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Evaluation and Selection of Technologies Improving the Quality of Life of Older People

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Abstract:

Purpose: *According to the UN population forecast by the year 2030 people aged 65 years and over will have made up 11.67% of the world's total population and 22.97% of the European population. So, in less than 10 years, almost every fourth Pole will be over 65 years old. It, therefore, seems necessary to examine how health, life and consumption needs of older people can be met and which technologies can improve the quality of life of older people. The main aim of the article is to identify, evaluate and build a ranking of gerontechnologies – technologies improving the quality of life of older people. The article also examines the influence of gender, age, education, and place of residence on the evaluation of gerontechnology groups.*
Design/Methodology/Approach: *The research was carried out with critical literature analysis, logical construct method as well as statistical research. A survey was conducted with the use of CATI and CAWI in the period December 2019 to January 2020 on a representative group of poles aged over 40 years old.*
Findings: *The research assessed and ranked nine main groups of technologies improving the quality of life of older people. The impact of gender, age, education, and place of residence on the assessment of these technologies was also examined.*
Practical Implications: *Identification of the highest-rated technology improving the quality of life of older people.*
Originality/Value: *To gain new knowledge in identifying the needs and expectations of future and current users of technologies that improve the quality of life of older people.*

Keywords: *Gerontechnology, elderly, older people, technology.*

JEL codes: *J14, J17, E21, O33.*

Paper type: *Research article.*

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1. Introduction

In the twenty-first century, the phenomenon of an ageing society is becoming increasingly noticeable. The report "World Populations Prospects 2019" states that for the first time in history, in 2018, persons aged 65 years or over worldwide outnumbered children under the age of five (UN DESA, 2019). Experts also predict that by 2050, the global number of persons aged 65 years or over will also surpass the number of adolescents and youth aged 15 to 24. In the European Union countries, one of the most noticeable and important trends is population ageing.

Taking into account data from the report “Demographic Scenarios for the EU”, the average life expectancy at birth in the EU is about 81 years and if this trend continues, in 2060 the share of the population over age 65 will be 32% of the total EU population, i.e. 521 million (European Union, 2019). In Poland, the average life expectancy for men in 2018 was 73.8 years (in 1990 - 66.2) and that of women - 81.7 (in 1990 - 75.2) (Central Statistical Office Poland, 2019). In 2018, the population in Poland was 38,411,148 and the group of people aged 65 years and over numbered 6,732,360 (Central Statistical Office Poland, 2019).

As of 1 January 2020, the median age of the world population was 30.9 years (Table 1). This means that at the beginning of 2020, half of the world's population was over 30.9 years old and half was younger. In 2010, the median age of the world's population was 28.5 years and in 2000 it was 26.3. In 2020, the highest median age was recorded for Japan with 48.4. In Europe, the median age of the population in 2020 was 42.5. The highest median age was recorded in Italy with 47.3 and the lowest in Albania with 36.6 and in Iceland with 37.5. Within 10 years, the median age in Europe increased by 2.2 years, from 40.3 years to 42.5 years. Over the last twenty years, the median age has increased on average by 4.9 years in European countries, with the highest increase recorded in Albania (9.4) and Lithuania (9.1), Norway (8.6), Portugal (7.9) and Romania (7.6). In turn, the median age of the population in Poland as of January 1, 2020, was 41.7 years and was 0.8 years lower than the median age of the European population. Over the last twenty years, the median age in Poland has increased by 6.7 years. According to the population forecast prepared by the United Nations (United Nations, 2017), by 2030 the median life expectancy in the world will be 33 years, in Europe 45.1 and Poland 46 years. However, in 2040, the median life expectancy in the world will be 34.6 years, in Europe 47.1 and Poland 49.7 years.

Table 1. *Median population age [%]*

	2000	**2010**	**2020**	**2030**	**2040**	**2050**
World	26.3	28.5	30.9	33.0	34.6	36.2
Europe	37.7	40.3	42.5	45.1	47.1	47.1
Poland	35.0	38.1	41.7	46.0	49.7	49.1

Source: *Own elaboration based on United Nations, World Population Prospects 2019.*

The phenomenon of population ageing is influenced by better medical care and dynamic development of the medical sector, greater self-awareness of people, as well as a desire to take care of their health and fitness. Ageing is governed by its laws - physical fitness is deteriorating, coordination, some activities that are easy to do for young people, for older people become a challenge. An older person cannot always count on the help of a younger family member and has to cope on his or her own. The phenomenon of an ageing society has an impact both on the policies of states and on their functioning. The ageing of the population requires investment in caring for the elderly and ensuring their proper living standards. It is also linked to the ageing of labour resources or a slowdown in economic growth.

Companies like to have senior experienced employees in their positions. As a result, staff can also be remarkably diverse in terms of age (incredibly young workers and older workers), which can lead to misunderstandings and problems. An important issue is to take action to make older people active in various areas of life. They should be given easier access to both technological and medical solutions or social and cultural activities. Due to the growing and more common phenomenon of society ageing, it is necessary to create technological solutions improving the quality of life of people both in Poland and worldwide. The gerontechnology sector, an environment that combines gerontechnology and technology can help. These are technologies that make life easier for the elderly. The term gerontechnology may not be extremely popular and people may be unaware of how useful and helpful technologies from this sector can be.

The article is divided into five sections. The first section focuses on reviewing subject literature and presenting perceptions on gerontechnology, as viewed by different authors. The second section describes how the classification of gerontechnology looks in literature review and also the authors presents their own classification of groups in the gerontechnology field. The next section of the article presents research methodology, techniques used in the research, sample distribution, etc. The following section is devoted to the description of the research, the aim of which is to identify the knowledge on gerontechnology in Poland and also to identify which groups of technologies would be most in demand among the society. This is accompanied by a ranking of gerontechnology classes.

Subsequently, the authors analyse in detail the evaluations of respondents and examine whether age, gender, education, place of residence influence the evaluation of gerontechnology groups. Finally, the article presents conclusions from the research. The research method is a diagnostic survey method with the use of a survey technique and the applied research tool is a survey questionnaire. Research techniques that are used in the survey are CATI (Computer Assisted Telephone Interview) and CAWI (Computer Assisted Web Interview).

