applied sciences

MDPI

Review

Siting of Healthcare Care Facilities Based on the Purpose of Their Operation, Demographic Changes, Environmental Characteristics, and the Impact on Public Health

Marko Jausovec [1], Nande Korpnik [1], Branko Gabrovec [2] and Vanja Skalicky Klemencic [1,*]

[1] Faculty of Civil Engineering, Transportation Engineering and Architecture, University of Maribor, Smetanova 17, 2000 Maribor, Slovenia; marko.jausovec@um.si (M.J.); nande.korpnik@um.si (N.K.)
[2] Centre for Health Care, National Institute of Public Health Slovenia, Trubarjeva 2, 1000 Ljubljana, Slovenia; Branko.Gabrovec@nijz.si
* Correspondence: vanja.skalicky@um.si; Tel.: +386-(2)-22-94-705

Abstract: A contemporary approach to the spatial design of healthcare care facilities faces numerous challenges at the crossroads of multidisciplinary topics of architecture and urbanism, healthcare, security, and organisational sciences. Due to the unique combination of uses, users and architectural expression, they are defined as urban nodes. With their inclusion, architects facilitate a better placing of healthcare facilities, indirectly improving human health. The purpose of the article is to seek guidelines for the siting of healthcare facilities to provide suitable and equal healthcare to different social structures, and for the optimal and fair spatial distribution of healthcare services. The descriptive method was used to review literature on the siting of healthcare facilities based on the purpose of their operation, demographic changes, environmental characteristics, and the impact on public health. This method was selected as it facilitates data acquisition from various sources and a comprehensive understanding of the topic discussed. The results of the research show how important the impact of the healthcare care facilities siting on human health and the wider social significance of the topic discussed is. The findings may provide guidelines and proposals for future spatial decisions.

Keywords: healthcare facility location; healthcare facility location modelling; hospital geographic location; healthcare facility location planning; healthcare facility spatial planning

Citation: Jausovec, M.; Korpnik, N.; Gabrovec, B.; Klemencic, V.S. Siting of Healthcare Care Facilities Based on the Purpose of Their Operation, Demographic Changes, Environmental Characteristics, and the Impact on Public Health. *Appl. Sci.* **2022**, *12*, 379. https://doi.org/10.3390/app12010379

Academic Editors: Stefano Invernizzi and Stojan Kravanja

Received: 1 December 2021
Accepted: 29 December 2021
Published: 31 December 2021

1. Introduction

Providing suitable and equal healthcare to various layers of society, and an optimal and fair spatial distribution of healthcare services are among the crucial questions concerning social protection. The reason is that the optimal spatial distribution and evenly distributed healthcare services enable users to access healthcare services and improve the spatial distribution of hospitals on the basis of related standards and regulations. Therefore, locations when siting healthcare facilities should be suitably evaluated [1].

A poor siting of facilities could impair related services and increase costs, making decisions on the location of facilities crucial to the strategic concept of private and public organisations (e.g., commercial buildings, warehouses, airports, police stations, hospitals, etc.). Global trends have made healthcare and the related siting of healthcare facilities more critical and important for society than lower fertility, increased life expectancy, and related population ageing and environmental issues [2].

Several application models have been developed to determine location when planning healthcare services. For developing countries, they were reviewed by Rahman and Smith [3], who divided them into four categories: (i) seeking optimal locations; (ii) defining optimal locations in a new area; (iii) measuring the effectiveness of past decisions on locations; and (iv) improving existing location patterns.

A crucial factor promoting human health and enabling people to fully utilise the healthcare system is good access to healthcare, which is impacted by numerous factors, i.e., the scope of healthcare services; demand for healthcare; population health; demographic characteristics; socioeconomic status; and geographic impedance between the population and healthcare services [4]. However, the concept of healthcare accessibility is complicated, and difficult to define and measure.

Access to healthcare is a multidimensional concept. Therefore, both spatial and non-spatial parameters, which are part of two categories of healthcare access: potential and realised access [5], must be taken into account [6]. Potential access refers to people having direct access to these services on the basis of existing conditions, but does not warrant their use. Realised access based on potential access focuses on the actual use of services. Both types of access are divided into spatial and non-spatial access, depending on how access is affected by spatial (e.g., siting and distance or travel time) and non-spatial (e.g., socioeconomic status or cultural background) factors [7–11]. Differences in spatial access are due to the location, and the uneven distribution of the population and healthcare providers.

The siting of healthcare facilities is a process, which must take into account several stakeholders: patients, who need access to facilities, physicians, who strive for attractive and easily accessible workplaces, taxpayers, who require good value for their contributions, and politicians, who aim to attain their goals [12].

When seeking suitable locations for the siting of healthcare facilities, large amounts of data on spatial and location aspects must be collected, aggregated and analysed to correctly assess crucial factors. Such analyses make use of combinations of location and multiple-criteria models. As part of information technology, a geographic information system (GIS) set up to store, obtain, modify, analyse and form data is frequently used in organisations responsible for healthcare management worldwide at regional and local levels. The use of the GIS systems may be crucial to the optimal siting of healthcare facilities and their spatial accessibility [1,13].

In healthcare, incorrect siting seriously affects communities, as healthcare facilities that are difficult to access are connected with increased morbidity and mortality [2]. From this aspect, optimal siting in healthcare is more important than in other fields. As a result, decisions made in this relation are more significant and must be made systematically by taking into account the complete spatial context.

On the assumption of good public health as a priority source of sustainable development in general, it is necessary to design public space to reduce stress and anxiety, increase user satisfaction, and promote health in urban space [14]. When siting healthcare facilities in the wider space, it is also crucial to be aware of the positive effects of a well-designed immediate outdoor space, which significantly affects the patient treatment process. The design of outdoor spaces must take into account various elements, which may contribute to a healing environment with positive effects on the patients' well-being and the results of their treatment, while enhancing the general effectiveness of hospitals. Despite the fact that hospital design has been affected mainly by economic factors in the past century, leading to potential restorative benefits of their immediate surroundings being neglected, the recently developed and integrated healthcare systems are more focused on the patients' needs in terms of treatment and services in view of their satisfaction [15].

An important finding attributed to sensory perceptional stimulation in the treatment process of hospitalised patients increasingly prompts the designers of care and healthcare facilities to improve physical and environmental elements of 'nature', contributing to the regeneration of physical and emotional states of sick people. It is no coincidence that the basic design principles in the Asclepieia in ancient Greece included "*the insertion of facilities that will be used for care in areas strongly connected with nature, with the holy forest*", equipped with open spaces for leisure and physical activities, which have a psychological effect on patients. The design of hospital outdoor spaces must be fully integrated in the design of hospital indoor spaces [14].

