

Review

Smart Cities' Applications to Facilitate the Mobility of Older Adults: A Systematic Review of the Literature

Nelson Pacheco Rocha ^{1,*} , Rute Bastardo ², João Pavão ³, Gonçalo Santinha ⁴ , Mário Rodrigues ⁵ , Carlos Rodrigues ⁴ , Alexandra Queirós ⁶ and Ana Dias ⁷

- ¹ IEETA-Institute of Electronics and Informatics Engineering of Aveiro, Department of Medical Sciences, University of Aveiro, 3810-193 Aveiro, Portugal
 - ² UNIDCOM, Science and Technology School, University of Trás-os-Montes and Alto Douro, Quinta de Prado, 5001-801 Vila Real, Portugal; rutebastardo@gmail.com
 - ³ INESC-TEC, Science and Technology School, University of Trás-os-Montes and Alto Douro, Quinta de Prado, 5001-801 Vila Real, Portugal; jpavao@utad.pt
 - ⁴ GOVCOPP-Governance, Competitiveness and Public Policies, Department of Social, Political and Territorial Sciences, University of Aveiro, 3810-193 Aveiro, Portugal; g.santinha@ua.pt (G.S.); cjose@ua.pt (C.R.)
 - ⁵ IEETA-Institute of Electronics and Informatics Engineering of Aveiro, Águeda School of Technology and Management, University of Aveiro, 3750-127 Águeda, Portugal; mjfr@ua.pt
 - ⁶ IEETA-Institute of Electronics and Informatics Engineering of Aveiro, Health Sciences School, University of Aveiro, 3810-193 Aveiro, Portugal; alexandra@ua.pt
 - ⁷ GOVCOPP-Governance, Competitiveness and Public Policies, Economics, Management, Industrial Engineering and Tourism, University of Aveiro, 3810-193 Aveiro, Portugal; anadias@ua.pt
- * Correspondence: npr@ua.pt; Tel.: +351-234-247-292



Citation: Rocha, N.P.; Bastardo, R.; Pavão, J.; Santinha, G.; Rodrigues, M.; Rodrigues, C.; Queirós, A.; Dias, A. Smart Cities' Applications to Facilitate the Mobility of Older Adults: A Systematic Review of the Literature. *Appl. Sci.* **2021**, *11*, 6395. <https://doi.org/10.3390/app11146395>

Academic Editors: Luis Hernández-Callejo, Víctor Alonso Gómez, Sergio Nesmachnow, Vicente Leite, Javier Prieto and Ângela Ferreira

Received: 17 June 2021

Accepted: 9 July 2021

Published: 11 July 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: This study aimed to identify: (i) the relevant applications based on information technologies and requiring smart cities' infrastructure to facilitate the mobility of older adults in URBAN SPACES; (ii) the type of data being used by the proposed applications; (iii) the maturity level of these applications; and (iv) the barriers TO their dissemination. An electronic search was conducted on Web of Science, Scopus, and IEEE Xplore databases, combining relevant keywords. Then, titles and abstracts were screened against inclusion and exclusion criteria, and the full texts of the eligible articles were retrieved and screened for inclusion. A total of 28 articles were included. These articles report smart cities' applications to facilitate the mobility of older adults using different types of sensing devices. The number of included articles is reduced when compared with the total number of articles related to smart cities, which means that the mobility of older adults it is still a not significant topic within the research on smart cities'. Although most of the included studies aimed the implementation of specific applications, these were still in an early stage of development, without the assessment of potential end-users. This is an important research gap since it makes difficult the creation of market-oriented solutions. Another research gap is the integration of knowledge generated by other research topics related to smart cities and smart mobility. Consequently, important issues (e.g., user privacy, data standardization and integration, Internet of Things implementation, and sensors' characteristics) were poorly addressed by the included studies.

Keywords: smart city; older adults; mobility; systematic review

1. Introduction

Population ageing is taking place worldwide. In most countries, people live longer and, overall, in better health conditions than before. Coping with such a demographic shift has become a major issue for public policies and has gained attention from international institutions [1,2].

Currently, the ideal political paradigm considered for the care of older adults is that they should continue living in the community rather than being forced to move to residential care units because of their cognitive and physical limitations. Though not recent,

it is within this context that the concepts such as ageing in place [3] or active ageing [4,5] have been developed. According to these concepts, the maintenance of patterns of activities and values typical of middle age can optimize opportunities for social participation, health conditions, and the safety of the individuals as they age [5–8]. This depends not only on the characteristics of the individuals but also on environmental factors [9], such as, for instance, urban infrastructures and services.

The Ageing in Cities Report from the Organisation of Economic Cooperation and Development (OECD) states that “designing policies that address ageing issues requires a deep understanding of local circumstances, including communities’ economic assets, history and culture. (. . .) Cities need to pay more attention to local circumstances to understand ageing, and its impact. They are especially well-equipped to address the issue, given their long experience of working with local communities and profound understanding of local problems” [10] p. 18.

The World Health Organization (WHO) age-friendly cities and communities’ approach [11] is in line with this concern. Following the idea that an age-friendly city is as a place where older adults are actively involved, valued, and supported with infrastructure and services that accommodate their needs, the WHO produced a guide identifying the key characteristics of an age-friendly environment in terms of service provision (e.g., healthcare services or transportation), built environment (e.g., housing, outdoor spaces, or buildings), and social aspects (e.g., civic, or social participation) [12]. Based on the experience, the WHO provides guidance [13] to ensure that research and initiatives held at country and regional levels on topics relevant to healthy ageing can be widely shared.

Although ageing societies pose diverse challenges, they also provide a large set of opportunities that society can benefit from [10]. Such opportunities include new developments in technology and innovation. In fact, due to technological advances in the last couple of decades, the use of smart technologies is increasingly considered an important means to promote active ageing [1,14]. Therefore, many researchers aimed to develop new services based on Information Technologies (IT), such as Ambient Assisted Living (AAL) [15–17], to enable older adults to achieve their full potential in terms of physical, social, and mental wellbeing.

Additionally, due to the technological developments, during the last few years the smart city paradigm has been the object of great attention from different sectors: scientific journals publish specific issues on this topic, local governments fight to label their city as such, firms advertise smart cities’ solutions, and international and national programs aim to promote adequate implementations [18]. In this respect, several initiatives of the European Commission, namely the Digital Agenda (one of the seven pillars of the Europe 2020 Strategy) and the Smart Cities and Communities initiative, aimed at bringing together cities, industry, and citizens through more sustainable integrated solutions [19].

1.1. Objective and Contributions

Systematic reviews allow us not only to answer clearly formulated questions, using systematic methods, but also to critically evaluate and synthesize results from multiple studies, thus consolidating knowledge and identifying gaps in a given research field.

Concretely, the systematic review reported in this article aimed to identify relevant IT-based applications requiring smart cities’ infrastructure to facilitate the mobility of older adults in the urban space and, consequently, their participation and inclusion in the community as full citizens.

To the best of our knowledge, the systematic review literature reported by this article constitutes the first review that covers the mobility of older adults supported by smart cities’ infrastructure. It aims to make the following contributions in terms of smart city applications to facilitate the mobility of older adults: (i) review of the main recently published research; (ii) identification and discussion of relevant applications; (iii) typification of the applications being developed; (iv) identification of current approaches to use sensors and smart city data to support the mobility of older adults; (v) analysis of the maturity level of

the reported applications; (vi) discussion about the main results and contributions of the current research; (vii) identification of the barriers for the dissemination of the identified applications; and (viii) identification of research gaps. These contributions might be useful to inform smart cities' stakeholders about state-of-the-art solutions with impacts on active ageing and the gaps of the current research.

1.2. Smart Cities and Smart Mobility

A set of characteristics has been identified as relevant in the context of smart cities [20,21]: smart governance, smart economy, smart environment, smart people, smart living, and smart mobility.

Smart mobility includes local, national, and international accessibility, and the availability of communication infrastructure or sustainable and safe transport systems and is aligned with the United Nations (UN) Sustainable Development Goals [22,23]. Smart mobility is often seen as related to the use of IT to adequately orchestrate services designed to improve urban mobility [24]. In this respect, a wide range of information services can be foreseen, such as intelligent transportation systems [25–28] or algorithms to infer mobility patterns [29,30]. These information services might contribute to the reduction of air and noise pollution, traffic congestion, and travel costs, while increasing individuals' safety [24,31,32].

Moreover, smart mobility might facilitate older adults' activities and participation, in line with the goals of active ageing and age-friendly cities and communities' approaches [13]. In its baseline report for the decade of healthy ageing, the WHO states that “engagement of older people and municipalities can steer the use of digital technology to support enabling environments—and reduce the digital divide between older and younger people” [1] p. 67, pointing out Chicago as a good example of a city in which the labels of Age-Friendly and Smart City have been brought together.

1.3. An Overview of Related Reviews

Several articles published in scientific journals [33–65] reported different types of reviews, including systematic literature reviews, related to various aspects of smart cities' implementation, including data analytics [33–37], systems architectures [38], data security [39–41], data security and Internet of Things (IoT) [42–44], IoT [45], ontologies [46], healthcare [47–49], energy efficiency [50], citizenship [51], smart city indicators [52], mobility [53–58] and age-friendly initiatives [59–65].

Looking specifically for reviews related to mobility or age-friendly initiatives (Table 1), is possible to conclude that the state-of-the-art studies did not aim to analyze relevant IT-based applications requiring smart cities' infrastructures to facilitate the mobility of older adults.

In turn, concerning age-friendly initiatives, the state-of-the-art reviews aimed to study aspects as the impact of smart cities in different countries [60–62], barriers to the implementation of age-friendly concepts in smart cities [59], the role of IT and the barriers and stressors for age and disability-friendly communities [65], and the impact of IT on the quality of life of older adults [63]. Finally, one article [64] is a narrative review on the role of mobility digital ecosystems for age-friendly urban public transport. However, this narrative review (not a systematic review), instead of performing a quantitative evidence-based analysis of empirical studies, aimed to present a discussion on how transport technology and transport mobility practices might contribute to the promotion of mobility rights of older adults and age-friendly mobility [64].

The article is outlined as follows. In Section 2, the proposed research questions and methods are detailed. The results are presented in Section 3. Finally, the discussion and answers to the research questions are presented in Section 4, and general conclusions are presented in Section 5.

Table 1. State-of-the-art reviews related to smart city mobility and age-friendly initiatives.

