smart cities

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Health Care in Cities Perceived as Smart in the Context of Population Aging—A Record from Poland

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Abstract: Population aging is a global problem affecting many modern economies. Thus, the article attempts to answer the following research questions: What demographic trends characterize cities considered smart, and is the health care offered by these cities adapted to the changes identified in this regard? In other words, can seniors feel safe now and in the near future? In search of an answer to such a question, data as well as demographic and health indicators were used from 16 Polish voivodeship cities mostly considered smart or aspiring to that title. The analysis covered the years 2010–2020. The results indicate a systematic aging of all surveyed urban communities. However, it is progressing at a rather different pace. Unfortunately, not all cities are adjusting the level of health care (medical and nursing staff and hospital infrastructure) to the needs of the growing number of seniors, which—in the future—may exacerbate regional and local medical and social problems. The analysis also shows that the best-performing cities in terms of health care development are Warsaw, Białystok, Kraków and Rzeszów—the units most often identified in international rankings as smart. Their "smartness" in this case lies in forward-looking management that takes into account the aging of the urban community in the process of developing medical care.

Keywords: human Smart Cities (SC); sustainable Smart Cities (SC); age-friendly Smart Cities (SC); city health care; aging of urban populations

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1. Introduction

For many years, cities have been perceived as attractive places to live due to their favorable economic, infrastructural, and social conditions [1,2]. In response to the growing demands of residents and the need to continuously improve the image of cities, there is also a growing interest in the Smart City (SC) concept, in which a city is seen as a center that offers an above-average standard of living conditions. The number of publications related to the design and implementation of smart city solutions is also growing rapidly [3–6].

Nevertheless, the development of smart cities has also its dark sides, which in practice and theory are far less often paid attention to. One of them is the issue of overlooking and excluding people with disabilities or seniors [7–10], who are unable to cope with technological advances. These groups may also have limited access to smart city solutions due to an income barrier that is a cause of economic exclusion.

In view of the above, smart cities should pay special attention to the problem of sustainability, and not only area-based one related to the consideration of the following aspects: technological, economic, social, and environmental, but also structural, relating to the individual groups that make up the urban community [11–14]. This is important for two key reasons. First, we cannot pretend that only young and healthy people live in smart cities, and this is the impression one can get by studying most of the research on SC issues, especially those based on the fascination with modern technologies and the fragmented description contained in case studies. Secondly, in many modern economies, the problem of aging is steadily increasing, making the group of seniors living in cities more and more numerous, so their life needs cannot be ignored in any case. Faster assimilation

and understanding of the above problems will facilitate the proper organization of smart cities and their functioning in the future.

Meanwhile, the literature on the subject—strongly shaping the ideas of local and regional decision-makers—about the desired image of a smart city is still dominated by technological topics relating to the application of information technology (IT) and Information and Communications Technology (ICT) [15–20]. Logistical [21–24] and infrastructural [25–28] issues also receive considerable attention. There is a growing number of publications addressing the environmental aspects of smart city life, due to growing number of climate issues [29,30]. However, social aspects still receive less attention [31]. In this trend, there are mainly studies and research in the field of citizen participation [32–34] in the process of creating smart city solutions, which definitely does not exhaust the social issues.

It should also be noted that much of the publications on smart cities are theoretical and/or polemical in their nature. Empirical studies of a broad and comparative scope appear less frequently and very often are case studies with a rather narrow focus [35–37]. Often, the same cities are being analyzed. This can distort the picture of the smart city due to the fragmentary and repetitive nature of the descriptions. Thus, there is a need for a differentiated and empirical approach to the study of various aspects of life in smart cities.

It is also worth mentioning that the consideration of smart cities is most often carried out with reference to city units located in highly developed economies, including primarily those located in Europe, the United States, or Australia [38]. Little attention is paid to emerging or developing countries, most likely due to the less spectacular image of the cities located there. This provides an additional rationale for taking up the research described in this article.

Given the above circumstances, this article seeks to answer the following research question: What demographic trends characterize cities considered smart, and is the health care offered by these cities adapted to the changes identified in this regard? To obtain the answer to the above question, the article includes the analysis of 16 Polish cities in the period 2010–2020. These are the capitals of voivodeships implementing the Smart City concept and aspiring to be a smart city. In the assessment of demographical processes, three indicators were used that illustrate the scope of aging of the population. The analysis of the health care state made use of information on the available medical and nursing staff and basic hospital infrastructure.

In order to achieve the research objectives set out above, the article begins with a review of the literature on the subject, organized according to the principle of content hierarchy. It opens with a consideration of the nature and development of smart cities, followed by a presentation of quality of life as the main humanistic premise for the creation of smart city solutions. This is followed by a narrowing of the issues to those related to the quality of life of seniors in smart cities, which is the main topic of consideration in this article. Based on the literature review, a research gap was formulated, that determines the further research area. The gap serves as a starting point for the description of the research problems, aims and methods in the methods section. The results are then presented taking into account the aging process of urban communities and the level of health care offered by the cities studied. The article closes with a discussion and final conclusions of a diagnostic and recommendatory nature.

The originality of the proposed research results from the following circumstances:

- conducting an empirical assessment of selected elements of quality of life in cities aspiring to be smart;
- focusing the research on non-technological aspects of life in smart cities;
- filling the research gap on the quality of health care in smart cities in the context of an aging population;
- addressing less attractive and more problematic issues related to smart city development;
- embedding research in 16 cities located in developing economies to assess the status of Smart City implementation in less economically developed countries.

The results of the research indicate a progressive aging of communities in Polish cities considered smart or aspiring to be so. However, the process is progressing somewhat more slowly in the best developed and most attractive urban structures. The most mature of the surveyed cities are also better at providing health care, which bodes well for the current and future quality of life of seniors. The above observations allow us to conclude that a higher level of sophistication in the development of smart city solutions is conducive to the quality of health care, and thus also to the potential quality of life of seniors.

