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THE CONCEPT OF SMART CITY IN TERMS OF IMPROVING THE QUALITY AND ACCESSIBILITY OF URBAN SPACE FOR THE ELDERLY; LITERATURE REVIEW

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Abstract
The paper presents the results of literature review concerned with the possibilities of using ICT for creating a new dimension of accessibility and quality of space. The aim of conducted research was to indicate the main strategies and use ICT as a contribution to the quality of life of the elderly. The article refers to the idea of age-friendly city in connection with the Smart City. As the method a systematic literature review was used, based on the available scientific databases. The results shows that the largest part of project activities in this area involves the use of Internet of Things infrastructure in the field of healthcare and for care services as well as for the maintenance of elderly's social contacts. Therefore, the concept of Smart City offers the elderly residents many options to compensate for psychophysical dysfunctions and related with them limitations in social life, however, it demands parallel education to develop digital competences for older people.

Keywords: **Smart ageing; Ageing society; Quality of life; Internet of Things,Independent living; Accessibility; Smart citizens.**

1. INTRODUCTION

The dynamically developing concept of smart city is seen as an opportunity to increase the efficiency of city management and to benefit from its resources, to ensure its sustainable development, to improve the quality of life of residents by providing better quality city services to residents, and thus to increase the competitiveness of the city [5]. In this concept, the city is defined as an ecosystem of smart solutions which is being developed, among others, owing to conscious and committed residents, to whom the city offers an opportunity for personal and professional development, and who, with their initiative and commitment, work for the benefit of local communities. The integrated activities comprise six areas indicated in the literature: smart economy, smart environment, smart governance, smart life, smart mobility, smart people [9].

Looking at contemporary challenges in urban development, it is hardly possible not to refer to such an important process as ageing population, which determines changes in the areas of economy, as well as social and spatial development. The revival of urban areas must take into account, inter alia, a growing number of people with functional limitations, and following it changes of the concepts of housing forms, increased demand and availability of health and social care, creating conditions for social activity of the elderly. The realization of the paradigms of contemporary senior policy necessitates that the elderly are treated as a group of people engaged in the life of intergenerational urban communities.

The aim of the paper is to indicate undertaken activities and research that serve the strategy of age- friendly cities, using the potential of modern ICT technology. We also have to adopt a perspective in the paper

that the older generation is not just a group at risk of social exclusion, a group of consumers and recipients of benefits. It is also a group with intellectual potential and experience, socially important, generating the development of structures and networks, products and services within the realm of the silver economy [16], and thus affecting the competitiveness of cities. Such a perspective has allowed us to generate many innovative products and services that measurably improve the quality of life of the elderly. We can mention here innovative forms of housing (including assisted apartments and technologies fostering the independence of the elderly), technologies in the field of health and social care, and a whole range of everyday products that compensate for functional disorders typical of old age. The concept of implementing smart city solutions into the strategies of urban senior policies has been indisputably acknowledged on a global scale, and thus the key question is in which areas can smart city solutions support the realization of the postulates of age friendly city?

2. AGE-FRIENDLY CITY AND SMART CITY: ITS CONCEPT FOR ACCESSIBILITY

A part of the strategy guaranteeing a harmonious development of all age groups is unambiguous with undertaking tasks aiming to alleviate the effects of the ageing process [11]. On the one hand, it is a response to social challenges, on the other hand – when comparing these age-friendly solutions with the concepts of sustainable development – we can see that it involves building accessibility and quality of the urban environment for all its inhabitants. Such an approach to define an ageing-friendly city has been adopted by the World Health Organization [35].