Topic	Reference	Title	Year
Mobility	[53]	<i>Emerging big data sources for public transport planning: a systematic review on current state of art and future research directions.</i>	2019
	[54]	<i>Smart parking: a literature review from the technological perspective.</i>	2019
	[55]	<i>The quality of smart mobility: a systematic review.</i>	2020
	[56]	<i>A systematic review of urban navigation systems for visually impaired people.</i>	2021
	[57]	<i>Enabling technologies for urban smart mobility: recent trends, opportunities and challenges.</i>	2021
	[58]	<i>Barriers and risks of Mobility-as-a-Service (MaaS) adoption in cities: a systematic review of the literature.</i>	2021
Age-friendly initiatives	[59]	<i>Implementation of age-friendly initiatives in smart cities: probing the barriers through a systematic review.</i>	2020
	[60]	<i>Smart and age-friendly cities in Romania: an overview of public policy and practice.</i>	2020
	[61]	<i>Smart and age-friendly cities in Russia: an exploratory study of attitudes, perceptions, quality of life and health information needs.</i>	2020
	[62]	<i>Smart and age-friendly communities in Poland: an analysis of institutional and individual conditions for a new concept of smart development of ageing communities.</i>	2020
	[63]	<i>Quality of life framework for personalised ageing: a systematic review of ICT solutions.</i>	2020
	[64]	<i>The role of mobility digital ecosystems for age-friendly urban public transport: a narrative literature review.</i>	2020
	[65]	<i>Use of connected technologies to assess barriers and stressors for age and disability-friendly communities.</i>	2021

2. Materials and Methods

This systematic review followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [66]. To achieve its objectives the following research questions were formulated:

- RQ1—What are the relevant smart city IT-based applications to facilitate the mobility of older adults?
- RQ2—What type of data (i.e., sensors and city data) are being used to support the proposed applications?
- RQ3—What are the maturity levels of the solutions being reported?
- RQ4—What are the barriers for the dissemination of the solutions that were identified?

Boolean queries were prepared to include all the articles that have in their titles, abstract or keywords a reference to smart city (i.e., one of the following expressions ‘Smart City’, ‘Smartcity’, ‘Smart-city’, ‘Smart Cities’, ‘Smartcities’ or ‘Smart-cities’) together with at least one of the following terms: ‘Elderly’, ‘Older’, ‘Senior’, ‘Ageing’ or ‘Aging’. The resources considered to be searched were two general databases, Web of Science and Scopus, and one specific technological database, IEEE Xplore. The literature search was concluded in April 2021.

As inclusion criterion, the authors aimed to include all the articles that reported evidence of explicit use of IT-based application requiring smart cities’ infrastructures to facilitate the mobility of older adults.

Considering the exclusion criteria, the authors aimed to exclude all the articles not published in English, without abstract or without access to full text. Furthermore, the authors also aimed to exclude all the articles that reported overviews, reviews and applica-

tions that do not explicitly require smart cities' infrastructures, or that were not relevant for the specific aim of this study.

The selection of the articles was performed in three steps:

- First, the authors removed the duplicates and the articles without abstract.
- The abstracts of the retrieved articles were screened against inclusion and exclusion criteria to exclude non relevant articles. When from the title and abstract of an article it was not possible to take a decision, the article was considered for the next step (i.e., full text screening).
- The full texts of the eligible articles were retrieved and screened for inclusion.

Then, the full texts of the included articles were analyzed and classified using a synthesis process based on the method proposed by Ghapanchi and Aurum [67] (i.e., terms and definitions used in the included articles were identified to create a primary list of application domains, which was afterwards refined by further analyses).

Data from each included article were extracted using a standardized form including: (i) article authors, title, and year of publication; (ii) aim of the study being reported; (iii) details of the applications being reported; (iv) details of the applied research methods; (v) methods applied for the assessment of the proposed applications; (vi) results; and (vii) author's interpretations.

In all the steps the articles were reviewed by at least two authors and any disagreement was discussed and resolved by consensus.

3. Results

Figure 1 presents the PRISMA flowchart of this systematic review.

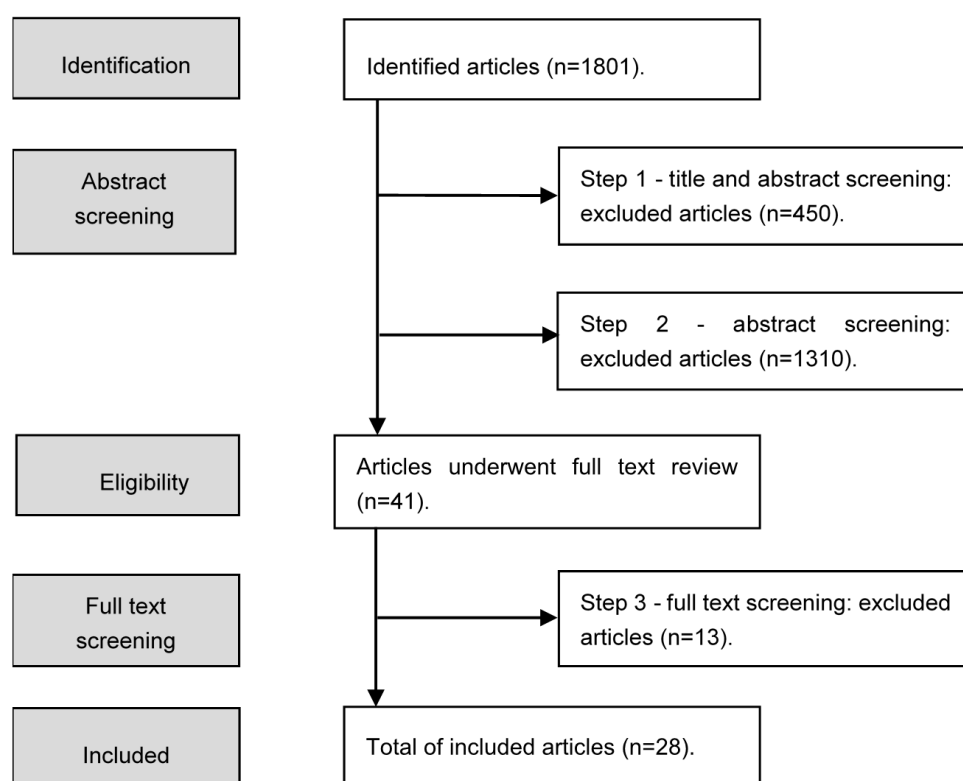


Figure 1. Study flowchart.

A total of 1801 articles were retrieved from the initial search on Web of Science (718 articles), Scopus (869 article) and IEEE Xplore (214 articles).

The initial step of the screening phase (i.e., step 1) yielded 1351 articles by removing the duplicates (348 articles) or the articles without abstracts (102 articles).

Based on abstracts (i.e., step 2), 390 articles were removed since they were not published in English, or they were overviews or reviews, editorials, prefaces, and announcements of special issues, workshops, or books. Moreover, 920 articles were removed because they did not report evidence of the explicit use of IT-based applications requiring smart cities' infrastructures to facilitate the mobility of older adults.

Finally, the full texts of the remaining 41 articles were screened (i.e., step 3) and 13 articles were excluded because they did not meet the inclusion criteria. Therefore, 28 articles [68–95] were included in this systematic review.

Of these 28 articles, some reported the same research projects: articles [79,80,85,87,88] were related to a Portuguese funded project called SmartWalk; articles [73,77] were related to a European funded project called City4Age; and articles [78,93] reported on the same application.

Considering the articles included for this systematic review, 18 were published in conference proceedings [68–70,72–74,79–87,89,91,92] and ten were published in scientific journals [71,75–78,88,90,93–95].

In terms of publication years, the included articles were published between 2013 (i.e., two articles [68,69]) and 2021 (i.e., one article [95]). The diagram in Figure 2 demonstrates that the trend of the development of IT-based applications requiring smart cities' infrastructures to facilitate the mobility of older adults is increasing, and more than two-thirds of the articles (i.e., 19 articles [77–95]) were published in the last four years.

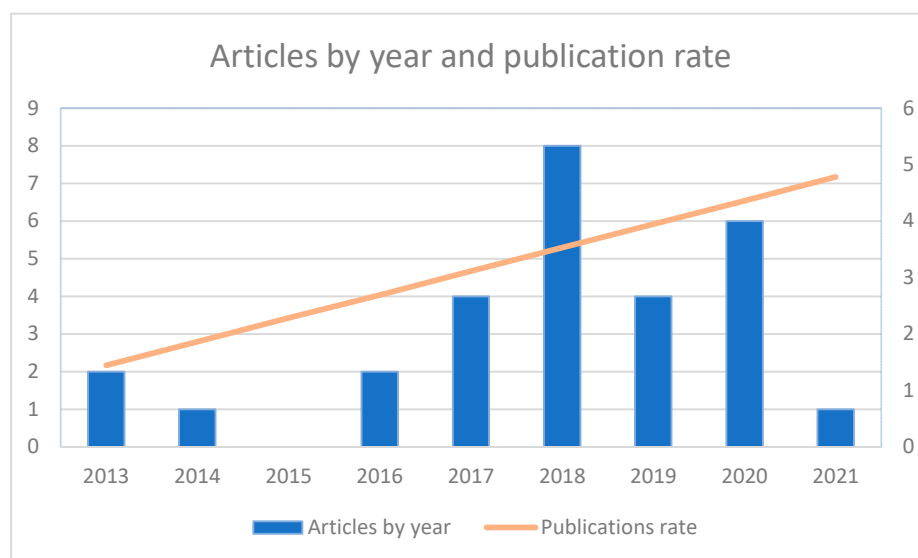


Figure 2. Articles by year and publication rate (calculated using RMS Lest Square Fit).

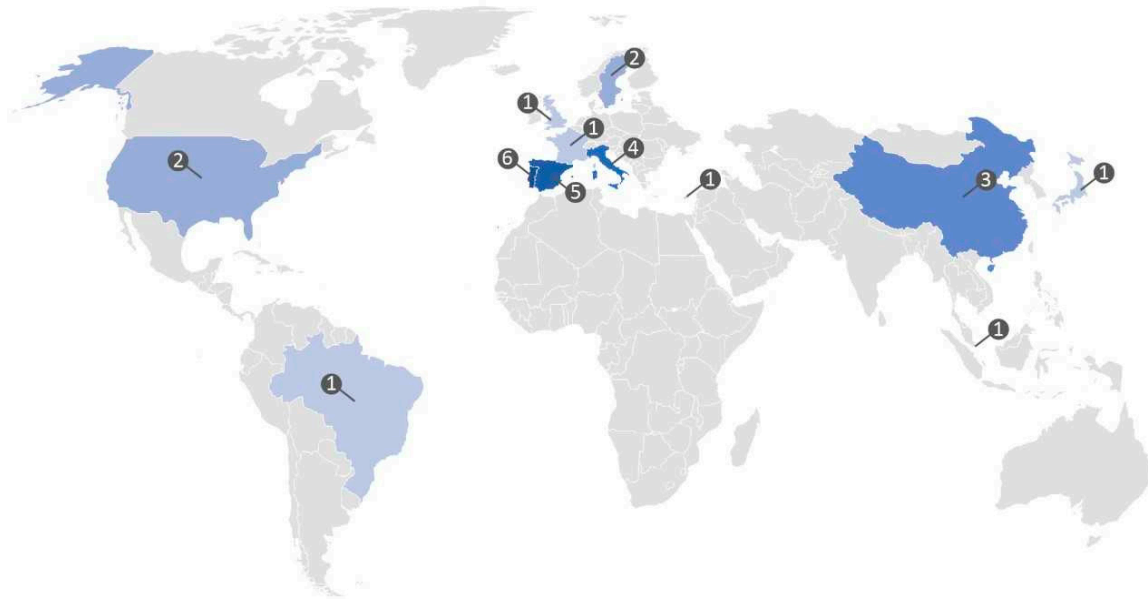
Figure 3 reveals the country of origin for all primary studies. Europe (in particular, Portugal, six articles [79,80,85,87,88], and Spain, five articles [68,73,75–77]) contributed the largest number of articles (i.e., 20 articles [68–73,75–80,83–85,87–89,92,93]). In turn, Asia contributed five articles [74,81,82,90,91], North America (i.e., United States of America) contributed two articles [86,94] and South America (i.e., Brazil) contributed one article [95].