2. Literature Overview

This chapter presents a literature study that forms a basis for identifying the research gap and defining the thematic scope of the research conducted. Three main themes are presented: (1) The concept and development of Smart Cities; (2) The improvement of quality of life as a rationale for creating smart city solutions; and (3) The issue of quality of life for seniors in smart cities.

2.1. The Concept and Development of Smart Cities

The idea of creating smart cities emerged in the 1990s [39,40]. It was a direct response to the problems of urban life related to, among other things, overcrowding, pollution, urban transportation, and the rising cost of living [41,42]. In the initial phase of Smart City development, the panacea for all these problems was to be the use of information and communication technologies to improve the quality of urban life [43]. As observers and/or participants in urban life, we can say with certainty that the use of modern traffic control systems, environmentally-friendly public transportation or e-public services has facilitated the functioning of urban communities and, in many cases, reduced the costs of their existing operations. With IT and ICT solutions, smart cities have become attractive places to live, due to the comfort, accessibility or speed of stakeholder service processes offered in them [44,45]. The phase of SC development focused on the virtually indiscriminate implementation of modern technologies and lasting until the first decade of the 21st century is referred to as Generation 1.0. Nevertheless, its side effect was the use of cities by technology providers only as attractive marketplaces, where the needs of the ultimate consumer—the resident—were marginalized [46,47].

For these reasons, Generation 2.0 smart cities have included the city as an active stakeholder, mediating the identification and satisfaction of residents' needs, in coordinating the relationship between business and the local community [48,49]. This, however, has not always had the desired effect of increasing the satisfaction and quality of life of urban communities, which is why Generation 3.0 cities have relied on residents' initiatives and their inclusion in the process of creating smart city solutions. Such solutions are possible through open access to data and participation in decisions made at the local government level [50–52]. Detailed examples of active participation of residents in the creation of smart cities are described in the next section of this literature review.

Notably, there is now a growing body of writing about Generation 4.0 smart cities, in which all urban stakeholders work together as part of a cohesive, sustainable ecosystem, working to improve the quality of life. These cities are also expected to fully integrate data acquired by the Internet of Things (IoT) to optimize the operation and efficiency of urban systems with the involvement of artificial intelligence methods.

Accordingly, the initial technocentrism of smart cities has evolved into anthropocentrism. The result is the Human and Sustainable Smart City [53,54], which focuses primarily on meeting the needs of urban communities with consideration and equality for all groups that make up those communities [55–58]. In such a city, modern technologies are merely a means to meet reported needs and shortages.

Given the progressive humanization of the Smart City concept, this article chooses to empirically identify the demographic changes taking place in modern cities that aspire to be smart, and to assess the extent, to which municipal authorities are taking steps to adapt the level of health care to aging urban communities. Such studies make it possible to confront

the recommendations of theory with economic reality and complement knowledge of the social aspects of SC operations. They, therefore, make Smart City research more sustainable. They also provide a basis for improving efforts to make real improvements in the quality of life in cities.

2.2. Quality of Life for All Stakeholders as a Rationale for Creating a Smart City

The concept of the smart city emerged in response to the growing attractiveness of urban life and the resulting need to improve the organization of cities so that, despite the growing population, they can still provide a friendly environment for work and leisure [59]. Initially, smart cities were developed primarily through the implementation and use of IT and ICT technologies [60,61]. The main stakeholders involved in their creation were smart city providers and city authorities [62]. However, this approach resulted in low satisfaction of social needs due to the lack of their identification and dialog between authorities and residents in search of answers to the question: How can smart technologies improve the quality of life?

For these reasons, the smart city concept was systematically refined and expanded to include the participation of additional stakeholders, namely: the local community, universities, and environmentalists. Such a view of the smart city has taken place according to successive economic helixes: triple, quadruple, and quintuple [63–66]. As a result, nowadays one writes not so much about a smart city, but about a sustainable city, in which the expectations and needs of all stakeholders are taken into account, so that their quality of life improves evenly and with respect for the natural environment [67–70].

It is worth noting that with the development of successive generations of smart cities, the approach to the principles of using IT and ICT technologies is changing. Their use is no longer the focus of urban decision-makers. What matters more is their usefulness to the community [71–73], which means that the identification of needs comes first, and only later the implementation of the desired smart city solutions follows. This phenomenon is identified and studied by Nakano and Washizu [74] using Japanese cities as an example. The authors additionally recommend the use of modern technologies primarily for communication between the various stakeholders to strengthen the feeling of community that fosters the creation of smart cities and improves the quality of life of their residents.

A viable example of including citizens in the co-creation of smart city space are urban applications that empower individual stakeholders and allow them to actively participate in city life. A study carried out by Zhu and Alamsyah [75] shows that their use enables real participation in city management, and gives residents a sense of psychological, social, and political agency. It is a great example of IT and ICT technology commitment to the sustainability of smart cities [76–78].

Another solution that promotes resident participation and social improvement is the so-called living labs [79,80], studied and described by Nguyen et al. [81] using the example of Catalonia. Their idea is to involve the community in innovative projects in the early stages of their implementation, inviting residents to co-create smart urban solutions and simulating real life problems. Such activities support the active participation of the urban community in deciding on the final form of smart cities [82,83].

It follows from the above that in the context of quality of life in the city, cooperation between different stakeholder groups is a very important aspect [84–86]. It enables the exchange of ideas and thoughts and—due to the accompanying synergistic effects—the level of satisfaction with urban life increases in all the communities that make up the urban community. Nevertheless, as emphasized by Clement et al. [87], this cooperation must be properly coordinated by the city government, which should be its initiator and manager. Thus, the city still remains the creator of smart urban solutions, but its role is changing from originally only a decision-making one to one of consensual- and coordination-driven [88] methods.

