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Strategy in smart cities and social inclusion of the elderly

Estrategia en ciudades inteligentes e inclusión social del adulto mayor

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ABSTRACT

Smart cities are increasingly necessary in today's society, however the social inclusion of the elderly within these seems a forgotten issue that needs to be considered for the construction of an inclusive society. The objective of this research is to explore the social inclusion of the elderly in smart cities, as well as their evolution, scientometric characteristics and trends by means of a bibliometric analysis. The work analyzes bibliometric metadata of 244 Scopus documents, published from 2010 to 2020 using Software R, Bibliometrix and Biblioshiny. The conclusions indicate that a growing interest is maintained over time, and this is perceived mainly in conferences; in addition, thematic trends reveal elements such as the internet of things, design and implementation, and e-commerce among others. Likewise, the emergence of the term *inclusive smart city* was evidenced, which considers the integration into society of vulnerable groups. It is expected that this work will serve as a reference for an inclusive design of smart cities.

Keywords
Strategy; empathy; Information and communication technologies; internet of things; gerontology

RESUMEN

Las ciudades inteligentes son cada vez más necesarias en la sociedad actual; sin embargo, la inclusión social del adulto mayor dentro de estas parece un tema olvidado que necesita considerarse para la construcción de una sociedad incluyente. El objetivo de esta investigación es explorar la inclusión social del adulto mayor en las ciudades inteligentes, así como la evolución, las características cienciométricas y las tendencias de estas por medio de un análisis bibliométrico. El trabajo analiza metadatos bibliométricos de 244 documentos de Scopus, publicados de 2010 a 2020, mediante el uso del software *R, Bibliometrix y Biblioshiny. Las conclusiones señalan que se mantiene un interés creciente en estos temas a través del tiempo, el cual se percibe principalmente en conferencias; además, las tendencias temáticas revelan elementos como el internet de las cosas, el diseño y la implementación y el comercio electrónico, entre otros. Asimismo, se evidenció el surgimiento del término* ciudad inteligente incluyente, *el cual considera la integración a la sociedad de los grupos vulnerables. Se espera que este trabajo sirva como referencia para un diseño inclusivo en las ciudades inteligentes.*

Palabras clave
Estrategia; empatía; tecnologías de la información y la comunicación; internet de las cosas; gerontología

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Introduction

The term *smart cities* (SC) has become an important research topic, as it is an undeniable option for the social inclusion of vulnerable groups, such as the elderly. This concept considers offering the elderly adequate and efficient spaces, which can be achieved through support in existing technologies and greater empathy towards them; however, these aspects are almost null in the current literature (Alvarado, 2018).

Torrinha & Machado (2017) state that a developed city can be classified as smart only if different plans that monitor the functions of national initiatives are activated, which allow measuring and analyzing the expected achievements and complying with development plans, the benefits in improving the quality of life of the inhabitants and including progress in its urban context by considering the social inclusion of the elderly.

This topic is a complex one since SCs are conceptualized from different contexts and terms due to the existence of diverse factors and needs that make them different. SCs have been the subject of study over the last few years in different countries and research focuses on economic growth, the internet of things, urban growth and design, which is grouped into architectural, social and infrastructure (Calderoni *et al*., 2012).

It is important to mention that information and communication technologies (ICT), together with the internet of things –and an innovative strategy– provide support to improve the quality of life by applying mobility and traffic models for the analysis of a city's problems. The changes impact pedestrian flow by contemplating the four areas of smart cities for citizens, which involve transportation, public services, security and smart buildings (Al-Khateeb, 2017).

It should be noted that, when considering social inclusion, the cooperation of various actions in society is mentioned, such as work performance, recreational exercises and access to education at any level. It is also important to design activities for the development of cognitive skills that allow receiving, processing and collecting information (Popovic & Masanovic, 2019). In view of this, it is necessary to highlight that population aging is a phenomenon of high impact on society, and in Mexico there are no institutions that provide an adequate service.

On the issue of the elderly, it is important that countries have the necessary capacity to meet the demands of the population growth of this group. Each country will be able to face this problem based on its competence, in the application of public policies that promote their survival, such as social security, health, work and family support (Torrado *et al*. 2014).

In view of the above, the objective of this work was to explore the topic of SCs and social inclusion of the elderly, as well as its evolution, characteristics and trends, by means of a bibliometric analysis. For this, emphasis was placed on economies such as Mexico's, where

it is recommended to consider the incorporation of different social groups and generate more empathy when implementing appropriate urban spaces, in order to provide a sustainable service to these groups.

A descriptive methodology was used and with the help of R software, Bibliometrix and Biblioshiny, a search was carried out for articles published in Scopus within the period from 2010 to 2020, based on keywords and their relationship with the development of the topic, as well as trends in the use of ICTs. It should be noted that the analysis on SCs and social inclusion of older adults is mainly studied in developed countries, which serves as a reference for future studies and their implementation in developing economies, such as Mexico.

This article is organized in four sections: introduction, literature review, methodology, results obtained and their discussion, as well as conclusions, where future lines of research are identified.

Literature review

The concept of SCs refers to the problem of having a balance between the use of hardware, software and various technologies, with the implementation of ICTs for their design, in addition to citizen participation, which, according to the World Health Organization (WHO) in 2002, considered an older adult to be any person over 60 years of age. These figures indicate that the population of older adults is increasing, resulting in concerns about dependency, autonomy and quality of life for these groups in the future. Talking about the older adult implies taking into account the process of deterioration, where losses in skills and abilities, both physical and mental, are suffered from the age of 60 onwards (Tió, 2014).

The integration of the factors implemented in the existing technologies responds to the various transformations in the cities and that are considered when a need arises that reflects its problematics, such as the increase in population. According to data provided by the United Nations Organization (2019), between 2011 and 2050, the population will increase by 2 billion people, i.e., from 7.7 billion today, to 9.7 billion in 2050.

From the above, it may be concluded that for the successful construction of SCs there must be three fundamental aspects: 1) the design, 2) the integrated methodology with an appropriate strategy and 3) the management of the various groups that implement their edification with the application of the corresponding methods and through the support of ICTs as the main engine (Orłowski *et al*., 2016).

In the review of research articles from developed countries on the initiatives proposed in this type of projects, the needs of older adults have not been fully resolved, so it is necessary

to consider that each city is different and has particular characteristics; likewise, it is important to respond to current and upcoming challenges. Each project will have a life cycle that will include planning, operation, monitoring and evaluation (Wenge *et al*., 2014).

From the literature review, methodologies and strategies are proposed that consider that each city has a different problematic. In relation to the articles reviewed, few analyze the topic on empathy with certain groups, so this is a relevant line of research regarding the inclusion of vulnerable groups, such as older adults in modern society.

Theoretical background

The term *sustainable development* was first applied in the Brundtland Report (1987), which talks about environmental degradation and social inequality, which generates habitat encroachment and causes ecological and social imbalance (Clarke *et al*., 2018).

During 1990, Maccani *et al*. (2014) initiated with the term SCs, which refers to urban development and describes the use of technology, innovation and globalization, based on technological aspects as a pillar of urban intelligence. With the new design in urban equipment and through the use of ICT –together with physical capital–, the necessary infrastructure is created for an adequate intelligent management, as well as an efficient and improved result in its economy.

Mattoni *et al*. (2015) explained the emergence of models with different approaches for the evaluation of SCs, focusing on the dynamics of the current reality, and highlighted the trends that some have with respect to others. According to Galende (2015), the report Mapping Smart Cities in UE, prepared by the Directorate General for Internal Policies of the European Parliament in January 2014, outlines the relevant points that set a SC on the road to success, and presents the analysis of 468 cities, which formulate suggestions for the future through a methodology based on the proposals for each city.