3.1. Quality of the Retrieved Studies

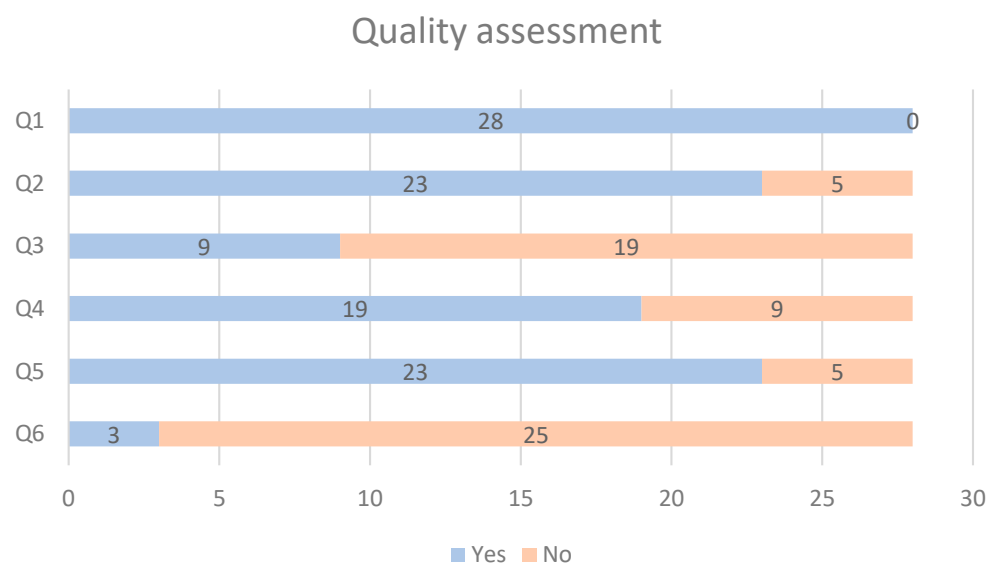
In addition to general inclusion and exclusion criteria, it is considered critical to assess the quality of primary studies. Therefore, the 28 articles were evaluated against a set of study quality assessment questions listed in Table 2, which were adopted and adjusted from other studies [96–98]. Two of the authors independently answered the questions according to binary scale (i.e., 1 for Yes or 0 for No) and any disagreements were resolved through discussion until consensus was reached.

Table 2. Study quality assessment questions.

#	Study Quality Assessment Questions
Q1	Are the objectives and aims of the study clearly identified?
Q2	Is the context of the study clearly stated?
Q3	Does the research methods support the aims of the study?
Q4	Has the study an adequate description of the technologies being used?
Q5	Is there a clear statement of the findings?
Q6	Are limitations of the study discussed explicitly?

**Figure 3.** Distribution of the selected articles by country.

As can be seen in Figure 4, all studies state the aims and objectives of the conducted research (Q1). In turn, only three articles explicitly included the limitations of the respective studies (Q6). Additionally, only nine articles conveniently described the research methods (Q3). The results for the remainder three questions varied from 23 (Q2 and Q5) to 19 (Q4).

**Figure 4.** Results of the quality assessment of the included articles.

3.2. Application Domains

Based on the analysis of the included articles, the following application domains were considered: (i) requirements and development platforms; (ii) accessibility; (iii) localization; (iv) mobility assistance; (v) health conditions monitoring; (vi) promotion of healthy lifestyles; and (vii) data analytics. Table 3 presents the classification of the 28 included articles.

Table 3. Classification of the included articles.

Application Domains	Reference	Title	Year
Requirements and development platforms	[68]	<i>Towards ambient assisted cities and citizens.</i>	2013
	[76]	<i>GAWA—manager for accessibility wayfinding apps.</i>	2017
	[89]	<i>Age and the city: the case of smart mobility.</i>	2020
Accessibility	[71]	<i>A service-oriented approach to crowdsensing for accessible smart mobility scenarios.</i>	2016
	[83]	<i>IoE accessible bus stop: an initial concept.</i>	2018
Localization	[72]	<i>A genetic-based localization algorithm for elderly people in smart cities.</i>	2016
	[81]	<i>OmimamoriNet: an outdoor positioning system based on Wi-SUN FAN network.</i>	2018
	[82]	<i>GPS trajectories based personalized safe geofence for elders with dementia.</i>	2018
Mobility assistance	[69]	<i>DisAssist: An Internet of Things and Mobile Communications platform for Disabled Parking Space Management.</i>	2013
	[70]	<i>On combining crowdsourcing, sensing and open data for an accessible smart city.</i>	2014
	[86]	<i>Smart mobility for seniors through the urban connector.</i>	2019
	[91]	<i>Beyond walking: improving urban mobility equity in the age of information.</i>	2020
	[95]	<i>Towards a collaborative model to assist people with disabilities and the elderly people in smart assistive cities.</i>	2021
Health conditions monitoring	[73]	<i>An architecture for combining open data with sensors' data for effective prevention of MCI and frailty in elderly people.</i>	2017
	[77]	<i>Definition of technological solutions based on the internet of things and smart cities paradigms for active and healthy ageing through cocreation.</i>	2018
	[84]	<i>Remote and non-invasive monitoring of elderly in a smart city context.</i>	2018
	[94]	<i>Wearable biosensor and hotspot analysis-based framework to detect stress hotspots for advancing elderly's mobility.</i>	2020
Promotion of healthy lifestyles	[75]	<i>Healthy routes in the smart city: a context-aware mobile recommender.</i>	2017
	[78]	<i>The Smart City Active Mobile Phone Intervention (SCAMPI) study to promote physical activity through active transportation in healthy adults: a study protocol for a randomized controlled trial.</i>	2018
	[79]	<i>Meet Smartwalk, smart cities for active seniors.</i>	2018
	[80]	<i>Smartwalk: personas and scenarios definition and functional requirements.</i>	2018
	[85]	<i>Customized walk paths for the elderly.</i>	2019
	[87]	<i>Smartwalk mobile—a context-aware m-health app for promoting physical activity among the elderly.</i>	2019
	[88]	<i>Supporting better physical activity in a smart city: a framework for suggesting and supervising walking paths.</i>	2019
	[93]	<i>User perception of a smartphone app to promote physical activity through active transportation: inductive qualitative content analysis within the Smart City Active Mobile Phone Intervention (SCAMPI) study.</i>	2020
Data analytics	[74]	<i>Identifying points of interest for elderly in Singapore through mobile crowdsensing.</i>	2017
	[90]	<i>Analysis of the temporal characteristics of the elderly traveling by bus using smart card data.</i>	2020
	[92]	<i>Classification of users' transportation modalities in real conditions.</i>	2020

3.2.1. Requirements and Development Platforms

Three articles were focused on the mobility requirements of older adults and IT platforms to help the development of new applications [68,76,89].

Sourbati [89] discussed the older adults' mobility practice in smart city environments as a phenomenon at the intersection of age, IT, and data, and aimed to study transport mobilities of older adults and mobility practices interactions with smart cities' IT services. The analysis highlighted age-bias in inherited transport systems, gaps in available data about older adults' mobility practices and IT use, and opportunities for more inclusive (and sustainable) smart transport. Moreover, based on the discussion of the older adults' mobility practices, the author presented the features of a journey planning application [89].

In turn, Lopez-de-Ipina et al. [68] proposed a proof-of-concept platform for ambient assisted cities able to sense the city to promote the creation of an ecosystem of user-centric applications to help older adults in their daily activities, considering their disabilities. This platform was developed within a research project, and the authors reported a work-in-progress and explained how they brought together the achievements of earlier works.

Finally, Rodriguez-Sánchez and Martinez-Romo [76] presented a platform to provide a universal and accessible solution to manage wayfinding applications that focuses on individuals with disabilities in outdoor and indoor environments. The platform is composed by different subsystems to perform user profiles management, accessibility data management, routes management and accessible application generation. The Assisted Multimodal Wayfinding Application was presented a case study: it can be installed on older adults' smartphones or wearable devices and combines text, maps, auditory, augmented reality, and tactile feedback to provide indoor and outdoor guidance considering personal factors (e.g., disabilities, impairments, or languages) [76].

The authors reported an accessibility guidelines validation and a prototype evaluation [76]. In terms of accessibility guidelines, the authors followed the Web Content Accessibility Guidelines (WCAG), version 2.0, and obtained the maximum level. In turn, the prototype was evaluated by a group of 20 participants (11 males and nine females, aged from 20 to 75), which were divided into the following categories: users without a disability (eight), blind users (three), limited vision users (four), deaf users (three) and wheelchair users (two). This evaluation was composed by three experiments: one for testing the application using Android devices, another for testing the application using iOS devices and the third one for testing the web interface. The evaluation methods include direct observation and questionnaires [76]. According to the results, the application could be used for supporting daily living activities [76].

3.2.2. Accessibility

Two articles [71,83] were considered as proposing applications to improve the accessibility of urban spaces.

Rodrigues et al. [83] proposed a smart bus stop, which would integrate all the features from the existing bus stops, as well as intelligent features to allow its adaptation to different users' needs. The authors reported an initial stage of the project and only the conceptual architecture was presented.

In turn, Mirri et al. [71] presented the design of an infrastructure called Smart Mobility for All (SMAll) aiming to support the mobility of impaired individuals within urban environments. Since a mobile user can be at the same time a consumer and a provider of the sensing services, the authors proposed both participatory sensing (i.e., mobile users actively engage in sensing activities by manually determining how, when, what, and where to sense) and opportunistic sensing (i.e., fully automated sensing activities without the involvement of the users) to collect that about the accessibility conditions of the urban spaces exploiting, for example, Radio-Frequency Identification (RFID) and Global Positioning System (GPS). Moreover, the crowdsensing data were aggregated with other data sources including official data about the transport infrastructure (e.g., static features and real-time information versus planned timetables). To prove the effectiveness

of the approach, the authors considered two scenarios illustrating urban accessibility issues involving a wheelchair user and an older adult.

3.2.3. Localization

Three articles [72,81,82] were considered within the scope of applications to determine the localization of older adults.

Considering that the city should provide outdoor monitoring for older adults while promoting their ability to perform leisure activities, the final aim of the study reported by Liouane et al. [72] was to ensure a localization service for older adults that should be provided in time and when it is necessary. According to the authors, they took advantage of the IoT paradigm for collecting heterogeneous data that are broadcast in the city. The assessment of the location performance was performed through a set of experimental simulations using the MATLAB environment.

Chen et al. [81] presented an outdoor positioning system that might be used to protect older adults, via estimating their locations in a city. Particularly, locations were estimated using machine learning algorithms from the data measured at multiple base-stations that are densely deployed over a city to construct an ad hoc network. A prototype system consisting of nine base-stations was deployed on a university campus to conduct an experiment to validate the proposed approach in terms of the performance of the communication networks and machine learning algorithms.