Despite the above statements (largely popularized by researchers and academics) and the emphasis on the role of residents in the creation of smart cities [89], in economic practice

the arguments cited above are not always taken into account [90,91]. The illusory nature of changes in the rules for implementing smart city solutions is pointed out, among others, by Engelbert et al. [92], who analyze the motives and effects of the implementation of European projects awarded to smart cities. Their conclusions show that the majority of projects are not consulted about with the residents, and applicants are guided primarily by the logic of political economy, seeking to satisfy their own interests and obtain only those effects that can boost their image. Hence the need to "look at" real and practical implementations of the smart cities concept, and to identify the not necessarily positive side effects accompanying these implementations.

Regardless of the extent of criticism of the Smart City concept, it is worth emphasizing that the very idea of improving the quality of urban life is extremely important for current and future generations. Even if not all the measures provided for in this regard bring the desired results, it is always worth making efforts to change the existing state of affairs. This is also, perhaps especially, important for the citizens of smart cities. As shown in the research of Ji et al. [93] conducted in Taiwan, the urban community is interested in the development of smart city concepts, including, first and foremost, the improvement of urban services. Interestingly, Taiwanese people are most concerned with improving "hard" services such as transportation, energy, safety, and—therefore—with achieving tangible infrastructure results.

In addition to the factors mentioned above, health, public education, safety, public participation, the state of the environment, culture, and the development of housing and buildings, along with the development of smart information and communications, are among the main determinants of urban quality of life [94]. Given that health care appears relatively much less frequently in research and literature on social issues, this article focuses on factors shaping the quality of urban life in this very area. The need for research in the subject area is also emphasized by Obringer and Nateghi [95], based on an extensive and critical review of the Smart City literature, noting that it is a topic that is less frequently covered, but important for the quality of life of urban communities.

Since the area of health in smart cities is a less frequently analyzed issue, the studies conducted in the article help fill the research gap that exists in this area. They provide information on the level of current and prospective health care for one of the groups at risk of social exclusion. Thus, they draw attention to the need for further humanization and sustainability of smart cities—features exposed in the next generations of SC presented earlier.

2.3. Quality of Life for Seniors in the Smart City

As hinted at in the previous section, the developers of smart cities boast that they are being built primarily to improve the quality of life of its residents. However, the credibility of this claim is contested and criticized in the literature [96–98]. One of the reasons for this criticism is the issue of economic and social exclusion, which can affect both residents of smart cities and cities located in the vicinity of urban units being considered smart [99].

Given the characteristics of a smart city described in the previous section, among the residents who are subject to exclusion, people with disabilities and seniors are most often mentioned. The main reasons for such exclusion are the lack of or low familiarity with the use of modern technologies and low income that prevents access to IT or ICT infrastructure.

Issues related to the potential social exclusion of people with disabilities and seniors are described within the social trend of smart city deliberations [100–102]. It is about the participation of all residents in the creation of smart city solutions. However, previous research shows that issues of exclusion and vulnerability of certain social groups are very rarely addressed. This problem is highlighted by Hatuka and Zur [103], among others, when analyzing the smartness of Israeli municipalities. They conclude that addressing inequalities in access to new technologies is on the margins of urban development strategies; therefore, it is important to shift attention from technological solutions to social aspects in order to build a sustainable socio-technological ecosystem.

Similar conclusions are reached by Wang et al. [104], who, when analyzing smart city strategies, find that very little attention is paid in them to seniors and people with disabilities. Their observations corroborate analyses conducted by Ivan et al. [105] on the example of Romanian cities, which show that smart growth programs do not indicate specific benefits dedicated to seniors, proving their marginalization and lesser importance in the urban community. This can result in the exclusion of these groups from the urban community, deepen the inequalities and exclude them from participation in the assumed improvement of quality of life. For these reasons, city authorities should identify the needs of those at risk of exclusion and implement them far more fully. This view is also supported by Antwi-Afari et al. [106], who state that smart cities must be more accessible to people with disabilities.

Seniors, who most often represent the group of post-working age people, are not economically active. Consequently, the most important aspects of their quality of life generally relate to economic, health, and leisure activities (tourism, culture, sports). In this context, the possibility of free movement also becomes important, hence a lot of space in the literature is devoted to mobility in age-friendly cities [107–112], which is a certain deepening of the already signaled logistical themes exposed within the Smart City concept.

When it comes to issues of health care in smart cities, among the most frequently discussed issues are [94]:

- providing health care services;
- monitoring of and informing about the hygiene practices;
- monitoring the condition of patients using IT and ICT technologies;
- health care education.

Within the above issues, there is a predominance of publications and studies on the use of modern technologies, such as the Internet of Things [113–116], which is typical of the analysis of the functioning of smart city solutions. There are also publications on the use of Big Data in medical care in order to more efficiently and accurately analyze residents' health information [117–120].

Interesting research in this area is being conducted by Chi et al. [121], as the authors do not just describe the performance of systems that monitor the health of seniors, but identify factors that affect their evaluation by the ultimate users. Their results show that seniors attach importance to the quality of the systems offered and the quality of information obtained through them. Their motivation to use the proposed solutions, in turn, is most influenced by the level of perceived threat of illness.

A lot of attention is also paid to applications supporting active aging [122–124]. Among solutions in this area, applications that locate and monitor the health of seniors, useful for conditions related to atrophy or memory loss, are particularly popular [125–127]. Other solutions of this type address leisure activities [128] and participation in urban life [129,130]. There are also applications that promote healthy lifestyles, including exercise, diet or lifestyle changes, among others [131–133]. Seniors are also offered to use interactive online platforms where they can exchange opinions, views, learn about cultural or sports attractions, and participate in shaping the living conditions in a smart city [134–136].

