Zdrowie Publiczne i Zarządzanie 2018; 16 (3): 177–186
www.ejournals.eu/Zdrowie-Publiczne-i-Zarzadzanie, doi:10.4467/20842627OZ.18.020.10433

Innovations in elderly care: Key success factors

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Abstract

The aim of the paper is to identify key determinants of effective implementation of innovations in respect to assisted living ecosystems for the elderly. Desk-study as a method was used and EBSCO (including Medline), ScienceDirect, Open Knowledge Repository, and BazEkon databases were researched. The scope of ageing and its key economic and social consequences are portrayed at the beginning. Then main categories of seniors' needs are presented. Consequently the main ways innovations and new technologies can respond to these needs are identified accompanied by senior citizens' particular attitude toward new technologies, especially ICT. Then Gerontechnology is presented not only as an important social innovation, but also as a leverage for more effective implementation of innovations and modern technologies in active and assisted living for seniors. The article ends with identification of three key success factors for effective implementation of innovations and new technologies by independently living seniors.

Key words: innovations in health care, ageing, independent seniors, economic and social consequences of ageing, gerontechnology

Słowa kluczowe: innowacje w ochronie zdrowia, starzenie się społeczeństw, samodzielnie zamieszkujący seniorzy, ekonomiczne i społeczne konsekwencje starzenia się, gerontechnologie

Ministerstwo Nauki i Szkolnictwa Wyższego

Przygotowanie do wydania elektronicznego finansowane w ramach umowy 641/P-DUN/2018 ze środków Ministra Nauki i Szkolnictwa Wyższego przeznaczonych na działalność upowszechniającą naukę.

Introduction

Innovations in health care (defined by the WHO as actions aimed at developing new, or improving the existing health policies, systems, products and technologies as well as services or methods of their provision, in order to enhance human health and well-being [1]) cover a wide range of activity areas and types. Innovations in health care are aimed at improving effectiveness and efficiency, quality, system stability, safety and/or access to health services. Due to the scope of the article, the necessary exclusions were made and only two categories were considered: medical and non-medical innovations. The former category is outlined broadly and includes innovations in medicine (divided by specialization or type), in the preparation and production of medical devices, medicinal products and medical equipment. Non-medical innovations are also understood widely and include all the new equipment, organizational and social solutions whose use has an indirect effect on the health and well-being of patients.

Although medical innovations are fast moving, attract more media attention (media willingly inform about new, innovative drugs or therapies), and the attention of millions of people, this article is devoted to non-medical innovations.

The subject of the analysis are innovations used in care of the elderly living independently. The otherwise interesting issue of defining the age of the elderly person (real age versus perceived age) is not discussed, and it is assumed that senior citizens are people over the age of 65 (following the method used by Eurostat).

The aging of societies is a global problem, but it is most often found in highly developed countries. The consequences of population aging are multidimensional and – in addition to medicine – include such areas as the

economy and economics (including their components such as: economic growth, labour market, social and health benefits) and society (including the social position of senior citizens, life with senior citizens, elderly care), to name just the areas that will be discussed further.

The growing share of older people in the social structure results in the need to provide them with adequate care, leading to the generation of increasingly higher costs. Intuitively speaking, introducing innovations in the field of care for seniors may stop the increase in costs and/or bring savings in care resources or in time expenditure. The issue of population aging is the subject of growing interest from key international institutions and organizations such as the UN [2], the World Bank [3] and the European Commission [4].

The aim of the article is to identify, based on the analysis of the literature on the subject, the key success factors in activities aimed at effective innovation implementation among senior citizens living independently.

The presentation of the method and the scale of the problem of population aging and its key dimensions will be followed by an outline of the specific needs of senior citizens and innovations leading to the improvement of the quality of senior care and gaining benefits in the scope of resources and care organization. The concept of gerontechnology, which is an example of social innovation per se, is presented in more detail, and the article ends with a list of key success factors in relation to the effective implementation of innovation in the care of elderly people living independently.