During the evolution of the SC concept, simultaneously, an analysis is presented covering the six main axes described by Heitlinger *et al*. (2018): 1) bringing together specialists in charge of participatory design research on SCs, 2) including network participants, 3) accumulating studies on the topic, 4) organizing working tables to raise future growth, 5) including citizens in participatory design, and 6) fostering research for publications and advances on the topic.

Finally, with the implementation of the new initiatives proposed by Fu & Lin in the design of SCs, urban spaces have been made interactive, thanks to an adequate functional and supportive design for citizens' daily activities (2014).

Smart cities

For a city to be classified with the smart concept, it needs the development and management of innovative services to provide the information about the behavior of the city to its inhabitants (Abella *et al*., 2019; Taamallah, Khemaja, & Faiz, 2019). Komninos *et al*. (2014) categorized SCs into two, according to their methodological planning strategies:

- *Top-down planning*. SCs that are designed from scratch, such as Korea, United States of Americas, Portugal and Cyprus. There is no citizen participation in their design. The development lifecycle happens through technology solutions via platforms to provide e-services and smart environments.

- *Bottom-up planning*. Specific problems are identified for each city, where competitive strategies that offer added value are implemented. Citizen participation is considered to detect needs, for example, cities such as Amsterdam, Manchester, Stockholm and Helsinki.

Maccani *et al*. (2014) define SCs as a system of systems –a concept that was accepted by the International Business Machines (IBM) in 2009–, with a growth of green areas, where the potential value of the application of various solutions related to ICTs, such as transportation, communication, water and energy, stands out. The development of resources together with social capital should be considered as part of the foundations, so that, through a collaborative model called Living Labs, processes linked to the 3Ps: public, private and people, could be integrated.

The process of the Livings Labs, is defined as:

> An urban area that leverages its technological and social infrastructure, which implements public-private partnerships supported by innovative governance in terms of policies, leadership and appropriate continuous management principles, to enable smart information services, with the goal of enhancing its critical capabilities (Xiaofeng & Junde, 2014, pp. 861-864).

Similarly, Heitlinger *et al*. (2018) consider that in the Livings Labs it is necessary to have the participation of designers, researchers and specialists in each area, in order to find a relationship between cities and nature, which includes all living beings in each habitat and that their existence is privileged.

Duarte (2016) refers in an article to the Human Smart Cities Manifesto, where there is citizen participation on urban equipment, in search of solutions aimed at communities that incorporate innovation, that offer cutting-edge services, opportunities in the commercial sector,

efficient governments that respond to the demands of citizens, and sustainability in the environment in all innovative processes, referring to technology, as well as social development.

The design of smart homes must comply with all the requirements and regulations to belong to this concept. It is also important to have the participation of governments in the supervision and establishment of construction standards, which comply with specific characteristics based on the guidelines followed by other developed countries, through urban planning in which policies and laws are defined, as well as the various regulations that facilitate a clear vision for the future.

All this will be possible with the help of home automation, through applications that control the environment in the home, automated blinds and domes, energy inspection, surveillance systems, detectors of installations in poor condition, and adequate air conditioning that regulates the temperature. It is necessary to have electrical energy systems that favor the saving of this, in conjunction with household appliances that are controllable and allow the supply of technologies within reach; finally, to rely on high-speed internet for better performance (Ghosh, 2018).

Reference is also made to city outskirts, and it is explained how to solve infrastructure problems, such as having an electricity supply with low-cost energy, waste collection with systems that emit zero pollution, inclusive ecological constructions, connectivity that helps access applications for the performance of activities, having agile public services to serve citizens, offering proposals to enjoy clean air and, in turn, systems that allow the purification of water in rivers.

ICTs and ICs

For an understanding of how to build and design SCs, it is necessary to have a vision on smart technologies and to emphasize the use of ICTs as a set of sensors and facilities that can gather large amounts of information made available to them (Meadows & Kouw, 2017; Kirwan, 2015).

The use of ICTs by society is increasing because it generates an interaction between humans and computers, which allows the inclusion of vulnerable groups, such as the elderly, who need innovative technology models. Because of the above, designers must develop a maker-designer-inventor mentality, in addition to creating experimental prototypes that include management processes, innovation, project management, information systems design and methodologies (Álvarez-Aros & Bernal-Torres, 2017; Lee & Wong, 2017).

De Oliveira & Kofuji (2016) mention that, with the implementation of SCs and the internet of things, it will be possible to create digital assistive technologies, located in the urban space, that support daily activities for vulnerable people, who will have at their fingertips the

necessary tools for their daily tasks, both indoors and outdoors. For a SC to develop, it must be inclusive and consider minorities, in addition to eliminating physical and digital barriers.

To Wu *et al*. (2019), technologies are able to adapt automatically by modifying their structure for decision making, having information for analysis, and identifying their behavior through real-time system data. It is important to acquire data through devices such as motion sensors, surveillance cameras, wireless internet –which is free–, or drones that anticipate behavior, and that in addition to being sustainable offer collaborative environments for learning between users and their environment.

Science, technology and engineering, as well as mathematics, are necessary elements for innovation. From these, governments identify opportunities to engage children and youth in technology-based education to be competitive, in addition to the inclusion of older adults (Lee & Wong, 2017).

Implementing SCs in developed countries

The accelerated process of urbanization in China has made economy to grow and has, therefore, boosted the standard of living of citizens; however, it has also brought negative factors, such as air pollution, heavy traffic and a pressure on natural resources. These factors have led to environmental deterioration, not only in the case of China –as mentioned by Li & Zheng (2016); Xiaofeng & Junde (2014)– but also in countries with this same structure, which are facing this problem, propitiated by the concept of SCs, which implies appropriate changes to prevent shortages.

The development plan in China went through three stages, divided into seven processes: 1) a policy supported by the general government towards local governments, governed by financial and fiscal policies; 2) infrastructure development; 3) implementation of smart equipment provided by governments; 4) data information management to store and disseminate information; 5) automation of government spaces, as well as decision making with smart technologies; 6) state-of-the-art public services that provide the necessary infrastructure; and 7) public regulation to improve quality services (Hu & Wang, 2016).

Although Wenge *et al*. (2014) mention that in countries classified as SCs, such as the United States, European Union countries, Japan, Korea and Singapore, i.e., those with ICT-related innovations, questions still persist such as: what are the characteristics of a SC, and how do citizens label them to belong to that category? This is due to the fact that a SC demands a correct planning, as well as a formulation of strategies that identify the steps to follow for a correct and successful development that contemplates innovative processes.

The most important thing is to provide common spaces for its development in conjunction with web platforms, as well as having digital applications that are of great help inside and outside the home, in addition to considering the inclusion of older adults so that they become familiar with the spaces (Caldwell, Forth and Guaralda, 2013).

Social inclusion of the elderly

Villafuerte *et al*. (2017), say that at the World Assembly on Ageing, held in Vienna in 1982, it was agreed to delimit in the category identified as *older adult* the segment of the population comprising 60 years and older. It is a reality that not all people age in the same way, so that chronological age can be a useful criterion, but not necessarily an exact reference for analysis and studies on this sector. Knowing the state of health of this population group, as well as their demands, has always been a matter of concern for governments, which has materialized in different actions, programs and levels of care, such as the consideration of their present and future requirements in the design of SCs.

The definition of the elderly (which, according to the WHO, includes all persons over 60 years of age and who are part of the so-called vulnerable groups) contemplates social exclusion, in which processes that weaken and break the social links that unite every individual with the community stand out, by obstructing and annulling, on many occasions, the possibility of a material and symbolic exchange between both elements (Busso, 2005).

When speaking of social inclusion, it is necessary to understand that there are various groups of people who belong to a very low socioeconomic level, who do not have the same opportunities or the conditions required for a better quality of life. Among the factors that exemplify this are economic factors, academic preparation, number of family members, and physical and mental health. In addition to the above, it should be considered that the main problem faced by these groups is the medical services to which they have access.