2. Materials and Methods

Knowledge generation in the field of healthcare facility spatial allocation is accelerating at a fast pace, while staying fragmented and interdisciplinary at the same time. This makes keeping up with state-of-the-art and being at the forefront of research difficult, as well as assessing the collective evidence in this specific area of research. This is why the literature review as a research method is more relevant than ever. By integrating findings and perspectives from multiple empirical studies, a literature review can address research questions with a power that no single study can match [16]. Therefore a narrative review [17] was used to review the literature on the spatial location of health and social care facilities. This method allows data to be obtained from a variety of sources, thus providing a comprehensive understanding of the area under study.

In the research, we focused on analyses of scientific, expert and a cross-sectional review of articles and research on the siting of healthcare care facilities based on the purpose of their operation, demographic changes, environmental characteristics, and the impact on public health. Due to its changed demographic and increasing needs, architects, urban planners, and policy makers requires a critical analysis of the architecture of healthcare care facilities from the aspect of use and usability in the future. Literature was searched in three databases, i.e., Science Direct, Web of Science and PubMed. The total number of search results was 293,362 as shown in Table 1.

Table 1. The Siting of Healthcare Care Facilities Literature Selected.

	Keyword	No. of Results	Selected Results	Final Selection
ScinceDirect	Healthcare facility location	22,125	14	3
	Healthcare facility location modelling	83,953	11	1
	Hospital geographic location	83,060	16	0
	Healthcare facility location planning	50,438	13	1
	Healthcare facility spatial planning	13,745	24	3
WEB OF SCIENCE	Healthcare facility location	1561	8	1
	Healthcare facility location modelling	1820	7	1
	Hospital geographic location	2014	6	1
	Healthcare facility location planning	891	5	1
	Healthcare facility spatial planning	317	7	2
PUB MED	Healthcare facility location	19,564	16	4
	Healthcare facility location modelling	6372	7	0
	Hospital geographic location	3285	1	0
	Healthcare facility location planning	3340	21	1
	Healthcare facility spatial planning	877	17	4
Total		**29,362**	**173**	**23**

Another step of methodology following the Prisma diagram scheme, consists of different segments: Determination, Review, Suitability, and Inclusion (Figure 1) and overview of inclusion and exclusion of criterion (Table 2).

The Spatial Allocation of Healthcare Facilities Review

Literature was searched in three databases as already mentioned before, i.e., Science Direct, Web of Science and PubMed.

Following duplicate exclusion and taking into account the inclusion criteria, 23 articles were part of the final analysis.

To provide the reader with further information on the studies included in this review, the following Table 3 outlines the details of the author, the year of publication, purpose of research and key findings.

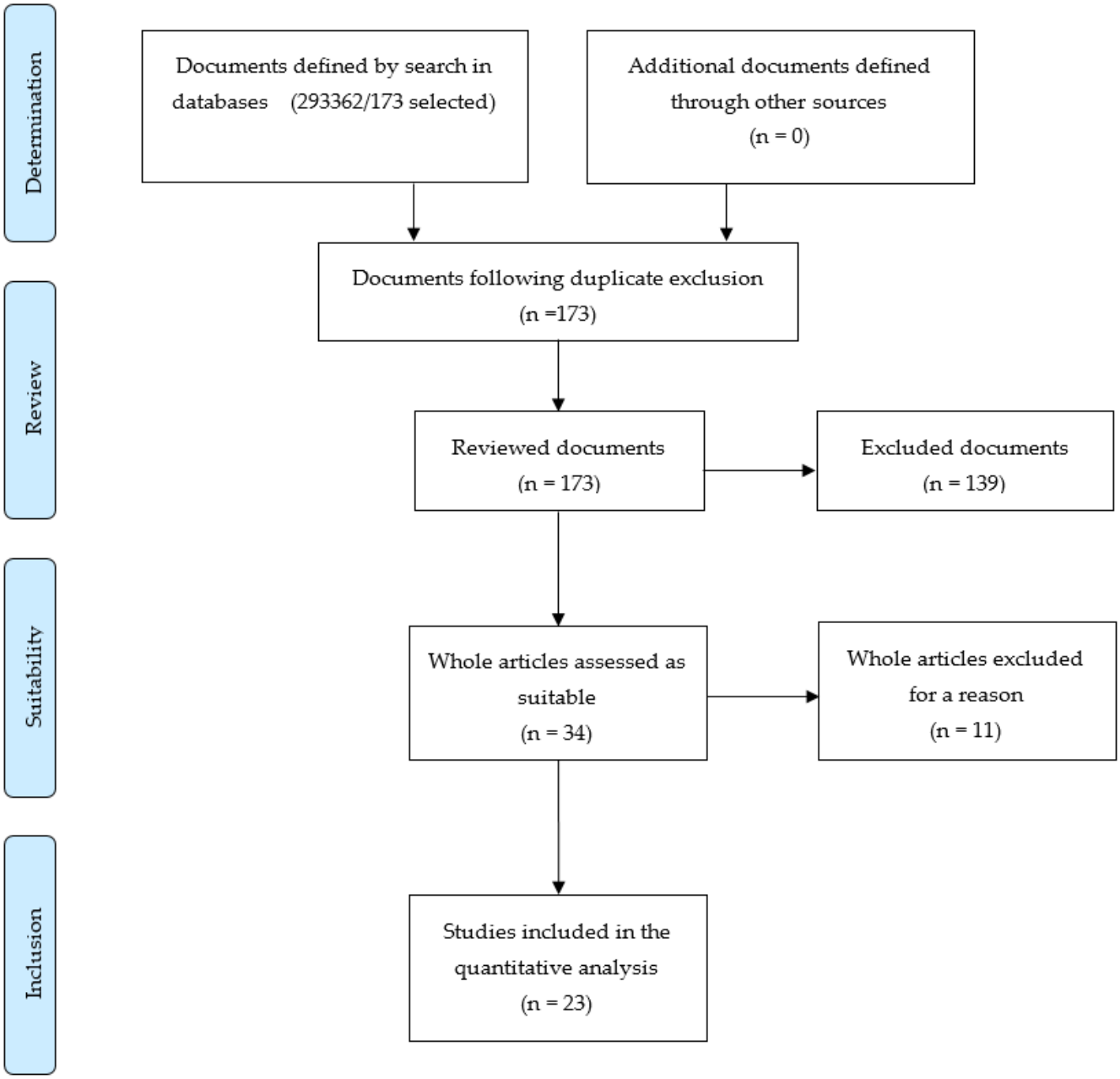

Figure 1. Adapted PRISMA diagram. PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Table 2. Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Published in Slovenian or English.	Not published in Slovenian or English.
Access to full text.	Access only to abstract or bibliographic data.
Original research scientific articles, monograph, review of a scientific article.	Discussion articles, academic articles, letters sent to the editorial office.
Thematic relevance.	Document not directly related to our review.
Selected words in the title, keywords and the abstract.	Literature that does not refer to the whole topic.
Articles published in 2010 and later.	Articles published prior to 2010.