Method

The following databases were used to achieve the goal: EBSCO (including the Medline base), ScienceDirect, Open Knowledge Repository and BazEkon. The following keywords were used (in various combinations, both in English and Polish): *aging/ageing*, *innovations*, *gerontechnology*, *technogenarians*, *starzenie się*, *innowacje* and *seniorzy*. Sources identification was performed in two stages: in the first one those sources were collected which included the search words in the titles and abstracts. After the initial selection (subjective selection based on the convergence of the publication title with the aim of the article), 194 entries were qualified for further evaluation. The second stage included reading the abstract and an overview of the entire publication. In the end, 84 publications were collected, which were then analyzed.

The aging of societies in the economic and social dimensions

This part shows that the problem of population aging is a big (and growing) challenge for the economies and societies of the 21st century, both on a global and regional scale, and becomes a subject of keen interest in key international institutions.

The aging of societies is a global phenomenon. Currently, there are 962 million people over 60 who inhabit the Earth. At the average annual growth rate of 3%, by 2030 there will be around 1,400 million of 60+ people living on our planet [5]. Along with the countries of Central Asia, Europe has become an area with a very high proportion of senior citizens in the population structure, and there are forecasts of a further extension of life expectancy and an increase in the participation of senior citizens.

According to the World Bank, the median age of a European and Central Asian citizen in 2010 was 34 years (these two areas have the highest median age, which is 10 years higher than the median for other areas), but demographic forecasts say that in in 2050 it could reach 44 years [6]. May 2018 Eurostat data showed that in early 2017 in European Union countries almost one fifth of the population (19.4%) was 65 or more (an increase of 3.4% compared to 2007), and 5.5% were people aged 80 or more. For Poland, these rates were respectively: 16.5% (increase by 3.1% in relation to 2007) and 4.2% [7].

Long-term forecasts show that by 2080, the share of people aged 80 or more in the population structure of EU countries might reach 13% (i.e. more than double). In this group, the number of the so-called older seniors – people over 85 – is also increasing. The growth in the share of senior citizens in the population structure is, on the one hand, the result of the extension of the expected life expectancy and, on the other, the low fertility rate.

Demographic changes and the aging of societies have far-reaching consequences for economies through the impact on economic growth [3], public policies, including in particular the pension policy [8, 9], population mobility [10] or – broadly speaking – the prosperity of societies and the wellfare of individuals [11]. The aging processes of the population affect more directly the health care systems, primarily the long-term care subsystem [12], which are an important component of economies.

In most publications, the aging of societies and the extension of life expectancy at birth are shown as having a negative impact on economic growth, as they lead to increased fiscal burdens. However, there are studies using quantitative analyses and models showing that when certain parameters change (raising the retirement age, investing in human capital in the logic of endogenous growth), the aging of societies can have a positive impact on the economic growth [9], i.a. by creating new market segments for senior citizens, for example, rejuvenating products [13]. At this point, one should also note the contribution of the 'silver economy' trend to the discussion on the economic consequences of aging populations, which also resonates at the level of the European Commission [14].

The growing share of senior citizens in societies translates into higher costs related to senior care, especially that of older seniors. Although we share the opinion that seniors can contribute to the creation of social added value (silver economy; sharing knowledge, experience and wisdom; care for children and loved ones, help in running a household, etc.), we must also point out the costs of aging. These could be divided into two kinds: financial and non-financial (social). The former are related to the

cost of health services, including treatment in facilities with nursing and medical care, rehabilitation, etc. Also, diseases related to old age are increasingly common. The most frequently researched cases include cancer, cardiovascular diseases and neurological complaints. Particular attention should be paid to dementia because of the scale of occurrence. Dementia is a group of syndromes associated with memory loss and other intellectual functions that strongly limit daily activities. There are about 40 types or causes of dementia, the best known being the Alzheimer's disease. Dementia is commonly associated with aging, as its risk increases with age and nearly doubles every 5 years after reaching the age of 60. The probability of dementia after the age of 65 amounts to 1 to 50, for people over 80 – 1 to 5, and over 85 years of age is already affecting every second senior [15]. Dementia is also closely related to the social costs of old age.