In turn, Cohen and Giffinger define smart city as "a well-functioning future-oriented city created by six areas (mentioned above) and based on the active involvement of conscious, independent and self-determined citizens" [10]. However, the definitions of smart city have been constantly evolving and are formulated in a variety of ways, progressively with the knowledge built on the experience of successive generations of smart city. Cities are also becoming "living labs" [29], e.g. by taking advantage of technology used to engage citizens in the co-creation process of cites [10]. The multidimensional character of the smart city concept has been summarized by Ojo A., Curry E., Janowski T., who point out that modern definitions of smart city revolve around the following concepts [20]:

- conceptualization of the nature of smart city as a form of urban innovations or a city with development perspectives in the field of economy, social policy, management, mobility, environment and lifestyle,
- the essence and significance of smart city – as bridging digital divide, lifelong learning, social inclusion and economic development, aimed at improving the quality of life, or also as innovative socio-technical and socio-economic growth of a city,
- attitude to the process in smart city – investment in social and human capital and investment in traditional (transport) & modern (ICT) communication infrastructure.

The modern interpretation of smart city and its accessibility, often referred to as Inclusive design, in meaning that modern ICT technologies can support people at risk of exclusion and facilitate their active participation in social life (especially Internet of Things infrastructure, recognized as the most effective activator supporting active and healthy life). So far – few scientific studies cover the links between the concept of age-friendly city and the idea of smart city, which prompted the Author to take up this topic.

A perspective of looking at the role of the elderly in society in age-friendly city was also adopted in the concept of "smart ageing", defined as "using technology, innovation and design in both public and private sectors to produce products, services, solutions and systems to improve the quality of life", among others in the field of assisted living [11]. The experience collected by the network of Age-Friendly Cities in eight activity areas of key importance for this program allows us to define effective strategies [33, 35]. The program also took into account the social aspects of the seniors' housing environment, expanding its scale from the micro-environment of apartment to the macro-environment of a district/neighborhood or city (creation of age-friendly cities, liveable community and lifetime neighborhood) [35]. It comprises e.g. accessible housing and "walkable" neighborhood, accessible public transport, readily-available information, also through the internet and supplemented by other means. A lot of experience gathered by cities involved in the realization of this program such as Barcelona, London or Vienna have already become flagship solutions, integrating the ageing aspect into the city's development strategy. In terms of searching for spatial and functional solutions friendly to the elderly, the emphasis was placed on the aspect of environmental dependencies between the user and the surrounding (user-centered design) [6, 15, 17, 34].

The guideline adopted in the search was the competence of older people to interact with the environment and the concept of universal design (also as inclusive design).

3. METHODOLOGY

In the study a systematic literature review was carried out, in line with the guidelines for the realization of that type of literature review [22, 24] and a research plan consisting of several stages was adopted. In the first stage, research questions were formulated on the basis of the existing knowledge:

– in what areas of spatial activity in cities can we search for links combining the concept of smart city and age-friendly city?
– what solutions in the scale of city, district, buildings and apartments are being implemented by smart cities to improve the quality of life of older residents?

The above questions clearly divide the scope of literature materials into research reports (of varying research quality) and reports on the carried out structural and implementation activities, as a documented record of gathered experience and its evaluation. To develop the systematic review, we applied scientific articles and project documents from the last five years (2014 – November 2019), published in Polish and English. To collect literature, the following databases were used: Web of Science, Elsevier, Scopus, Springer, Google Scholar and references found in original data sources. The research was carried out in October and November 2019. At the searching stage, the following keywords were used: in the first stage of searching – smart city, ageing society, age-friendly city; in the next selection stage the following words were added: elderly, quality of life, smart citizens, ICT technology, Internet of Things (Fig. 1).

In the next stage, the strategy specifying how to include literature materials for further research was defined: first – based on the selection criteria, and then – the selection of the collected material in terms of quality of the presented research or problem issues, in line with the criteria specified in the checklist (Table 1). The following basic literature selection criteria were applied:

- in the research results we indicated the use of ICT as a support of system solutions in the smart city that contribute to the quality of life of the elderly (if the spatial solutions were not concerned),
- all publications focusing solely on the technological side of the described solutions were rejected in advance,
- the degree of impact of the applied solutions on the functioning of an elderly person in space and in social life was determined on different scale (solutions on the scale of city, district and neighborhood or a single apartment).