It is important to ensure that these groups have independence, peace of mind and security, without forgetting that, as time goes by, their physical and mental capacities diminish. For this, it is necessary to have systems that are implemented in their daily lives, which provide cutting-edge services for dignified aging, with the help of devices that monitor their daily activities, without forgetting other people who, due to their conditions, need to remain at home (Lunardini *et al*., 2017; Ngankam *et al*., 2019).

Specifically, for the vulnerable group made up of the elderly, there should be areas that offer spaces for creativity and innovation and that register constant movement; however, not all have been included due to the lack of social participation. By not having adequate transportation, nor the required infrastructure, it becomes necessary to offer friendly technologies with innovative projects, in addition to comprehensive solutions to all citizens,

to make available to them information and cutting-edge technologies that support them (Woolrych *et al*., 2018).

When considering a case study of inclusion of older adults, it is necessary to approach it from a digital vision and contemplate the various agents involved in the process, as well as the environment where they develop. It is necessary to reflect on the following questions: how to achieve success, how to integrate them into society, and when are the projects developed? Likewise, a methodology is needed, as mentioned by Meadows & Kouw (2017), that is clear in the processes to be followed and that highlights all the elements.

SCs and the social inclusion of the elderly

Currently, the world is making significant progress in meeting the diverse needs of the population. Designing a SC requires proper planning, as well as the formulation of strategies that take into consideration the increase in the population of older adults. It is necessary to identify the steps to follow for a correct development of innovative processes, with the creation of common spaces within environmental settings and instruments that improve the social sector by including comprehensive health services, safe spaces and friendly cutting-edge technologies. Models are also required that recognize the experience acquired over the years, software that compiles their daily activity and is an important part of the means of transportation and training for the use of technologies.

Suryotrisongko *et al*. (2017) refer to four pillars focused on the new trend for the adequate care of older adults: accessibility, safety, problem solving and flexibility. The first involves having user-friendly equipment, the second refers to the implementation of functional designs that do not constitute a risk for older adults, the third explains the design and equipment of adequate instruments to solve the existing problem, and the fourth requires that the facilities can be used under any circumstances.

During literature review, the term *inclusive smart city* (ISC) was found, which is generated from proposing an element of utmost importance: the inclusion of this vulnerable group. It is not only about designing spaces that are functional, it is also necessary to have empathy, as shown in Figure 1, and to understand the problems currently faced by most developing countries, where this group has been excluded.

De Oliveira & Kofuji (2016) mention that it is necessary to offer older adult groups technologies that provide them with support, as well as the design of interactive tools in devices that obtain information in real time: about the environment, air level and current traffic, in order to propose tools that display information about medical assistance and health care places near their location, rest areas, information about places with high levels of

insecurity, traffic signs, GPS locators and signs with visible information, to mention some items that could be implemented for the benefit of this group.

There is a need for designs that are friendly to older adults and cater to their needs, that technology is at their fingertips, and there is continuous mobility. As mentioned by Woolrych *et al*. (2018), the government should provide them with support in services such as transportation, training for learning technology, and security (in response to the fact that many of them are afraid to leave their homes). Partnerships between the public and private sectors are of great importance, and that these do not look out for their own interests or monopolize technology by companies or the government, but are publicly accessible.

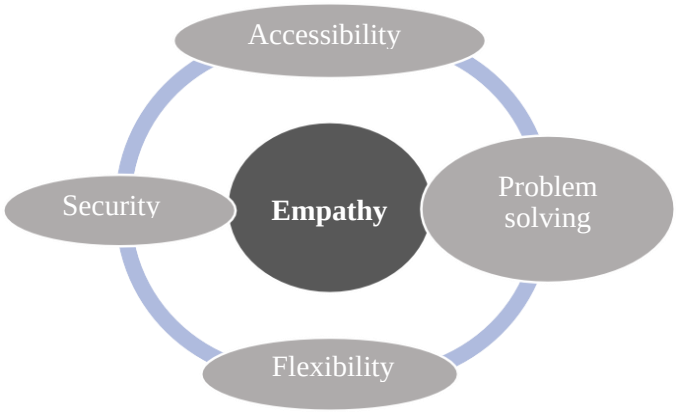


Figure 1. Fundamental pillars for the design of an ISC

Source: developed by the author with data from Suryotrisongko *et al*. (2017).

In addition, there is a need for web platforms and digital applications that consider the inclusion of older adults to become familiar with the spaces and serve as aids within and outside the home (Rizzo & Deserti, 2014; Tymkiewicz, 2019; Yamamoto *et al*., 2010). Tymkiewicz (2019) states that, for a city to be friendly, it needs to meet the following points established by the World Health Organization:

- The diversity of older adults.
- Promote inclusion in all social and economic activities.
- Respect their lifestyle and decision making.
- Prevent and respond to their needs.

Another key factor for the success of a SC is the implementation of technologies that offer security to its inhabitants, as Schuilenburg & Peeters (2018) indicate, since it is necessary that they propitiate tranquility on public roads, as well as in homes, through the creation of software that measure and detect the patterns of criminals, and highlight high-risk locations with systems included to light poles, integrated to wifi, surveillance cameras, motion sensors, panic buttons and microphones that monitor any aggression; all of which would allow the police department to be aware and provide timely assistance.

Most cities today do not have proper lighting, which encourages individuals to show their social inhibitions. There is a need for urban spaces that are not exclusionary, that provide safety and comfort with the help of functional architecture. It is not only about providing more lighting, but also implementing optimal design that provides brighter light in spaces, with motion sensors (Cho *et al.*, 2019). Table 1 shows the physical, social and psychological changes faced by older adults, as well as the conditions that can favorably influence them.

The construction of a SC is a major challenge in developing countries, where the recorded increase in the number of older adults requires that their needs be considered by those responsible for its design. The choice must be made to understand this vulnerable group, their mobility, the physical deficiencies they suffer, as well as to include mechanisms that simulate some of their disabilities (whether auditory, visual or psychomotor) in order to consider everyday limitations.

Most of the spaces that have futuristic designs have become exclusive due to the lack of adequate materials. It is necessary to have textures that do not represent any risk for the elderly; in addition, colors that provide better visibility should be used, in order to raise the mood, and include spaces with adequate slopes for circulation and horizontal spaces, where there is more lighting. Every designer must offer options to improve the problems of the elderly, investigate their needs, provide solutions, be an educator to transmit the knowledge acquired, as well as a communicator that serves as a bridge between agencies, organizations and end users.

We must prioritize the needs to be addressed and the tools that can make the lives of older adults have better conditions. It is not an impossible task to accomplish; however, as long as the personal interests of governments and leading companies in certain technological sectors persist, the minimum change to provide adequate environments will not be achieved.

Table 1. Changes and their determining factors

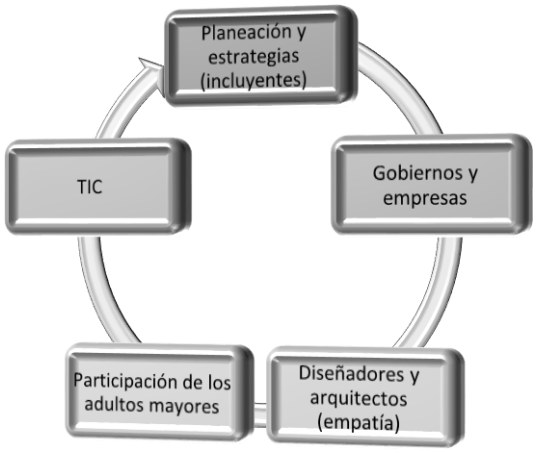
Changes in the elderly	Conditions for quality of life
Physical	
Decrease in physical exercise, sedentary lifestyle, chronic diseases	Green areas and friendly spaces where they can perform physical activities, free of pollution

Reduced muscle mass and more fragile bones	Spaces that allow them to move without any type of physical barrier, which is achieved from an inclusive design with the help of services and furniture based on their needs
Decreased vision	Propose non-reflective materials, smooth textures, warm colors and soothing tones
Hearing impairment	Use of appropriate signage, proximity motion sensors for roadways and crosswalks
Social	
Dependency leading to increased stress	Basic criteria that help them to relax both in the house and outdoors, with the help of appropriate installations, lighting, furniture and colors
Transition from work to retirement	Supporting technologies, design of interactive tools with devices that help them to communicate in the environment
Lack of security by isolating themselves in their homes	Software that detects high-risk locations, systems embedded in light poles, wifi cameras, panic buttons that connect to the police department, surveillance drones, and adequate lighting to reduce crime.
Psychological	
Loss of skills/disorientation/memory loss	Instruments that provide them with information about the places where they are located, appropriate traffic signs, signs with visible information, GPS locators
Decreasing mood	Technologies that promote tranquility on public roads, offer group activities and coexistence with other people

Source: developed by the author with data from Vázquez-Honorato & Salazar-Martínez (2010).