2. Literature Review

The ageing of the population is a serious and demanding process and it brings many difficulties and inconveniences of everyday life of senior people. The sector of science handling with such problems is gerontechnology. Gerontechnology consists of two areas – gerontology and technology. In Kapur's view, gerontology is the scientific study of ageing processes, and it is the study of physical, mental, and social changes that occur amongst older individuals as they age (Kapur, 2018). The technology consists of two primary components (Kumar *et al.*, 1999):

1. The physical component which comprises items such as products, tooling, equipment, blueprints, techniques, and processes;
2. The informational component which consists of know-how in management, marketing, production, quality control, reliability, skilled labour, and functional areas.

Technology is always connected with obtaining certain results, resolving certain problems, completing certain tasks using particular skills, implementing knowledge, and exploiting assets (Lan *et al.*, 1996). Gerontechnology is a field of study focusing on the development of technologies with an aim to improve elderly people's life. One of the oldest definitions of gerontechnology was presented by Bouma and it is as follows: *"the study of technology and ageing for the improvement of the daily functioning of the elderly"* (Bouma, 1992). According to Sale's definition, gerontechnology can help elderly people to identify and slow down the effects of the age-related modifications of the neural and musculoskeletal system (Sale, 2018).

Jansson and Kupiainen (2017) claim that it is a technology that attempts to study and develop equipment, services and surroundings that can support the elderly and prevent deterioration of functional capacity which is caused by ageing. Petermans and Piau (2017) deem that the idea of gerontechnology is also modern geriatrics, whose main goal is maintaining cognitive and physical functions of the patient, based on the diagnosis and treatment of acute and chronic diseases. Graafmans, Taipale and Charness (1998) describe gerontechnology as a science of technology and ageing aimed at the improvement of daily lives of older adults. Halicka (2019) claims that gerontechnology should enable older adults:

- to prevent problems,
- to increase self-reliance without changing skills and environment,
- to compensate for the loss of options if the facilities are unable to provide them,
- to provide the service only if needed,
- to streamline the existing projects.

Gerontechnology deals with communication between older people and their family members through the use of digital and information technologies, allowing older people to maintain their independence and improve their mental health by monitoring and maintaining constant contact with their environment (Blaschke *et al.*, 2009). Rzeczynski (2009) argues that the gerontechnology paradigm is constituted at the crossroads of progressive technology and advanced older age, in an interdisciplinary field of science where technology is directed towards the aspirations and capabilities of the elderly, with the aim of researching, developing and designing products and services to maintain good health, full participation in society and independent living. Traditionally, gerontechnology focuses on the application of (Micera *et al.*, 2008):

1. advanced technologies to address motor and cognitive disability,
2. wearable systems to recognize problems related to reduced functional capacity,
3. technological aids to compensate for deficits and increase the level of autonomy at home.

Gerontechnology is applied to assist and support older adults to "age in place" successfully by maintaining independence and proper quality of life, as well as to support those offering care, either in private homes or care home settings (Leroi *et al.*, 2018). Gerontechnology can enhance the performance and opportunities of older citizens in new roles that fit their new ambitions and those new roles include changed work, leisure, living and also modified social situations (Harrington, 2000). Some definitions present a broader view of the problem, some narrow it down. However, there is no single generally applicable definition and for that reason the authors of the article create their own definition of gerontechnology for research purposes. The authors of the article understand gerontechnology as technologies improving the quality of life of elderly people, facilitating access of seniors to all goods, services, and infrastructure.

Analysing subject literature, it is possible to find a variety of studies on particular types of gerontechnology (Halicka, 2019). With regard to the phenomenon of ageing population, the first example of gerontechnology is that of improving and protecting the health of older people. Among other things, technologies supporting the health of the elderly such as mobile applications for smartphones are analysed (Hicks *et al.*, 2009). Halicka and Ejdys analyse another interesting technology that can be useful in supporting elderly people in their daily life, featuring a variety of robots that care for the elderly (Halicka and Ejdys, 2018). Literature also contains research on the use of virtual reality and video games in the process of rehabilitation of elderly people and the improvement of their motor skills (Lamoth *et al.*, 2011). Other technologies quite often analysed are technologies supporting the functioning of older people in their homes (smart homes) (Martin *et al.*, 2008).

The examples given above are only some of the technologies available to support older people. Literature review shows that some of the technologies studied are related to health, safety at home, caring for the elderly (robots) or improving mobility. Other technologies may also include entertainment, education, or communication. Therefore, it is necessary to group individual gerontechnologies.

3. Classification of Gerontechnologies

With gerontechnology in mind, there are various types of technologies supporting the functioning of older people. Technologies that immediately come to mind include for instance trolleys that improve the mobility of seniors or simple devices that improve the functioning of older people at home. Over time and with the development of the technological sector, more and more advanced systems, devices, and instruments are emerging to make life easier for the elderly. The use of electronics and IT solutions in the design of assistive technologies is becoming more and more important. As a result, the use of technology may be easier and more intuitive, but for the elderly, it may also present some kind of psychological problems and barriers. Therefore, designers, computer scientists and originators of such technologies try to make the operation of their devices as friendly as possible and easy to the elderly.

Nowadays, there are many different technologies, including those designed to support older people in their everyday life. One of the first classifications of technologies created at the beginning of the development of gerontechnology sector was classification proposed by Bouma. He identified four groups of technologies with the biggest impact on the needs of seniors (Bouma, 2001):

1. Technologies expanding the field of seniors' choices (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 for the diminishing capacity of a senior body (e.g. glasses, hearing aids, devices for stabilizing wheelchairs in means of transport, electric wheelchairs),
4. Technologies supporting caretakers of the elderly (e.g. video alarms, ergonomic toilets).

Bouma *et al.* (2007) presented their gerontechnology classification in a slightly different way - they distinguished six main technology groups:

1. Chemistry and biochemistry;
2. Architecture and building;
3. Communication and information;
4. Mechatronics and robotics;
5. Design and ergonomics;

Sale (2018) defined gerontechnology as a new branch of assistant technologies in health and social domains, combining gerontechnology and technology, where the primary fields of application concern technological environments such health, housing, mobility, communication, leisure and also work of older people.