Social costs are also related to the fulfillment of those social roles by senior citizens which increase the risk for others, for example, seniors performing the role of drivers [16], passengers or passers-by, or may lead to discomfort experienced by people in the surroundings because of their contact with the elderly (seniors as family members, whose relatives must take care of them, devote time and engage resources; seniors as bothersome clients, requiring a special approach, customers, etc.). The question of what the final balance of benefits and costs is remains open (it is relatively easier to estimate costs than benefits). In the opinion of World Bank analysts, the final balance should also be carried out by Poland [17].

Aging processes can be considered from different perspectives: individual, closest social (family), further social (neighbourhood, local community), cultural, also from the regional perspective or that of the entire country, and finally from the perspective of the entire world.

Since aging processes are subject to far-reaching changes, they must be analyzed taking into account the dynamics in the social and economic environments. People entering old age at the end of the second decade of the 21st century form a more diverse group, are better educated, wealthier, with greater expectations reagrding their surroundings (particularly regarding the health care system and technology).

When analyzing the processes of aging, it is extremely interesting to take a closer look at two trends. As part of the first trend, the aging of the body, mind and emotions are perceived and classified using the biomedical approach, as a disease. Within the logic of combating disease, this perception results in striving to restore the aging body to the state of youth (including through plastic surgery or aesthetic medicine). The other trend is represented by corporations, professionals and institutions that perceive various physical, mental and emotional changes that accompany the body aging process. The effect of this is the creation of technologies supporting people in their senior age so that they can peacefully grow old in their natural environment, that is in their own homes. This market is focused on adapting technology and architecture to potential changes in life functions such as hearing, memory, maintaining balance, vision or other physical or cognitive abilities, as well as creating technologies (robots, hearing aids, etc.) to meet the emotional needs.

To a great extent, the aging process is also culturally conditioned. In some circles, youth is treated as a norm, and old age as pathology [18].

Old age and older people perceptions include stereotypes where the old person is simply a pensioner, widower / widow, sick, limited in many life functions and filled with negative emotions. This stereotype is contrasted with research results showing older people as adjusting their life goals and motivations in a way aimed at trying to preserve cheerfulness (good mood) rather than broadening their knowledge, which can cause some discomfort [19]. There are also studies showing positive emotions of seniors such as satisfaction with life and happiness [14].

In this context, the issue of introducing innovative solutions and devices that improve the safety of seniors and make life easier becomes increasingly important in the daily life of senior citizens. This, however, cannot be done without first knowing their needs.

The needs and expectations of senior citizens

Aging processes generate specific needs that have been grouped by researchers in the following five categories: health, housing, mobility/transport, communication/information, and work/volunteering/hobby [20]. Although these categories can be applied to any other age group, in the case of senior citizens they are highly specific.

With regard to health, it is necessary to maintain motor functions and cognitive skills as long as possible, while in the case of living needs, the priority is given to the need to move easily in apartments (and access to apartments) or ergonomic and safe solutions in the kitchen, bathroom or toilet. Ease of access and security can also be applied to mobility and transport needs. With regard to communication and information, it is fundamental that additional needs arising from the seniors' deterioration of hearing and seeing be taken into account. Also, work/volunteering/hobby are very specific in the case of seniors as they serve to sustain their cognitive and intellectual functions for as long as possible. In the case of so defined needs, there is a fairly consistent opinion that they are still not well researched (also due to the considerable heterogeneity of the senior group). It might be helpful to construct a theoretical ecosystem for seniors living independently [21].

A special place among the needs of the senior population is occupied by maintaining individuality (*empowerment*), which is emphasized by modern geriatrics [22]. Maintaining the independence of seniors is becoming increasingly complex due to the growing number of seniors who often suffer from dementia and limited mobility. Active aging is getting more and more prominence, the aging process is getting longer and is well-established in prevention and promotion.

Physical well-being, fitness, mental health, cognitive functions as well as social and spiritual well-being are key elements in maintaining autonomy, and therefore can be regarded as the needs of senior citizens [23].

For each of these issues, you can in turn assign technologies that are classified due to the functions they are oriented to, i.e. cognitive, motor, sensory and emotional needs, and those related to social involvement.

Innovations as one of the ways to mitigate problems related to the aging of societies

Innovations in health care are most often combined with information and communication technologies (ICT). The literature shows that they lead to increasing the effectiveness of health care systems [8, 24].