As the literature review shows, the description of health care in smart cities is not ideal. It is characterized by a certain fragmentation and a very technicized approach. Researchers focus on modern technologies, often neglecting the human aspect, including the aforementioned problems of social and economic exclusion. In addition, most studies assume that the city has already reached a far advanced level of meeting basic social needs, which is not true, especially in emerging and developing economies. For these reasons, this article chooses to analyze the problem of health care in the context of aging urban communities with a special focus on the problems of the developing economy (Polish economy). This will make it possible to introduce a less optimistic, but important research thread, into the area of consideration of social issues in smart cities and fill the existing gap in this area.

The gap identified from a review of the above research threads relates primarily to the lack of analysis on meeting the basic health needs of residents of cities, that aspire to be smart. Meanwhile, these are needs that are crucial to the realization of higher-order desires, such as the recreation, sports and culture described above. Their omission and neglect lead to social exclusion and prevents the creation of true Human and Sustainable Smart Cities. Filling this gap will help answer the question of whether the implementation of the smart city concept is not piecemeal and illusory, and whether it distracts attention from more serious social problems. Such illusiveness may be particularly true for cities aspiring to be smart in developing economies facing financial shortfalls. For these reasons, the research was carried out using Polish cities as an example.

3. Materials and Methods

The considerations in the previous chapter helped to set the framework, within which the humanistic aspects of life in the Smart City are analyzed, with a particular focus on senior issues. Based on these, issues requiring deeper analysis were identified. The manner and scope of conducting the research on the demographic and medical determinants of the quality of life of seniors in smart cities in the developing economy is presented in Section 3.1, while the characteristics of the cities studied are provided in Section 3.2.

3.1. Research Intentions, Data, and Methods

The literature studies presented have identified gaps that need to be filled and provide the rationale for the research presented in this article. They relate to the need to:

- conduct empirical research in the social area of SC's functioning, especially in developing economies that have difficulties in implementing smart urban solutions (they allow to confront the recommendations of theory with practice and formulate improvement recommendations);
- pay more attention to health care as a key determinant of quality of life;
- identify the level of adaptation of cities to the needs of residents at risk of economic and social exclusion, i.e., seniors.

Given the importance of the problem of providing medical care to a growing group of senior citizens and the aspirations of smart cities to continuously improve the quality of life for all residents, the article seeks to answer the following research question: What demographic trends characterize cities considered smart, and is the health care offered by these cities adapted to the changes identified in this regard?

The analysis for such a question was conducted on the basis of 16 Polish voivodeship cities identified both in the literature and practice as smart cities or aspiring to that title. The research covered the years 2010–2020 and was carried out in three stages:

1. Assessment of the demographic situation of the surveyed cities.
2. Analysis of the level of health care in the surveyed cities.
3. Comparison of the results of the demographic assessment with the results of the analysis of the level of health care in the surveyed cities.

Due to the socio-humanistic theme of the considerations carried out, the identification of demographic trends was carried out using three indicators to determine the advancement of aging processes in urban communities. They are easy to interpret, since they illustrate the share of seniors in the total population and in relation to people of working age. The results obtained allow determining the scale of the current and future threat of social and economic exclusion of seniors. This diagnosis makes it possible to take preventive measures and can contribute to making smart cities more sustainable and humanistic.

In the case of medical care, indicators used in assessing the quality of life of smart cities and taking into account the state of medical and nursing staff, as well as hospital infrastructure, were used. As already mentioned, improving the quality of life is the main goal of creating smart cities, and the selected indicators allow to assess it in the context of adjustment to the observed demographic processes. The comparative analysis carried

out confronts the demographic state of affairs with the preparedness of the surveyed cities to care for seniors, which provides a basis for improvement measures to prevent the accumulation of demographic and social problems in the future.

The following indicators were used in assessing the demographic situation of the surveyed cities:

(a) the ratio of the population in the post-working age to the population in the working age ($R_{pw/w}$) (in Poland, the working age for women is from 18 to 59 and for men from 18 to 64):

$$R_{pw/w} = \frac{P_{pw}}{P_w} \tag{1}$$

where:
P_{pw}—population of post-working age;
P_w—population of working age.

(b) the community's elderly burden factor (EBF):

$$EBF = \frac{P_{65+}}{P_w} \tag{2}$$

where:
P_{65+}—population aged 65 years and older;
P_w—population of working age.

(c) the percentage of people aged 65 and older in the total population ($P_{\%65+}$):

$$P_{\%65+} = \frac{P_{65+}}{P_t} \tag{3}$$

where:
P_{65+}—population aged 65 years and older;
P_t—total population.

The aforementioned quantities made it possible to assess and compare the process of advancing community aging in the studied cities over time and space.

In the analysis of the level of health care, indicators traditionally used in assessing its quality were used, that is namely:

(a) the number of physicians per 10,000 residents (R_{ph}):

$$R_{ph} = \frac{N_{ph}}{N} \tag{4}$$

where:
N_{ph}—the number of physicians employed at their primary place of work;
N—population expressed in 10 thousand.

(b) the number of nurses per 10,000 residents (R_n):

$$R_n = \frac{N_n}{N} \tag{5}$$

where:
N_n—the number of nurses employed at their primary place of work;
N—population expressed in 10 thousand.

(c) the number of hospital beds per 10,000 residents (R_{hb}):

$$R_{hb} = \frac{N_{hb}}{N} \tag{6}$$

where:
N_{hb}—number of hospital beds;
N—population expressed in 10 thousand.

Parameters defined in this way made it possible to analyze the state of staffing and basic hospital infrastructure and compare its performance between cities and over time. This analysis additionally used the average annual rate of change illustrating the development of the studied trends over time, that is, from 2010 to 2020:

$$\sqrt[n-1]{\frac{y_n}{y_0}} \tag{7}$$

where:

y_n—the value of the variable in the last period;
y_0—the value of the variable in the first period;
n—the number of periods.

Information from the Local Data Bank of Statistics Poland [137] was used to calculate the above indicators. Detailed characteristics of the studied cities are presented in the next section.