Another classification of gerontechnology in literature divides technologies into the following groups: smart homes, robotics, virtual reality and gaming, telemedicine (for clinicians and consumers), social connectedness (Morris *et al.*, 2012). Considering recent literature output, it is possible to find information that gerontechnology is related to (Fernandez *et al.*, 2017):

- telehealth and telemedicine services;
- communication devices for seniors;
- social networks for the elderly;
- lifelong learning for mental health;
- mobility and rehabilitation;
- assistive technologies and devices;
- household accidents detection;
- emotion/affect/mood recognition and regulation;
- personalized ambient adaptation;
- social/care robots and agents.

There are several classifications of gerontechnology, but none of them is binding, therefore the authors of the article propose their own authorial classification based on literature review. They distinguish nine main groups of technologies:

G1. Health;
G2. Education;
G3. Interpersonal communication;
G4. Safety;
G5. Mobility;
G6. Care;
G7. Leisure;
G8. Housing;
G9. Digital accessibility.

The first group of technologies is related to health. It concerns all matters relating to the care of the health of the elderly. Technologies in this group could, for example, be health applications for smartphones, video-chatting with doctors. The next group is connected with the education of older people. Technologies in this group focus on the educational development of seniors and examples of technologies can include various online courses and schools for seniors.

The third group is called interpersonal communication. Technologies from this group are connected with simplified communication of seniors with members of their families. Simplified smartphones, social media for seniors are examples of technologies in this group. Another group of technologies is related to the safety of seniors. Elderly people are exposed to various types of accidents; hence their safety is extremely important. This could be supported by such technologies as various systems for monitoring seniors and notifying, informing their families and/or emergency services.

The next group indicates mobility technologies addressed at older people. Examples of technological devices in this group are modern trolleys, scooters, devices designed to move. Elderly care is especially important; hence the sixth group is a group related to care. It can be exemplified by modern robots that use AI (Artificial Intelligence).

Another group of technologies are technologies linked with the leisure of seniors and example technologies can be virtual adventures, special electronic books designed especially for seniors. The next group is a group named “housing”. The role of technologies in this group is to facilitate the everyday life of older people at home. The last group of technologies is digital accessibility. Examples of technologies in this group are on-screen keyboard and speech recognition programs. Table 2 presents examples of gerontechnologies from each of the above-mentioned groups:

Table 2. *Examples of gerontechnologies*

Acronym	**Group**	**Example of technology**
G1	Health	VitalBand
G2	Education	Tablets
G3	Interpersonal communication	OhmniLabs
G4	Safety	Pocketfinder
G5	Mobility	Wheelie7
G6	Care	Care robot – Rudy
G7	Leisure	Rendever
G8	Housing	Walabot Home
G9	Digital accessibility	iN2L

Source: *Own elaboration.*

VitalBand is an example of technology that falls under the category "Health". This band contains functions as controlling heart rate, respiration rate, emergency voice calls out, automatic fall detection and step count and calories burned (VitalTech, 2020). This device might help control the health of older people. Vicentin *et al.* presented the effectiveness of the combined computer program and physical activity program in preventing cognitive loss in the elderly living in the local community of Vila Clementino, Sao Paulo, Brazil (Vicentin *et al.*, 2018). It has been proven that a combined computer and physical activity program can improve overall cognitive

performance in independent older people. Pinto *et al.* on the other hand, carried out a study to test the openness of older people to new technologies and to check the possibilities and willingness of older people to develop their basic competences. The information obtained in the course of the study may be used to implement a new, cost-effective, and useful telehealth product soon (Pinto *et al.*, 2014).

Education is also an important aspect of older people's lives. With tablets that are also designed for older people, older people can check information, weather, and even participate in various simplified courses for seniors. Such tablets are generally large, and it is easy and pleasant to read information from them. Human communication can be a big problem for older people. Nowadays, technology offers a variety of devices that make it easier for seniors to communicate with their families. An example of such technology is the Ohmni Supercam device/robot. This device provides a connection and comfort in communicating. It is operated remotely and gives family full control over communication. Also, for seniors, it is easy and comfortable to use (Ohmnilabs, 2020).

Pocketfinder is an ideal example of technology from the "Safety" group. This device is a GPS that takes care of the safety of the elderly, enables monitoring, locating, and tracking (Pocketfinder, 2020). Mobility problems are quite common among older people. With the development of technology, more and more advanced devices are created, which make it easier for seniors to move around freely and independently (Winkowska *et al.*, 2019). One such device is the Wheelie. It is the world's first face-controlled wheelchair, which allows older people to drive using facial expressions (Hoobox, 2020).

Taking care of the elderly is extremely important, and family members do not always have time to take care of their seniors. The future of elderly care rests in robots with different functions. An example of such a robot is Rudy. This robot is an AI device that helps seniors remain mentally sharp, socially connected and physically healthy (INF Robotics, 2020). As part of the ISISEMD project, Mitseva *et al.* (2012) have designed, implemented, verified, and evaluated the Assistive Technology Platform for Personalised Home Care (telecare) for cognitively impaired elderly people and their caretakers, offering intelligent home support services. The study presents the results of indirect assessments of user satisfaction with the system, technology and service acceptance and quality of life as a result of using these services.

Older people have a lot of free time; hence technology that fits perfectly the "Leisure" category is Rendever. It is a virtual reality platform that gives senior care communities the ability to have fun and enjoy life again. It offers users a variety of games and different activities (Rendever, 2020). Pan *et al.* (2018) present such technology as Digital Storytelling. It is a form of an active reminder that compiles personal data provided by a person in a chronicle of their life and presents them on a digital platform.

It can be exceedingly difficult and dangerous for older people to function alone at home. On the market it is possible to find many "Housings" devices that make it easier for the elderly to live alone at home. An example of such a device is Walabot Home Fall Alert System. This device automatically detects falls, calls emergency and thanks to this, a senior may receive immediate help (Walabot, 2020).

The last group of technologies addressed at older people is “Digital accessibility”. An example of such technology is iN2L. This technology connects seniors with what interests and fulfils them and enables them to share conversations, learning, interactions, and fun with each other (iN2L, 2020).