The selection of criteria for further evaluation was prepared on the basis of earlier mapping review of literature, and the selected criteria are presented in Table 1. The content of the publication was checked by two researchers in terms of its ultimate inclusion into further analyses (in terms of the scientific value of publication), and in questionable cases it was confronted with the opinion of a third researcher.

4. RESEARCH RESULTS INVOLVING THE IMPACT OF ICT ON SPATIAL SOLUTIONS FOR THE AGEING SOCIETY

Indisputably, the idea to create a smart city represents a holistic approach to solving contemporary problems and to developing a system which would respond to the challenges of modern cities and the needs of their inhabitants. For this reason, the said

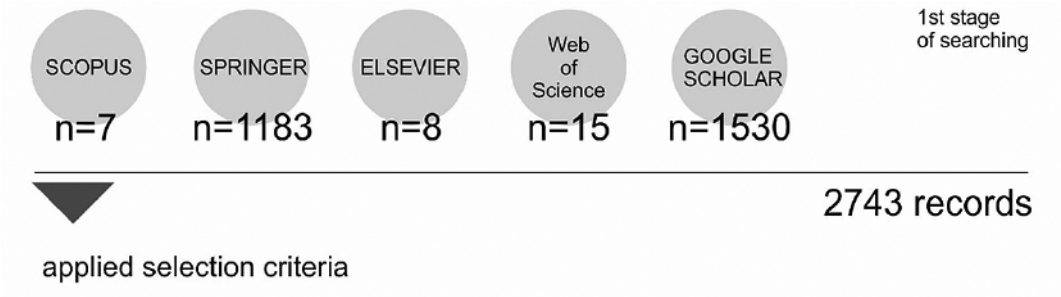

Figure 1.
Scheme of adopted research plan

Table 1.
Checklist – evaluation criteria of publications

Assessment criterion	Description of criterion	Code of criterion
scientific value of the publication	texts directly related to the discussed issues, with precisely defined methodology	1
	texts directly related to the discussed issues, with poorly outlined methodology	2
	texts partly related to the discussed topic,	3
	texts loosely related to the discussed topic	4
relationship with relevant research issues	independent living	A
	cognitive decrease prevention	B
	falls prevention	C
	prevention of social isolation	D
	monitoring outdoor activity	E
the found relation of the discussed solutions with the concept of age-friendly city in selected areas	– independent living, housing – outdoor spaces and buildings – community support and health services – social participation	Y / N

concept includes, among others, the context of sustainable development, but it should be emphasized that the sustainability of the smart city should be measured by the supporting role of ICT, which means that in order to solve urban problems, IT and technological solutions are applied as a communication and involvement pathway of many groups of stakeholders [10]. This also implies the need for cross-sectoral cooperation, educational activities, changes of legal regulations and changes in the management of data and technology.

The analysis of literature on the development of ICT technologies supporting the elderly demonstrates that over the last five years, the interest in the issues involving the functioning of the 65-plus generation as part of the smart cities has been gradually increasing. However, the implemented solutions are not subject to thorough evaluation, and there are still few publications in this area, and it especially applies to those which directly involve spatial aspects. With respect to the priority areas of activity in the age-friendly city related to the quality of space, three basic areas of ICT were distinguished for the purposes of the study in terms of the quality of life of the elderly and their equal participation in the development of a sustainable city:

- integrating role of ICT technologies in social participation, enhancing social capital and Inclusive Smart City,
- availability of health and social care as well as urban services,
- promoting independence in housing environment.