3.2. Research Sample Characteristics

As already mentioned, 16 Polish voivodeship cities were analyzed. Their characteristics are included in Table 1 and their geographical distribution is illustrated in Figure 1.

Table 1. Characteristics of the surveyed cities.

City	Inhabitants	Surface	Industry
Białystok	296,000	102 km^2	Electro-mechanical (electronics, machinery and metal), wood, clothing, food, and printing industries
Gorzów Wlk.			
Gdańsk	471,000	263 km^2	Shipbuilding, petrochemicals, energy, apparel, metals
Katowice	292,000	165 km^2	Mining, business services, automotive
Kielce			
Kraków	782,000	327 km^2	Tourism, business services, trade, banking services
Lublin	338,000	147 km^2	Energy, chemical, food, tobacco
Łódź			
Olsztyn			
Opole			
Poznań	532,000	262 km^2	Electromechanical, chemical, commercial, transportation
Rzeszów			
Szczecin			
Toruń			
Warsaw	517,000	517 km^2	Electrical engineering, transportation equipment, chemical, food, printing
Wrocław	643,000	293 km^2	Machinery, transportation equipment, food, electro-technical, metal, clothing, and chemical industries

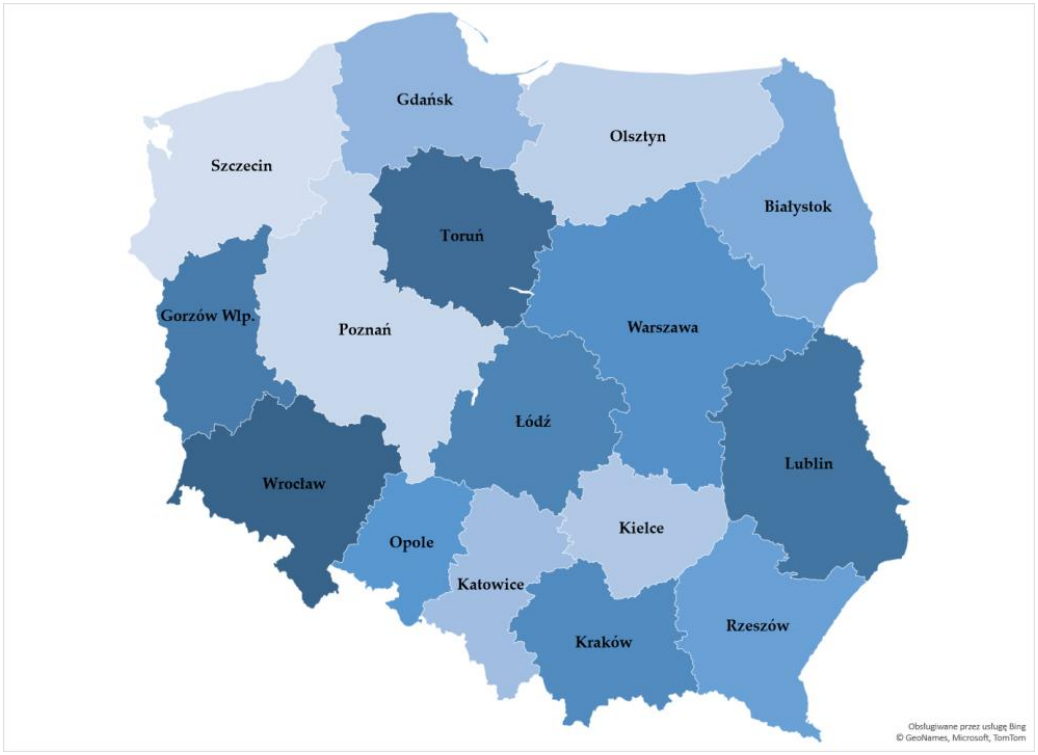

Figure 1. The localization of studied cities.

In the literature, the following cities are most often considered smart: Warsaw, Kraków, Łódź, Wrocław, Poznań and Gdańsk. At the same time, it is emphasized that these cities are in the initial stages of implementing and developing the Smart City concept, and the process is accompanied by tensions between economic, environmental, and social goals. Nevertheless, changes in the way these cities are managed are noticeable and aimed at improving the quality of life of residents [138].

It is also worth mentioning that Polish cities, including smart cities, are struggling with a lack of financial resources to develop urban infrastructure and provide residents with the desired quality of life, which can be considered a phenomenon typical of emerging and developing economies [139,140]. Moreover, as Masik and Gajewski's [141] analysis shows, even though the strategies of large Polish cities emphasize the need for change and the inclusion of local communities in co-determining development directions, they, nevertheless, lack the need and desire for deep, long-term transformation.

4. Results

Due to the duality of the considerations carried out, the results of the research are presented in the following two subsections. The first refers to the demographic determinants of life in Polish smart cities. It seeks to answer the following question: How fast is the process of aging of urban communities progressing, and what is the variation in this process across cities? The second subsection assesses the level of health care offered by the surveyed cities and allows us to determine whether and to what extent the analyzed units are adapting to changes in the age structure of the urban community?

4.1. Seniors in Polish Cities in Demographic Terms

The first part of the study analyzed demographic indicators characterizing selected cities. Thus, Figure 2 shows the percentage of the post-working age population per 100 people of working age.