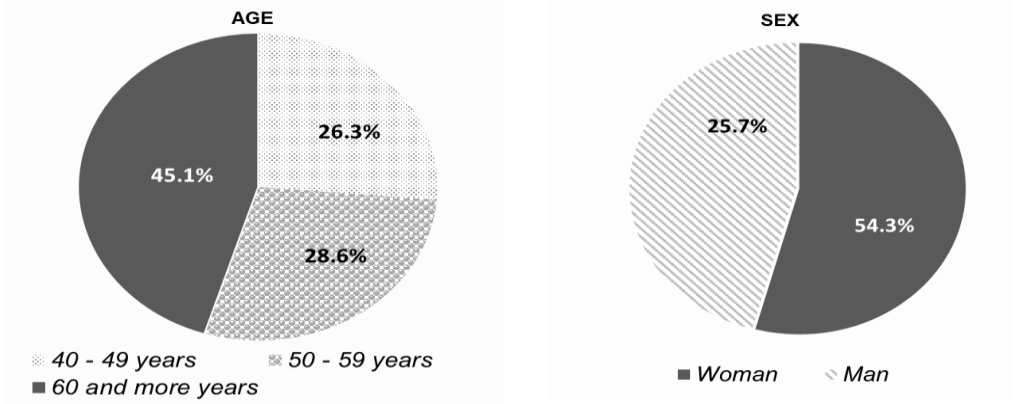
Examples given above are only a small part of all available options. Technology is developing at an incredible pace and newer and more advanced technological solutions are appearing every day, obviously including those dedicated to the elderly.

A thorough review of literature on gerontechnology indicates that so far research on gerontechnology has been concentrated mainly on specific individual technological solutions. There were no studies on several types/classes of gerontechnology. So far there has also been no evaluation and ranking of available gerontechnologies. The authors decided to make such a ranking for nine groups of gerontechnologies selected in this chapter, them being: health (G1), education (G2), interpersonal communication (G3), safety (G4), mobility (G5), care (G6), leisure (G7), housing (G8), digital accessibility (G9).

4. Methodology

To evaluate and create a ranking of gerontechnology groups, surveys were conducted. The survey was conducted between December 2019 and January 2020 on a representative sample of 1152 Poles aged over 40. Gerontechnology issues concern mainly parents of people over 40 years of age, and in the perspective of twenty years of their own. The survey was conducted with the use of CAWI (Computer-Assisted Web Interview) and CATI (Computer-Assisted Telephone Interviewing) methods. Considering the fact that not every respondent had contact with the assessed gerontechnology groups, the questionnaire initially characterized nine gerontechnology groups and then gave specific examples for each group. The respondents represented all provinces in Poland. More than half of the respondents (672 persons) - 58.3% have an elderly person under care. In the sample structure, 625 respondents were women and 527 men (Figure 1). 303 respondents were aged 40-49, 329 people - 50-59 and 520 respondents - over 60 (Figure 1).

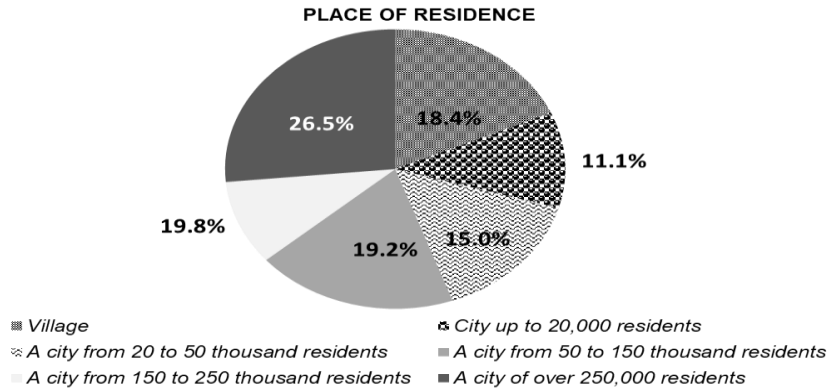
***Figure 1**. Gender and age structure of respondents*



***Source:** Own elaboration.*

About 18.4% of the respondents (212 persons) were people living in the countryside, about 11.1% of the respondents (128) were people living in the city up to 20,000 residents, 15% of the respondents (173 persons) were people from a city numbering 20 to 50,000 residents, 19.2% (221 persons) were people from a city inhabited by 50 to 150,000 residents. About 9.8% of respondents (113 persons) live in cities with 150 to 250,000 inhabitants and 26.5% (305 persons) are respondents living in big cities with over 250 thousand inhabitants (Figure 2).

***Figure 2.** Structure of respondents by place of residence*



***Source:** Own elaboration.*

5. Research Results

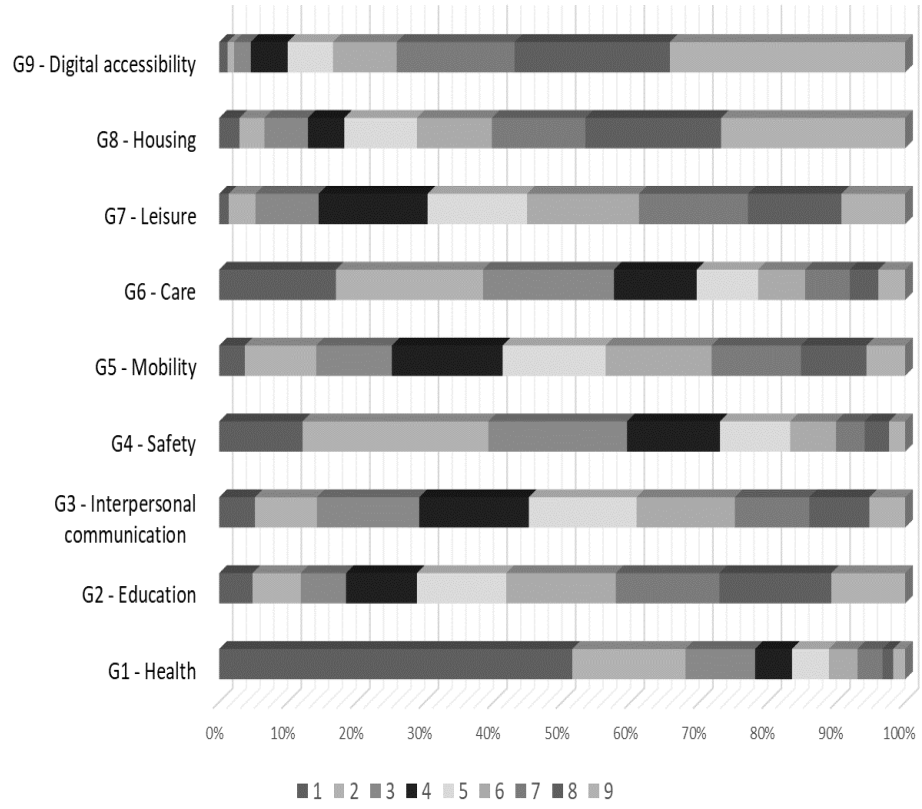
5.1 Ranking of Groups of Gerontechnologies