Technology made available to older adults offers extensive wireless information (Pulli *et al*., 2012; Tymkiewicz, 2019), which can be used for decision making in favor of this group. Yamamoto (2010), for his part, explains the pros and cons of technological applications that sometimes limit daily life; for example: the home meal service that promotes the passivity of the adult by not buying the supplies or participating in their preparation, and that in the absence of this interaction, social isolation is generated that causes sadness and anxiety, in addition to affecting the physical, mental and emotional health of the individual. Figure 2 shows the various factors involved in the social inclusion of older adults.

Figure 2. Factors involved in inclusión



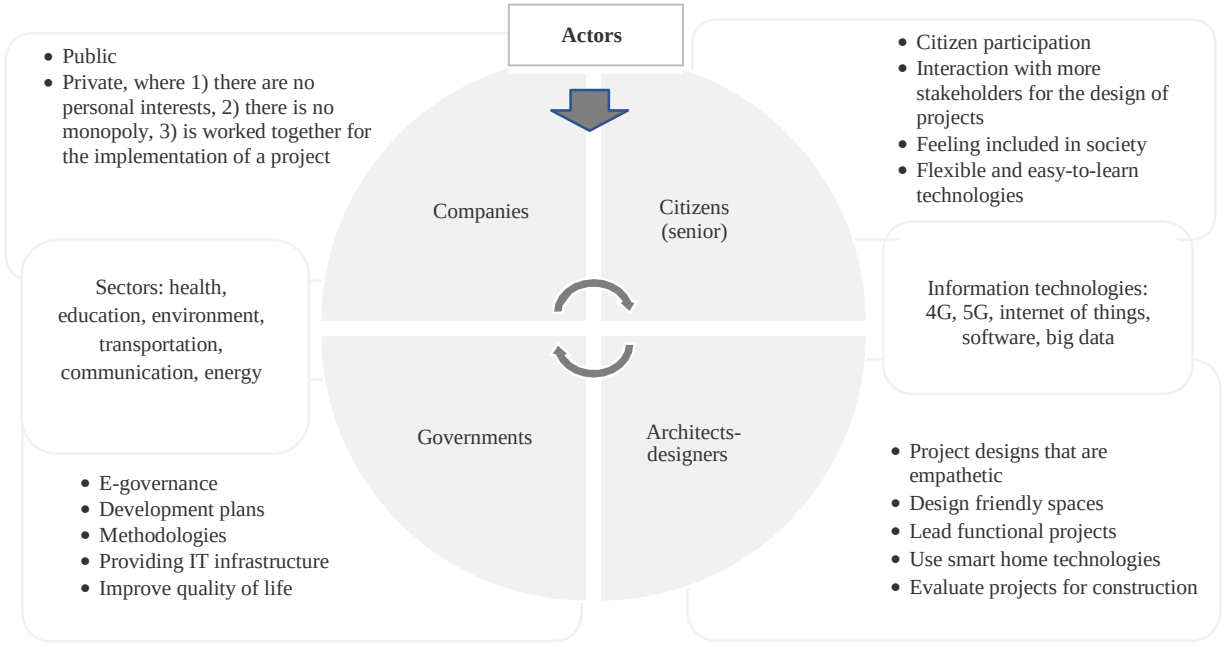
Source: developed by the author with data from Yamamoto (2010).

With this purpose, technologies focused on social participation of the elderly should be considered, by designing accessible spaces that contemplate vulnerable people or those with disabilities. For this purpose, group activities of technological interaction should be carried out, where there are no physical barriers and where continuity and circulation are promoted. Support is required in the use of ergonomic furniture within an adequate conditioning of the spaces, and environmentally friendly signage.

In addition to the technological environment, marketing campaigns aimed at the elderly should be implemented, providing information on the use of Internet and applications to improve the quality of life with its use, while incorporating them into today's society, so it is also necessary to promote self-sufficiency, supported by their relatives or external people.

To avoid the exclusion of this vulnerable group, it is possible to make use of tools that are necessary for their communication, such as Internet, applications like Skype, Zoom and Hangouts, which allow them to be in contact with their loved ones. It is also important to encourage the management of social networks such as Facebook, Instagram, Messenger, WhatsApp and Twitter, as they keep them informed in real time. Smart applications that make their daily tasks easier, in addition to achieving their independence –since most of them live alone at home– are of utmost importance (Cerna, Poulova & Svobodova, 2018). Figure 3 explains the various actors and the specifications needed to work together in each area and achieve optimal social inclusion.

Figure 3. Actors involved in inclusion



Source: developed by the author with data from Cerna *et al*. (2018).

Methodology

For this work, a bibliometric analysis was performed using the programs R, Bibliometrix and Biblioshiny, as these are bibliometric tools for systemic analysis (Aria & Cuccurullo, 2017). This methodology establishes that the steps to have a clear vision are: to identify stakeholders, based on studies from reliable sources, to make projections about the type of future to be achieved and, at the same time, to draw a comparison with the current situation, as well as to face the problem by setting medium and long-term objectives.

For this purpose, a search was carried out in the Scopus database in April 2020. This search was conducted in English, as it is the language in which a greater number of publications can be found. The keywords were: *smart city, smart cities, design, urban growth, social inclusion, urban sustainable development, urban design, architecture, sustainability, information technologies, green buildings, gerontology* and *social inclusion of older adults*. Subsequently, an advanced search was performed by using combinations of the connectors *and* and *or*; in addition, for plural searches with different terminology, the terms were included: *Smart cit*-design; Smart cit*-architecture; Smart cit*-elderly*. A total of 244 results were obtained, including various types of documents.

In relation to debugging information, a filter was applied to the topic of SC, design, architecture and social inclusion, and articles with similar titles and information not relevant to this work were eliminated.

Data search

Table 2 shows the results of the different search criteria that were performed with the use of keywords; in addition, combinations were used with each of these and connectors were included in the various records of the advanced search. Keywords such as *older adults*, *gerontology*, *inclusion* and *empathy* are the ones that reported the highest incidence. The word empathy denoted an important decrease in the information of this work.