4.1. Integrating role of ICT technologies in social participation, enhancing social capital and Inclusive Smart City

Integrating role of ICT technologies in social participation is the most comprehensive range of activities and research works in studies analysed in review (10 records). When analyzing the development of urban macro-environment, including districts, in the process aiming to achieve ageing-friendly space, we can observe that the participation of older people is of key importance in this process. The completed research studies and project initiatives with the participation of the elderly in smart cities emphasize their role in co-creating urban technologies, both as recipients of solutions tailored to real needs, as well as an experienced group providing knowledge about local values and conditions. The above fits into the concept of smart city development of the generation 3.0., and into the contemporary vision of conscious and active residents. However, we must remember that the importance of ICT technologies for a group of older residents can go beyond the obvious measure of their effectiveness. It was confirmed, among others, by the research conducted by the team Righi, Sayago, Blat on a designing process of services and technology with the participation of the elderly in Barcelona (a web-based community platform to offer three types of services related to local activity and co-creating scenarios in urban areas) [25]. First of all, the neighborhood platform was initially a source of information about the needs and interests of the group members, but ultimately it became more important as an impulse for new behaviors, establishing wider contacts in the group, even without using the platform's functionality. An important conclusion of the research is also that in the activities for the benefit of local communities with the participation of the elderly, it is vital to include cross-age design – treating the elderly as members of the community, who pursue goals similar to those realized by other age groups. Another, very interesting look at the potential of modern technologies in the creation of infrastructure, services, social networks as part of districts as a "smart district" was presented by Schulz, Arnold and Kirsch [27]. The scale of a district is indi-

cated here as a proper area unit, within which the elderly are provided with the access to basic services and social contacts, and the elderly are a test group to check the efficiency of the system. The research studies were carried out on a small scale, but they indicate the role of interface accessibility for end users, the importance of the participation of all stakeholders in the creation of these solutions and, most importantly, the fact that the integration of city services, as e.g. a platform or smart district application not only integrates residents but also shows them visibly individual city services and enhances their availability (reduces distances).

The use of ICT in the development of an ageing-friendly city can be found in the literature more and more frequently in terms of the concept of Inclusive Smart City [21, 23]. The role of ICT in providing better access to public spaces has been growing, although the number of scientific reports referring directly to the elderly in this respect is small. Such an approach is presented, e.g. in the works of the international team for the project D4 Age-friendly Buildings, Cities and Environments, implementing projects as part of the network of European Innovation Partnership on Active and Healthy Ageing as the activity area of Inclusive Smart City . In the work participated researchers, practitioners and representatives of various and social organizations from Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Switzerland, Turkey, Great Britain. The realization of digital-accessibility and the development of other smart technologies in creating the accessibility of space and that of public utility buildings (such as AXS Map, Access earth, AccessNow, Wheelmap) is carried out in cooperation with their potential users [3, 18], which is referred to as crowdsourcing. The process comprises such aspects as exploring mobile crowdsourcing of older citizens' opinions on their neighborhood to support decision-making process of planning urban environments [32]. Such a model of cooperation and social audits of space not only allows for the provision and regular updating of data, but it is also an education process of technologically enabled community members (smart citizens) in the field of the latest standards of accessibility [12]. One of such examples is an Australian application that allows auditing and reporting comments to local governments, developed by the team of Thorne, Li, Sivaraman and Bridge. The application clearly identifies four categories of spatial objects: spaces (buildings and parks), links (walkways and ramps), access points (doors and gates) and services (park benches, telephone booths and toilets). In addition, the application allows for the geolocation of individual audits [32]. The functionalities of this application also allow to update photos of individual objects. Research results address the effectiveness of this type of tools at the level of technological efficiency [2], but there is no assessment of the effectiveness of this tool in the processes aiming to improve urban space. Nevertheless, the realized research projects assign ICT an active role as a source of information on how space is used by people with disabilities and by the elderly. It is also a method of diagnosing and monitoring urban space problems and fostering dialogue between residents and local authorities.