Lin et al. [82] argued that wandering is among the most problematic, dangerous, and frequent behaviors of individuals with dementia and that frequent wanders are more vulnerable to experiencing adverse events than the healthy ones, ranging from falling, getting lost, elopement or boundary transgression to emotional distress. To minimize wandering-related adverse consequences, the authors proposed a geofence based in a virtual boundary delineated around an area of interest that can be created with a variety of different technologies, such as WiFi, cellular mobile, RFID and GPS. Moreover, a data mining-based approach was used to construct a personalized safe geofence by mining older adults' historical GPS trajectories. In terms of validation, an open dataset of older adults' GPS traces was used and, according to the authors, the qualitative results showed that the method is workable for constructing personalized safe geofences by mining older adults' GPS trajectories [82].

3.2.4. Mobility Assistance

Considering the articles related to mobility assistance, Lambrinos and Dosis [69] focused on an application to enhance the parking experience from the perspective of impaired individuals, while four articles [70,86,91,95] reported studies aiming to support older adults when moving in the city.

Lambrinos and Dosis [69] proposed a smart parking management system called DisAssist which takes advantage of the capabilities of mobile devices to allow users to find, reserve and access real-time parking availability information obtained via machine-to-machine communications.

Mirri et al. [70] proposed a system that exploits real time data provided by bus operating companies combined with data produced by sensors and crowdsourcing data to provide routes tailored to older adults' specific needs. The users might access two mobile applications: mobile Pervasive Accessibility Social Sensing (mPASS) and WhenMyBus. The first collects data about urban accessibility and provides older adults with personalized and accessible pedestrian paths and maps, while the second aims to support older adults who travel by bus in the city by providing real time information about transport availability and accessibility facilities.

The important features of these applications are the integration of data produced by sensors (i.e., gyroscope, accelerometer, and GPS) and data gathered via crowdsourcing by users, together with official accessibility reviews conducted by experts. The authors argued that although any instance of the crowdsourced and sensed data may be unreliable,

aggregating a large amount of information related to the urban area makes the data more trustworthy (i.e., an error made by a single sensor, or a single user, become less significant as the volume of data increases). Additionally, the data quality might be increased when considering their aggregation with accessibility reviews conducted by experts.

Badii et al. [91] described a concept based on various technologies, including location-based services, augmented reality, and crowdsourcing. Specifically, a smartphone application prototype was developed to support wheelchair users with a customized information service. The important features of the system are path navigation and public participation. Path navigation is focused on individuals who find moving difficult (especially those who use wheelchairs) and aimed to provide an effective and accurate map information service and travel route planning, with two path navigation modes (i.e., wheelchair and walking). In turn, public participation allows users to take photos and upload the improper public facilities around them, such as a broken blind path, a broken elevator, and a damaged or blocked ramp. The positioning information of the photos can be uploaded to the urban management platform, providing data for urban management and maintenance.

Vargas-Acosta et al. [86] presented the Urban Connector, a mobile application that provides relevant information about city services to assist older adults during their travels within a city and to mitigate their risks (e.g., being caught in traffic congestion, getting lost, or being involved in a crash). Based on the recommendations followed in the design of the Urban Connector, an Android-native prototype has been developed, which was tested for a period of 30 days with a group of 38 older adults as early adopters.

Finally, Matos et al. [95] proposed the SafeFollowing application to provide collaborative support for individuals with disabilities and older adults in adverse situations from qualified agents and volunteers. In concrete, the SafeFollowing mobile application allows users to ask for assistance by sending a notification to agents and volunteers who are nearby. The SafeFollowing evaluation consisted of two scenarios (i.e., a situation in which an older adult receives special care provided by an agent, and a situation in which an agent helps a wheelchair user). After performing tests on the above SafeFollowing scenarios, a questionnaire based on the Technology Acceptance Model was used to gather the opinions of the participants.

3.2.5. Health Conditions Monitoring

Four articles [73,77,84,94] described solutions aiming to monitor the health conditions of older adults when moving in the urban spaces.

Lee et al. [94] proposed a wearable biosensor (i.e., a smart watch) and hotspot analysis-based framework to continuously monitor older adults' interactions with the built environment aiming to support interventions to minimize stressful interactions. To test the proposed framework, stress hotspots were detected based on the data related to 30 older adults, which were collected during two weeks of their daily trips. The detected stress hotspots were then investigated by site inspections and interviews with subjects. According to the authors, the proposed sensing framework strengthens the smart city paradigm and can be a basis for optimizing interventions to improve the mobility of older adults.

Through highlighting the importance of integrating social resources into the core of what a smart city is, the ideas presented in [73,77], which took part in the same project (City4Age), were related to the use technologies for the prevention of mild cognitive impairment and frailty in older adults.

Open data services available in the smart city technological infrastructure together with data collected by wearables, smart phones and sensors were used to track the users within the city, including visited points of interest and some activities performed, such as visiting a family member, and their usage of public transportation (e.g., buses or railway trains). The authors claimed that this tracking is useful to build a comprehensive and predictive picture of older adults' wellbeing and health conditions, aiming to sustain better health outcomes and deliver early interventions to anticipate needs [73,77].

Medrano-Gil et al. [77] reported the cocreation framework used for the Madrid City4Age pilot, which involved informal interviews with representatives of public transport organizations and a manager from a private older adults' care service, as well as structured interviews with a manager of day centers and home care services and the people responsible for social services of a municipality of fifty thousand inhabitants. In turn, [73] described the architecture supporting an innovative approach for interfacing open data from smart cities (e.g., public transportation or weather conditions) with data acquired (e.g., walking or enter home) via multiple sensors, namely GPS, Bluetooth Low Energy (BLE) beacons, smartphones, and smart wristbands.

A similar solution was presented in article [84], which described a smartphone-based prototype for remote and non-invasive older adults' monitoring. In the described implementation, a smartwatch with a heart rate monitor and a tri-axial accelerometer was used to determine if a dangerous situation is occurring (e.g., abrupt changes of the heart rate or a sudden acceleration, followed by a state of quiet that might be a sign of fall or fainting).

3.2.6. Promotion of Healthy Lifestyles

Eight articles focused the promotion of healthy lifestyles [75,78–80,85,87,88,93].

Article [75] reported a context-aware recommender application that offers personalized recommendations of exercise routes to older adults according to their health conditions and real-time information from a smart city. The application has predefined routes and recommends the best route based on a memory-based method that employs neighborhood search (i.e., to determine groups of similar individuals) and information acquired from the smart city infrastructure such as air quality, ultraviolet radiation, wind speed, temperature, or precipitation. The older adults can then select the best course according to their profile (e.g., age, effort, or distance) and can inform the application about unexpected situations that could affect other users. Moreover, they can also propose new routes. The application was configured for two cities and first tested with simulated users whose age distribution and medical statistics followed the reports of the WHO and the World Heart Federation. Later, an experiment was conducted to verify that the quality of the recommendations provided by the system were similar to those obtained by simulation.

A similar approach was followed by the SmartWalk project that was described by five articles [79,80,85,87,88]. The objective of the SmartWalk project was to implement a platform to promote physical activity by older adults, through the suggestion of routes that met both the individual requirements in terms of physical activity and personal preferences. The choice of routes is made by a healthcare professional that considers the individual health conditions. The vision and general architecture of the SmartWalk project was presented in two articles [79,88], while a set of personas and scenarios that were developed to help the systematization of the system functional requirements was presented in [80]. Moreover, the algorithm to determine the routes was described in [85] and the SmartWalk application was presented in [87].

Finally, articles [78,93] were related to the project Smart City Active Mobile Phone Intervention (SCAMPI), which evaluates an application to promote physical activity together with data acquisition related to behavior, mode of travel, duration, and speed. The application collects data in real time on location and travel speed using GPS. Moreover, accelerometers are used to provide an objective assessment of physical activity.

Ek et al. [78] presented the design of a two-arm parallel randomized controlled trial to assess the application promoting physical activity selected for SCAMPI trial in terms of monitoring behavior change towards active transport. The primary outcome is moderate-to-vigorous intensity physical activity, while secondary outcomes include time spent in active transportation, perceptions about active transportation and health related quality of life. In turn, Lindqvist et al. [93] presented a qualitative study that aimed to examine the acceptance and user experience of the referred application promoting physical activity.

3.2.7. Data Analytics

Concerning the application of data analytics, three articles [74,90,92] were identified. The studies aimed to process data to determine activities and behaviors of older adults in the urban space.

The study presented in [74] adopts a smartphone-based mobile application as a tool to better understand the daily activity of older adults. Using the smartphone sensor information collected through the mobile application, the authors intended to prove that it is possible to identify the points of interest of older adults in Singapore.

In turn, in the study reported by [90], a large volume of smart card data was used to determine the public transport travel behavior of older adults in Beijing, China, that were classified as long, medium, and short bus-travelers considering their objective mobility characteristics. According to the authors, the findings might be used to tailored mobility policies of the cities.

The research reported in [92] aimed to understand the older adults' means of traveling considering contextual data and data coming from the smartphones. The correct classification of transportation can be also used for providing suggestions in the context of public or private transportation.

3.3. Types of Data Being Used

Since smart city technological platforms aim to promote automated and intelligent processes based on the analysis of vast quantities of data, data gathering is an important issue for the proposed applications. According to the included studies, the data acquired from the smart city infrastructure were complemented with continuous data gathered by personal sensors that are gradually being pushed into the market (Table 4).

Table 4. Types of data being used by the proposed applications.

Types of Sensors	NotSpecified	Location	Movement and Speed	Using Transport	Physiological Parameters	Points of Interest	Presence of Vehicles	Air Quality	Weather Conditions	Illumination
Smartphone's sensors										
Unspecified	[68]	[92]	[73,77,92]		[93]					
Gyroscopes and accelerometers			[70,71]							
Global Positioning System		[79,80,82,87,88]	[70,71,73,77,93]	[73,77]		[73,74,76,77]				
Bluetooth Low Energy beacons			[73,77]	[73,77]		[73,76,77]				
Wearables										
Body Area Network		[72]			[73,79,80,87,88]					
Smartwatch					[84,94]					
Sensors of deployed in the cities										
Unspecified	[68]		[70]					[75,80,88]	[75,80,88]	[80]
Magnetic sensors							[69]			
Radio-Frequency Identification		[71,82]								
QR-Code						[76]				

As shown in Figure 5, 18 of the examined articles indicated the use of personal sensors or sensors from the smart city infrastructures to gather different types of data. Sixteen articles referred to the use of personal sensors (e.g., sensors deployed in the older adults' smartphones or wearables), and nine articles referred to the use of sensors deployed in the city. Only seven articles referred to the use of both personal sensors and sensors from the smart city structure.

Looking at the technological details presented by the articles, ten articles considered the concept of IoT, although just two articles referred to the protocols being used. Mechanisms to aggregate data from different sensors and to guarantee the quality of these data were presented in two articles, while five articles mentioned the need for data interoperability, although just one referred to how interoperability can be achieved.