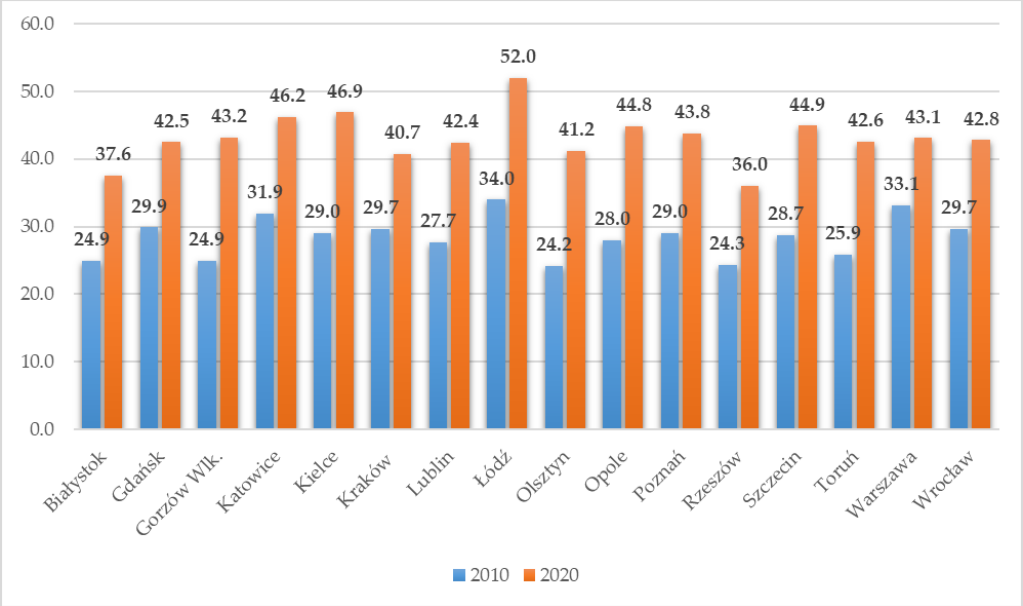

Figure 2. Population of post-working age per 100 people of working age in the surveyed Polish cities in 2010 and 2020.

The data presented in Figure 2 show that the number of people of post-working age has increased significantly in all cities over the 11 years studied. This is a result of the low natural growth rate observed in Poland over the past few decades and the systematic aging of Polish society. For the surveyed cities, this means a clear decline in the stock of people capable of working and a growing share of seniors in the urban community. Indeed, in 2010 there were 24 to 34 people of post-working age per 100 people of working age, and in 2020 there will be 36 to 52. The continuation of this trend, including, above all, the rate of change, in the coming years poses a serious threat to the social security system, health care, and the efficiency of the economy.

The group of cities with the highest value of the described indicator (above 40) in 2020 included as many as 14 of the 16 surveyed cities. The highest number of people of post-working age characterized the populations of: Łódź, Kielce, Katowice and Szczecin, while the lowest was recorded in Rzeszów and Białystok. In the case of Kielce and Szczecin, the demographic change in the analyzed range was very significant, as in 2010 these cities were at the lower limits of the range characterizing the number of people of post-working age per 100 residents of working age. The relatively low value of the examined indicator in Rzeszów and Białystok can be justified by the fact that these cities are regional centers for the development of industry and services, which means that they offer many attractive jobs attracting people of working age.

The above observations and insights are confirmed by the data presented in Figure 3 on the population elderly burden (aged 65+). After eliminating the differences in the retirement age of men and women in Poland, the number of seniors per one person of working age is admittedly lower than shown in Figure 2, but the upward trend is still very clear, and the data show that in 2020 seniors accounted for from 27% to more than 39% of the potential labor force, while in 2010 the size of this demographic group ranged from 17% to about 25%. The highest and lowest elderly burden was recorded in the same cities as the data cited above.

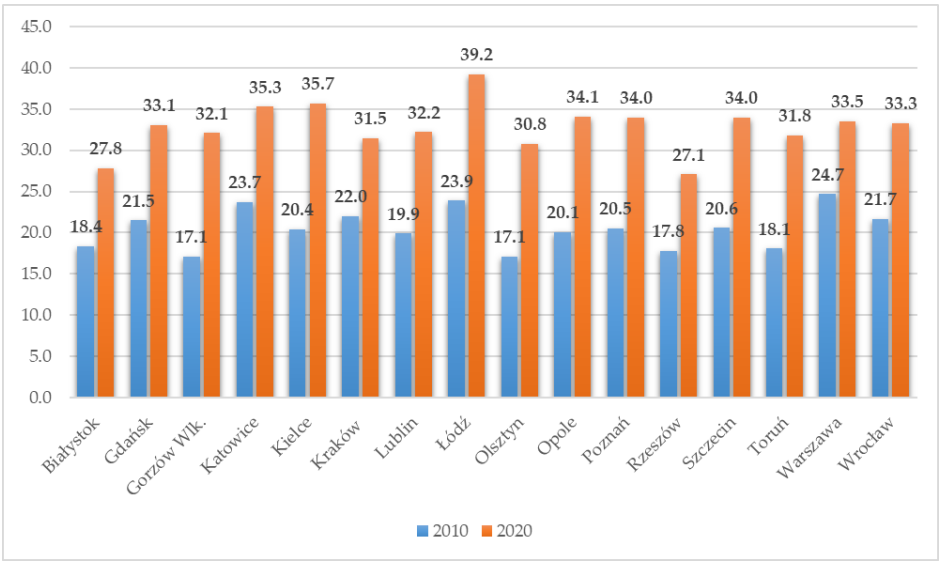

Figure 3. The elderly burden ratio in the surveyed Polish cities in 2010 and 2020.

The next stage of demographic analysis considered the percentage of people aged 65 and older in the total population, and its results are shown in Figure 4.