Taking into account the increasing costs generated by the growing group of seniors, one can and should ask whether and to what extent innovations and modern technologies can help solve the problem of population aging. We are observing an increase of interest in senior users of technology, from the areas of science, industry and politics. Many research centres affiliated with renowned universities have been established (e.g. Age Lab at MIT, the Georgia Institute of Technology's Human Factors and Aging Laboratory), special projects are initiated (e.g. European Ambient Assisted Living project), and robots accompanying older people are constructed (e.g. Aibo, Ifbot, Wakamura or Paro).

The issue of innovation in relation to senior citizens constitutes a rich field for analysis. Innovations could be divided into medical innovations (i.e. regarding the procedures of tools and methods used in medicine, in particular in geriatrics, neurology, cardiology, rheumatology and orthopedics) and non-medical innovations (all other types). Emphasis should be given on the importance of medical innovations leading to the maintenance of physical and mental independence and preventing the deterioration of physiological functions (which is a necessary condition of good quality of life) of older people [25], especially in the area of nanotechnology [26]. Medical strategies based on nanotechnology include nanostructured changes on the surface, nanoparticles, nanoelectronics and nanoparticle-based functional polymer coatings. The use of nanotechnology leads, among other things, to a greater compatibility of implants, tissue regeneration, removal of neoplastic changes, or replacement of organs or tissues. New types of therapies and diagnoses are being developed, arising from the cooperation between specialists in various fields and disciplines [26].

Although we acknowledge the importance of medical innovations, only issues of non-medical innovations will be addressed below, and in relation to only one category of senior citizens, namely people who live independently and run their own households. Analyses show that maintaining seniors in good condition, so that they can live for as long as possible, is not only beneficial to them, but also allows to eliminate the additional costs related to residential care. Innovations and modern technologies can help in maintaining a good condition of seniors. There are many publications in the literature that prove this [27]. However, it should be remembered that the very rapid progress in the access and exchange of information on the Internet makes it necessary to control these processes so that they are not arbitrary [28]. It is especially important when the use of the Internet does not lead to positive results (facilitating access to, exchange and improvement of communication) but also to strengthening emotional loneliness, as research shows [29].

Recently, the positive role of innovations and modern technologies has been shown and emphasized in a King's College report on long-term care in the UK and other EU countries. The five recommendations presented there, including better house designs for seniors (adapted to their needs and simple to adapt) and improving seniors' access to formal and informal care, also contain indications about technology: better use of technology (defined as any device that helps people to do things that they could not do without this technology), greater scope of telemedicine use, and the introduction and use of telecare and alarm (notification) systems [30].

The problem is for these innovations and technologies to be effectively used by seniors, taking into account the restrained and / or reluctant attitude of seniors to modern technologies. This is an area that has not been fully explored yet, with many questions that still require satisfactory answers.

On the one hand, some research shows the restrained or even reluctant attitude of seniors to using computers, smartphones, the Internet or technologically advanced home appliances [31, 32], and on the other there are senior citizens who display a positive attitude [15, 33], or even groups of technology enthusiasts (technogenarians). The term 'technogenarians' was first used in the media in 2001, when Cynthia Fox defined a group of rich people from the baby boomers generation who, entering the senior age, fully appreciated the new technologies and wanted to use them to a large extent [34]. The term was extended by Kelly Joyce and Meika Loe to all elderly people using technology on a daily basis to maintain or improve their health [18].

Research on the determinants of innovations and modern technologies acceptance by seniors has led to determining six groups of factors influencing their decisions in this area. These are associated with: (1) challenges arising from independent living, (2) behavioural capacities, (3) personal opinions on the use of innovation and technology, (4) impact of the social environment, (5) influence of organizations and institutions, and (6) role of the physical environment [35]. A simple model has also been created to explain the acceptance of modern technologies by seniors. The model shows that senior citizens assess the use of modern technologies better when: they feel more stressed due to their unmet needs, have a stronger sense of self-efficacy, are more open to new information, are more strongly persuaded by external sources, and are strongly conditioned by their own experience. According to this model, seniors use three attributes in this evaluation: perceived efficaciousness, perceived usability and perceived collateral damages [36].