In turn, 16 articles referred to concerns related to the privacy, integrity and confidentiality of the data gathered by personal sensors, but only one described the implementation of mechanisms for data protection.

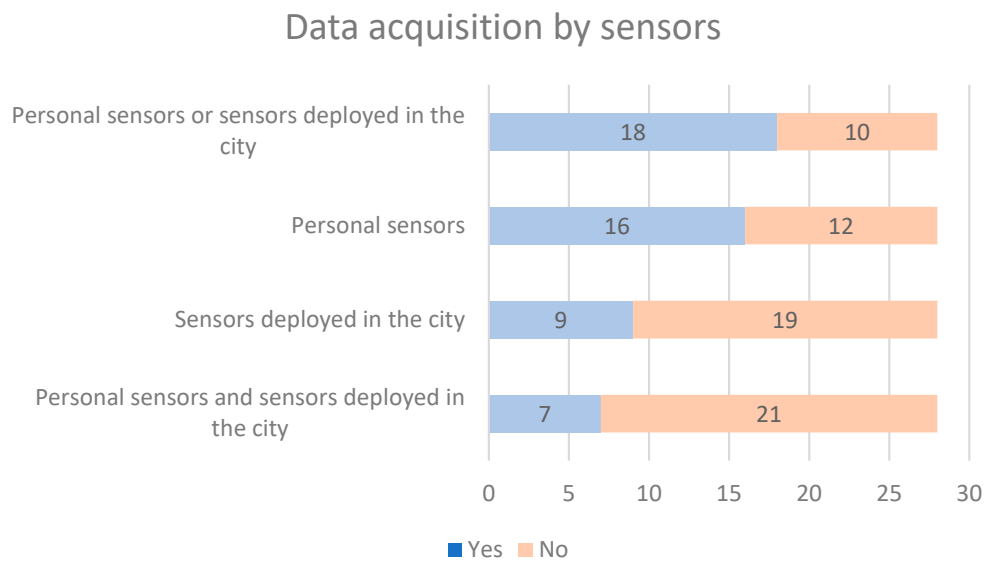


Figure 5. Number of articles reporting data gathered by personal sensors and sensors deployed in the city.

In addition to the data gathered by the sensors, several articles reported the integration of open data from the smart city (Table 5), namely publicly available accessibility information [68], transport infrastructures [68–71,73,77,78], real-time data about public transport [70,71] and points of interest in the city [76].

Table 5. Open data from the smart city.

Type of Data	References
Accessibility of the city	[68]
Transport infrastructures	
Roads	[85]
Parking	[69,71]
Public transport	[68,70,71,73,77]
Scheduled data (e.g., buses)	[70,71]
Shared transport	[71]
Real-time transport data	
Real-time data of public transport	[70,71]
Touristic features	[76]

Moreover, seven articles [70,71,74,75,86,91,95] reported the implementation of crowdsourcing mechanisms (Table 6).

Table 6. Articles reporting crowdsourcing.

References	Aims
[70]	To determine urban accessibility (i.e., barriers and facilities).
[71]	To determine urban accessibility (i.e., barriers and facilities).
[74]	To identify the points of interest among the older adults.
[75]	To determine the route's status.
[86]	To identify recommended places.
[91]	To determine problems of walking environments.
[95]	To support the coverage of individuals with disabilities.

3.4. Maturity Level

In terms of the development of applications, it is important distinguish the different development phases, each one with a different maturity level (e.g., requirements,

analysis, design and implementation, testing, and evolution or maintenance). As can be seen in Table 7 and Figure 6, a significant percentage of the included studies aiming to develop smart cities' applications to support the mobility of older adults were still in an early development phase (i.e., description of concepts or architectures). In turn, 11 articles [72,74,76,81,82,85,86,90,92,93,95] reported proof-of concept prototypes. Four of these articles [76,86,93,95] reported the participation of older adults for the qualitative evaluation of the prototypes, although the measured outcomes were poorly described, and the number of participants was small. Finally, one article [94] reported the assessment of prototypes in a real-life scenario.

Table 7. Maturity level of the proposed solutions.

Maturity Level	References
Concepts for further development	[77,78,80,83,91]
Architectures	[68–71,73,75,79,84,87–89]
Proof-of-concept prototypes	[72,74,76,81,82,85,86,90,92,93,95]
Assessments in real-life scenarios	[94]

Number of articles by maturity level and years

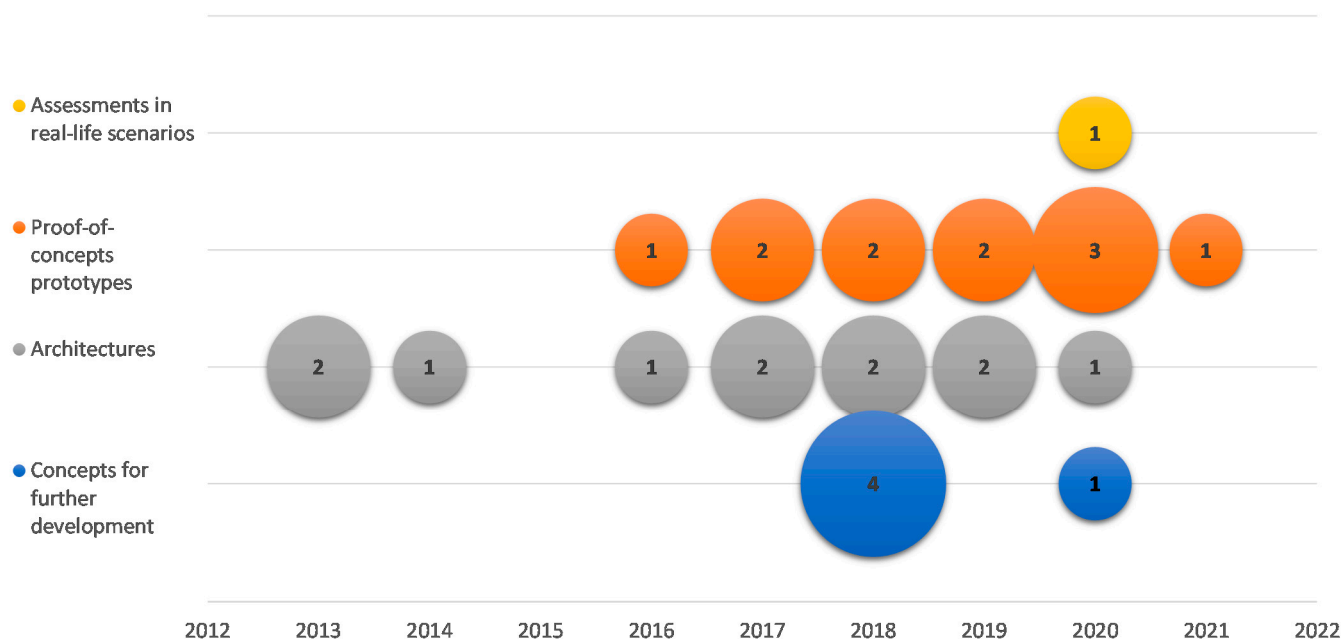


Figure 6. Number of articles by maturity level and years.

In the study reported in article [94], which aimed to develop a wearable biosensor and hotspot analysis-based framework to continuously monitor the older adults' stressful interactions with the built environment, it was conducted a pilot. Thirty older adults participated in various types of data collection, including controlled route and daily trips, so that stress hotspots could be identified. As a result, the authors concluded that hotspot analysis with wearable biosensors can detect spatiotemporal stressful interactions between the older adults and the built environment.

4. Discussion

Looking for the first research question (i.e., the relevant smart city applications to facilitate the mobility of older adults), seven application domains emerged from this systematic review: (i) requirements and development platforms (three articles); (ii) accessibility (two articles); (iii) localization (three articles); (iv) mobility assistance (five articles); (v) health

conditions monitoring (four articles); (vi) promotion of healthy lifestyles (eight articles); and (vii) data analytics (three articles).

These results are in line with current concerns related to the improvement of environmental factors [9], including urban infrastructure and services, to facilitate active ageing [10,11] and the promotion of the wellbeing of older adults [99], and show that smart cities, if well-equipped to address the needs of their older adults, might facilitate their mobility [10,11].

In terms of the type of data being used by the proposed applications (i.e., the second research question), the different articles reported the use of data acquired from the smart city infrastructure, such as air quality, weather conditions, or light conditions and open data available in the smart city databases, namely static data (e.g., city accessibility, transport infrastructures and touristic points of interest), and real-time data about public transport. On the other hand, sensors deployed in the older adults' smartphones and wearables were used to acquire continuous monitoring data to determine localization, movement, speed, points of interest, or utilization of public transport, as well as to monitor physiological parameters. Moreover, one fourth of the articles reported the implementation of crowdsensing mechanisms.

Using sensors to constantly monitor individuals has the potential to put them at risk. Therefore, secure data transmission and the guarantee that the stored data would only be accessed by individuals who are authorized are important requirements [39–41]. If these requirements are not satisfied, data such as the location of an individual at a given time might be used for nefarious purposes (e.g., to know when and for how long the individuals are out of their homes). Despite the importance of data privacy, integrity, and confidentiality, just one of the included articles described mechanisms to guarantee data protection. This can be considered a major barrier for the dissemination of the applications being developed and future work must pay special attention to privacy and security issues when using emerging sensor technologies.

Considering the need to use huge amounts of data from different sources, interoperability and data quality, standardization and aggregation are key aspects [46]. However, these aspects are almost absent in the studies reported by the included articles, which also negatively impacts the dissemination of the applications.

Concerning the maturity level of the applications being reported (i.e., the third research question), most of the included articles generally tended to describe technological solutions, which were still far from consolidated solutions.

Twenty-seven articles proposed concepts for further development, defined architectures, or presented prototypes that were developed to demonstrate the feasibility of the concepts. Four articles reported the participation of older adults in the evaluation of the prototypes, although the experimental setups had limitations in terms of the measured outcomes, and the number of participants. Only one article reported the assessment of the proposed application in a real-life scenario. It is worth emphasizing the importance of going beyond technological determinism and, accordingly, to consider the impact on the target users.

This low maturity level is an important drawback when comparing the included studies with similar research using different approaches. For instance, in terms of the monitoring of health conditions and the promotion of healthy lifestyles, the scientific literature reports relevant research studies based on robust methods and involving a significant number of participants to assess the impact of mobile health applications (e.g., [100,101]).

Therefore, concerning the fourth research question (i.e., what are the barriers for the dissemination of the solutions that were identified?), it is possible to conclude that the lack of assessment in real-life scenarios, together with a set of unsolved aspects related to the data being used (i.e., data privacy, integrity, and confidentiality, data interoperability, data aggregation, and data quality) constitute major barriers for the dissemination of smart cities' applications to facilitate the mobility of older adults.

5. Conclusions

The study reported by this article aimed to review smart city applications to facilitate the mobility of older adults. Relevant application domains were identified, including requirements and development platforms, accessibility, localization, mobility assistance, health conditions monitoring, promotion of healthy lifestyles, and data analytics.