Initially, the respondents answered the question as to which of the following nine groups of gerontechnologies is most important in the context of older people's functioning: health (G1), education (G2), interpersonal communication (G3), safety

(G4), mobility (G5), care (G6), leisure (G7), housing (G8), digital accessibility (G9). They ranked these groups of gerontechnologies from 1st to 9th place, where 1 means the highest-rated, most important gerontechnology group and 9 - the least important (Figure 3). It was assumed that important gerontechnology is the one which, in the respondents' opinion, took places from 1st to 3rd rank.

Analysing Figure 3, it can be seen that over 78% of respondents attached the greatest importance to gerontechnology from the area of health (place from 1 to 3), almost 60% of respondents consider gerontechnology from the group of safety (59.5%) and care (57.6%) as important. The lowest rating was given to the G9 digital accessibility group. Less than 34.3% of respondents consider it to be the least significant (last 9th place). The following gerontechnology groups were considered the least important in the context of older people's functioning: leisure - 7th place, housing – 8th place, digital accessibility – 9th place in the ranking. Table 3 presents the above gerontechnology ranking.

Figure 3. *Evaluation of gerontechnology groups*



Source: *Own elaboration.*

Table 3. *Ranking of groups of gerontechnology*

Group of gerontechnology	**Average rating of the group of gerontechnology**	**Ranking**
G1 - Health	2.42	1
G2 - Education	5.74	6
G3 - Interpersonal communication	4.89	4
G4 - Safety	3.51	2
G5 - Mobility	5.08	5
G6 - Care	3.65	3
G7 - Leisure	5.75	7
G8 - Housing	6.64	8
G9 - Digital accessibility	7.31	9

Source: *Own elaboration.*

5.2 Gender Impact on Gerontechnology Assessment

In the further part of the study, it was verified whether age affects the evaluation of nine groups of gerontechnologies. A critical level of significance was assumed at p=0.1. The non-parametric Mann-Whitney U test (Wilcoxon, 1945; Mann and Whitney 1945) (Table 4) was used to investigate the effect of gender on the evaluation of gerontechnology in the health area.

Table 4. *Statistics of the Mann-Whitney U test for assessment of a group of gerontechnologies*

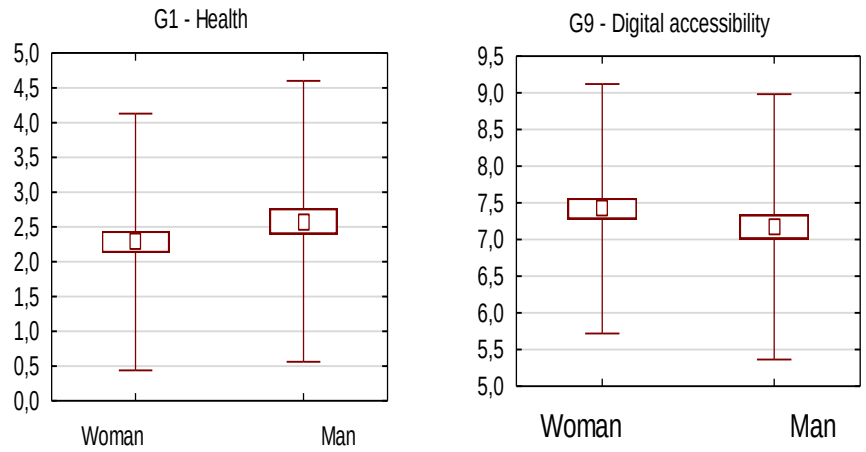
Acronym	**Statistics of the Mann-Whitney U test**		
	U	**Z**	**p**
G1	151737.00	-2.30197	**0.021337**
G2	159743.50	0.87875	0.379538
G3	164247.50	0.07812	0.937729
G4	161160.00	-0.62695	0.530689
G5	160386.00	0.76454	0.444546
G6	162881.00	0.32103	0.748186
G7	163558.00	0.20069	0.840942
G8	160023.50	-0.82898	0.407118
G9	150931.50	2.44516	**0.014479**

Source: *Own elaboration.*

Analysing Table 4, it can be observed that significant gender differences in the assessment of gerontechnology groups ($p < 0.1$) occur only in the case of gerontechnology from health (G1) and digital accessibility (G9) groups. In case of other gerontechnology groups, no significant differences between the assessment of these groups and gender were observed. Therefore, with 90% probability, it should be stated that gender does not affect the assessment of seven gerontechnology groups such as education (G2), interpersonal communication (G3), safety (G4), mobility (G5), care (G6), leisure (G7), housing (G8). Analysing respondents' answers in detail in the context of gerontechnology in the health area, it can be

observed that for men gerontechnology is less important than for women. The mean value of male responses is 2.6 and female responses is 2.2 (Figure 4). In case of gerontechnology from the area of digital accessibility, the opposite is true. The average male response is 7.1 and female response is 7.4, with response 1 being the most important and 9 the least important.

Figure 4. *Gerontechnology assessment in term gender groups*



Source: *Own elaboration.*

5.3 Influence of Age, Education and Residence on the Evaluation of Gerontechnology

It was further examined whether age, education and place of residence influence the evaluation of the nine gerontechnology groups. The ANOVA Kruskal-Walls test (Table 5) was used to examine the influence of age, education, and place of residence on the assessment of each gerontechnology group. It should be emphasized that in the assessment of respondents 1 means that a given gerontechnology group takes the first place in the framing, i.e. it is the highest rated. On the other hand, grade 9 means that a given group is the last one in the ranking, so it is the least important. A given grade could be awarded only once by the respondent. Thus, two different gerontechnology groups could not get the same place, nor could they get the same grade.