Studies show that the ability of the elderly to use home appliances depends on whether they understand the principles of operation of a given device. This may depend on the understanding of a similar but already known

technology. While this can help with new devices, it can also be an obstacle to the discovery of new features/functionality that the technology they are familiar with does not have, and so be an obstacle to discovering advanced features. Older people experience a decrease in cognitive abilities related to attention, perceptual encoding and memory (signaling and recalling). Therefore, the way of informing seniors about new technologies is very important [37]. The process of familiarizing seniors with new technologies by providing information and knowledge about them (in a manner adapted to seniors' perception) can be helped either by specially created information centres about new technologies, or institutions and organizations that are already operating, such as libraries or senior centres [38]. It is worth remembering that the attitude of seniors to new technologies is strongly conditioned by their social bonds [39].

In the care of senior citizens, especially when they live independently and run their own households, it is important to detect a decrease or deficiency of daily activities of seniors, which may help carers to take rapid preventive actions. Opinion polls in the senior populations on the sensors used to monitor their daily home activities carried out by Pol et al. [40] showed that the seniors in the 68–93 age group positively evaluated the possibility of using sensors and indicated that this innovation enables them to live independently. For the study, wireless recording devices (sensors) installed at home were used. The sensor system consisted of 16 simple binary devices including infrared sensors recording movement in a given part of the house, magnetic sensors mounted on room and furniture doors (registering the closing and opening time), and sensors used to monitor the water flushing system in the toilet. The recording devices were analyzed by intelligent software containing a learning feature. In this way, the programme registered the activity patterns of the resident throughout the day. However, the tested system did not have a threat detection function.

In this study, respondents did not raise the problem of privacy violation by the technology, which was critised in other studies. The ability to monitor daily activities by specialists and carers thanks to the transmission of data strengthened the sense of security and improved the quality of life among the respondents.

The results of research on the factors determining the seniors' approval of innovations and modern technologies often end in intuitive conclusions, like those saying that technical devices and applications used by seniors must be equipped with various functions such as control, diagnosis, prevention, help, rehabilitation, optimization of therapeutic activities, promotion of healthy aging or predicting adverse health effects [23], and that they must be used at various levels of aging, i.e. both at the early stages of healthy aging, to inhibit the deterioration of seniors' functioning, and at the stage of weakness and disability, in order to help patients and their carers.

Gerontechnology: Meeting the needs and expectations of senior citizens

There is a wealth of literature on the use of innovative devices and applications by seniors, such as sensors monitoring the surroundings, smart fabrics/clothing, software associated (or not) with telehealth, but the results of these studies are often questioned due to methodology weaknesses and limitations [41]. As a consequence, there is hardly any empirical evidence on the effectiveness of these technologies, as most publications are more focused on the study of patient satisfaction and the possibility of applying a given innovation than on its cost effectiveness.

Despite the existence of such limitations and weaknesses, it must be pointed out that there are substantial grounds for arguing that a holistic approach to seniors' use of modern technologies represented by the gerontechnology movement can be very helpful.

The emergence of gerontechnology can be interpreted in terms of social innovation [42], and it is in this sense that the term is used in the article.

Publications using this term appeared first in the 1990s. Gerontechnology was understood as conducting research, producing and introducing specific technologies for the use of the entire senior population or their select groups [43]. This was connected with widely defined technologies for the control of seniors, including applications that are user-friendly for the senior population. Gerontechnology was created at the meeting point of two areas: gerontology and modern technologies. If gerontechnology is to be interpreted in terms of scientific areas and disciplines, it can be considered as a multibranch and multidisciplinary approach addressing topics taken from at least three different areas of knowledge (engineering and technical sciences, medical sciences, health sciences and social sciences) and nine disciplines (respectively: architecture and urban planning, electrical engineering, applied informatics, medical engineering, health sciences, basic medical and pharmaceutical sciences, economics and finance, sociological sciences and psychology). Harmonizing with the idea of gerontechnology is also modern geriatrics, whose main goal is maintaining the cognitive and physical functions of the patient, based on the diagnosis and treatment of acute and chronic diseases [23].