Table 2. Search list and results

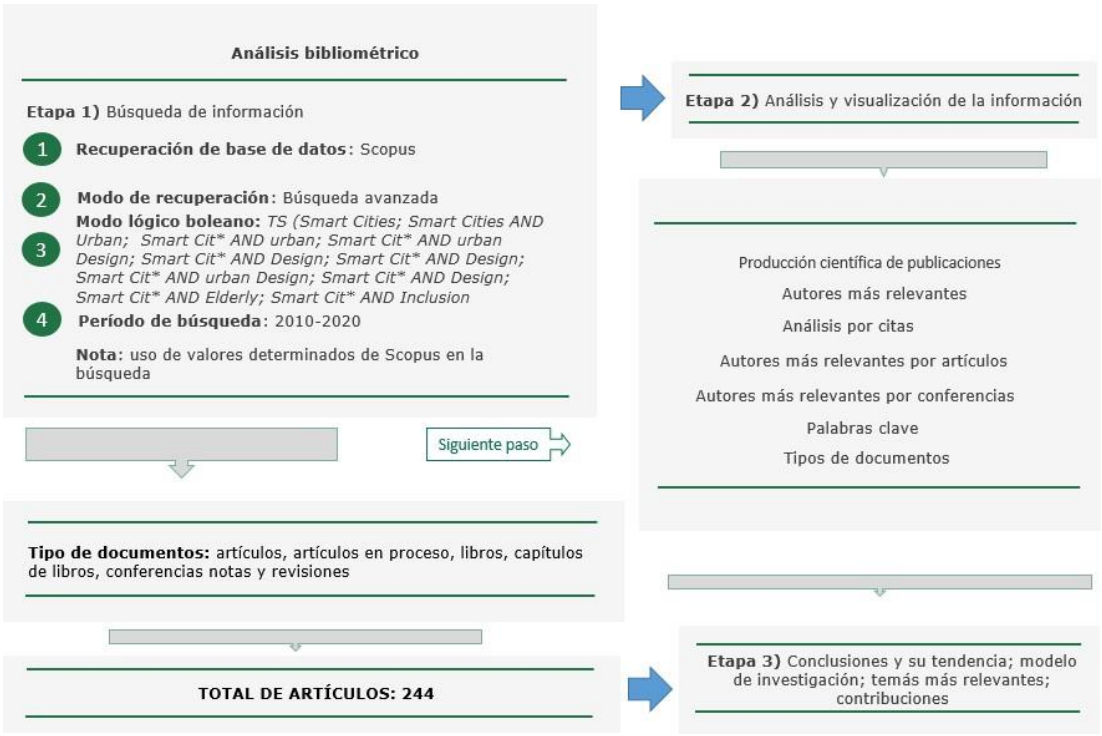
Search keywords	Results	Search keywords	Results
Document title/ abstract/keyword: *Smart Cities*	26 916	Article title/abstract/keyword: *Smart Cit*AND* Article title: *informationtechnologies*	37
Document title/ abstract/keyword: *Smart Cities AND* Document title/summary/keyword: *urban*	7 411	Article title/abstract/keyword: *Smart Cit* AND* Article title: *green building*	37
Document title/ abstract/keyword: *Smart Cit* AND* Document title/summary/keyword: *urban design*	1 551	Article title: *Social inclusionAND* Article title: *elderly*	15
Article title/abstract/keyword: *Smart Cit* AND* Article title/abstract/keyword: *sustainable cit**	1 319	Article title/abstract/keyword: *Smart Cit* AND* Article title: *architecturedesign*	12
Article title/abstract/keyword: *Smart Cit* AND* Article title: *design*	1 155	Article title: *Smart Cit* AND* Document title/ abstract/keyword: *design AND* Document title/ abstract/keyword: *elderly*	11
Article title/abstract/keyword:*Smart Cit* AND* Article title/abstract/keyword:*sustainable development*	908	Article title: *Smart Cit* AND* Document title/ abstract/keyword: *design AND* Document title/ abstract/keyword: *elderly*	11

Search keywords	Results	Search keywords	Results
Título de artículo: *Smart Cit* AND* Article title/abstract/keyword:*urban design*	506	Document title/ abstract/keyword: *Social inclusion of olderadults*	5
Título de artículo: *Smart Cit* AND* Article title/abstract/keyword: *architecture*	248	Article title: *Smart Cit* AND* Document title/ abstract/keyword: *geron**	1
Título de artículo: *Smart Cit* AND* Título de artículo: *design*	239	Article title: *Smart Cit* AND* Article title: *design AND* Document title/ abstract/keyword: *inclusion*	2
Article title/abstract/keyword:*Smart Cit* AND* Article title: *sustainability*	74	Article title: *Smart Cit* AND* Document title/ abstract/keyword: *design AND* Document title/ abstract/keyword: *empathy*	2

Source: developed by the author with data from the software R, Bibliometrix and Biblioshiny, (2020).

Figure 4 shows the methodology applied to the bibliometric analysis, divided into three stages. The first stage was the search for information, subdivided into four points: 1) the search for scientific articles in the Scopus database, 2) the way in which the advanced search was performed where the information was segmented, 3) the search for keywords with the use of connectors, and 4) the search period (from 2010 to 2020).

Figure 4. Methodology: bibliometric analysis



Source: developed by the author with data from the software R, Bibliometrix and Biblioshiny, (2020).

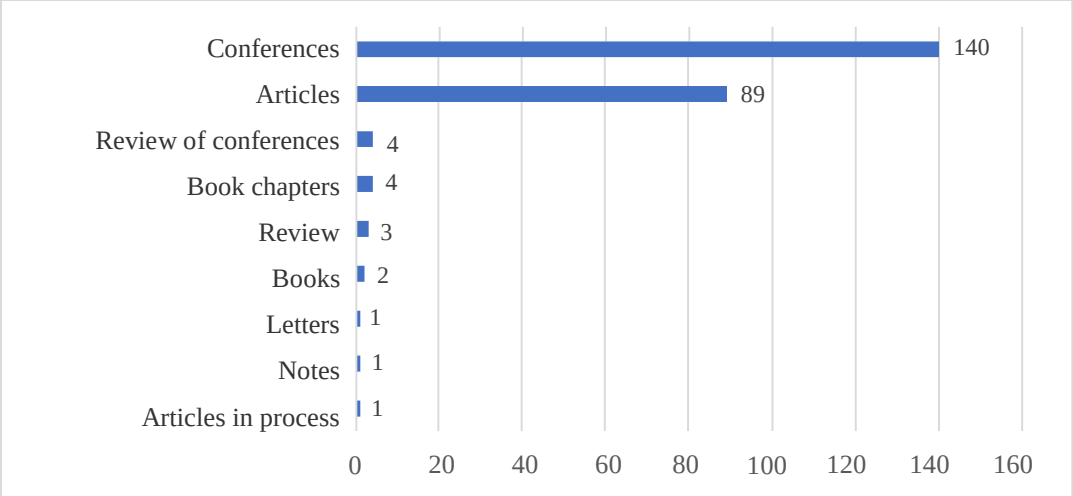
In the second stage, the analysis and visualization of all the information collected was carried out, with the most recognized authors, the annual scientific production, the analysis by citations, the most relevant authors by articles, as well as the conferences given, the key words and, finally, the types of documents.

In stage three, the conclusions are presented, as well as the trends in developed countries, the most relevant topics on SCs and social inclusion of the elderly.

Results

This section shows results with the type of documents, annual scientific production, analysis by citations, authors by articles, authors by conferences and keywords from 2010 to 2020. The search yielded a total of 244 documents, which are shown in chart 1, classified by categories from highest to lowest. We started with conferences –which are the largest dissemination medium, due to the constant change in technologies, together with the great growth reported by the cities– and ended with articles in progress.