The results show that there is an ongoing effort to take advantage of the smart cities' paradigm to make cities more age-friendly by facilitating the mobility of older adults, namely by using a diversity of sensing data provided by a broad range of sensors. However, issues such as user privacy, data standardization and integration, and sensors' characteristics were poorly addressed. The results also show that there is a lack of maturity of the developed applications, which constitutes a major barrier to their dissemination. Moreover, it is foreseen that the number of articles related to the topic will increase in the future, since the research effort increased over the years: the oldest articles that were included were published in 2013 and more than two-thirds of the included articles were published in the last four years.

According to the study protocol (e.g., search keywords and inclusion and exclusion criteria) this review only considered the research related to smart cities' applications specifically focused on facilitating the mobility of older adults. However, older adults constitute a heterogeneous population group with different needs, life experiences, expectations, and personal factors, which means that, when needed, there are older adults able to use applications developed for the general population. In this respect, one of the limitations of this study is related to the fact that there are other smart cities' applications and services developed for the general population that can be used by older adults to facilitate their mobility (e.g., pedestrian mobility [102], multi-modal routes' support [103], smart parking [54], traffic management [104], assistance to drivers [105,106], intelligent transport systems [25,105,106], or mobility as a service [38,58]). Moreover, it should be noted that this review did not consider other possible studies aiming to facilitate the mobility of older adults without being supported in smart city infrastructures, nor articles whose primary focus was not the use of IT (e.g., [107]). Additionally, the review did not consider articles published after March 2021.

Moreover, it is always possible to point out limitations about both the chosen keywords and the databases that were used in the research. Likewise, since most articles were published in conference proceedings, there will certainly be similar articles that have not been included because they were presented in non-indexed conferences. It should also be noted that the grey literature was not considered in this review and that this can be seen as a gap of some significance.

Despite these limitations, in methodological terms, the authors tried to follow rigorous procedures for the articles' selection and data extraction, so that the results are relevant for identifying IT-based applications requiring smart cities' infrastructures to facilitate the mobility of older adults, which may contribute to future developments.

Based on the findings of this systematic literature review, it is possible to conclude that most of the identified studies supported older adults' requirements, which means that there is a trend in the research of practical solutions. However, only one article reported an experimental set-up to assess the proposal solution in a real-life scenario. The remainder articles proposed concepts, architectures, and proof-of-concept prototypes. Four proof-of-concept prototypes were validated by older adults, but the respective experimental designs exhibit limitations.

The technological solutions should respond to user needs and not the other way around. As such, it is possible to conclude that the assessment of the smart cities' applications should be emphasized, as well as the use of robust methodological approaches. Robust evidence is required to show that new developments are valid, reliable, cost-effective, and able to make a difference. Collecting this evidence requires considerable resources to integrate new applications into real life conditions, to be used by many users for long periods of time [108].

Since this review identified a research trend to develop practical solutions and a considerable investment is being made to bring together smart city stakeholders, including industry, to create market-ready solutions [19], the low maturity level of the developments is a major gap on the current research related to IT-based applications requiring smart cities' infrastructures to facilitate the mobility of older adults.

Together with sustainable and environmentally friendly mobility, mobility-as-a-service, traffic management, namely using different data analytics techniques [33–37], and autonomous vehicles are important concerns in the current smart mobility research [57]. Surprisingly, these topics are almost absent in the set of the included studies. Moreover, other relevant topics of the smart cities' research, such as user privacy, data standardization and integration, IoT implementation, and sensors' characteristics, are poorly addressed by the included studies. Therefore, according to the results, another research gap emerged, which is related to the difficulty of incorporating into the specific topic of this systematic review, the knowledge generated by the research related to other topics related to smart cities. Since smart cities are digital ecosystems resulting from a combination of business models and innovation to transform the cities' processes, structures, and strategies [38], researchers should consider these ecosystems to promote a comprehensive view and to take advantage of all relevant smart cities' developments.

After this systematic review, it is possible to conclude that some attention should be given to the fact that the total number of included articles is not very representative within the total number of articles related to smart cities. Furthermore, most of the included articles were published in conference proceedings. Therefore, the implementation of smart cities is still not largely imbued within the active ageing domain, as can be seen in other topics (e.g., AAL [15–17]). Therefore, IT-based applications requiring smart cities' infrastructure to facilitate the mobility of older adults still represent a relevant research opportunity.

Author Contributions: Conceptualization, N.P.R.; writing—original draft preparation, N.P.R.; writing—review and editing, N.P.R., R.B., J.P., G.S., M.R., C.R., A.Q. and A.D.; investigation, N.P.R., R.B., J.P., G.S., M.R., C.R., A.Q. and A.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was partially funded by Fundação para a Ciência e a Tecnologia in the scope of the project UID/CEC/00127/2021.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: N.P.R., M.R., and A.Q. were authors of some included studies, but they did not analyze these studies. The authors declare no other conflict of interest.

References

1. World Health Organization. *Decade of Healthy Ageing: Baseline Report*; WHO: Geneva, Switzerland, 2020.
2. World Health Organization. *Global Report on Ageism*; WHO: Geneva, Switzerland, 2021.
3. Sixsmith, A.; Sixsmith, J. Ageing in place in the United Kingdom. *Ageing Int.* **2008**, *32*, 219–235. [\[CrossRef\]](#)
4. World Health Organization. *Active Ageing: A Policy Framework*; WHO: Geneva, Switzerland, 2002.
5. World Health Organization. *A Glossary of Terms for Community Health Care and Services for Older Persons*; WHO: Geneva, Switzerland, 2004.
6. Havighurst, R.J. Successful aging. *Process Aging Soc. Psychol. Perspect.* **1963**, *1*, 299–320.
7. Rowe, J.W.; Kahn, R.L. Successful Aging. *Gerontologist* **1997**, *37*, 433–440. [\[CrossRef\]](#)
8. Cosco, T.D.; Prina, A.M.; Perales, J.; Stephan, B.C.M.; Brayne, C. Operational definitions of successful aging: A systematic review. *Int. Psychogeriatr.* **2014**, *26*, 373. [\[CrossRef\]](#)
9. Annear, M.; Keeling, S.; Wilkinson, T.I.M.; Cushman, G.; Gidlow, B.O.B.; Hopkins, H. Environmental influences on healthy and active ageing: A systematic review. *Ageing Soc.* **2014**, *34*, 590–622. [\[CrossRef\]](#)
10. OECD. *Ageing in Cities*; OECD Publishing: Paris, France, 2015.
11. World Health Organization. *Global Age-Friendly Cities: A Guide*; World Health Organization: Geneva, Switzerland, 2007.

12. Buffel, T.; Phillipson, C. Can global cities be ‘age-friendly cities’? Urban development and ageing populations. *Cities* **2016**, *55*, 94–100. [\[CrossRef\]](#)
13. World Health Organization. *Age-Friendly Environments in Europe*; A handbook of domains for policy action; WHO Regional Office for Europe: Copenhagen, Denmark, 2017.
14. Van Hoof, J.; Kazak, J.K.; Perek-Białas, J.M.; Peek, S. The challenges of urban ageing: Making cities age-friendly in Europe. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2473. [\[CrossRef\]](#) [\[PubMed\]](#)
15. Dobre, C.; Mavromoustakis, C.X.; Garcia, N.M.; Mastorakis, G.; Goleva, R.I. Introduction to the AAL and ELE Systems. In *Ambient Assisted Living and Enhanced Living Environments*; Elsevier: Amsterdam, The Netherlands, 2017; pp. 1–16.
16. Van Grootven, B.; van Achterberg, T. The European Union’s Ambient and Assisted Living Joint Programme: An evaluation of its impact on population health and well-being. *Health Inform. J.* **2019**, *25*, 27–40. [\[CrossRef\]](#) [\[PubMed\]](#)
17. Stara, V.; Rossi, L.; Borrelli, G. Medical and para-medical personnel’ perspectives on home health care technology. *Informatics* **2017**, *4*, 14. [\[CrossRef\]](#)
18. Santinha, G.; Dias, A.; Rodrigues, M.; Queirós, A.; Rodrigues, C.; Rocha, N.P. How Do Smart Cities Impact on Sustainable Urban Growth and on Opportunities for Entrepreneurship? Evidence from Portugal: The Case of Águeda. In *New Paths of Entrepreneurship Development*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 31–53.
19. Allwinkle, S.; Cruickshank, P. Creating smarter cities: An overview. *J. Urban Technol.* **2011**, *18*, 1–16. [\[CrossRef\]](#)
20. Marcos-Pablos, S.; García-Peñalvo, F.J. Technological ecosystems in care and assistance: A systematic literature review. *Sensors* **2019**, *19*, 708. [\[CrossRef\]](#)
21. Vanolo, A. Smartmentality: The smart city as disciplinary strategy. *Urban Stud.* **2014**, *51*, 883–898. [\[CrossRef\]](#)
22. Papa, E.; Lauwers, D. Smart mobility: Opportunity or threat to innovate places and cities. In Proceedings of the 20th international conference on urban planning and regional development in the information society (REAL CORP 2015), Gent, Belgium, 5–7 May 2015; pp. 543–550.
23. Assembly, G. *United Nations: Transforming Our World: The 2030 Agenda for Sustainable Development*; UN: New York, NY, USA, 2015.
24. Benevolo, C.; Dameri, R.P.; D’auria, B. Smart mobility in smart city. In *Empowering Organizations*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 13–28.
25. Mangiaracina, R.; Perego, A.; Salvadori, G.; Tumino, A. A comprehensive view of intelligent transport systems for urban smart mobility. *Int. J. Logist. Res. Appl.* **2017**, *20*, 39–52. [\[CrossRef\]](#)
26. Sumalee, A.; Ho, H.W. Smarter and more connected: Future intelligent transportation system. *Int. J. Res.* **2018**, *42*, 67–71. [\[CrossRef\]](#)
27. Pauer, G. Development potentials and strategic objectives of intelligent transport systems improving road safety. *Transp. Telecommun. J.* **2017**, *18*, 15–24. [\[CrossRef\]](#)
28. Reagan, I.J.; Cicchino, J.B.; Kerfoot, L.B.; Weast, R.A. Crash avoidance and driver assistance technologies—Are they used? *Transp. Res. Part F Traffic Psychol. Behav.* **2018**, *52*, 176–190. [\[CrossRef\]](#)
29. Tosi, D.; Marzorati, S. Big data from cellular networks: Real mobility scenarios for future smart cities. In Proceedings of the 2016 IEEE second international conference on big data computing service and applications (BigDataService), Oxford, UK, 29 March–1 April 2016; pp. 131–141.
30. Calabrese, F.; Colonna, M.; Lovisolo, P.; Parata, D.; Ratti, C. Real-time urban monitoring using cell phones: A case study in Rome. *IEEE Trans. Intell. Transp. Syst.* **2010**, *12*, 141–151. [\[CrossRef\]](#)
31. Frank, L.; Kavage, S.; Litman, T. *Promoting Public Health through Smart Growth: Building Healthier Communities through Transportation and Land Use Policies and Practices*; Smart Grow BC: Vancouver, BC, Canada, 2006.
32. Bencardino, M.; Greco, I. Smart communities. Social innovation at the service of the smart cities. *TeMA-J. Land Use Mobil. Environ.* **2014**. [\[CrossRef\]](#)
33. Moustaka, V.; Vakali, A.; Anthopoulos, L.G. A systematic review for smart city data analytics. *ACM Comput. Surv.* **2018**, *51*, 1–41. [\[CrossRef\]](#)
34. Brohi, S.N.; Bamiah, M.; Brohi, M.N. Big data in Smart Cities: A systematic mapping review. *J. Eng. Sci. Technol.* **2018**, *13*, 2246–2270.
35. Souza, J.T.d.; Francisco, A.C.d.; Piekarski, C.M.; Prado, G.F.d. Data mining and machine learning to promote smart cities: A systematic review from 2000 to 2018. *Sustainability* **2019**, *11*, 1077. [\[CrossRef\]](#)
36. Soomro, K.; Bhutta, M.N.M.; Khan, Z.; Tahir, M.A. Smart city big data analytics: An advanced review. *Wiley Interdiscip. Rev. Data Min. Knowl. Discov.* **2019**, *9*, e1319. [\[CrossRef\]](#)
37. Kong, L.; Liu, Z.; Wu, J. A systematic review of big data-based urban sustainability research: State-of-the-science and future directions. *J. Clean. Prod.* **2020**, *273*, 123142. [\[CrossRef\]](#)
38. Anthony Jnr, B. Managing digital transformation of smart cities through enterprise architecture—A review and research agenda. *Enterp. Inf. Syst.* **2020**, *15*, 1–33. [\[CrossRef\]](#)
39. Ahmed, S.; Shah, M.A.; Wakil, K. Blockchain as a Trust Builder in the Smart City Domain: A Systematic Literature Review. *IEEE Access* **2020**, *8*, 92977–92985. [\[CrossRef\]](#)
40. Laufs, J.; Borrión, H.; Bradford, B. Security and the smart city: A systematic review. *Sustain. Cities Soc.* **2020**, *55*, 102023. [\[CrossRef\]](#)
41. Machin, J.; Batista, E.; Martínez-Ballesté, A.; Solanas, A. Privacy and Security in Cognitive Cities: A Systematic Review. *Appl. Sci.* **2021**, *11*, 4471. [\[CrossRef\]](#)