Gerontechnology already has its institutional international dimension – the International Society of Gerontechnology (ISG), which has published a scientific quarterly (*Gerontechnology*) since 2001.

Recently, gerontechnology themes have also been discussed in Polish literature on the subject [44–46].

The multi-branch and multidisciplinary nature of gerontechnology means that it is used by architects, designers, constructors, engineers, medical producers and employees (from such areas as nursing, medicine, gerontology, geriatrics, environmental protection, psychology, developmental psychology). This collaboration is to result in devices, applications and technical solutions

that best meet the needs of seniors, and although collaboration is the constitutive principle of gerontechnology, opinions can be found in the literature pointing to the still-persistent dominance of engineers, researchers and producers over representatives of the medical and social spheres or seniors [47].

At the initial stages of its development, gerontechnology identified four groups of technologies with the greatest impact on meeting the needs of seniors [20]: (1) Technologies expanding the field of seniors' choice (e.g. telephone, radio, e-mail or means of transport), (2) Technologies protecting against losses (e.g. control of the quality of nutrition or the quality of the physical and biological environment), (3) Technologies compensating the diminishing capacity of the senior body (e.g. glasses, hearing aids, devices for stabilizing wheelchairs in means of transport, electric wheelchairs), (4) Technologies supporting carers of the elderly (e.g. video alarms, ergonomic toilets).

The success of gerontechnology as an approach integrating the needs of various interested parties in the aging processes have led to initiating the active participation of seniors at the early stages of design work on new devices and technologies. Seniors participate in: developing new applications for existing technologies, activities oriented at developing new technologies, and testing and modifying prototypes [48]. It is pointed out that there are many ways, methods, approaches and instruments used to involve seniors in the innovation process. The use of a given method depends on the context. Interestingly, however, in most cases, the inclusion of seniors in the design process did not lead to greater approval by the seniors of the innovation and / or the use of the product in whose creation they were actively involved. The study ended with the conclusion that co-design by seniors should be part of a wider strategy including the needs of seniors and the evaluation of the results of introducing new devices and technologies [48]. The fact that the co-design of devices or applications by seniors does not guarantee their final approval by that age group can be proved by the technically flawless support system for senior citizens, called HandyHelper [49] – a wireless intelligent sensor system – which was finally evaluated both by seniors and their carers as little or moderately useful [50].

The gerontechnology concept continues to evolve and develop. Some disciplines that gerontechnology embraces are aspiring to make a stronger mark. An example is psychology and the concept of psychogerontechnology recently introduced in scientific literature [51].

Recent publications on gerontechnology [41] distinguish ten key areas (drawing a picture of collaboration and cooperation between various fields and specialists in this field):

- telehealth and telemedicine services: scientists build expert systems using i.a. probabilistic reasoning and pattern recognition techniques, which support medical decisions in services primarily directed to older people;
- devices for communicating with seniors: there have been intense efforts to create technical systems and devices that would enable seniors to be more independent. In addition to simple devices that help seniors and their carers in everyday activities, intelligent communication systems and devices for more effective and efficient elderly care appear, ensuring also comfort and safety [52]. Here, the important role is played by mobile devices providing access to databases;
- social networks for seniors: strong social ties and social integration play an important role in maintaining health and providing psychological comfort for older people, leading to improved quality of life, reducing the risk of cognitive functions deterioration and, as a result, protecting against earlier death. However, creating special social networks and expanding the use of computers by seniors remains a big challenge;
- lifelong learning for mental health: includes third-age universities, educational trips, community-based activities and volunteer activities that aim to stimulate the mind of the senior person, to increase their physical activity and to maintain healthy social bonds. Acquiring knowledge through computers, services available on the web, semantic Internet applications as well as learning and teaching can largely replace the work of people (experts or caregivers);
- mobility and rehabilitation methods: mobility is a basic requirement for the independence of individuals and their participation in social life. In the case of people with motor disabilities, such constraints create barriers to achieving goals that are important to any person. Mobility and rehabilitation methods are closely related to biomedical engineering;
- technologies and supporting devices: products representing them are designed to broaden access for people with physical or cognitive limitations, value impairment or disability. Older people must be equipped with alternative interfaces connecting people with a computer, such as devices for entering commands into a computer, on-screen keyboard, reading tools, screen reading tools, speech recognition programmes, etc.;
- accident detection at home: slips and falls are the main source of injuries to older people. Chances of surviving an accident at home are higher when people who live independently get quick help. Thanks to intelligent technologies, medical notification systems are created. Here the key role is played by the architecture of expert systems with great capacities for recording phenomena (powerful perception capabilities);
- recognizing and influencing emotions and moods: there is more and more evidence that positive emotions play an important role in creating a healthy interpersonal atmosphere. Emotional intelligence, accurate assessment and expression of emotions in relation to yourself and others, and control over emotions in a way that makes life easier involves a set of interrelated skills and processes. The issue of the emotional dimension of computer use and artificial intelligence acquires a special meaning here;