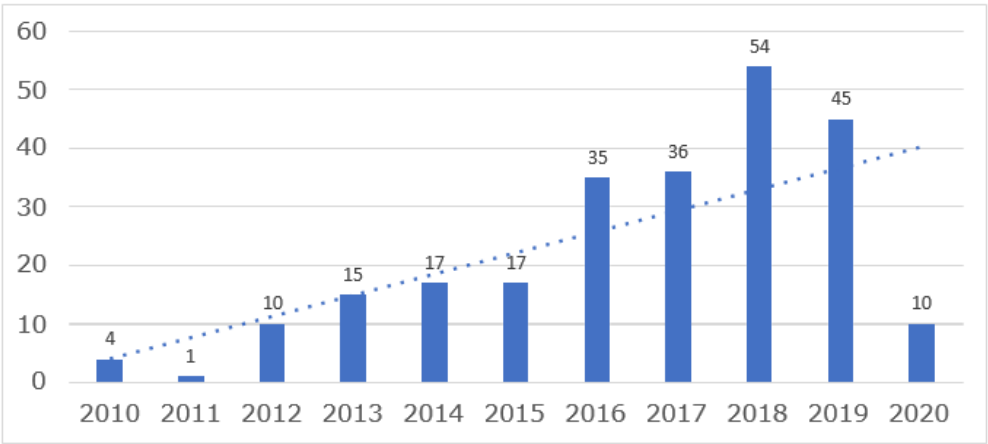
Chart 1. Type of documents



Source: developed by the author with data from the software R, Bibliometrix and Biblioshiny (2020).

Chart 2 shows the annual scientific production of the articles described above. In the search carried out, it was found (from the period 2010-2020) that there is a growing interest in the subject, which has had a significant increase as it has been studied by various expert researchers in the area.

Chart 2. Annual scientific production

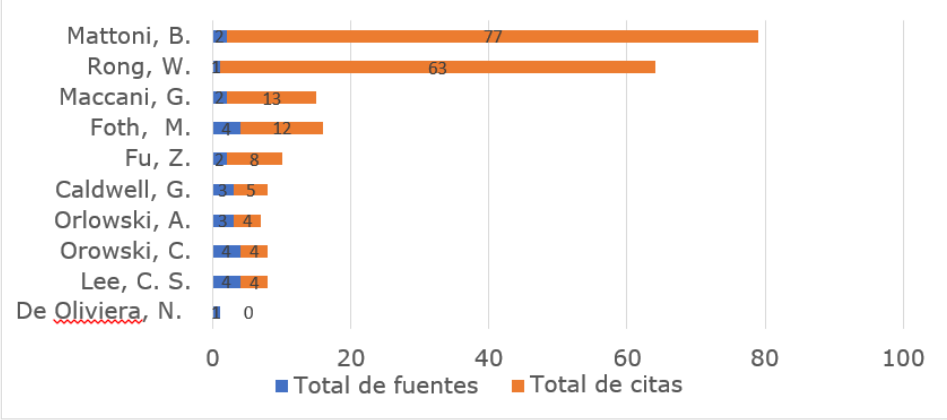


Source: developed by the author with data from the software R, Bibliometrix and Biblioshiny, (2020).

In relation to the analysis by citations, the most relevant article, with a total of 77, is the one by Benedetta Mattoni (2015), called A multilevel method to evaluate, design and renew the integration of smart cities, which studies the lack of uniformity and the lack of

practical methodologies that support the evaluation models. Other authors with relevant research are: Marcus Foth in 2013, with four articles and twelve citations; Chien-Sing Lee in 2017, with four articles and four citations; and Cezary Orlowski in 2016, with four articles and four citations, as shown in chart 3.

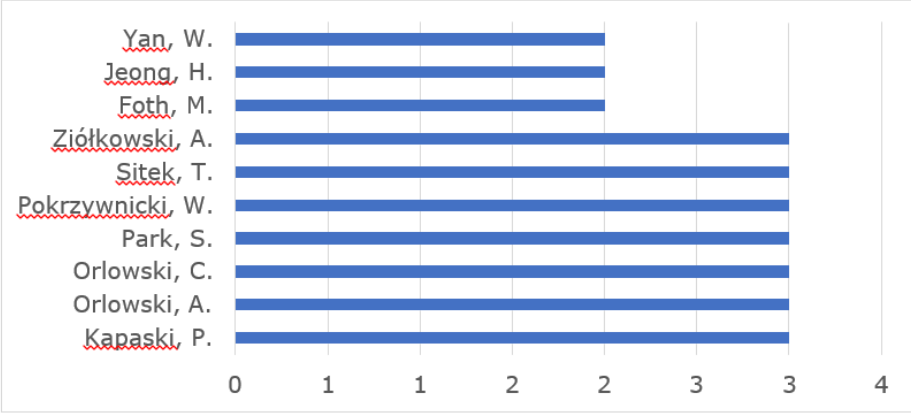
Chart 3. Citation analysis



Source: developed by the author with data from the software R, Bibliometrix and Biblioshiny (2020).

In addition, the information was classified by authors, published articles and conferences presented at various congresses. Chart 4 shows the selection of ten authors, highlighting a total of three articles: Case-based reasoning method, Decision support systems, Knowledge management that talks about case analysis on SCs designs.

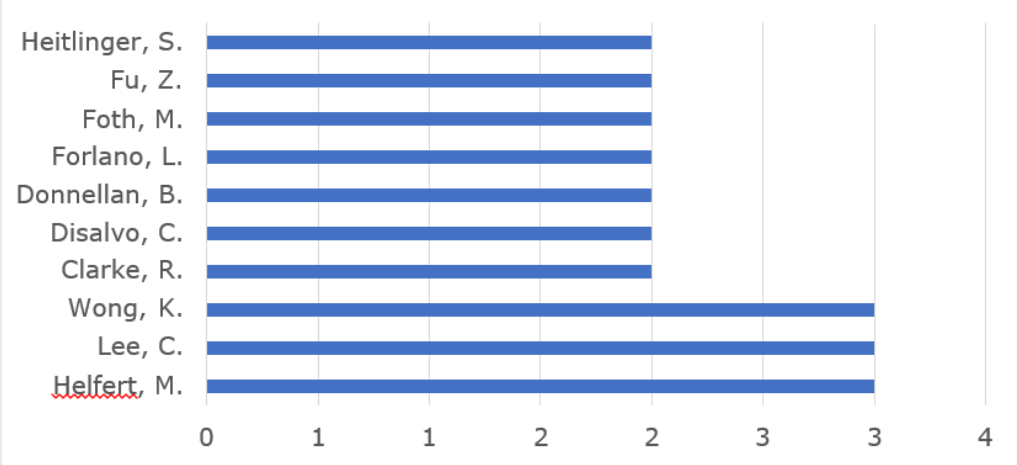
Chart 4. Authors by article



Source: developed by the author with data from the software R, Bibliometrix and Biblioshiny, (2020).

Chart 5 shows the authors who have published conferences, where the importance of Markus Helfert and Chien-Sing Lee *et al*. are highlighted, both in 2019, with a total of three conferences related to action design research in practice (the case of smart cities), which invites reflection on research methodologies to conduct an adequate literature review.

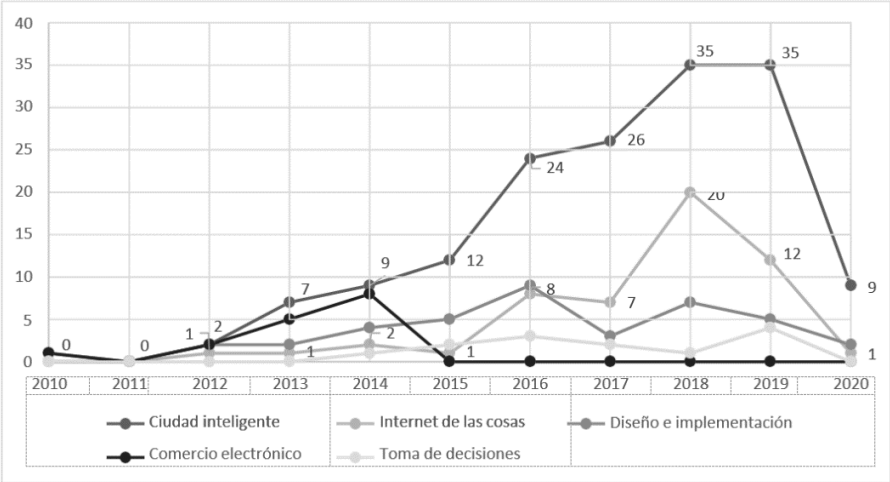
Chart 5. Authors by conferences



Source: developed by the author with data from the software R, Bibliometrix and Biblioshiny (2020).