4.2. Availability of various forms of healthcare

In the view of challenges brought about demographic changes, including the growing population of older people, the demand for the availability and quality of healthcare and care services is also increasing. Appropriate spatial solutions can definitely raise the efficiency of this system, but the opportunities that ICT technologies bring along, combined, e.g. with technological solutions, are a response to the growing expectations of older people, including the need for security in the housing environment. In general, to implement the concept of a healthy housing environment, we need solutions which address physical health, mental health, independent living, building social capital and self-management [13]. The directions to be followed in the search for new solutions in the healthcare sector include primarily comprehensive support for the elderly (in-home monitoring, assisted living) and providing access to medical staff at different times of the day. New data collection capabilities allow to undertake activities to protect the elderly in their apartments: various wearable sensors are factors to ensure the rise of control of an elderly person in their living environment, and thus they change the quality of the living environment, introducing new functionalities thanks to ICT technologies.

As it was clarified on the basis of desk studies by Song, (Song et al.), there are three ways in achieving health and well-being in ageing populations: engaging the elderly in healthy activities (prevention), reducing the challenges in the environment and supporting the daily health needs and medical care [31]. Also the role of the elderly as patients is changing –

they are becoming active participants not only in the treatment process, but also in preventive measures thanks to the growing pro-health education.

4.3. Promoting independence in housing environment, availability of care services

According to the AT&T report, ICT technologies are of primary importance for the ageing population, since they compensate for the dysfunctions of the elderly, increase security, ensure the opportunity of independent living, and provide cognitive assistance, monitoring, and social communication [4]. Problem areas in the field of technological support for the elderly in the place of residence comprise the following [26]:

- independence in the place of residence, preventing the falling by physical training and exercises: e.g. remote monitoring, smart bed, smart sofa,
- safety in the place of residence: safety systems and alarms, home security systems, motion / movement sensors,
- healthcare availability: safety bracelets, activity wristbands, personal health monitors, daily medical testing,
- preventing the decrease of cognitive performance by personal brain training and reminders, e.g. exercise and memory games,
- preventing social isolation by encouraging users to establish and maintain active social relations: social robots, devices and applications enabling contact with the loved ones,
- support in the field of instrumental activities of daily living (IADL): domestic / services robots (i.e. cooking, cleaning, bathing),
- support in the form of informal care, e.g. family caregiving and contact, daily function assistant,
- 24-hour home care – monitoring detection and intervention.

The mainstream research most frequently represented in the literature, involving the role of ICT in compensating for the dysfunctions of the elderly and improving their relationship with the housing environment, focuses on developing solutions in the field of Internet of Things (IoT) infrastructure. This infrastructure is recognized as the most effective activator among technological solutions that can support active and healthy life. In the home environment, it is a monitoring and intervention system for early detection of changes in the psychophysical condition of the elderly [1, 19, 28]. Among geriatric factors pointed out in the research of the international research team of the City4Age project, the following areas were indicated as the ones which are predisposed to monitor the areas of daily activity of seniors: motility, activities of daily living (ADL), instrumental activities of daily living (IADL), socialization, cultural engagement, quality of housing and neighborhood, physical aspects of health, cognitive ability [19] (i.e. project DALIA or GIRAFF+ system of a network of home sensors and a mobile communication platform) [30]. At the same time, these are the factors whose impact should be taken into account.

Numerous forms of AT (Assistive Technologies) and AAL (Ambient Assistive Living) solutions are used to enhance comfort and safety, improve integration and independence of the elderly in the housing environment [8, 30]. IoT services are used for early detection and prevention of cognitive performance decrease and in the cases of falling of the elderly [11]. It is becoming a new platform of assessment of the housing environment, It is important mainly for the personalization of health and care services as well as for prevention [1]. The basic indicators of daily activity, whose monitoring is used in IoT in the housing microenvironment are as follows: number of steps, distance covered, and walking average speed, type of POI (points of interest), number of visit per POI, visit duration, number of trips, used bus lines, distance, and time per trip [1]. At the same time, ICT has an impact on the quality of the housing environment, due to support social interaction and fitness activities. Thanks to this, ICT also extend its functionality [30].