- personalized ambient adaptation; creating an environment in which people are surrounded by intelligent and intuitive interfaces that are installed on all types of devices and are able to recognize and respond to people in a discreet and often unnoticeable manner, offering a path to natural interfaces that are adaptable and anticipate different needs. Intelligent computer personalization and data management play an important role in this area;
- robots performing care functions and functions of intermediaries: robots performing various activities and serving various purposes in medical care (going beyond surgery and rehabilitation) and social care, are considered one of the most important technological innovations of the 21st century. This is related to knowledge-based systems.

By delineating (possible) directions for further development for gerontechnology, we concur with the European Geriatric Medicine Society (EuGMS) [23] that firstly one should find full and satisfying answers to two questions:

1. What evidence is there that gerontechnologies are effective in enabling independent living for seniors? Some research results indicate lack of conclusive evidence in this respect [31, 53].
2. What are the devices created especially for fragile seniors?

Priority gerontechnology activities may include:

- acquiring knowledge about the approval of technologies and determinants of its use in everyday life of seniors, taking into account the diversity of technologies and the pace of their development;
- study of the impact of stigmatization ('old man') and emotional patterns in the use and development of technology by older people;
- building a flexible and progressive classification of technological needs, taking into account the spectrum from healthy aging to disability, to better adapt these tools to special needs and clinical context;
- developing methods for assessing innovative technologies for seniors already at the early stages of development of these technologies, with a strong representation of end users;
- abandoning the narrow definition of technology for seniors and developing partnerships with other medical specializations that are confronted with the same problems, from pediatrics to rehabilitation;
- building a partnership between geriatricians, patients and organizations of carers of the elderly, engineers, industry and researchers involved in economics in order to create innovative business models;
- broadening knowledge about ethical issues and the consequences of social technological innovations [23, p. 283].

Examples of applications used in the care of senior citizens

In the literature there are many examples of innovative devices and technologies dedicated to seniors – two are presented below to illustrate measures aimed at improving the quality of life for seniors living independently: the ISISEMD project and robots accompanying seniors.

The ISISEMD project (*intelligent system for independent living and self-care of seniors with cognitive problems or mild dementia*) was directed to carers of the elderly [15]. It lasted 30 months (from March 2009 to August 2011) and grouped 12 partners representing final recipients of care services for the elderly from Denmark, Great Britain, Greece and Finland, large companies such as Hewlett Packard and Alcatel-Lucent as well as small and medium-sized enterprises, academic centres and one public institution. In the second year of the project's operation, specialized monitoring systems were installed in the homes of elderly people with cognitive disorders in Denmark, Great Britain, Greece and Finland. Technologies supporting people with dementia were represented by various devices available on the market, ranging from computers with touch screens, sensors recording such parameters as temperature, indoor traffic, smoke detectors, cooking activities, to a GPS system that allows to see the current location of an elderly person outside home. The main objective of the project was to maintain or increase the safety of elderly people affected by dementia and living independently, and to achieve a positive effect in terms of perceived quality of life.

The project was to bring benefits to carers and society [15, pp. 3–4].

The results of this study have shown that each of the people affected by dementia has specific, individual needs related to different stages of dementia. This, in turn, set different requirements for the services provided to these people. It was important to ensure that the system worked with a minimum participation of the senior, and that it had built-in automatic functions due to the limited learning opportunities of seniors and their modest experience in the use of modern technologies. The project was a success.