One of the most important co-authors found, both in the article and conference categories, was Foth Marcus in 2019, with a total of two conferences, in which he unveiled his methodologies for collaborative design practices towards coexistence in "Urban futures more than human: speculative participatory design to avoid ecocidal smart cities". Chart 6 shows the most used keywords resulting from the bibliometric analysis in the research articles analyzed, from 2010 to 2020: smart city, with 159 coincidences; internet of things, with 53; design and implementation, with 40; e-commerce with 16 and decision making with 13.

Chart 6. Keywords from 2010 to 2020



Source: developed by the author with data from the software R, Bibliometrix and Biblioshiny, (2020).

Findings

The findings of this research are of utmost importance as they reveal that the issue of SCs is on the rise, a situation that should be considered in the future strategies of countries to jointly implement projects with the help of the government. Likewise, companies that include these vulnerable groups in their technological platforms will be able to do so.

It was found that there are three main elements that stand out in the IC context. First, the element of the internet of things, which plays a key role in the current lives of citizens and the tasks they perform, a situation that is no different in the context of SCs. Secondly, the element of design and implementation as a key factor for the comprehensive development of SCs, thus requiring further formulation of public policies. Third, the element of e-commerce, which represents a significant factor because it facilitates the acquisition of goods by the elderly and other excluded groups that traditionally cannot travel to physical stores. Because of the above, a profound change is needed between policy formulation, citizen awareness and the designers of future SCs in both developed and developing countries.

Conclusions

The topic of SCs maintains a trend of growing interest throughout the last decade, and this is mainly manifested in conferences as the main form of dissemination. It is concluded that the emerging thematic trends are mainly oriented towards elements such as the internet of things and the importance of design and implementation, as well as e-commerce. We also found the

emergence of the term *inclusive smart city* (ISC), which considers the integration of vulnerable groups, such as the elderly, into society. The promotion of innovative technologies serves to solve problems in urban spaces through the participation of architects, urban designers, researchers and the government in the design process.

In addition to the above, the opinion of citizens is extremely important so that, together, projects are analyzed and planned with a vision of respect for the environment and with infrastructures that respond to the needs of each city. All this can provide innovative services by establishing new business models and methodologies that help technological development; for example, the internet of things, which provides the opportunity for the elderly to be included in these processes.

The issue of SCs should respond to the challenges of each country, both in developed and developing countries, and should be based on technologies that can be applied in the home, in cities, in sectors and in industries. In this sense, it is important to emphasize that SCs aim to include all citizens in the same context, with the help of tools that facilitate independence and autonomy within spaces that are in constant movement and exposed to complicated situations.

Finally, as a future line of research, it is necessary to continue with the study of the most relevant factors that allow greater participation and social-cognitive engagement among older adults, in a community environment that facilitates interaction with new and current generations. Likewise, environmentally friendly strategic planning is required, by creating awareness among citizens, designers and the government to implement social inclusion practices in the smart city environment.

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REFERENCES

Abella, A.; Ortiz-de-Urbina-Criado, M. & De-Pablos-Heredero, C. (2019). A methodology to design and redesign services in smart cities based on the citizen experience. *Information Polity*, *24*(2), 183-197. http://dx.doi.org/10.3233/IP-180116

Al-Khateeb, A. (2017). Design and Implementation of Human Mobility Embedded System for Urban Planning of Smart City. *SMARTGREENS*, 337-345. http://dx.doi.org/10.5220/0006374103370345

Alvarado, R. A. (2018). Ciudad inteligente y sostenible: hacia un modelo de innovación inclusiva. *PAAKAT: Revista de Tecnología y Sociedad*, *7*(13). https://dx.doi.org/10.32870/pk.a7n13.299

Álvarez-Aros, E. L. & Bernal-Torres, C. A. (2017). Modelo de innovación abierta: énfasis en el potencial humano. *Información tecnológica*, *28*(1), 65-76. http://dx.doi.org/10.4067/S0718-07642017000100007

Aria, M. & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of informetrics*, *11*(4), 959-975.

Busso, G. (2005). Pobreza, exclusión y vulnerabilidad social. Usos, limitaciones y potencialidades para el diseño de políticas de desarrollo y de población, *VIII Jornadas Argentinas de Estudios de Población (AEPA)*. Tandil: Buenos Aires.

Brundtland, G. (1987). El desarrollo sostenible. *Informe de la Comisión Mundial sobre el Medio Ambiente y Desarrollo*. Asamblea General de las Naciones Unidas. https://desarrollosostenible.wordpress.com/2006/09/27/informe-brundtland

Calderoni, L.; Maio, D. & Palmieri, P. (2012). Location-aware mobile services for a smart city: Design, implementation and deployment. *Journal of theoretical and applied electronic commerce research*, *7*(3), 74-87. http://dx.doi.org/10.4067/S0718-18762012000300008

Caldwell, G. A.; Foth, M. & Guaralda, M. (2013). An urban informatics approach to smart city learning in architecture and urban design education. *IxD&A (Interaction Design and Architecture (s))*, *17*, 7-28.

Cerna, M.; Poulova, P. & Svobodova, L. (2018). The Elderly in SMART Cities. In *International KES Conference on Smart Education and Smart E-Learning* (pp. 224-233). Springer, Cham. https://doi.org/10.1007/978-3-319-92363-5_21

Cho, Y.; Jeong, H.; Choi, A. & Sung, M. (2019). Design of a Connected Security Lighting System for Pedestrian Safety in Smart Cities. *Sustainability*, *11*(5), 1308. https://doi.org/10.3390/su11051308

Clarke, R.; Heitlinger, S.; Foth, M.; DiSalvo, C.; Light, A. & Forlano, L. (2018). More-than-human urban futures: speculative participatory design to avoid ecocidal smart cities. In *Proceedings of the 15th Participatory Design Conference: Short Papers, Situated Actions, Workshops and Tutorial-Volume 2* (pp. 1-4). https://doi.org/10.1145/3210604.3210641

De Oliveira, J. S. & Kofuji, S. T. (2016). Inclusive Smart City: Expanding design possibilities for persons with disabilities in the urban space. In *2016 IEEE International Symposium on Consumer Electronics (ISCE)* (pp. 59-60). https://doi.org/10.1109/ISCE.2016.7797370

Duarte, A. (2016). *The Human Smart Cities Manifesto: A Global Perspective. Human Smart Cities: Rethinking the Interplay between Design and Planning*, 197. https://0-doi-org.biblioteca-ils.tec.mx/10.1007/978-3-319-33024-2_11

Fu, Z. & Lin, X. (2014). Building the co-design and making platform to support participatory research and development for smart city. In *International Conference on Cross-Cultural Design* (pp. 609-620). Springer, Cham. https://doi.org/10.1007/978-3-319-07308-8_58

Galende, H. V. (2015). Smart cities: una apuesta de la Unión Europea para mejorar los servicios públicos urbanos. *Revista de estudios europeos*, (66), 25-51.