Table 3. Description of studies included in the literature review.

Author and Year	Purpose of Research	Key Findings
Dulin et al., 2010 [18]	The article presents the use of GIS in the understanding of primary healthcare needs in communities. GIS is used to assess the patterns of healthcare use, including attributes at the community level, to identify the geographical regions that need access to healthcare most urgently.	The results showed that the use of GIS for generally accessible data at the community and patient levels may rapidly identify the areas that need a better access to primary healthcare services most urgently. This model may improve access to healthcare.
Shahid et al., 2010 [19]	The article compares distance measurements in the spatial analytical modelling of the healthcare service planning. The research compares the following three methods: Euclidean, Manhattan and Minkowski, which are used to assess distances from patient homes to hospitals.	The results showed that the assessed measurements of distances and travel times are the most accurate, but cannot be used directly in spatial analytical modelling. The Euclidean method underestimates road distance and time; the Manhattan method usually overestimates both. The Minkowski method partially improves their deficiencies, as it is adaptable, suitable for the analytical modelling and more accurate than conventional measurements. Its use improves the reliability of spatial analytical models.
Burkey, Bhadury, Eiselt, 2012 [12]	The research studies the efficiency and equality of the geographic accessibility of hospitals in four US states using the criteria of efficiency, the availability of services and equality. It compares existing and optimal locations.	The results of the research showed that existing locations provide a nearly optimal geographic healthcare access and foresee options for improvement.
Dewulf et al., 2013 [20]	The purpose of the research was to verify whether simple methods to determine healthcare accessibility (physician-to-population ratios–PPR) used by policymakers in Belgium are sufficiently accurate to suitable determine healthcare shortage areas. At the same time, the goal was to study how such methods work out in comparison with more advanced methods based on geographic information systems (GIS).	It was established that the PPR method used by policymakers in Belgium merely supports a rough estimate of healthcare accessibility, particularly due to large adjacent areas (medical areas). Significant differences in the quantity and spatial distribution in shortage areas were established using various methods.
Gonçalves, Ferreira, Condessa, 2014 [21]	The research addressed the decision-making process regarding the siting of large public buildings, which responds to the increasing demand for more rationality of public investments by taking into account the quality of services and addressing spatial issues. The analysis is used to define the best location for a public hospital in a Portugal region.	The results show that segmentation to macrolocations and microlocations is a special feature of the used approach. The merger of the relative criteria keys (better/worse), the contributions of the geospatial analysis (e.g., centres of gravity) and quantitative data (e.g., minimum travel time) with other sources is crucial to the decision-making process regarding the location of public buildings.
Dehe, Bamford, 2015 [22]	The article studies and compares two modelling methods used to make decisions on the locations of healthcare facilities and pertaining infrastructure. The proposed models are based on seven main criteria (environment and safety, size, total costs, accessibility, design, risks and population profile) and 28 sub-criteria.	By developing and studying models for decision analyses, which apply several criteria, the article contributes to the rationalisation of the selection of healthcare facility and infrastructure locations, particularly in future decisions. The results also enable providers to additionally study the characteristics of the modelling to develop a reliable decision-making framework.

Table 3. *Cont.*

Author and Year	Purpose of Research	Key Findings
Yang et al., 2016 [23]	The study analyses the balance of the spatial distribution of hospitals in Wuhan in China. The objective of the study is to improve the Huff model to analyse the accessibility of healthcare facilities.	The results show that the latter is better in central urban areas than in the suburbs. The study proposes the multi-criteria evaluation (MCE) to assess location when constructing new hospitals, which may significantly improve the accessibility of healthcare facilities.
Ahmadi-Javid, Seyedi, Syam, 2017 [2]	The research constitutes a classification framework for various types of healthcare facilities in terms of their location and a literature review based on it. The issue of the selection of healthcare facility locations is divided into more detailed tables in 10 descriptive dimensions.	The results of the research define research gaps in the location selection of each health facility and provide possible future directions. Literature and future research options are analysed from the aspect of the modelling approach and issue solving methods.
Mueller, Klein, Hof, 2018 [24]	The study presents tools for simple spatial simulations for urban planning in small municipalities, which may also be used to determine locations of healthcare facilities.	The presented tool can be practically used in daily administrative procedures in small municipalities and may contribute to more useful sustainable urban planning.
Graham, 2018 [25]	The study addresses the population characteristics and the geographic coverage of primary healthcare facilities by using two approaches to study factors related to the accessibility of doctors in Northern Ireland.	The results show that the population coverage with primary healthcare is higher in more at-risk areas, small areas and areas with more older adults. The average travel distance is related to shortage, the age of the population and the size of the area. Policymakers should consider the methodology and the results to make decisions on the locations of healthcare facilities and the provision of services. The key factor in decisions on the locations of healthcare facilities is the harmonisation of the population needs for services and the supply of medical resources.
Gu, L. Li, D. Li, 2018 [26]	The article developed a two-tier spatial distribution model for elderly healthcare facilities for older adults in large residential communities by taking into account the economical accessibility, which was used in a case study in Nanjing in China.	A deeper insight in spatial data disclosed by GIS foster the acquisition of potential locations of elderly healthcare facilities. By their optimization, this two-tier model improves the fairness and efficiency of access to healthcare services for older adults. It may also be used to assist policymakers in providing suitable healthcare services for low-income older adults.
Lopes, Ribeiro, Remoaldo, 2018 [27]	The article focuses on the planning of healthcare services based on accessibility measures based on the latest healthcare reform in Portugal. The case study was used for continental Portugal. Various scenarios were developed to measure and compare the impact on accessibility for the population.	The results related to the accessibility of emergency services between 2001 and 2011 show that the distance is acceptable in most of the country. However, significant differences between urban and rural areas were detected. It was established that a lower level of accessibility in rural areas particularly affected older adults.
Mishra et al., 2019 [28]	The study focuses on the methodology that uses GIS and multiple-criteria decision-making to achieve spatial efficiency in the development of healthcare facilities.	It was found that the most important criterion in decisions on the suitability of healthcare facility locations is accessibility from residences to facilities. The findings of the study may benefit national policymakers in the development of healthcare facilities by suitably allocating funds to shortage areas, improving the healthcare index and the quality of life.