Robots are increasingly used in senior care. A review of publications on the interaction of older people and robots by Zafrani and Nimrod [54] leads to the conclusion that a more in-depth and robust research is needed, based on a solid methodological foundation, covering all aspects of this issue. The authors propose a holistic model to study these interactions, including the physical, social and cultural dimensions, with different segments of the senior group, types of robots as well as group and individual interactions. The proposed model assumes the study of the use of robots, the effects of their use and long-term barriers.

Robots constructed with the aim of helping the elderly represent a wide spectrum: from robots resembling animals (Paro, Aibo) through companion and help robots (Ifbot, Wakamura), to anthropomorphic robots with facial expressions (Kismet) [55]. Although most robots are not designed specifically for the elderly, the producers present them as technologies serving seniors and helping to withhold deterioration of cognitive functions, fighting loneliness or reminding of the necessity to take medication. There is hope that robots will help seniors at home, which will reduce the costs associated with the care of seniors in hospitals or care and treatment centres.

The experiences reported by Niven [56] with the iRo robot prototype (invented name) have yielded interesting results. iRo was conceived and produced by a Danish company specializing in the production of devices supporting the elderly. At first it was used to study the interactions between seniors and intelligent robots. Depending on the programme in which iRo was equipped, it could perform certain activities or provide an interface to digital technologies. For example, it could act as an alarm clock or operate audio devices. Communication with iRo was easy. You did not need to learn special commands because iRo understood and spoke Danish (iRo was not sophisticated, however). iRo could blink, nod, smile and grimace. It was made of plastic, electronics and actuators. Depending on the programme, iRo could have different applications. For the tests, a programme was used, based on which iRo played games and puzzles with seniors. In doing this, iRo made comments and phrases such as: "I will have to think of some clever move" or "You have to jump". The constructors equipped iRo with a board that was spread between the robot and the playing senior.

Laboratory experiments with iRo testing ended with only a partial success and showed that even when technology can be beneficial to the health and well-being of seniors, they might reject such technology [56] because they do not want to be positioned (perceived) by others as old, lonely and weak.

Boundary conditions for effective innovations implementation in the seniors' environment

On the basis of the literature analyzed above, one can point out three key success factors in effective introduction of innovations and new technologies into senior care:

1) adoption and development of the approach represented by the gerontechnology movement, particularly:
   - in-depth analysis of the needs of seniors: they constitute a highly heterogeneous group;
   - adoption of a participatory style in contacts with seniors, especially in the field of working on new applications of existing technologies and in work on new technologies;
   - the need to apply the principle of maximal simplicity in the construction of devices and the automation of their functions; however, we need to balance the proportions and first become familiarized with their needs because too easy handling of devices and their high automation are not positively evaluated by seniors [47];
2) using adequate language, forms and channels of communication with seniors: here personalization of the message and taking into account the social bonds in which seniors function should play a fundamental role;
3) providing psychological support for seniors, including strengthening the sense of agency and autonomy.
   - In no way do these three key factors guarantee success and should be interpreted only as boundary conditions, insufficient for efficient and effective introduction of innovations and modern technologies to the world of seniors. Fortunately for researchers, seniors cannot be described with simple algorithms, tools and methods.

Notes

[1] Referring to a statement of the Chinese scientist He Jiankui, Associated Press reported that in November 2018 two girls were born whose genome had been modified at the embryonic stage by means of the CRISPR-cas9 genome-editing technique, https://www.termedia.pl/ mz / Genetically-modified-people-Chinese-scientist-He-Jiankui-claims-from-now-future-on-world, 32221.html (accessed: 28.11.2018).

[2] It is illustrated by the course of 73 sessions of the UN General Assembly at the UN headquarters in New York on 27 September 2018, during which a session on "Alliance for a Positive and Healthy Ageing and the Achievement of Sustainable Development Goals" was organized; https://www.un.org/development/desa/ageing/news/2018/09/unga73/ (accessed: 28.11.2018). Earlier, in December 2010, the UN General Assembly formed a special working group caled "The Open-Ended Working Group on Ageing".

[3] Leaving aside the question of the possibility of giving it the status of a separate, independent discipline.

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