42. Liao, B.; Ali, Y.; Nazir, S.; He, L.; Khan, H.U. Security analysis of IoT devices by using mobile computing: A systematic literature review. *IEEE Access* **2020**, *8*, 120331–120350. [\[CrossRef\]](#)
43. Yu, Z.; Song, L.; Jiang, L.; Sharafi, O.K. Systematic literature review on the security challenges of blockchain in IoT-based smart cities. *Kybernetes* **2021**. ahead-of-print. [\[CrossRef\]](#)
44. Lee, E.; Seo, Y.-D.; Oh, S.-R.; Kim, Y.-G. A Survey on Standards for Interoperability and Security in the Internet of Things. *IEEE Commun. Surv. Tutor.* **2021**, *23*, 1020–1047. [\[CrossRef\]](#)
45. Hajjaji, Y.; Boulila, W.; Farah, I.R.; Romdhani, I.; Hussain, A. Big data and IoT-based applications in smart environments: A systematic review. *Comput. Sci. Rev.* **2021**, *39*, 100318. [\[CrossRef\]](#)
46. De Nicola, A.; Villani, M.L. Smart City Ontologies and Their Applications: A Systematic Literature Review. *Sustainability* **2021**, *13*, 5578. [\[CrossRef\]](#)
47. Pacheco Rocha, N.; Dias, A.; Santinha, G.; Rodrigues, M.; Queirós, A.; Rodrigues, C. Smart cities and healthcare: A systematic review. *Technologies* **2019**, *7*, 58. [\[CrossRef\]](#)
48. Buttazzoni, A.; Veenhof, M.; Minaker, L. Smart City and High-Tech Urban Interventions Targeting Human Health: An Equity-Focused Systematic Review. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2325. [\[CrossRef\]](#)
49. da Rosa Tavares, J.E.; Victória Barbosa, J.L. Ubiquitous healthcare on smart environments: A systematic mapping study. *J. Ambient Intell. Smart Environ.* **2020**, *12*, 1–17. [\[CrossRef\]](#)
50. Kim, H.; Choi, H.; Kang, H.; An, J.; Yeom, S.; Hong, T. A systematic review of the smart energy conservation system: From smart homes to sustainable smart cities. *Renew. Sustain. Energy Rev.* **2021**, *140*, 110755. [\[CrossRef\]](#)
51. Clarinval, A.; Simonofski, A.; Vanderose, B.; Dumas, B. Public displays and citizen participation: A systematic literature review and research agenda. *Transform. Gov. People Process Policy* **2020**, *15*, 1–35. [\[CrossRef\]](#)
52. Purnomo, F.; Prabowo, H. Smart city indicators: A systematic literature review. *J. Telecommun. Electron. Comput. Eng.* **2016**, *8*, 161–164.
53. Zannat, K.E.; Choudhury, C.F. Emerging big data sources for public transport planning: A systematic review on current state of art and future research directions. *J. Indian Inst. Sci.* **2019**, *99*, 601–619. [\[CrossRef\]](#)
54. Barriga, J.J.; Sulca, J.; León, J.L.; Ulloa, A.; Portero, D.; Andrade, R.; Yoo, S.G. Smart parking: A literature review from the technological perspective. *Appl. Sci.* **2019**, *9*, 4569. [\[CrossRef\]](#)
55. Nagy, S.; Csiszár, C. The Quality of Smart Mobility: A Systematic Review. *Sci. J. Sil. Univ. Technol.* **2020**, *109*, 117–127.
56. El-Taher, F.E.-Z.; Taha, A.; Courtney, J.; McKeever, S. A systematic review of urban navigation systems for visually impaired people. *Sensors* **2021**, *21*, 3103. [\[CrossRef\]](#) [\[PubMed\]](#)
57. Paiva, S.; Ahad, M.A.; Tripathi, G.; Feroz, N.; Casalino, G. Enabling Technologies for Urban Smart Mobility: Recent Trends, Opportunities and Challenges. *Sensors* **2021**, *21*, 2143. [\[CrossRef\]](#) [\[PubMed\]](#)
58. Butler, L.; Yigitcanlar, T.; Paz, A. Barriers and risks of Mobility-as-a-Service (MaaS) adoption in cities: A systematic review of the literature. *Cities* **2020**, *109*, 103036. [\[CrossRef\]](#)
59. Torku, A.; Chan, A.P.C.; Yung, E.H.K. Implementation of age-friendly initiatives in smart cities: Probing the barriers through a systematic review. *Built Environ. Proj. Asset Manag.* **2020**. ahead-of-print. [\[CrossRef\]](#)
60. Ivan, L.; Beu, D.; van Hoof, J. Smart and Age-Friendly Cities in Romania: An Overview of Public Policy and Practice. *Int. J. Environ. Res. Public Health* **2020**, *17*, 5202. [\[CrossRef\]](#) [\[PubMed\]](#)
61. Ziganshina, L.E.; Yudina, E.V.; Talipova, L.I.; Sharafutdinova, G.N.; Khairullin, R.N. Smart and age-friendly cities in Russia: An exploratory study of attitudes, perceptions, quality of life and health information needs. *Int. J. Environ. Res. Public Health* **2020**, *17*, 9212. [\[CrossRef\]](#)
62. Podgórnjak-Krzykacz, A.; Przywojska, J.; Wiktorowicz, J. Smart and Age-Friendly Communities in Poland. An Analysis of Institutional and Individual Conditions for a New Concept of Smart Development of Ageing Communities. *Energies* **2020**, *13*, 2268. [\[CrossRef\]](#)
63. Baraković, S.; Baraković Husić, J.; van Hoof, J.; Krejcar, O.; Maresova, P.; Akhtar, Z.; Melero, F.J. Quality of life framework for personalised ageing: A systematic review of ICT solutions. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2940. [\[CrossRef\]](#) [\[PubMed\]](#)
64. Loos, E.; Sourbati, M.; Behrendt, F. The Role of Mobility Digital Ecosystems for Age-Friendly Urban Public Transport: A Narrative Literature Review. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7465. [\[CrossRef\]](#)
65. Zanwar, P.; Kim, J.; Kim, J.; Manser, M.; Ham, Y.; Chaspari, T.; Ahn, C.R. Use of Connected Technologies to Assess Barriers and Stressors for Age and Disability-Friendly Communities. *Front. Public Health* **2021**, *9*, 578832. [\[CrossRef\]](#)
66. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G.; Group, P. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Ann. Intern. Med.* **2009**, *151*, 264–269. [\[CrossRef\]](#) [\[PubMed\]](#)
67. Ghapanchi, A.H.; Aurum, A. Antecedents to IT personnel's intentions to leave: A systematic literature review. *J. Syst. Softw.* **2011**, *84*, 238–249. [\[CrossRef\]](#)
68. López-de-Ipiña, D.; Klein, B.; Vanhecke, S.; Pérez-Velasco, J. Towards ambient assisted cities and citizens. In Proceedings of the 2013 27th International Conference on Advanced Information Networking and Applications Workshops, Barcelona, Spain, 25–28 March 2013; pp. 1343–1348.
69. Lambrinos, L.; Dosis, A. DisAssist: An internet of things and mobile communications platform for disabled parking space management. In Proceedings of the 2013 IEEE Global Communications Conference (GLOBECOM), Atlanta, GA, USA, 9–13 December 2013; pp. 2810–2815.