A research project worth mentioning, which addresses the above issues is the project ACTIVAGE, a Large Scale Pilot project, focused on IoT as a key enabler for the successful deployment of Smart Living solutions that positively affect active and healthy ageing. The developed solutions comprised services whereof objectives are as follows: 1) to prevent the decrease of cognitive performance by personal brain training and reminders, 2) to prevent the falling by physical training and exercises and 3) to prevent the social isolation by encouraging users to establish and maintain active social interactions through mobility [11].

5. DISCUSSION OF RESULTS

The main conclusion from the conducted research, with the use of the indicated method is the fact that smart ageing is an evidently promising research topic, but there are no systematic analyses involving the

subject of ICT in the context of ageing. This is both a conclusion from the Author's research and the only cross-sectional study conducted by Song, Song et al. [31]. This is a synthesis of extensive research in this field and it indicates three main directions of further development of smart ageing: technologies, ageing medical care, behavior and social issues. The advantage of this study is an extensive analysis of publications on websites, moreover, also website analysis of 4500 organizations funded by National Institutes of Health.

In the found literature sources, there are, in principle, no spatial or planning issues, except for studies that involve the applications that identify spatial barriers in terms of user's needs. Moreover, in some projects the most needed components of ICT for the elderly's comfort was defined accordingly to the indicated needs and then co-created tools were created. For example, in the multi-center project The Activage the Internet of Things paradigm was indicated as important factor in deploying the most optimal solutions for the elderly. The conducted desk studies allowed to identify several basic areas of activity in which modern ICT technologies can measurably improve the quality of life of the elderly:

- independent living (investigated in 11 studies),
- cognitive decrease prevention (investigated in 4 studies),
- falls prevention in housing environment (investigated in 8 studies),
- prevention of social isolation (investigated in 11 studies),
- monitoring outdoor activity (investigated in 7 studies).

In the spatial dimension – they support the accessibility and functionality of the housing environment or social spaces, but when we assess the impact of ICT on the changes in spatial solutions, we can state that the impact is indirect. The largest part of research and project activities involves the use of the Internet of Things infrastructure in the field of healthcare and for care services as well as for the maintenance of social contacts. The limitation of the research work was that active and healthy seniors were the sample, however, most participants were in age of 80. and more (i.e. in work of Abril-Jiménez et al. [1], Schulz, Arnold et al. [27]). Further studies for the oldest group with functional disability in activities of daily living are needed, especially for early detection of events that could impact negatively in physical and cognitive status of older citizens. The optimal models of interaction should be defined according to the type of disability.

IoT extends the functionality of space at various scales, becoming in this way an additional dimension of its accessibility. At the same time, it is a conclusion involving the methods of space assessment in terms of its availability – the use of ICT technology should be one of the criteria for its assessment. With respect to the impact of smart solutions on the quality of life of seniors, a significant number of literature sources are focused on the issues related to the barriers in the use of ICT by the elderly, due to the limitations of functional and cognitive abilities.

6. SUMMARY

Indisputably, the concept of Smart City offers the elderly residents many options to compensate for psychophysical dysfunctions and related with them limitations in social life. Looking at this issue in terms of city scale, from the perspective of equalizing the capability and standard of living of all social groups – it largely involves the infrastructure and solutions enhancing the availability of urban services and strengthening social contacts in the housing environment. On the other hand, taking into account the heterogeneity of the group of the elderly, the ICT technologies offer an opportunity to personalize such services. The currently popular concept of 'smart ageing' is a step towards the promotion of the well-being of ageing population by using technology focusing on assistive and medical technology. In the realm of physical environment, such solutions do not have a direct impact, but looking at this issue from the perspective of behavioural quality – they create a new dimension of accessibility and quality of space.