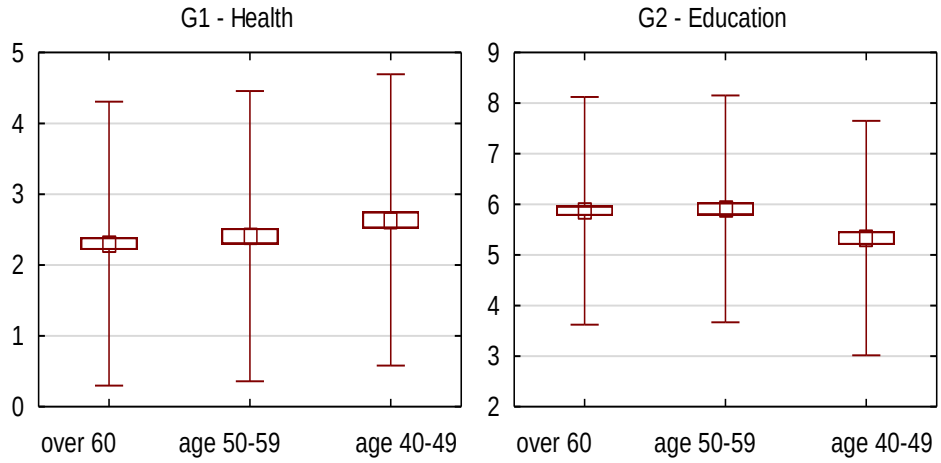
Analysing Table 5, it can be concluded with 90% probability that age does not affect the assessment of the following gerontechnology groups: interpersonal communication (G3), safety (G4), mobility (G5), care (G6), leisure (G7), housing (G8), digital accessibility (G9). Figure 5 graphically illustrates acceptance response values of gerontechnology groups (statistically significant) in three age groups.

Table 5. *Statistics of the ANOVA Kruskal-Walls test for assessment of a gerontechnology group*

Acronym	Statistics of the ANOVA Kruskal-Walls test (age)		Statistics of the ANOVA Kruskal-Walls test (education)		Statistics of the ANOVA Kruskal-Walls test (residence)	
	T	**p**	**T**	**p**	**T**	**p**
G1	1	**0.0005**	1	0.8945	1	0.9789
G2	6	**0.0048**	6	0.3963	6	0.5898
G3	5	0.7579	5	0.2061	5	**0.0282**
G4	3	0.4689	3	0.4710	3	**0.0830**
G5	5	0.8738	5	0.1817	5	0.6636
G6	3	0.2275	3	0.8768	3	0.6494
G7	6	0.7971	6	**0.0010**	6	0.1975
G8	7	0.6392	7	0.6526	7	0.9317
G9	8	0.4028	8	0.5930	8	0.8922

Source: *Own elaboration.*

Figure 5. *Age-based assessment of gerontechnologies*



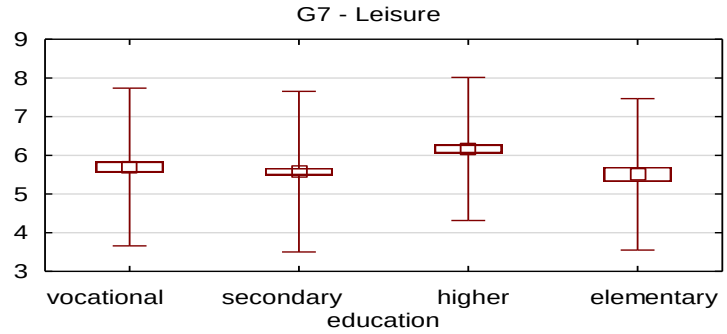
Source: *Own elaboration.*

Analysing Figure 5, it can be observed that the highest rating was given to gerontechnology in the area of health by persons over 60 years of age, the lowest by the youngest respondents. On the other hand, gerontechnology in the area of education was rated highest by the respondents aged 40-49.

Analysing Table 5, one can also notice statistically significant differences ($p < 0.1$) depending on education when evaluating the functionality of gerontechnology groups from the leisure area (G7). In case of other gerontechnology groups, no significant differences between the evaluation of these groups and education were observed. Therefore, with a 90% probability, it can be stated that education does not

affect the evaluation of all gerontechnology groups except for G7 - leisure. On the other hand, it can be stated with 90% probability that the place of residence does not influence the assessment of the following gerontechnology groups: health (G1), education (G2), mobility (G5), care (G6), leisure (G7), housing (G8), digital accessibility (G9). Figure 6 graphically illustrates the values of gerontechnology groups' acceptance responses (statistically significant) depending on education.

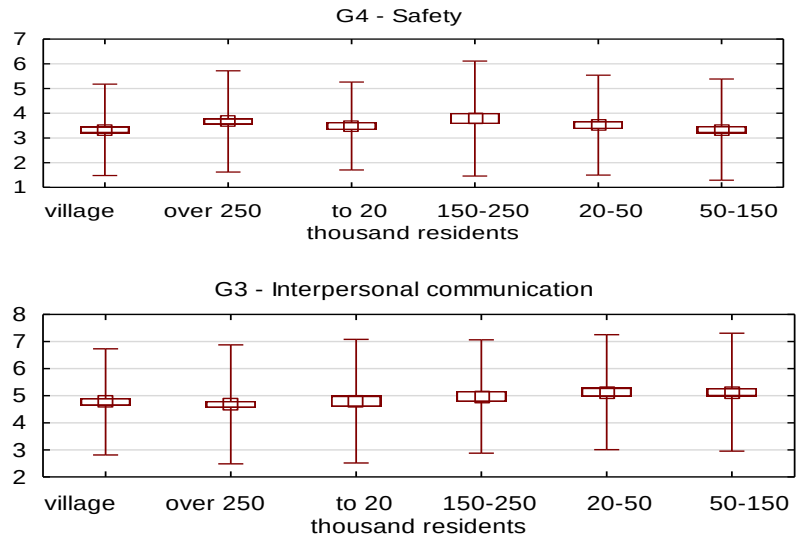
Figure 6. *Education-based assessment of gerontechnologies*



Source: *Own elaboration.*

Analysing Figure 6, it can be observed that the leisure gerontechnology group is the least important for people with higher education. On the other hand, this group was rated highest by people with elementary education (mean score 5.5). Figure 7 graphically illustrates acceptance response values of gerontechnology groups (statistically significant) considering the place of residence.