Table 3. *Cont.*

Author and Year	Purpose of Research	Key Findings
Erdoğan, Stylianou, Vasilakis, 2019 [29]	The article presents an open-source tabular tool as support in decisions on facility locations.	Using the tool in a healthcare case study, computer tests showed that comparable values can be optimally solved in decision making on the location of facilities.
Farughi et al., 2019 [30]	The main objectives of the research are to devise a healthcare system, increase the level of coverage, and reduce operating costs. The study proposes a new multiple target mathematical model to form compact, balanced and adjacent districts in healthcare systems. The target functions reduce heterogeneous distortion and monitoring costs for hygiene and public healthcare.	The results show that a model is devised to ensure that all services required by each town within a district are provided and reduce the heterogeneity of districts in terms of services required in their towns. In general, the formal structure of the model fosters dealing with issues and providing services in districts at the same time.
Tan et al., 2019 [31]	This study provides useful information on the planning and design of urban green areas with specific characteristics that could improve their accessibility and aesthetic quality, particularly from the aspect of older adults.	The results show that the duration of visits to green areas positively affects the mental and social health of people. The statistical model showed that such a connection is particularly important to women and people with low social support and social capital.
Chen et al., 2020 [32]	The research focuses on disparities in the inequality of healthcare for older adults in spatial and temporal terms.	The findings may assist policymakers in the planning of healthcare services for the increasingly older population and with the provision of information on carers for prompt and efficient treatment.
Cheng et al., 2020 [33]	The objective of this study is to examine the spatial access to primary, secondary and tertiary healthcare services for older adults with an explicit focus on fairness and equal distribution of geographic accessibility.	The findings show that spatial distribution holds an important role in the accessibility of healthcare services.
Serrano-Gemes, Rich-Ruiz, Serrano-del-Rosal, 2020 [34]	The goal of the review article was to select qualitative evidence to understand the participants' reasons for their decisions on the locations of care for older adults. The analysis included 46 articles.	The main outcome is the differentiation of several reasons for each group of people participating in the decision-making process on the locations of care. The reasons are divided into three factors: retention, pull or push. Such a differentiation facilitates a more detailed and in-depth analysis of the motivation of various groups participating in this process.
Khashoggi, Murad, 2020 [35]	The purpose of the article is to study the questions of healthcare planning and focus on the potential of the GIS models in solving these questions by using analytical approaches, i.e., to use analytical approaches to solve the problem of healthcare planning using the GIS models.	The main outcome is the development and use of analytical approaches using the GIS models to support two important aspects of healthcare planning: monitoring and modelling an epidemic despite a lack of medical information and its management, and assessing spatial inequality regarding healthcare accessibility to determine the optimal distribution of medical resources.
Weiss et al., 2020 [36]	The purpose of the study is to assess whether individuals can access healthcare and to make the first high-resolution global maps of travel times to healthcare facilities.	The results show that 91.1 per cent of the global population can reach a hospital/clinic if they have access to a motorised vehicle, but only 56.7 per cent can go on foot. Maps point out the additional vulnerability of individuals in low-income areas, where long travel times are related to higher transport costs.

Table 3. *Cont.*

Author and Year	Purpose of Research	Key Findings
Boisjoly et al., 2020 [37]	The purpose of the feature is to qualitatively define the spatial accessibility of healthcare services by public transport on an example of eight main Canadian metropolitan areas and compare healthcare accessibility among vulnerable population groups. The research points out the challenges related to the suburbanisation of poverty in large Canadian metropolitan regions are the need to provide efficient services of public transport to hospitals on the outskirts.	The results show that more vulnerable people in metropolitan areas have better access to hospitals by public transport. This study is relevant to researchers and policymakers, who strive to improve healthcare accessibility, particularly for vulnerable population groups.
McCarthy et al., 2021 [38]	The objective of this study was to assess the impact of hospital closures in relation to the share of the population that can reach a secondary healthcare facility within 15, 30, 45 or 60 min.	The research points out the significance of healthcare accessibility, particularly in remote areas. For example, recent closures of rural hospitals (106) in the USA affect the population's access to hospital treatment. The results show that the closures of rural hospitals prevented 0–0.97 per cent of the population to access a hospital within 15 min.

The review was conducted using five key search terms that were used for the review process. Figure 2 outlines these key criteria in percentage for the studies which underwent full text review and denotes the strength of individual criteria.

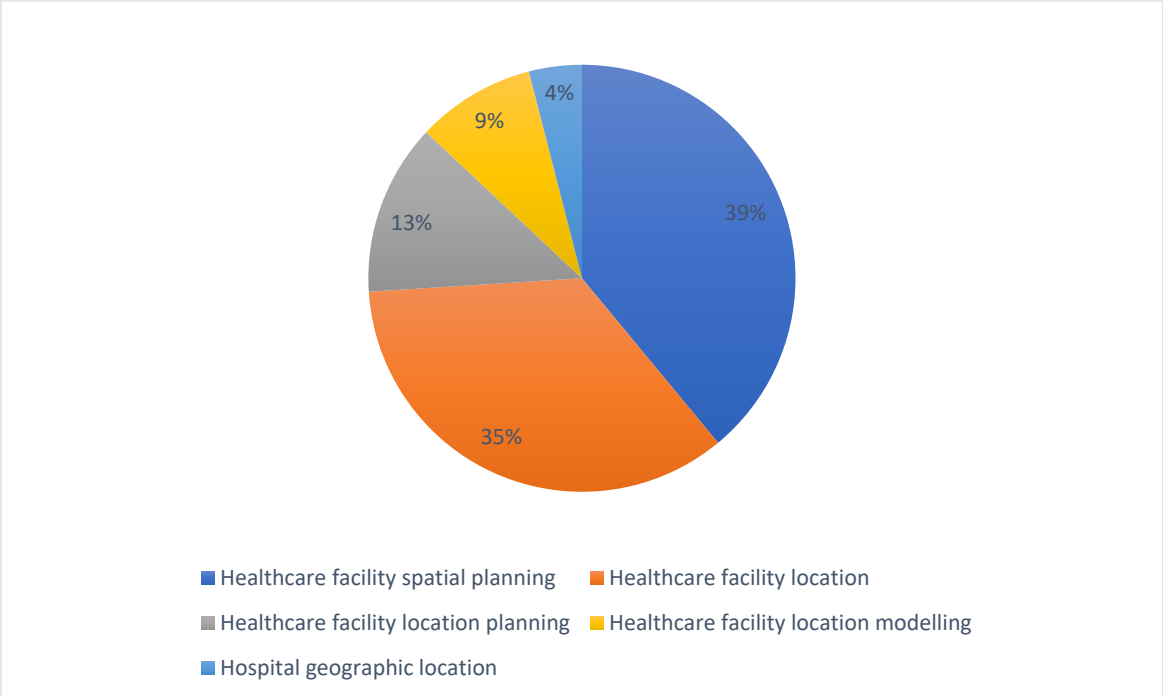

Figure 2. Percentage of key search criteria for the studies that underwent full text review.

3. Results

3.1. Planning Strategies

In this review, the reasons mentioned in the different studies included in our results have been classified in key themes: tools and models, geographic accessibility and access

equality. Table 4 below provides insight into the alignment of them with individual study findings.