70. Mirri, S.; Prandi, C.; Salomoni, P.; Callegati, F.; Campi, A. On combining crowdsourcing, sensing and open data for an accessible smart city. In Proceedings of the 2014 Eighth International Conference on Next Generation Mobile Apps, Services and Technologies, Oxford, UK, 10–12 September 2014; pp. 294–299.
71. Mirri, S.; Prandi, C.; Salomoni, P.; Callegati, F.; Melis, A.; Prandini, M. A service-oriented approach to crowdsensing for accessible smart mobility scenarios. *Mob. Inf. Syst.* **2016**, *2016*, 2821680. [\[CrossRef\]](#)
72. Liouane, Z.; Lemlouma, T.; Roose, P.; Weis, F.; Messaoud, H. A genetic-based localization algorithm for elderly people in smart cities. In Proceedings of the Proceedings of the 14th ACM International Symposium on Mobility Management and Wireless Access, Valletta, Malta, 2–6 November 2016; pp. 83–89.
73. de los Ríos Pérez, S.; Castrillo, M.P.; Abril-Jiménez, P.; Montalvá-Colomer, J.B.; Cabrera-Umpiérrez, M.F.; Waldmeyer, M.T.A. An architecture for combining open-data with sensors' data for effective prevention of MCI and frailty in elderly people. In Proceedings of the 2017 IEEE 3rd International Forum on Research and Technologies for Society and Industry (RTSI), Modena, Italy, 11–13 September 2017; pp. 1–5.
74. Hasala, M.S.; Pik Lik Lau, B.; Kadaba, V.S.; Balasubramaniam, T.; Yuen, C.; Yuen, B.; Nayak, R. Identifying points of interest for elderly in Singapore through mobile crowdsensing. In *Proceedings of the 6th International Conference on Smart Cities and Green ICT Systems, Volume 1*; SCITEPRESS, Science and Technology Publications: Setúbal, Portugal, 2017; pp. 60–66.
75. Casino, F.; Patsakis, C.; Batista, E.; Borràs, F.; Martínez-Ballesté, A. Healthy routes in the smart city: A context-aware mobile recommender. *IEEE Softw.* **2017**, *34*, 42–47. [\[CrossRef\]](#)
76. Rodriguez-Sánchez, M.C.; Martinez-Romo, J. GAWA—Manager for accessibility Wayfinding apps. *Int. J. Inf. Manage.* **2017**, *37*, 505–519. [\[CrossRef\]](#)
77. Medrano-Gil, A.M.; de los Ríos Pérez, S.; Fico, G.; Montalvá Colomer, J.B.; Cea Sánchez, G.; Cabrera-Umpierrez, M.F.; Arredondo Waldmeyer, M.T. Definition of technological solutions based on the internet of things and smart cities paradigms for active and healthy ageing through cocreation. *Wirel. Commun. Mob. Comput.* **2018**, *2018*, 1949835. [\[CrossRef\]](#)
78. Ek, A.; Alexandrou, C.; Nyström, C.D.; Direito, A.; Eriksson, U.; Hammar, U.; Henriksson, P.; Maddison, R.; Lagerros, Y.T.; Löf, M. The Smart City Active Mobile Phone Intervention (SCAMPI) study to promote physical activity through active transportation in healthy adults: A study protocol for a randomised controlled trial. *BMC Public Health* **2018**, *18*, 1–11. [\[CrossRef\]](#) [\[PubMed\]](#)
79. Rodrigues, M.; Santos, R.; Queirós, A.; Silva, A.G.; Amaral, J.; Gonçalves, L.J.; Pereira, A.; da Rocha, N.P. Meet smartwalk, smart cities for active seniors. In Proceedings of the 2018 2nd International Conference on Technology and Innovation in Sports, Health and Wellbeing (TISHW), Thessaloniki, Greece, 20–22 June 2018; pp. 1–7.
80. Queirós, A.; Silva, A.G.; Simões, P.; Santos, C.; Martins, C.; da Rocha, N.P.; Rodrigues, M. Smartwalk: Personas and scenarios definition and functional requirements. In Proceedings of the 2018 2nd International Conference on Technology and Innovation in Sports, Health and Wellbeing (TISHW), Thessaloniki, Greece, 20–22 June 2018; pp. 1–7.
81. Chen, Y.; Sakamura, M.; Nakazawa, J.; Yonezawa, T.; Tsuge, A.; Hamada, Y. OmimamoriNet: An Outdoor Positioning System Based on Wi-SUN FAN Network. In Proceedings of the 2018 Eleventh International Conference on Mobile Computing and Ubiquitous Network (ICMU), Auckland, New Zealand, 5–8 October 2018; pp. 1–6.
82. Lin, Q.; Liu, X.; Wang, W. GPS Trajectories Based Personalized Safe Geofence for Elders with Dementia. In Proceedings of the 2018 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computing, Scalable Computing & Communications, Cloud & Big Data Computing, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI), Guangzhou, China, 8–12 October 2018; pp. 505–514.
83. Rodrigues, J.M.F.; Martins, M.; Sousa, N.; Rosa, M. IoE accessible bus stop: An initial concept. In Proceedings of the Proceedings of the 8th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion, Thessaloniki, Greece, 20–22 June 2018; pp. 137–143.
84. Bellagente, P.; Crema, C.; Depari, A.; Ferrari, P.; Flammini, A.; Lanfranchi, G.; Lenzi, G.; Maddiona, M.; Rinaldi, S.; Sisinni, E. Remote and non-invasive monitoring of elderly in a smart city context. In Proceedings of the 2018 IEEE sensors applications symposium (SAS), Seoul, Korea, 12–14 March 2018; pp. 1–6.
85. Amaral, J.; Rodrigues, M.; Gonçalves, L.J.; Teixeira, C. Customized Walk Paths for the Elderly. In Proceedings of the International Conference on Information Technology & Systems, Quito, Ecuador, 6–8 February 2019; Springer: Berlin/Heidelberg, Germany, 2019; pp. 754–763.
86. Vargas-Acosta, R.A.; Becerra, D.L.; Gurbuz, O.; Villanueva-Rosales, N.; Nunez-Mchiri, G.G.; Cheu, R.L. Smart Mobility for Seniors through the Urban Connector. In Proceedings of the 2019 IEEE International Smart Cities Conference (ISC2), Casablanca, Morocco, 14–17 October 2019; pp. 241–246.
87. Bastos, D.; Ribeiro, J.; Silva, F.; Rodrigues, M.; Santos, R.; Martins, C.; Rocha, N.; Pereira, A. Smartwalk mobile—a context-aware m-health app for promoting physical activity among the elderly. In Proceedings of the World Conference on Information Systems and Technologies; Springer: Berlin/Heidelberg, Germany, 2019; pp. 829–838.
88. Rodrigues, M.; Santos, R.; Queirós, A.; Silva, A.; Amaral, J.; Simoes, P.; Gonçalves, J.; Martins, C.; Pereira, A.; da Rocha, N.P. Supporting Better Physical Activity in a Smart City: A Framework for Suggesting and Supervising Walking Paths. *Adv. Sci. Technol. Eng. Syst. J.* **2019**, *4*, 404–413. [\[CrossRef\]](#)
89. Sourbati, M. Age and the City: The case of smart mobility. In Proceedings of the International Conference on Human-Computer Interaction, Copenhagen, Denmark, 19–24 July 2020; Springer: Berlin/Heidelberg, Germany, 2020; pp. 312–326.

90. Shi, Z.; Pun-Cheng, L.S.C.; Liu, X.; Lai, J.; Tong, C.; Zhang, A.; Zhang, M.; Shi, W. Analysis of the Temporal Characteristics of the Elderly Traveling by Bus Using Smart Card Data. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 751. [\[CrossRef\]](#)
91. An, D.; Wang, J.; Wang, P.; Yang, Y.; Pu, Y.; Ke, H.; Chen, Y. Beyond Walking: Improving Urban Mobility Equity in the Age of Information. In Proceedings of the International Conference on Applied Human Factors and Ergonomics, San Diego, CA, USA, 16–20 July 2020; Springer: Berlin/Heidelberg, Germany, 2020; pp. 204–209.
92. Badii, C.; Difino, A.; Paoli, I.; Paolucci, M.; Nesi, P. Classification of Users' Transportation Modalities in Real Conditions. In Proceedings of the DMSVIVA, Pittsburgh, PA, USA, 7–8 July 2020; pp. 74–81.
93. Lindqvist, A.-K.; Rutberg, S.; Söderström, E.; Ek, A.; Alexandrou, C.; Maddison, R.; Löf, M. User Perception of a Smartphone App to Promote Physical Activity Through Active Transportation: Inductive Qualitative Content Analysis Within the Smart City Active Mobile Phone Intervention (SCAMPI) Study. *JMIR mHealth uHealth* **2020**, *8*, e19380. [\[CrossRef\]](#)
94. Lee, G.; Choi, B.; Ahn, C.R.; Lee, S. Wearable Biosensor and Hotspot Analysis-Based Framework to Detect Stress Hotspots for Advancing Elderly's Mobility. *J. Manag. Eng.* **2020**, *36*, 4020010. [\[CrossRef\]](#)
95. Matos, C.M.; Matter, V.K.; Martins, M.G.; da Rosa Tavares, J.E.; Wolf, A.S.; Bittenbender, P.C.; Barbosa, J.L.V. Towards a Collaborative Model to Assist People with Disabilities and the Elderly People in Smart Assistive Cities. *JUCS J. Univers. Comput. Sci.* **2021**, *27*, 65. [\[CrossRef\]](#)
96. Shahin, M.; Liang, P.; Babar, M.A. A systematic review of software architecture visualization techniques. *J. Syst. Softw.* **2014**, *94*, 161–185. [\[CrossRef\]](#)
97. Dybå, T.; Dingsøyr, T. Empirical studies of agile software development: A systematic review. *Inf. Softw. Technol.* **2008**, *50*, 833–859. [\[CrossRef\]](#)
98. Yang, L.; Zhang, H.; Shen, H.; Huang, X.; Zhou, X.; Rong, G.; Shao, D. Quality Assessment in Systematic Literature Reviews: A Software Engineering Perspective. *Inf. Softw. Technol.* **2020**, *130*, 106397. [\[CrossRef\]](#)
99. Connelly, K.; Mokhtari, M.; Falk, T.H. Approaches to understanding the impact of technologies for aging in place: A mini-review. *Gerontology* **2014**, *60*, 282–288. [\[CrossRef\]](#) [\[PubMed\]](#)
100. Mao, Y.; Lin, W.; Wen, J.; Chen, G. Impact and efficacy of mobile health intervention in the management of diabetes and hypertension: A systematic review and meta-analysis. *BMJ Open Diabetes Res. Care* **2020**, *8*, e001225. [\[CrossRef\]](#) [\[PubMed\]](#)
101. Tong, H.L.; Quiroz, J.C.; Kocaballi, A.B.; Fat, S.C.; Dao, K.P.; Gehringer, H.; Chow, C.K.; Laranjo, L. Personalized mobile technologies for lifestyle behavior change: A systematic review, meta-analysis, and meta-regression. *Prev. Med.* **2021**, *24*, 106532. [\[CrossRef\]](#) [\[PubMed\]](#)
102. Carter, E.; Adam, P.; Tsakis, D.; Shaw, S.; Watson, R.; Ryan, P. Enhancing pedestrian mobility in smart cities using big data. *J. Manag. Anal.* **2020**, *7*, 173–188. [\[CrossRef\]](#)
103. Rocha, N.P.; Santinha, G.; Rodrigues, M.; Rodrigues, C.; Queirós, A.; Dias, A. Mobility Assistants to Support Multi-Modal Routes in Smart Cities: A Scoping Review. *J. Digit. Sci.* **2021**, *3*, 26–40. [\[CrossRef\]](#)
104. Skabardonis, A. Traffic management strategies for urban networks: Smart city mobility technologies. In *Transportation, Land Use, and Environmental Planning*; Elsevier: Amsterdam, The Netherlands, 2020.
105. Arena, F.; Pau, G.; Severino, A. An overview on the current status and future perspectives of smart cars. *Infrastructures* **2020**, *5*, 53. [\[CrossRef\]](#)
106. Mchergui, A.; Moulahi, T.; Othman, M.T.; Nasri, S. Enhancing VANETs broadcasting performance with mobility prediction for smart road. *Wirel. Pers. Commun.* **2020**, *112*, 1629–1641. [\[CrossRef\]](#)
107. Phannil, N.; Jettanasen, C. Design of a Personal Mobility Device for Elderly Users. *J. Healthc. Eng.* **2021**, *2021*, 8817115. [\[CrossRef\]](#)
108. Rashidi, P.; Mihailidis, A. A survey on ambient-assisted living tools for older adults. *IEEE J. Biomed. Health Inform.* **2012**, *17*, 579–590. [\[CrossRef\]](#) [\[PubMed\]](#)