Ghosh, S. (2018). Smart homes: Architectural and engineering design imperatives for smart city building codes. In *2018 Technologies for Smart-City Energy Security and Power (ICSESP)* (pp. 1-4). https://doi.org/10.1109/ICSESP.2018.8376676

Heitlinger, S.; Foth, M.; Clarke, R.; DiSalvo, C.; Light, A. & Forlano, L. (2018). Avoiding ecocidal smart cities: participatory design for more-than-human futures. In *Proceedings of the 15th Participatory Design Conference: Short Papers, Situated Actions, Workshops and Tutorial-Volume 2* (pp. 1-3). https://doi.org/10.1145/3210604.3210619

Hu, Y. & Wang, J. (2016). Building smart government or developing industry? Study on the designs of local smart city pilot projects in China. In *Proceedings of the 17th International Digital Government Research Conference on Digital Government Research* (pp. 532-533). https://doi.org/10.1145/2912160.2912234

Kirwan, C. G. (2015). Defining the middle ground: a comprehensive approach to the planning, design and implementation of smart city operating systems. In *International Conference on Cross-Cultural Design* (pp. 316-327). Springer, Cham. https://doi.org/10.1007/978-3-319-20907-4_29

Komninos, N.; Tsarchopoulos, P. & Kakderi, C. (2014). New services design for smart cities: a planning roadmap for user-driven innovation. In *Proceedings of the 2014 ACM international workshop on Wireless and mobile technologies for smart cities* (pp. 29-38). https://doi.org/10.1145/2633661.2633664

Lee, C. S. & Wong, K. D. (2017). Developing community-based engagement in Smart Cities: A design-computational thinking approach. In *2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 832-836). https://doi.org/10.1109/IEEM.2017.8290008

Li, F. & Zheng, B. (2016). Design of the smart city planning system based on the internet of things. *International Journal of Smart Home*, *10*(11), 207-218. http://dx.doi.org/10.14257/ijsh.2016.10.11.18

Lunardini, F.; Basilico, N.; Ambrosini, E.; Essenziale, J.; Mainetti, R.; Pedrocchi, A. & Borghese, N. A. (2017). Exergaming for balance training, transparent monitoring, and social inclusion of community-dwelling elderly. In *2017 IEEE 3rd International Forum on Research and Technologies for Society and Industry (RTSI)* (pp. 1-5). https://doi.org/10.1109/RTSI.2017.8065964

Maccani, G.; Donnellan, B. & Helfert, M. (2014). Action design research in practice: the case of smart cities. In *International Conference on Design Science Research in Information Systems* (pp. 132-147). Springer, Cham. https://doi.org/10.1007/978-3-319-06701-8_9

Mattoni, B.; Gugliermetti, F. & Bisegna, F. (2015). A multilevel method to assess and design the renovation and integration of Smart Cities. *Sustainable Cities and Society*, *15*, 105-119. https://doi.org/10.1016/j.scs.2014.12.002

Meadows, M. & Kouw, M. (2017). Future-making: inclusive design and smart cities. *Interactions*, *24*(2), 52-56. https://doi.org/10.1145/3046429

Ngankam, H. K.; Pigot, H.; Parenteau, M.; Lussier, M.; Aboujaoudé, A.; Laliberté, C. & Giroux, S. (2019). An IoT Architecture of Microservices for Ambient Assisted Living Environments to Promote Aging in Smart Cities. In *International Conference on Smart Homes and Health Telematics* (pp. 154-167). Springer, Cham. https://doi.org/10.1007/978-3-030-32785-9_14

Organización de las Naciones Unidas. (2019). Documento de divulgación. https://population.un.org/wpp/Publications/Files/WPP2019_PressRelease_ES.pdf

Organización Mundial de la Salud. (2002). Envejecimiento activo: un marco político. *Revista Española de Geriatría y Gerontología*, *37*(2), 74-105.

Orłowski, C.; Ziółkowski, A.; Orłowski, A.; Kapłański, P.; Sitek, T. & Pokrzywnicki, W. (2016). Smart Cities System Design Method Based on Case Based Reasoning. In *Transactions on Computational Collective Intelligence XXV* (pp. 43-58). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-53580-6_4

Popovic, S. & Masanovic, B. (2019). Effects of Physical and Social Activity on Physical Health and Social Inclusion of Elderly People. *Iranian Journal of Public Health*, *48*(10), 1922. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6908910/

Pulli, P.; Hyry, J.; Pouke, M. & Yamamoto, G. (2012). User interaction in smart ambient environment targeted for senior citizen. *Medical & biological engineering & computing*, *50*(11), 1119-1126. https://doi.org/10.1007/s11517-012-0906-8

Rizzo, F. & Deserti, A. (2014). Small scale collaborative services: the role of design in the development of the human smart city paradigm. In *International Conference on Distributed, Ambient, and Pervasive Interactions* (pp. 583-592). Springer, Cham. https://doi.org/10.1007/978-3-319-07788-8_54

Schuilenburg, M. & Peeters, R. (2018). Smart cities and the architecture of security: pastoral power and the scripted design of public space. *City, Territory and Architecture*, *5*(1), 13. https://doi.org/10.1186/s40410-018-0090-8

Suryotrisongko, H.; Kusuma, R. C. & Ginardi, R. H. (2017). Four-hospitality: Friendly smart city design for disability. *Procedia Computer Science*, *124*, 615-623. https://doi.org/10.1016/j.procs.2017.12.197

Taamallah, A.; Khemaja, M. & Faiz, S. (2019). A web-based platform for strategy design in smart cities. *International Journal of Web Based Communities*, *15*(1), 62-84. https://doi.org/10.1504/IJWBC.2019.098698

Tió, F. B. A. (2014). Concepto de adulto mayor. *Revista Universitaria de la Educación Física y el Deporte*, *51*(6), 7.

Torrado, A. M.; Sánchez, L.; Somonte, R.; Cabrera, A. M.; Henríquez, P. C., & Lorenzo, O. (2014). Envejecimiento poblacional: una mirada desde los programas y políticas públicas de América Latina, Europa y Asia. *Revista Novedades en Población, 10*(19), 18-29.

Torrinha, P. & Machado, R. J. (2017). Assessment of maturity models for smart cities supported by maturity model design principles. In *2017 IEEE International Conference on Smart Grid and Smart Cities (ICSGSC)* (pp. 252-256). https://doi.org/10.1109/ICSGSC.2017.8038586

Tymkiewicz, J. (2019). The Role of an Architect in Creating the Image of an Elderly-Friendly Sustainable Smart City. *Buildings*, *9*(10), 223. https://doi.org/10.3390/buildings9100223

Vázquez-Honorato, L. A., & Salazar-Martínez, B. L. (2010). Arquitectura, vejez y calidad de vida. Satisfacción residencial y bienestar social. *Journal of Behavior, Health & Social Issues*, *2*(2), 57-70.

Villafuerte R., J.; Alonso, Y.; Alcaide, Y.; Leyva, I. & Arteaga, Y. (2017). El bienestar y calidad de vida del adulto mayor, un reto para la acción intersectorial. *MediSur*, *15*(1), 85-92. http://www.medisur.sld.cu/index.php/medisur/article/view/3239/2265

Wenge, R.; Zhang, X.; Dave, C.; Chao, L. & Hao, S. (2014). Smart city architecture: A technology guide for implementation and design challenges. *China Communications*, *11*(3), 56-69. https://doi.org/10.1109/CC.2014.6825259

Woolrych, R.; Sixsmith, J.; Makita, M.; Fisher, J. & Lawthom, R. (2018). Exploring the potential smart cities in the design of age-friendly urban environments. *Gerontechnology*, *17*, 67. https://doi.org/10.4017/gt.2018.17.s.067.00

Wu, X.; Yang, M. & Zhang, X. (2019). Design of Smart City Evaluation Based on the Theory of "White Bi". In *International Conference on Intelligent Human Systems Integration* (pp. 357-362). Springer, Cham. https://doi.org/10.1007/978-3-030-11051-2_55

Xiaofeng, L. & Junde, S. (2014). The top design methodology of smart city in China. In *2014 7th International Conference on Intelligent Computation Technology and Automation* (pp. 861-864). https://doi.org/10.1109/ICICTA.2014.206

Yamamoto, G.; Hyry, J.; Pouke, M.; Metso, A.; Hickey, S. & Pulli, P. (2010). Senior citizens' interaction with smart ambient environment. In *2010 IEEE International Technology Management Conference (ICE)* (pp. 1-8). https://doi.org/10.1109/ICE.2010.7477027