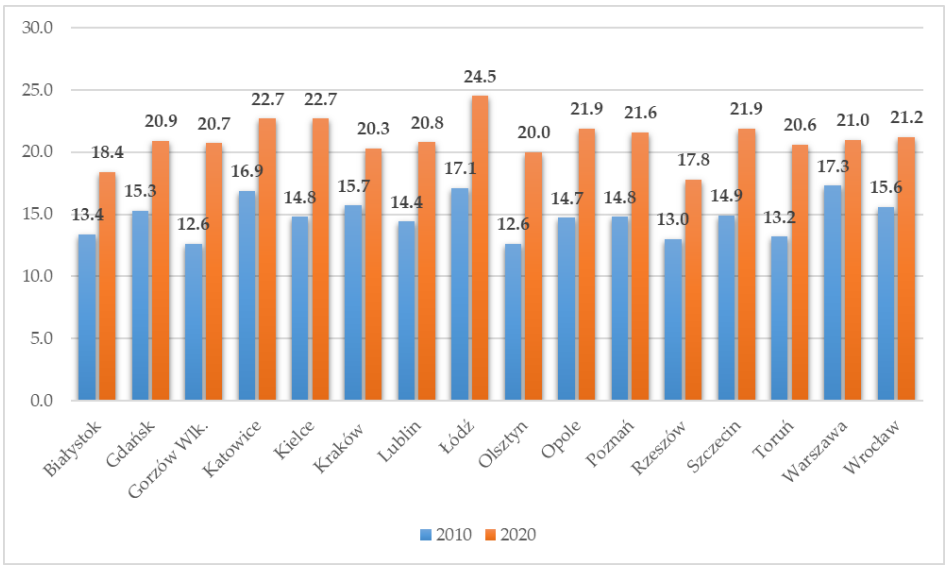

Figure 4. Percentage of people aged 65 and older in the total population in the surveyed Polish cities in 2010 and 2020.

After including people in the pre-working age group in the analyzed resources, the trends identified earlier remained unchanged. This means that the problems of aging in Polish society will affect not only those currently in the working age, but also future generations, and to a greater extent than before. Approximately 1/5–1/4 of the Polish population is currently seniors, indicating the serious problems of providing retirement benefits and health care to such a large population group in relation to the productive people now and in the future. It also demonstrates the scant effectiveness of social programs supporting total fertility rate growth in Poland. This problem may be particularly acute given Poland's growing economy, which, for years, has been struggling to catch up with Western European countries.

As a summary of the analysis of demographic indicators, Table 2 shows their average annual rate of change.

Table 2. Average annual rate of change in senior demographic indicators between 2010 and 2020 in surveyed Polish cities.

Cities	Demographic Indicators		
	Post-Working Age Population per 100 People of Working Age	**The Demographic Elderly Burden Factor**	**The Percentage of People Aged 65 and Older in the Total Population**
Białystok	4.21%	4.21%	3.22%
Gdańsk	3.58%	4.41%	3.17%
Gorzów Wlk.	5.66%	6.50%	5.09%
Katowice	3.77%	4.06%	2.99%
Kielce	4.92%	5.76%	4.37%
Kraków	3.20%	3.65%	2.60%
Lublin	4.35%	4.93%	3.75%
Łódź	4.34%	5.07%	3.66%
Olsztyn	5.46%	6.06%	4.73%
Opole	4.81%	5.43%	4.07%
Poznań	4.21%	5.19%	3.85%
Rzeszów	4.01%	4.29%	3.19%
Szczecin	4.58%	5.14%	3.93%
Toruń	5.10%	5.80%	4.55%
Warsaw	2.68%	3.09%	1.96%
Wrocław	3.72%	4.38%	3.11%

Unfortunately, it was very high in all areas being studied. The factor that increased the most evidently and the fastest was the demographic elderly burden factor in the surveyed cities. Only in Warsaw and Kraków (attractive Polish metropolises) did the average annual rate of this burden not exceed 4%. The situation was the worst in Gorzów Wlk. and Olsztyn—less economically developed cities located in agricultural and tourist areas. In both of these cities, the rate of growth of the percentage of people aged 65 and over in the total population also reached the highest values, which means that these cities face the most serious risk of urban aging in the future. This risk, in turn, is smallest for the aforementioned Warsaw and Kraków. Thus, in view of the results obtained, it can be concluded that the Polish cities most often cited as smart are the least likely to face rapid urban population aging. This may be the result of both the favorable economic and development conditions typical of these cities and the polarization of the regions outside of their area.

4.2. Health Care in the Context of Aging Urban Communities

The results of the above analyses clearly indicate the current and future need to strengthen health care, since the growing group of seniors means an increased incidence of chronic diseases including diseases typical for old age (such as atherosclerosis, circulatory failure, respiratory failure or diabetes). For these reasons, the trends identified above were contrasted with indicators of the level of health care in the surveyed cities. Thus, Figure 5 shows the number of physicians per 10,000 in all surveyed cities in 2010 and 2020. As can be seen from the data included there, this number varied widely. In 2010 it ranged from 29.3 (Toruń) to 66.6 (Lublin), and in 2020 it ranged from 32.4 (Gorzów Wlk.) to 80.8 (Rzeszów). Nonetheless, it is worth mentioning that the analyzed indicator increased in all the surveyed cities. The highest increases were recorded in: Rzeszów, Szczecin, Olsztyn and Katowice. Three of the aforementioned cities (Olsztyn, Szczecin

and Katowice) are cities with a significant risk of aging urban communities, in which the increase in the analyzed indicator may, on the one hand, already indicate increasing health care needs, and, on the other hand, prognosticates quite well for the current and future possibilities of satisfying these needs. The situation in Gorzów Wlk., Łódź and Toruń, where the number of physicians per 10,000 residents was the lowest, increased little over the 11 years of analysis, and the rate of adverse demographic changes was above average, should be evaluated lower.