REFERENCES

[1] Abril-Jiménez, P., Rojo Lacal, J., de los Ríos Pérez, S. et al. (2019). Ageing-friendly cities for assessing older adults' decline: IoT-based system for continuous monitoring of frailty risks using smart city infrastructure. *Ageing Clin Exp Res.* Doi:10.1007/s40520-019-01238-y.

[2] Almao E. C., Golpayegani F. (2019). Are Mobile Apps Usable and Accessible for Senior Citizens in Smart Cities? *Nature Switzerland* AG 2019 J. Zhou and G. Salvendy (Eds.): HCII 2019, Springer, LNCS 11592, 357–375.

[3] A Smart City Is an Accessible City. Available at https://g3ict.org/headlines/a-smart-city-is-an-accessible-city?fbclid=IwAR3AMQ0QTDZNTgV_ORskibNGZRDL7plMTW9RF7t7ci3PPXU2FmszOixCwJo

[4] AT&T (2017). Smart Cities for All: a vision for an inclusive, Accesible Urban Future. https://smartcities4all.org/wp-content/uploads/2017/06/Smart-Cities-for-All-A-Vision-for-an-Inclusive-Accessible-Urban-Future-min.pdf.

[5] Ciupa Sz.: Miasto inteligentne – model tradycyjny czy zintegrowany? http://smartcity-expert.eu/model-funkcjonowania-smart-city/ (Smart city – traditional or integrated model?)

[6] Cutler, L. (2000). Assessing the environment of older adults. [in:] R. L. Kane & R. A. Kane (Eds.), Assessing Older People: Measures, Meaning, and Practical Applications. New York: Oxford University Press, 360–382.

[7] Cohen B. Building the smart city: advancing in six fields of action. Available at https://hub.beesmart.city/smart-city-indicators/.

[8] Cook, A. M., & Polgar, J. M. (2014). Assistive technologies: Principles and practice. Elsevier Health Sciences, 240–262.

[9] Giffinger R., Fertner C., Kramar H., Kalasek R., Pichler-Milanoviü N., Meijers E. (2007). Smart Cities: Ranking of European Medium-Sized Cities, Centre of Regional Science (SRF), Vienna University of Technology, Vienna, 11.

[10] Fazlagić J. (2016). The Concep of Smart Cities in the Context of Productivity of Knowledge Workers Aged 65+. *Zeszyty Naukowe Uczelni Vistula. Rocznik 2016. Numer. 46*(1) Ekonomia X, 79–90.

[11] Fico G., Montalva J., Medrano A., Liappas N., Mata-Díaz A., Cea G. Arredondo M.T. (2017). Co-creating with consumers and stakeholders to understand the benefit of Internet of Things in Smart Living Environments for Ageing Well: the approach adopted in the Madrid Deployment Site of the ACTIVAGE Large Scale Pilot. H. Eskola et al. (eds.), *EMBEC & NBC 2017, IFMBE Proceedings* 65, 1089–1092

[12] Hamraie A.: A Smart City Is an Accessible City. Available at https://medium.com/the-atlantic/a-smart-city-is-an-accessible-city-d587390f78a4.

[13] IMS Institute for Healthcare Informatics (2014). Bringing Healthy Living to Ageing Citizens: the role of technology. Available at https://www.coursehero.com/file/13311670/Role-of-Technology-Bringing-healthy-living-to-ageing-citizens-IMS/.

[14] Innovation And Cooperation Plan D4. Age-Friendly Buildings, Cities And Environments 2016-2018. Joint Progress Report, 2018.

[15] Kane, R. A., Cutler, L. J., Lum, T. Y., Degenholtz, H. B., & Yu, T.-C. (2007). Resident outcomes in small-house nursing homes: A longitudinal evaluation of the initial Green House program. *Journal of the American Geriatrics Society*, 55, 832–839.