Table 4. Key themes involved in siting of healthcare care facilities. (X—Key theme alignment with individual study findings).

Author and Year	Tools and Models	Geographic Accessibility	Access Equality
Dulin et al., 2010 [18]	X		
Shahid et al., 2010 [19]	X	X	
Burkey, Bhadury, Eiselt, 2012 [12]	X		X
Dewulf et al., 2013 [20]	X		
Gonçalves, Ferreira, Condessa, 2014 [21]		X	X
Dehe, Bamford, 2015 [22]	X		
Yang et al., 2016 [23]	X		
Ahmadi-Javid, Seyedi, Syam, 2017 [2]	X		
Mueller, Klein, Hof, 2018 [24]	X		
Graham, 2018 [25]		X	
Gu, L. Li, D. Li, 2018 [26]	X		
Lopes, Ribeiro, Remoaldo, 2018 [27]		X	X
Mishra et al., 2019 [28]	X		
Erdoğan, Stylianou, Vasilakis, 2019 [29]	X		
Farughi et al., 2019 [30]	X		
Tan et al., 2019 [31]		X	X
Chen et al., 2020 [32]			X
Cheng et al., 2020 [33]		X	X
Serrano-Gemes, Rich-Ruiz, Serrano-del-Rosal, 2020 [34]			X
Khashoggi, Murad, 2020 [35]	X		
Weiss et al., 2020 [36]		X	
Boisjoly et al., 2020 [37]		X	
McCarthy et al., 2021 [38]		X	

3.2. Tools and Models

Numerous tools and models are available to determine or seek optimal locations of healthcare facilities. Over the past decade, many studies on the locations of healthcare facilities included geographic information systems (GIS) in systemic analyses.

To understand primary healthcare needs in communities, Dulin et al. [18] showed that using GIS for generally accessible data at the community and patient levels may rapidly identify the areas that need a better access to primary healthcare services most urgently, and proved that using such a model can improve access to healthcare. More advanced methods of healthcare accessibility based on GIS were also addressed by Dewulf et al. [20]. In their research, they verified simple models to determine healthcare accessibility (PPR) used by policymakers in Belgium. Since these are large adjacent medical areas, it was established that healthcare is only roughly accessible.

The development of a two-tier spatial distribution model for elderly healthcare facilities for older adults in large residential communities by taking into account the economical accessibility is further addressed by Gu, L. Li and D. Li [26]. Spatial data disclosed by GIS in Nanjing in China foster the acquisition of potential locations of elderly healthcare

facilities. By their optimisation, this two-tier model improves the fairness and efficiency of access to healthcare services for older adults, and assists policymakers in providing suitable healthcare services for low-income older adults.

Mishra et al. [28] found in their study in 2019 that the most important criterion in decisions on the suitability of healthcare facility locations is accessibility from residences to facilities by using GIS and multiple-criteria decision-making. These findings benefit national policymakers in the development of healthcare facilities by suitably allocating funds to shortage areas, improving the healthcare index and the quality of life. Khashoggi and Murad [35] also focus on the potentials of the GIS models, particularly to assess spatial inequality regarding healthcare accessibility and determine the optimal distribution of medical resources.

Another study comparing distance measurements in the spatial analytical modelling of the healthcare service planning was carried out in 2010 by Shahid et al. [19] using three methods to assess the distance from a patient's residence to hospital, i.e., Euclidean, Manhattan and Minkowski. The results showed that measurements of distances and travel times cannot be used directly in spatial analytical modelling.

Dehe and Bamford [22] compared in 2015 two modelling methods used to make decisions on the locations of healthcare facilities and pertaining infrastructure, which are based on seven main criteria (environment and safety, size, total costs, accessibility, design, risks and population profile) and 28 sub-criteria. By developing and studying decision-making models, they contributed to the rationalisation of the selection of healthcare facility and infrastructure locations, particularly in future decisions. On the other hand, the study by Farughi et al. [30] in 2019 proposed a new multiple target mathematical model to devise a healthcare system, increase the level of coverage and reduce operating costs. The model is devised to ensure that all services required by each town within a district are provided.

Among the numerous tools for seeking the optimal location of healthcare facilities is an open-source tabular tool, which serves as support for decision making and is presented in an article in 2019 by Erdoğan, Stylianou and Vasilakis [29]. Using the tool in a healthcare case study, computer tests showed that comparable values can be optimally solved in decision making on the location of facilities.

A study analysing the balance of the spatial distribution of hospitals in Wuhan in China includes analyses of the accessibility of healthcare facilities and proposes the multi-criteria evaluation (MCE) to assess location when constructing new hospitals [23]. Its objective was to improve the Huff model. It showed that the accessibility of healthcare facilities is better in central urban areas than in the suburbs, and that the proposed model may significantly improve the accessibility of healthcare facilities.

In contrast with complex approaches used by the GIS tools or complex analytical modelling, simple spatial simulations for urban planning in small municipalities provide information support to urban planners, architects and policymakers to tackle interrelated challenges of urban systems and assess the consequences of special planning strategies [24]. Such tools are useful in daily administrative procedures in small municipalities and can contribute to more useful sustainable urban planning, taking into the consideration the walking distances to healthcare centres as a spatial attractiveness and on the other hand the ground values being the highest in the city centres and lowest in the outskirts.

As a response to growing demand for greater prudence regarding public investments by taking into account the quality of services and addressing spatial issues, Gonçalves, Ferreira and Condessa analysed [21] the decision-making processes on the siting of large public buildings using an example of defining the best location for a public hospital in a Portugal region. The analysis showed that segmentation to macrolocations and microlocations is a special feature of the used approach, and that the merger of the relative criteria keys (better/worse), the contributions of the geospatial analysis (e.g., centres of gravity) and quantitative data (e.g., minimum travel time) with other sources were crucial to the decision-making process regarding the location of public buildings.

3.3. Geographic Accessibility

The time it takes people to travel to a properly equipped and adequately staffed healthcare facility is a measure of human well-being that is constrained by a number of geographically varying factors.

Healthcare facilities may be classified by location. From the aspect of the modelling approach and location issue solving methods, Ahmadi-Javid, Seyedi and Syam [2] in 2017 analysed literature and defined research gaps for each type of healthcare facility and divided them into more detailed tables in 10 descriptive dimensions. Such an approach was used to define research gaps and provide possible future directions to select locations for each type of healthcare facility. Another study emphasises the significance of healthcare accessibility, particularly in remote areas. The results show that the closures of rural hospitals prevented 0–0.97 per cent of the population to access a hospital within 15 min [38].