Figure 7. *Gerontechnology assessment based on the place of residence*



Source: *Own elaboration.*

Analysing Figure 7, it can be concluded that the Interpersonal Communication Geotechnology group (G3) was rated highest among the respondents living in large cities - over 250,000 inhabitants (average score on the scale from 1 to 9 is 4.6). On the other hand, this group was rated the lowest among respondents living in cities with 50 to 150 thousand inhabitants (mean score 5.9). In turn, the group of gerontechnologies in the area of safety was rated highest by respondents living in villages and towns with 50 to 150 thousand inhabitants (mean score 3.3). Gerontechnologies from this group were rated lowest by respondents living in towns with 150 to 250 thousand inhabitants.

6. Conclusion

In this article, initially, based on a literature review, 9 groups of gerontechnology were identified: (G1), education (G2), interpersonal communication (G3), safety (G4), mobility (G5), care (G6), leisure (G7), housing (G8), digital accessibility (G9). Subsequently, the ranking of gerontechnology groups was built. The results of the research show that in the opinion of Poles the most important group of gerontechnologies, in terms of functionality, is the gerontechnology group from the health area. More than 78% of respondents consider this group to be especially important (from 1st to 3rd place in the ranking). The second place in the ranking is taken by the group of gerontechnology from the safety area and the third place by care. According to respondents, the least important group of gerontechnologies is digital accessibility - the last place in the ranking. Only about 34% of respondents consider this group as particularly important.

In the further part of the study, it was examined whether gender, age, education, and place of residence influence the evaluation of the gerontechnology group functionality. The results of the research show that gender can have an impact on the evaluation of functionality only in the case of two gerontechnology groups: health and digital accessibility. For women, the gerontechnology group in the area of health is more important than for men. Men, on the other hand, rate the gerontechnology group from the area of digital accessibility higher than women.

The conducted research proves that age can be important for the evaluation of gerontechnologies from the areas: health, education. Respondents aged over 60 evaluate gerontechnology from the area of health higher than other respondents. In turn, education gerontechnology group is rated lowest by the oldest respondents (over 60 years of age). The research shows that education can affect the evaluation of only one gerontechnology group: leisure. This technology was rated lowest by people with higher education, and highest by respondents with elementary education.

In their further research, the authors intend to conduct research in other countries and then compare the rankings of gerontechnology groups. Moreover, the authors also want to consider in their research various gerontechnology evaluation criteria,

for example economic, social, ethical and technical aspects (Ejdys, 2020; Nazarko *et al.*, 2017; Nazarko, 2017). To build rankings in subsequent studies they intend to use Multi-Criteria Decision Making methods (Halicka, 2020; Chodakowska *et al.*, 2017; Kacprzak, 2019).

References:

Blaschke, Ch.M., Freddolino, P.P., Mullen, E.E. 2009. Ageing and technology: a review of the research literature. The British Journal of Social Work, 39, 641-656.

Bouma, H. 2001. Creating adaptive technological environments. Gerontechnology, 1, 1-3.

Bouma, H. 1992. Gerontechnology: Making technology relevant for the elderly. In Gerontechnology, Bouma, H., Graafmans, J.A.M., Eds., IOS Press: Amsterdam, Netherlands, 1-5.

Bouma, H., Fozard, J.L, Bouwhuis, D.G., Taipale, V. 2007. Gerontechnology in perspective. Gerontechjournal.net, 6, 196-198.

Chodakowska, E., Nazarko, J. 2017. Environmental DEA method for assessing productivity of European countries. Technological and Economic Development of Economy, 23, 589-607. doi: 10.3846/20294913.2016.1272069.

Demographic Scenarios for the EU 2019, European Union. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/demographic-scenarios-eu.

Ejdys, J. 2020. Trust-Based Determinants of Future Intention to Use Technology. Foresight and STI Governance, 14, 60-68. doi:10.17323/2500-2597.2020.1.60.68.

Fernandez-Cabellero, A., González, P., Navarro, E. 2017. Gerontechnologies - current achievements and future trends, Expert Systems, 34. doi:10.1111/exsy.12203.

Graafmans, J.A.M., Taipale, V., Charness, N. 1998. Gerontechnology: a sustainable investment in the future, Studies in Health technology and informatics. IOS Press, Amsterdam, The Netherlands.

Halicka, K. 2019. Gerontechnology - The assessment of one selected technology improving the quality of life of older adults. Engineering Management in Production and Services, 11, 43-51. doi: 10.2478/emj-2019-0010.

Halicka, K. 2020. Technology Selection Using the TOPSIS Method. Foresight and STI Governance, 14, 85-96. https://doi.org/10.17323/2500-2597.2020.1.85.96.

Halicka, K., Ejdys, J. 2018. Sustainable Adaptation of New Technology: The Case of Humanoids Used for the Care of Older Adults. Sustainability, 10, 3770. doi:10.3390/su10103770.

Harrington, T.L., Harrington, M.K. 2000. Gerontechnology. Why and How, Herman Bouma Foundation for Gerontechnology. Eindhoven, The Netherlands.

Hicks, L.L., Fleming, D.A., Desaulnier, A. 2009. The application of remote monitoring to improve health outcomes to a rural area. Telemedicine and E-Health, 15, 664-671. doi: 10.1089/tmj.2009.0009.

Hoobox, Wheelie. Available online: https://hoobox.one/products/wheelie/.

iN2L. Available online: https://in2l.com/our-solution/.

INF Robotics, Rudy. Available online: https://infrobotics.com/#rudy.

Jansson, T., Kupiainen, T. 2017. Aged People's Experiences of Gerontechnology Used at Home. A narrative literature review, Helsinki Metropolia University of Applied Sciences, Bachelor of Health Care, Degree Programme of Nursing, Final thesis. Available online: https://pdfs.semanticscholar.org/4ec8/9f40fe452a6f4518ed44a64d41a41d2ba9ad.pd.