[16] Klimczuk, A. (2016). Comparative Analysis of National and Regional Models of the Silver Economy in the European Union. *International Journal of Ageing and Later Life, 10*(2), 31–59. Available at SSRN: https://ssrn.com/abstract=2828138

[17] Marquardt G., Bueter K., Motzek T. (2014). Impact of the design of the built-environment on people with dementia: an evidence-based review. *Health Environments Research & Design Journal, 8*(1), 127–157.

[18] Mirri, S., Prandi, C., Salomoni, P., Callegati, F., and Campi, A. (2014). On Combining Crowdsourcing, Sensing and Open Data for an Accessible Smart City. International Conference on Next Generation Mobile Apps, Services and Technologies, 294–299.

[19] Mulero R., Almeida A., Azkune G., Abril-Jiménez P., Arredondo Waldmeyer M.T. (2018). An IoT-Aware Approach for Elderly-Friendly Cities. IEEE Xplore, Vol.6, 7941–7957.

[20] Ojo A., Curry E., Janowski T. (2014). Designing next generation smart city initiatives – harnessing findings and lessons from a study of ten smart city programs. Proceedings of the European Conference on Information Systems (ECIS), Tel Aviv, Israel, 1–14.

[21] de Oliveira Neto J.S., Takeo Kofuji S. (2016). Inclusive Smart City: An Exploratory Study. M. Antona and C. Stephanidis (Eds.): UAHCI 2016, Part II, LNCS 9738, 456–465.

[22] Orłowska A., Mazur Z., Łaguna M. (2017). Systematyczny przegląd literatury: na czym polega i czym różni się od innych przeglądów? (Systematic literature review: how it works and how it differs from other reviews?) Ogrody Nauk i Sztuk, 2017, 350–363.

[23] Pérez-Delhoyo R., García-Mayor C., Mora H., Gilart-Iglesias V., Andújar-Montoya M.D. (2017). Improoving urban Accessibility: a methodology for urban dynamics analysis in smart, sustainable and inclusive cities. [in:] Brebbia C.A., Galiano-Garrigos A. (eds.) Urban Regeneration & Sustainability. Wit Press, Southampton, Boston 2017, 1–11.

[24] Petticrew, M., Roberts, H. (2006). Systematic Reviews in the Social Sciences. Oxford: Blackwell.

[25] Righi V., Sayago S., Blat J. (2015). Urban ageing: technology, agency and community in smarter cities for older people. Communities & Technologies. At Limerick, Ireland, 119-129.

[26] Rönty J. VTT (2018). Technical Research Centre of Finland Ltd, Smart living technologies for the ageing population-case Finland.

[27] Schulz A., Arnold O., Kirsch L. (2014). Smart districts in an ageing society. IEEE Global Conference on Consumer Electronics, 1–4.

[28] Shahrestani S. (2017). Internet of Things and Smart Environments.

[29] Shelton T., Zook M., Wiig A. (2015). The 'actually existing smart city', *Cambridge Journal of Regions, Economy and Society*, 8, 13–25.

[30] Skouby K.E., Kivimäki A., Haukipuro L., Lynggaard P., Windekilde I. (2014). Smart Cities and the Ageing Population. *Outlook. Visions and research directions for the Wireless World*, 12.

[31] Song I-Y., Song M., Timakum, T., Tyu S-R., Lee H. (2018). The landscape of smart ageing: topics, applications and agenda. *Data & Knowledge Engineering*, 115, 68–79.

[32] Thorne, J., Li, A., Sivaraman, V., Bridge, C. (2014). Mobile Crowdsourcing Older People' s Opinions to Enhance Liveability in Regional City Centres. [in:] Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 2014 IEEE Ninth International Conference on IEEE, 1–7.

[33] Tinker A., Ginn J. (2015). An Age Friendly City: how far has London come? King's College London, London.

[34] Waller S., Masterson A., Finn M. (2013). Improving the patient experience. Developing Supportive Design for People with Dementia. The King's Fund's Enhancing the Healing Environment Programme 2009–2012, London.

[35] World Health Organization (2007). Global age-friendly cities: A guide. World Health Organization.