On the other hand, Graham [25] addresses the population characteristics and the geographic coverage of primary healthcare facilities and finds that the key factor in decisions on the locations of healthcare facilities is the harmonisation of the population needs for services and the supply of medical resources. The use of two approaches to study factors related to the accessibility of doctors in Northern Ireland showed that the population coverage with primary healthcare is higher in more at-risk areas, small areas and areas with more older adults. The average travel distance is related to shortage, the age of the population and the size of the area. Graham concludes that policymakers should consider the methodology and the results to make decisions on the locations of healthcare facilities and the provision of services.

The latest healthcare reform in Portugal also focuses on the measures of healthcare service accessibility. In their research, Lopes, Riberio and Remoldo [27] focus on the planning of healthcare services based on accessibility by preparing various scenarios. By applying the study to continental Portugal, it was found that emergency services were acceptably accessible in a significant part of the area between 2001 and 2011. However, important differences between urban and rural areas were disclosed, which affects particularly older people.

Location-related accessibility of healthcare services is crucial particularly for the older and socially disadvantaged population. A contribution in 2020 by Boisjoly et al. [37] aimed to qualitatively define the spatial accessibility of healthcare services by public transport and confirmed the said hypothesis with a finding that more vulnerable population in Canadian metropolitan areas have a better access to hospitals by public transport. Maps of travel times to healthcare facilities support an assessment of whether individuals can access healthcare services if required. 91.1 per cent of the global population can reach a hospital/clinic within an hour if they have access to a motorized vehicle, but only 56.7 per cent can go on foot [36]. Tan et al. [31] point out the planning and design of urban green areas with specific characteristics that could improve their accessibility and aesthetic quality, particularly from the aspect of older adults. Green areas have a positive impact on mental and social health, which is crucial to the high-quality life of older adults.

3.4. Access Equality

Much research on hospitals allocation focuses on the relationship between hospital accessibility and population age and on the accessibility of hospital care for certain groups. They also assess the effectiveness of hospital locations in terms of access equality, such as the number of physicians per capita or the average distance between patients and physicians in rural and urban areas.

In 2012 Burkey, Bhadury and Eiselt [12] examined the efficiency and equality in geographic accessibility provided by hospitals. They used GIS to measure quantitatively defined efficiency criteria and service and equality availability, and further studied the efficiency and equality of the geographic accessibility of hospitals in four US states. A comparison of existing and optimal locations showed that existing locations provide a nearly optimal geographic healthcare access but with room for improvement. However,

they saw, that if the goal was solely to guarantee a minimum level of service, equality of access improved at the expense of efficiency.

Inequality of healthcare for older adults in spatial and temporal terms is in the centre of the study by Chen et al. [32], which is of assistance to policymakers when planning healthcare services for the increasingly older population and providing information on carers for prompt and efficient treatment.

The findings of studies show that spatial distribution holds an important role in the accessibility of primary, secondary and tertiary healthcare services for older adults with an explicit focus on fairness and equal distribution of geographic accessibility [33]. Various reasons are stated in decisions on the locations of care for older adults. In 2020, Serrano-Gemes, Rich-Ruiz and Serrano-del-Rosal [34] analysed 46 articles to understand these reasons using a set of qualitative evidence. The reasons were divided into three factors: retention, pull or push. Such a differentiation facilitates a more detailed and in-depth analysis of the motivation of various groups participating in the decision-making process.

4. Discussion

This narrative review focused on the siting of healthcare care facilities based on the purpose of their operation, demographic changes, environmental characteristics, and the impact on public health. The findings reveal that better siting of such facilities and better spatial design may contribute to better human health and well-being and also affording users various opportunities to fulfil certain psychophysiological, social and spiritual needs. It is also indicated that the field is wide and partially covered in literature, as the provision of suitable and equal healthcare to various layers of society, and an optimal and fair spatial distribution of healthcare services are among the crucial questions in relation to social protection.

With their inclusion, architects influence a better siting of healthcare facilities, indirectly contributing to better human health and well-being. In the 21st century, architects and spatial designers face a plethora of related social and ecological challenges, including demand-adapted supply with basic services [2]. Decisions on the locations of facilities play a crucial role in the strategic design of a wide range of private and public organisations (e.g., commercial facilities, warehouses, airports, police stations, hospitals, etc.). The reason for this is that poorly sited facilities or an inadequate number of facilities can result in significantly higher costs and poorer services for customers. In healthcare, incorrect decisions on the siting of facilities seriously affect communities. For example, healthcare facilities that are difficult to access are probably related to increased morbidity and mortality. From this aspect, the selection of locations in healthcare is more important than in other fields. In addition, global trends, such as lower fertility rates, increased life expectancy and related increasing number of older adults, increasing environmental problems (e.g., noise and pollution), and problems with the locations of healthcare facilities have become more critical and important for society [2]. Seeking suitable locations is a process, which must take into account various stakeholders: patients, who need access to facilities, physicians, who strive for attractive and easily accessible workplaces, taxpayers, who require good value for their contributions, and politicians, who aim to attain their goals [12]. Consequently, decisions on the locations of facilities are crucial to the strategic concept of many private and public organisations, particularly healthcare facilities, since in healthcare, incorrect siting decisions seriously affect communities and are connected with increased morbidity and mortality [2].

It is evident that health systems have a considerable environmental impact but that they can also have positive effects on the environment. Currently, the healthcare sector contributes significantly to carbon footprint and although hospitals make up the largest share of carbon emissions, the footprint of the sector is multi-faceted, including pharmaceutical production, the design of medical infrastructure, procurement, and within private medical practice [39]. Consequently, reducing the environmental impact of health care is important, not least because human health is inextricably linked to the health of the environment.

Therefore, the World Health Organisation defined an environmentally sustainable health system as one that "improves, maintains or restores health, while minimizing negative impacts on the environment and leveraging opportunities to restore and improve it, to the benefit of the health and well-being of current and future generations". Within the healthcare sector, environmental sustainability occurs when resources are used as efficiently as possible, without compromising the quality of care for patients. Furthermore, avenues for action are proposed that can form the core of a strategy for fostering environmental sustainability in health systems as: adopting a national environmental sustainability policy for health systems; minimizing and adequately managing waste and hazardous chemicals; promoting an efficient management of resources; promoting sustainable procurement; reducing health systems' emissions of greenhouse gases and air pollution [40]

Analysing the results found in this review in a more thorough and complete manner, many reasons have been found to classify three key themes on siting of healthcare care facilities: tools and models, geographic accessibility and access equality.