Kacprzak, D. 2019. A doubly extended TOPSIS method for group decision making based on ordered fuzzy numbers. Expert Systems with Applications, 116, 243-254. doi: 10.1016/j.eswa.2018.09.023.

Kapur, R. 2018. Understanding the Significance of Gerontology. Available online: https://www.researchgate.net/profile/Radhika_Kapur/publication/323779673_Understanding_the_Significance_of_Gerontology/links/5aaa6f57aca272d39cd78bbf/Understanding-the-Significance-of-Gerontology.

Kumar, V., Kumar, U., Persaud, A. 1999. Building Technological Capability through Importing Technology: The Case of Indonesian Manufacturing Industry. J. Technol. Transfer, 24, 81-96.

Lamoth, C.J., Caljouw, S.R., Postema, K. 2011. Active video gaming to improve balance in the elderly. Studies in Health Technology and Informatics, 167, 159-164.

Lan, P., Young, S. 1996. International Technology Transfer Examined at Technology Component Level: A Case Study in China. Technovation, 16, 277-286. doi:10.1016/0166-4972(96)00005-3.

Leroi, I., Watanabe, K., Hird, N., Sugihara, T. 2018. Psychogeritechnology in Japan: Exemplars from a super-aged society. International Journal of Geriatric Psychiatry, 33, 1533-1540. doi:10.1002/gps.4906.

Mann, H.B., Whitney, D.R. 1945. On a test of whether one of two random variables are stochastically larger than the other. Annals of Mathematical Statistics, 18, 50-60.

Martin, S., Kelly, G., Kernohan, W.G., McCreight, B., Nugent, C. 2008. Smart home technologies for health and social care support. Cochrane Database Syst. Rev., 8, CD006412. doi:10.1002/14651858.CD006412.pub2.

Micera, S., Bonato, P., Tamura, T. 2008. Gerontechnology. IEEE Engineering in Medicine and Biology Magazine**,** 27, 10-14. doi:10.1109/memb.2008.925213.

Mitseva, A., Peterson, C.B., Karamberi, C., Oikonomou, L.C., Ballis, A.V., Giannakakos, C., Dafoulas, G.E. 2012. Gerontechnology: Providing a helping hand when caring for cognitively impaired older adults-intermediate results from a controlled study on the satisfaction and acceptance of informal caregivers. Current Gerontology and Geriatrics Research, 401705. doi:10.1155/2012/401705.

Morris, M., Physiotherapy, Ch., Ozanne, E., Miller, K., Santamaria, N., Pearce, A., Said, C., Phys, B.A. 2012. The Smart Technologies for older people: A systematic literature review of smart technologies that promote health and wellbeing of older people living at home. The University of Melbourne, Melbourne, Australia.

Nazarko, J., Ejdys, J., Halicka, K., Magruk, A., Nazarko, Ł., Skorek, A. 2017. Application of Enhanced SWOT Analysis in the Future-oriented Public Management of Technology. Procedia Engineering, 182, 482-490. doi:10.1016/j.proeng.2017.03.140.

Nazarko, L. 2017. Future-Oriented Technology Assessment. Procedia Engineering, 182, 504-509. doi:10.1016/j.proeng.2017.03.144

Ohmnilabs. Available online: https://ohmnilabs.com/solutions/seniorcare/.

Pan, Y., Simonian, N., Beleno, R., Liu, L., Kaufman, D., Astell, A. 2018. Impact of digital storytelling experience among people living with dementia. Gerontechnology, 17, 73s. doi:10.4017/gt.2018.17.s.072.00.

Petermans, J., Piau, A. 2017. Gerontechnology: Do not miss the train, but which is the right carriage? European Geriatric Medicine, 8, 281-283. doi: 10.1016/j.eurger.2017.06.011.

Pinto, J.M., Coppola, J.F., Stanford, M., Gaur, C., Gaur, D. 2014. Educational effects of telehealth implementation on older adults with socio-economic disparities. IEEE

Long Island Systems, Applications and Technology Conference, LISAT, 1-6 May, 06845208. doi:10.1109/LISAT.2014.6845208.
Pocketfinder. Available online: https://pocketfinder.com/.
Rendever. Available online: https://rendever.com/how-it-works.
Rzeczynski, B. 2009. Gerontechnology in public space. Przegląd Komunalny, 3, 86-87.
Sale, P. 2018. Gerontechnology, Domotics and Robotics. In Rehabilitation Medicine for elderly patients, Masiero, S., Carraro, U., Eds. Springer International Publishing, 161-169. doi:10.1007/978-3-319-57406-6.
The Central Statistical Office. 2019. Poland in numbers. Available online: https://stat.gov.pl/obszary-tematyczne/inne-opracowania/inne-opracowania-zbiorcze/polska-w-liczbach-2019,14,12.html.
The Central Statistical Office. 2019. Demographic Yearbook. Available online: https://stat.gov.pl/obszary-tematyczne/roczniki-statystyczne/roczniki-statystyczne/rocznik-demograficzny-2019,3,13.html.
United Nations. 2019. World Population Prospects: The 2019 Revision. Available online: https://population.un.org/wpp/Download/Standard/Population/.
Vicentin, A.P., Bonilha, A.C., Andreoni, S., Lamoth, C., Ramos, L.R. 2018. Computer-based intervention effects on cognitive functions in older population: Cohort study in São Paulo - Brazil. Gerontechnology, 17, 75s. doi:10.4017/gt.2018.17.s.075.00.
VitalTech, VitalBand. Available online: https://www.vitaltech.com/vitalband.
Walabot Home. Available online: https://walabot.com/walabot-home/how-it-works.
Wilcoxon, F. 1945. Individual comparisons by ranking methods. Biom. Bull., 1, 80-83.
Winkowska, J., Szpilko, D., Pejić, S. 2019. Smart city concept in the light of the literature review. Engineering Management in Production and Services., 11, 70-86. doi:10.2478/emj-2019-0012.
Word Population Prospects. 2019. United Nations, Department of Economic and Social Affairs. Available online: https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf.