challenged may, as well, be people "who have cognitive, emotional, or (/and also other – o.n.) physical disabilities" (8), – based on related organic sequels. Accordingly (only as regards the necessity for health assistance) such long-term needs "range from the regular use of prescription medicines to 24 hour care" (8).

Given, including the large differences within the respective necessary approaches, an acceptable definition of the special (at least: ”health care”) needs, must consider basically, in a targeted individual, the existence of: ”functional limitations, need for health-related services” and the ”presence of a health condition” with a ”minimum expected duration (e.g., 12 months)” (7) – but without the existence, yet, of a ”gold standard” in the domain.

Additionally to all these, there always have to be taken into account, too, the family/ community/ socio-economic, related needs of such (neurologically challenged, with other disabilities or very old) people.

Regarding disability, we consider that this is not just a health problem; it is a complex phenomenon that reflects the interaction between a person's bodily characteristics and societal traits. Overcoming, the difficulties faced by people with disabilities, requires interventions to eliminate their social and environmental barriers” (7).

A specific and stronger proof of the subject addressed in this paper, is the fact that in 2014 the "WHO Global Action Plan 2014-2021 about Disability Prevention: A Better Health for All The People with Disabilities" was issued - a well-structured strategic plan, which aims to be an important impetus for the governments of the WHO-affiliated states of UN, to firmly improve their support policies in order to increase the quality of life for people with disabilities (about 1,000,000,000 worldwide), which makes the fight against disabilities a high priority (9).

Until the beginning of the 20th century, the home represented the foundation of the family unit (traditional), having the role of a locus of: identity, position and evaluation - external. Nowadays more and more people live much more independently than they have in previous decades (10).

Ambient assisting living (AAL) represents the systems that may support completely the living area of a person and has the potential to facilitate the elderly to live longer and more safety in their family environments, allowing them to continue their current activities, facilitating participation in more activities at home and in the community and improving the cost-effectiveness and quality of health and social services (11).

Ambient Assisted Living (AAL) is multifaceted and is supporting the persons in their homes, communities and work places (12)

A practical use of technology is the introduction of home networks, which involve notions such as: "smart homes" (the user can command from the distance o lot of home functions including security functions – for example: through an emergency call that can be automatically activated in a call centre (13), “tele-health / tele-care” and even, possibly, “tele-medicine” to allow people with serious illnesses / conditions /and special needs to maintain an appropriate quality of life (QOL) at home (10).

In a recent literature review (14) (from 2015): first generation AAL (“wearable devices”, “response to an emergency” etc.) and second generation AAL technologies (“home sensors”, “automatic response to emergencies”, “may feel intrusive” etc.) 14 are already established within the marketplace and include wearable devices and all kinds of home sensors, but most of third generation technologies (“integration of home sensors and wearable devices”, “prevention, monitoring and assistance”, “less obtrusive”) (14), which are more sophisticated are still in the research and development phase and may benefit from discussing theoretical discourses.

Assistive technology is an umbrella term referring to specialized technology used by people to adapt how specific tasks are performed (15).

Assistive technology includes low-tech devices, such as eyeglasses or walkers, as well as high-tech devices, such as hardware, software, and peripherals that assist people with disabilities in accessing computers or other information technologies (15).

AAL is the result of a progression from individual devices assisting with one task or activity of daily living (ADL) to ambient systems in which the assistance or support completely encompasses the living area and the person.

The Activity of Daily Living Independence Evaluation Scale (ADL) - Katz ADL Index (16) is the most appropriate tool to assess the functional status by measuring the patient's ability to perform daily activities independently, usually used to detect problems in the performance of daily activities and to plan in consequence the special care needing. A score of 6 indicates full function, 4 indicates moderate impairment and 2 or less indicates severe functional impairment” (17).

Another tool also used to assess the functional status of a patient is the Instrumental Activities of Daily Living Scale (I/ADL) (18). This tool is valuable for evaluating patients with early-stage disease, both to assess the level of disease and to determine the patient's ability to care for him or her-self. Performance of IADLs requires both mental and physical capacity. The IADL scale measures the functional impact of emotional, cognitive, and physical impairments. Only four IADLs are used when determining if an individual is eligible to receive personal care service. IADLs are scored based on what an individual can do rather than what he/she is doing. That's why IADL should be scored based on how an individual usually performs a task” (19).

Because of the specific physical and mental changes that appear in aging population**,** making them more fragile

including with an higher potential of falling**, must be mentioned some factors that involved in traumatic fractures/ falls in the elderly: aging-related impairments (**visual disturbance**;** altered gait**;** decreased muscle in the hip); **conditions** (para/ tetra-paresis, primary/ secondary osteoporosis, cerebrovascular/ cardiovascular attacks, Parkinson's disease, dementias)**; outdoor/ indoor environmental factors (**rugged road, poor lighting; bad weather; carpets, unprotected threads on the floor; **s**lippery bathtubs; pets)**; lifestyle (**exercise/ endurance, nutritional status; alcoholism/ drug use)**; medication (**benzodiazepines**,** tricyclic antidepressants**,** antipsychotics**,** barbiturates) (20).

Home safety guidance is very important for combating the above mentioned traumatic fractures / falls in the elderly/ disabled people. If in the living area appears an issue that can have a potential risk of falls (for ex.: wet floors, thick edged carpets, low lighting) – there are recommended to be done adapted changes for safety of the users (non-slip mats, flat edged carpets or fixing with adhesive, adequate lighting especially in risk area) (20).

Assisted/smart homes incorporate technology into the framework of their components (10). Venkatesh et al. evaluates that technology could have an important role in the living area of one person and could interact with social and physical space in order to be able to realize / maintain the notion of a home as a unitary whole (21).

”Technology (technological space)” optimally interacts in smart homes (or at least, is desirable) with all other spaces. Even if such a model cannot basically lead to a full such interaction (physical and social spaces must interact anyway), it still offers a conceptual and practical framework that takes into account the importance of technological innovation in the home (10).

The technology, including the advanced form of it, could determine a better quality of life (QoL) of the users. In this way the home network may help people with special needs to interact more actively with other people or other needed services, and thus they could also be monitoring for their safety.

Smart homes and home networks on which they are based - can thus help to perform operational tasks such as: telecare (tele-assistance - allows people to be evaluated and monitored remotely by medical staff) and telemedicine, respectively, which allows a virtual medical service to be brought into the home of the person requesting such a professional service – being in fact, a new modern form of home care.

Thus, “smart” houses can be useful/ used to the increase of QoL of people whose activity is limited to home/ home environment and/or those with severe neurologic and ambulation deficits.

This is possible by equipping the house with assistive devices that allow users a better development of daily activities, improving their "activity" and "participation„ in terms of ICF-DH - and in this way, the QOL.

Smart homes use assistive devices currently used in home security systems, such as: infrared sensors, protective sleeves against high pressures, magnetic spring switches but also other devices like: infrared controllers – similar to TV remote controls; gas, smoke, heat detectors; door opening systems – electric doors. Where there is interconnectivity of various devices that are programmed to operate under predetermined conditions, can be extended, by the existing internal (home) network to external monitoring and control.

So, these homes include a number of devices that complement the wide range of assistive technology.

Smart home technology systems can be divided into two main categories:

- Active devices such as control panels and switches, with which the user comes into direct contact and uses them.
- Passive devices such as sensors and radio receivers, with which the user has no direct contact

These devices along with other technological systems generate four main types of augmentative technologies that can increase the level of independence (22):

1. Assistive technologies, represented by devices or systems that allow the individual to perform an activity that prior to using these accessories was impossible to perform or to increase the ease and safety of its development.
2. Adaptive technologies through which a system or device can be modified in accordance with the user's needs to facilitate the development of an activity.
3. Technologies with general/comprehensive/“for everyone” design are made on the principle that the devices and systems can be used by a wide variety of users.
4. Medical devices that include all products, within health centres, some even used at home for (tele-): prevention, diagnosis, monitoring, treatment/ recovery, care (22).

According to some researchers (22), the design of these homes, for being as much as possible adequate to usre’s needs must take into account (at least - n. N.) six aspects: ”accessibility, easy to use, flexibility and adaptability, functionality, interactivity, reliability and maintainability, replicability and ease of installation, extension capacity”.

The home network has both positive and negative aspects. One of the negative aspects is caused by remaining set on „always on” profile which makes it easily attacked (first by computer hackers); at the same time, this kind of network can be infected, thus requiring, for security, an updatable antivirus program (10).

For a home system that includes interconnected devices to be able to meet the needs of the elderly and/or disabled, effectively, system errors must be minimized and well controlled.

Assistive technologies (technologies that support the elderly and/or people with disabilities in living independently) must be safe, as users may dependent on them and must be designed for users who may have a wide range of deficits. The issues of user variety and the environment in which the systems can be installed to make these devices safe and easy to use, must be understood.

According to the needs of elderly/ disabled people for enhancing their QoL, we summarize bellow some **assistive devices that can be used in people homes for facilitating their ADL**:

- Maxi Sky600 is a ceiling-mounted lifting device used for transferring the patient also in his own house in a comfortable way, being an useful help including for the caregivers/ family (23).
- Walking Jacket is a device compatible with Maxi Sky600 that can be used even in the rehabilitation program. This system is applied on a suspended bar type device provided with 2 hinges and ensures a safe and stable support during walking and/or gait re-education exercises (24).
- Another example of an assistive device used to improve the quality of life in people with disabilities is the elevator attached to stairs built to ensure comfort, safety and ease of use (preferably platforms). This type of elevator has an easy-to-use control system, which is especially useful for those with impaired hand skills (25).
- The bathroom can be completely adapted allowing people with (loco) motor deficits to benefit from proper hygiene. An example of a bathtub (adapted for people with limited mobility) that offers a comfortable and convenient way to take a full body bath - this model allows the patient to step in the bathtub through a door and sit on an automatic seat, resistant to slipping. Once the bath is completed and the water is drained, the chair lifts the person easily and safely so that he can return to orthostatism) (26).
- A very consistent and valuable contribution of our team leaded by Prof. Univ. Onose Gelu is the invention of a mecatronic orthetic divice (awarded in 2008 with a gold medal at the International Inventions Salon in Geneva) with possible further application of advanced type of non-invasive BCI/BMI systems.

Futuristic directions regarding AAL

To improve the wellbeing and autonomy of older adults, in 2008 was established an EU platform called „ AAL Programme" that includes projects that have, in a variety of ways, taken their research to market. These AAL projects prove that innovative technologies might be developed to respond to people needs and can have a real success in smart homes field (27).
In this platform are mentioned 10 AAL innovations that have create a real impact: CapMouse - Helping the disabled interact with technology; Connected Vitality - A new deeper level of communication; Domeo - Advanced helper robots at home; Express 2 Connect - Combatting loneliness by empowering individuals; Fearless - Achieving safety through simplicity; Inclusion Society - Supporting the wellbeing of elderly persons at home; MyLife - Software that supports independence; RGS - Virtual reality for post-stroke care; Rosetta - Addressing the needs of users and carers; We Care - Connecting people through smart services (27).
The CapMouse project was instigated in order to develop a prototype of a hands-free computing device, using a head mounted capacitative sensor controlled by the lips that can be used as an input for a human-machine interface.
The technology is aimed at disabled older adults and those with spinal injuries as a way to use the computer while unable to use his hands (27). A non-invasive CAPacitive sensor oral MOUSE interface for the disabled adults. The product is a functional end-user tested prototype of a device, which enables the use of electronic equipment by using ones lip (27).
In this perspective, can be mentioned here that a group of researchers lead by Prof. Univ. Gelu Onose from the Neuro-Rehabilitation Clinic Division from Teaching Emergency Hospital "Bagdasar-Arseni" (THEBA) have succeeded in 2008, to develop a project/ clinical trial on the largest (known until now) group of patients - quadriplegic - held in THEBA, at the request of and in collaboration with the prestigious research institute: Fraunhofer / Institute FIRST, Berlin called "Electro-encephalography (EEG) based brain-computer interface (BCI) clinical trial in chronic quadriplegics, using a robotic arm device as functional assistive technology" (28). "The study promises the development of a rational and effective procedure of screening and training post-SCI tetraplegics for EEG–BCI/BMI use, given the reality that only a moderate fraction of these may be able to ultimately benefit" (28).

Another futuristic project DOMEO has developed mobility assistive and companion robots to provide personalised domestic services. They have successfully trialled advanced robotic devices in real homes, with real people, and are now looking to commercialise the technology in order to deliver the maximum impact to its user base (27).

Virtual training (through so-called "serious games") can be a technological key to ensure the continuity of home care, to strengthen self-management, to increase compliance with the care plan and to prevent the risks and, ultimately, to increase the strength of patients and become independent and confident as much as possible. Starting from a clinical basis, the virtual coach will be able to customize and adapt the objectives according to the progress made in the recovery of deficiencies or disabilities (29).

Therefore, coaching systems will provide personalised rehabilitation recommendations to people with disabilities, for improving their activity of daily living and also their body functions and healthy habits and in this way to help in "reinsertion into their home or community" and to live as independent as possible. The technological systems could help patients through their "advancements in terms of sensors devices for monitoring the patient's vital parameters and location" to personalize and adapt their treatment based on the information received from the beneficiaries and to be more safety supervised (30).

Even if all these futuristic directions are having great potential, an survey regarding AAL (31) (made by a group of researchers from Macedonia) have identified that current AAL research lacks in experimental results with data from continuous monitoring. Based on this survey it was identified that AAL is a field that has potential to create a supportive environment that should focus on non-intrusive ambient sensor data gathering.

Discussions and Conclusions

AAL can contribute to an increased autonomy, self-confidence and mobility (11) in people whose activity is limited to home environment, such as "the oldest olds" and/ or those with severe neuro-/ loco-motors disabilities, and so to reduce the risk of institutionalization, enhance security, prevent social isolation, thus allowing "older adults to age in place" (11).

An important role in achieving this goal is representing by working in a multidisciplinary team: experts in the field of health - rehabilitation, gerontology -, social experts, technical/ informatics/ engineering experts. These collaborations lead to more complex environmental systems which can satisfy the multidimensional (physical, medical, psychological and social) needs of a disabled / older population (14).

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