The experiences indicate that there are a variety of tools and models available to help determine or seek out the best locations for health-care institutions. Spatial analytical modelling uses the developed methods and models, which are crucial to the assessment of distances between patients and care (for example, Euclidean, Manhattan and Minkowski), and the suitability of locations in view of the level of coverage with multiple target mathematical models and tabular tools (e.g., Huff model, MCE model) with the objective of reducing heterogeneous distortion and monitoring costs for hygiene and public healthcare [19,30]. Simple spatial simulations for urban planning can also provide information support to urban planners, architects and policymakers to assess the consequences of special planning strategies, as the walking distances to healthcare centres positively influencing the spatial attractiveness, as well as addressing soil sealing and ground values being the highest in the city centres and lowest in the outskirts [23]. More advanced methods to achieve spatial efficiency are based on geographic information systems (GIS) and are compatible with multiple-criteria decision-making and analytical approaches to solving the problem of healthcare planning [18,20,25,28,35]. Important criteria in models used to make decisions on the locations of healthcare facilities and pertaining infrastructure include the environment and safety, size, total costs, accessibility, design, risks and the population profile [2,22].

Furthermore, the geographic accessibility with the travel time to an adequately equipped and staffed healthcare facility is a measure of human well-being constrained by a number of regionally changing factors, the most immediate of which is travel time to a healthcare institution thus emphasising the geographical location. Namely, the analysed travel times to the healthcare facilities show that 91.1 per cent of the global population can reach a hospital within an hour with a motorised vehicle, but only 56.7 per cent can go on foot [36,37]. Therefore, to support the decision-making process regarding the location of healthcare facilities, the segmentation to macrolocations and microlocations by merging the relative criteria keys (better/worse), the contributions of the geospatial analysis (e.g., centres of gravity) and quantitative data (e.g., minimum travel time) with other sources is crucial [19,21]. We can further assess that the average travel distance to care is related to shortage, the age of the population and the size of the area [25].

Moreover, to evaluate the suitability of a location, the equality of accessibility must be studied using the criteria of efficiency, the availability of services and equality [12]. It must also be verified whether simple methods to determine healthcare accessibility are sufficiently accurate to suitable determine healthcare shortage areas [20]. Therefore, evaluating the success of hospital locations in terms of access equity, such as the number of physicians per capita or the average distance between patients and physicians in rural and urban areas, is a critical criterion [34]. Additionally, to plan healthcare services for the increasingly older population and provide information on carers for prompt and efficient treatment, attention must be paid to the inequality of healthcare for older adults in spatial and temporal terms [33] with better coverage in more at-risk areas and rural areas [27].

5. Conclusions

The results of the research show the impact of the healthcare care facilities siting on human health and the extraordinary social significance of the topic discussed. This review, however, is not without limitations as the challenge of converting a global set of location criteria that encompasses equipment to a central hospital or a local health centre presents an important challenge. Therefore, further qualitative approach, which will allow findings on more detailed spatial aspects and characteristics specific to the local context of healthcare care facilities, is required. Despite this, the research highlights the importance of analysing optimal siting and the related feedback as essential to providing suitable and equal primary, secondary and tertiary healthcare to various layers of society. The article also adds to the body of evidence available to designers, planners, policymakers, and hospital administrators who want to create and support health-promoting environments.

Furthermore, after this extensive review we can more clearly define the architect's role in siting of healthcare care facilities. The site itself must be verified first by technical and operational spatial mapping methods. This verification also includes a spatial political view of the development of the urban centre and the place itself. This is the easier operational aspect of spatial verification and positioning. It should not be overlooked, however, that these are variable parameters depending on the time, the sector and the development of the disciplines themselves in terms of content, activity and the development of the urban environment itself. This positioning can be verified by mathematical models already developed and by applying the various established tools on the patient-care-accessibility relationship and the broader coverage. Additionally, very important is the siting and even more so the design of the architecture itself, which also follows mental methods and covers the emotional aspect of the architecture. In modernism, this kind of design was not much known or practised but given today's knowledge and the complexities of spatial planning, this aspect of design can also be very important for the users themselves.

Author Contributions: Conceptualization, B.G. and N.K.; methodology, B.G., M.J. and V.S.K.; formal analysis, M.J. and V.S.K.; writing—original draft preparation, M.J. and V.S.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by »ARRS-CRP-2019« The analysis of Slovenian health care and social care architectural solutions (Slovenian Research Agency, grant number V5-1905).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Soltani, A.; Inaloo, R.B.; Rezaei, M.; Shaer, F.; Riyabi, M.A. Spatial analysis and urban land use planning emphasising hospital site selection: A case study of Isfahan city. *Bull. Geogr. Socio-Econ. Ser.* **2019**, *43*, 71–89. [CrossRef]
2. Ahmadi-Javid, A.; Seyedi, P.; Syam, S.S. A survey of healthcare facility location. *Comput. Oper. Res.* **2017**, *79*, 223–263. [CrossRef]
3. Rahman, S.-U.; Smith, D.K. Use of location-allocation models in health service development planning in developing nations. *Eur. J. Oper. Res.* **2000**, *123*, 437–452. [CrossRef]
4. Tang, J.-H.; Chiu, Y.-H.; Chiang, P.-H.; Su, M.-D.; Chan, T.-C. A flow-based statistical model integrating spatial and nonspatial dimensions to measure healthcare access. *Health Place* **2017**, *47*, 126–138. [CrossRef]
5. Joseph, A.; Phillips, D. *Accessibility and Utilization*; Harper and Row: New York, NY, USA, 1985.
6. Khan, A.A. An integrated approach to measuring potential spatial access to health care services. *Socio-Econ. Plan. Sci.* **1992**, *26*, 275–287. [CrossRef]
7. Luo, W.; Wang, F. Measures of Spatial Accessibility to Health Care in a GIS Environment: Synthesis and a Case Study in the Chicago Region. *Environ. Plan. B Plan. Des.* **2003**, *30*, 865–884. [CrossRef] [PubMed]
8. Wang, F.; Luo, W. Assessing Spatial and Nonspatial Factors for Healthcare Access: Towards an Integrated Approach to Defining Health Professional Shortage Areas. *Health Place* **2005**, *11*, 131–146. [CrossRef]

9. Wan, N.; Zhan, F.B.; Zou, B.; Chow, E. A relative spatial access assessment approach for analyzing potential spatial access to colorectal cancer services in Texas. *Appl. Geogr.* **2012**, *32*, 291–299. [CrossRef]
10. Bissonnette, L.; Wilson, K.; Bell, S.; Shah, T.I. Neighbourhoods and potential access to health care: The role of spatial and aspatial factors. *Health Place* **2012**, *18*, 841–853. [CrossRef] [PubMed]
11. Wang, F. Measurement, Optimization, and Impact of Health Care Accessibility: A Methodological Review. *Ann. Assoc. Am. Geogr.* **2012**, *102*, 1104–1112. [CrossRef]
12. Burkey, M.; Bhadury, J.; Eiselt, H. A location-based comparison of health care services in four U.S. states with efficiency and equity. *Socio-Econ. Plan. Sci.* **2012**, *46*, 157–163. [CrossRef]
13. Farajzadeh, A.M.; Masoomy, M. Spatial analysis of public library in No. 12 district of Tehran using GIS. *MJSP* **2006**, *10*, 191–212.
14. Giofrè, F.; Đukanović, Z. *Health Spaces*, 1st ed.; Inter-University Research Centre TESIS "Systems and Technologies for Healthcare Buildings": Florence, Italy, 2015.
15. Neducin, D.; Krkljes, M.; Kurtovic-Folic, N. Hospital outdoor spaces: Therapeutic benefits and design considerations. *Facta Univ. Ser. Arch. Civ. Eng.* **2010**, *8*, 293–305. [CrossRef]
16. Snyder, H. Literature review as a research methodology: An overview and guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [CrossRef]
17. Wong, G.; Greenhalgh, T.; Westhorp, G.; Buckingham, J.; Pawson, R. RAMESES publication standards: Meta-narrative reviews. *BMC Med.* **2013**, *11*, 20. [CrossRef] [PubMed]
18. Dulin, M.; Ludden, T.; Tapp, H.; Blackwell, J.; de Hernandez, B.; Smith, H.; Furuseth, O. Using Geographic Information Systems (GIS) To Understand A Community's Primary Care Needs. *J. Am. Board Fam. Med.* **2010**, *23*, 13–21. [CrossRef]
19. Shahid, R.; Bertazzon, S.; Knudtson, M.L.; A Ghali, W. Comparison of distance measures in spatial analytical modeling for health service planning. *BMC Health Serv. Res.* **2009**, *9*, 200. [CrossRef] [PubMed]
20. Dewulf, B.; Neutens, T.; De Weerdt, Y.; Van de Weghe, N. Accessibility to primary health care in Belgium: An evaluation of policies awarding financial assistance in shortage areas. *BMC Fam. Pract.* **2013**, *14*, 122. [CrossRef] [PubMed]
21. Goncalves, J.; Ferreira, J.A.; Condessa, B. Making regional facility location decisions: The example of Hospital do Oeste Norte, Portugal. *Geospat. Health* **2014**, *9*, 1–6. [CrossRef] [PubMed]
22. Dehe, B.; Bamford, D. Development, test and comparison of two Multiple Criteria Decision Analysis (MCDA) models: A case of healthcare infrastructure location. *Expert Syst. Appl.* **2015**, *42*, 6717–6727. [CrossRef]
23. Yang, N.; Chen, S.; Hu, W.; Wu, Z.; Chao, Y. Spatial Distribution Balance Analysis of Hospitals in Wuhan. *Int. J. Environ. Res. Public Health* **2016**, *13*, 971. [CrossRef]
24. Mueller, C.; Klein, U.; Hof, A. An easy-to-use spatial simulation for urban planning in smaller municipalities. *Comput. Environ. Urban Syst.* **2018**, *71*, 109–119. [CrossRef]
25. Graham, B. Population characteristics and geographic coverage of primary care facilities. *BMC Health Serv. Res.* **2018**, *18*, 398. [CrossRef] [PubMed]
26. Gu, T.; Li, L.; Li, D. A two-stage spatial allocation model for elderly healthcare facilities in large-scale affordable housing communities: A case study in Nanjing City. *Int. J. Equity Health* **2018**, *17*, 183. [CrossRef]
27. Lopes, H.; Ribeiro, V.; Remoaldo, P. Spatial Accessibility and Social Inclusion: The Impact of Portugal's Last Health Reform. *GeoHealth* **2019**, *3*, 356–368. [CrossRef]
28. Mishra, S.; Sahu, P.K.; Sarkar, A.K.; Mehran, B.; Sharma, S. Geo-spatial site suitability analysis for development of health care units in rural India: Effects on habitation accessibility, facility utilization and zonal equity in facility distribution. *J. Transp. Geogr.* **2019**, *78*, 135–149. [CrossRef]
29. Erdoğan, G.; Stylianou, N.; Vasilakis, C. An open source decision support system for facility location analysis. *Decis. Support Syst.* **2019**, *125*, 113116. [CrossRef]
30. Farughi, H.; Tavana, M.; Mostafayi, S.; Arteaga, F.J.S. A novel optimization model for designing compact, balanced, and contiguous healthcare districts. *J. Oper. Res. Soc.* **2019**, *71*, 1740–1759. [CrossRef]
31. Tan, Z.; Lau, K.; Roberts, A.; Chao, S.; Ng, E. Designing Urban Green Spaces For Older Adults in Asian Cities. *Int. J. Environ. Res. Public Health* **2019**, *16*, 4423. [CrossRef] [PubMed]
32. Chen, G.; Wang, C.; Jin, P.; Xia, B.; Xiao, L.; Chen, S.; Luo, J. Evaluation of Healthcare Inequity For Older Adults: A Spa-tio-Temporal Perspective. *J. Transp. Health* **2020**, *19*, 100911. [CrossRef]
33. Cheng, L.; Yang, M.; De Vos, J.; Witlox, F. Examining geographical accessibility to multi-tier hospital care services for the elderly: A focus on spatial equity. *J. Transp. Health* **2020**, *19*, 100926. [CrossRef]
34. Serrano-Gemes, G.; Rich-Ruiz, M.; Serrano-Del-Rosal, R. Reasons for the Place of Care of the Elders: A Systematic Review. *Healthcare* **2020**, *8*, 436. [CrossRef] [PubMed]
35. Khashoggi, B.; Murad, A. Issues of Healthcare Planning and GIS: A Review. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 352. [CrossRef]
36. Weiss, D.; Nelson, A.; Vargas-Ruiz, C.; Gligorić, K.; Bavadekar, S.; Gabrilovich, E.; Bertozzi-Villa, A.; Rozier, J.; Gibson, H.; Shekel, T.; et al. Global Maps of Travel Time To Healthcare Facilities. *Nat. Med.* **2020**, *26*, 1835–1838. [CrossRef]
37. Boisjoly, G.; Deboosere, R.; Wasfi, R.; Orpana, H.; Manaugh, K.; Buliung, R.; El-Geneidy, A. Measuring accessibility to hospitals by public transport: An assessment of eight Canadian metropolitan regions. *J. Transp. Health* **2020**, *18*, 100916. [CrossRef]
38. McCarthy, S.; Moore, D.; Smedley, W.; Crowley, B.; Stephens, S.; Griffin, R.; Tanner, L.; Jansen, J. Impact of Rural Hospital Clo-sures On Health-Care Access. *J. Surg. Res.* **2021**, *258*, 170–178. [CrossRef] [PubMed]

39. Malik, A.; Lenzen, M.; McAlister, S.; McGain, F. The carbon footprint of Australian health care. *Lancet Planet. Health* **2018**, *2*, e27–e35. [CrossRef]
40. Martinez, G.S.; Krauss, M.K.; Menne, B.; Permanand, G. *Environmentally Sustainable Health Systems*; World Health Organization, Regional Office for Europe: Copenhagen, Denmark, 2017.