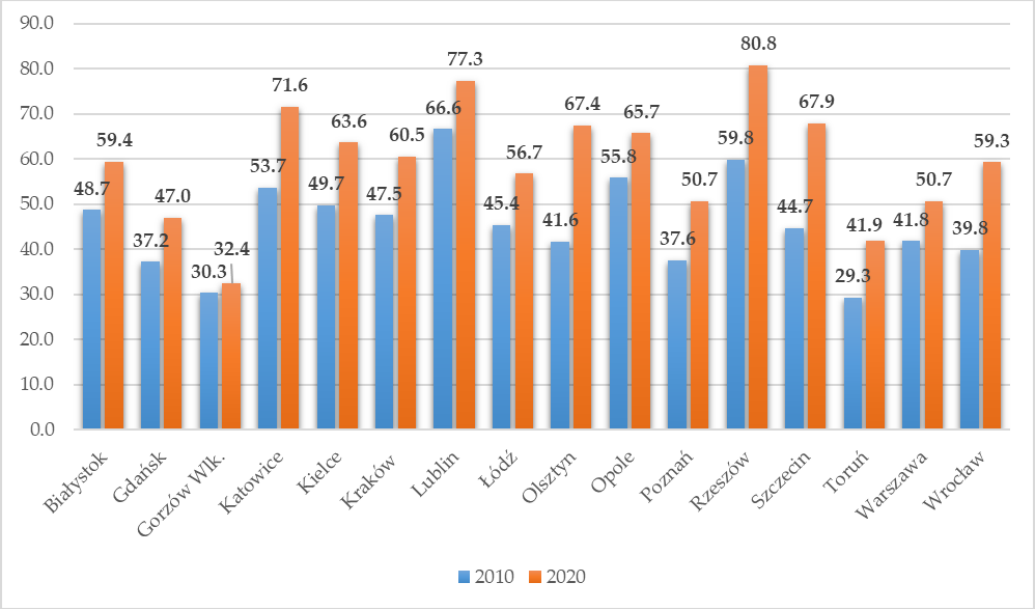

Figure 5. The number of physicians per 10,000 residents in the surveyed Polish cities in 2010 and 2020.

It is worth referring here to the average values for Poland and the European Union member states. Thus, in 2020, the average number of doctors per 10,000 residents in Poland was about 40, which placed us 9th in the European Union (the highest value of this indicator of about 67 was observed in Italy and Hungary) [127]. In most of the surveyed cities, the number of physicians per 10,000 residents was higher than the average for Poland, which is due to the fact that these are voivodeship capitals with high population density and concentration of socio-economic life. Nevertheless, it is worth adding that Gorzów Wlk. remains below the Polish average in both surveyed periods, which indicates the very poor situation of this city in terms of medical care.

In addition to medical care, nursing care plays an important role in geriatric-type conditions, which is why the number of nurses per 10,000 residents in the surveyed Polish cities in 2010 and 2020 can be found in the following analysis (Figure 6). As in the case of medical care, the nursing care also varied widely. In 2010, there were between 73.3 (Gdańsk) and 140.8 (Katowice) nurses per 10,000 residents. In 2020, the ratio was from 74.4 (Szczecin) to 177.8 (Rzeszów). The largest increases in this regard were recorded in: Kielce, Lublin and Rzeszów. In conjunction with the increase in the number of physicians, it can be concluded that the level of health care in these city units has improved, despite the fact that, apart from Kielce, these cities were not particularly exposed to unfavorable demographic changes. A low and weakly growing number of nurses, however, characterized—as was the case with the number of physicians—such cities as: Gorzów Wlk., Szczecin and Toruń. This group also included: Gdańsk, Poznań, Warsaw and Wrocław, nevertheless, the process of aging of urban communities there was not as intense as in the cities mentioned above.

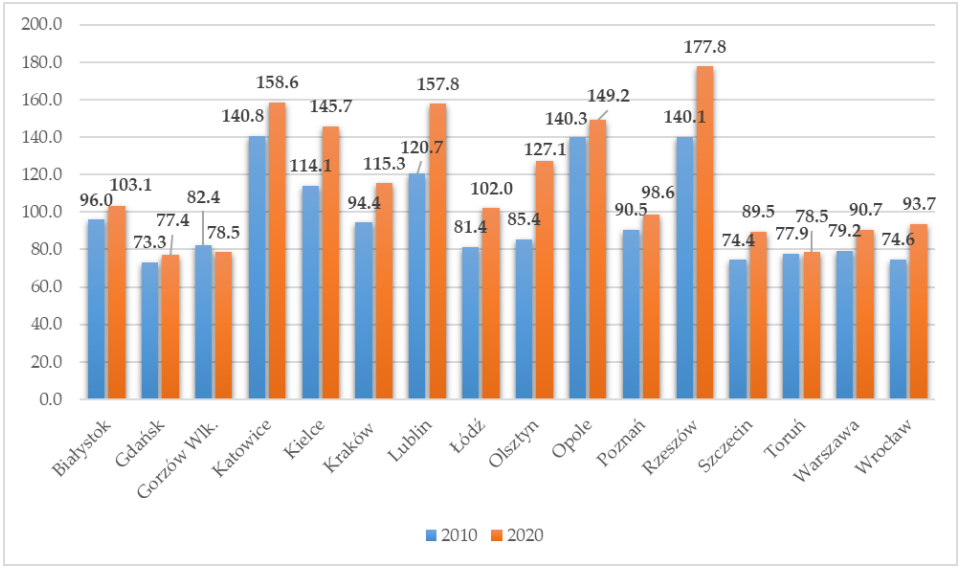

Figure 6. The number of nurses per 10,000 residents in the surveyed Polish cities in 2010 and 2020.

It is worth adding, however, that in terms of the number of nurses per 10,000 residents, Poland is ranked as the penultimate country in the European Union (followed only by Greece). The average for Poland is 50 nurses per 10 thousand residents, while in highly developed countries its value significantly exceeds 100 (e.g., Norway—180; Iceland—145; Germany—129) [127]. Although all the surveyed cities are characterized by an indicator higher than the one calculated collectively for Poland, only in a few cities its value approaches the one of the European leaders. This may cause problems in the future with the provision of long-term medical care, including geriatric or palliative care.

In addition to the number of doctors and nurses, medical infrastructure, including the average number of hospital beds per community, is also important in assessing the quality of health care. Thus, the size of this indicator for 2010 and 2020 in the surveyed cities is shown in Figure 7.

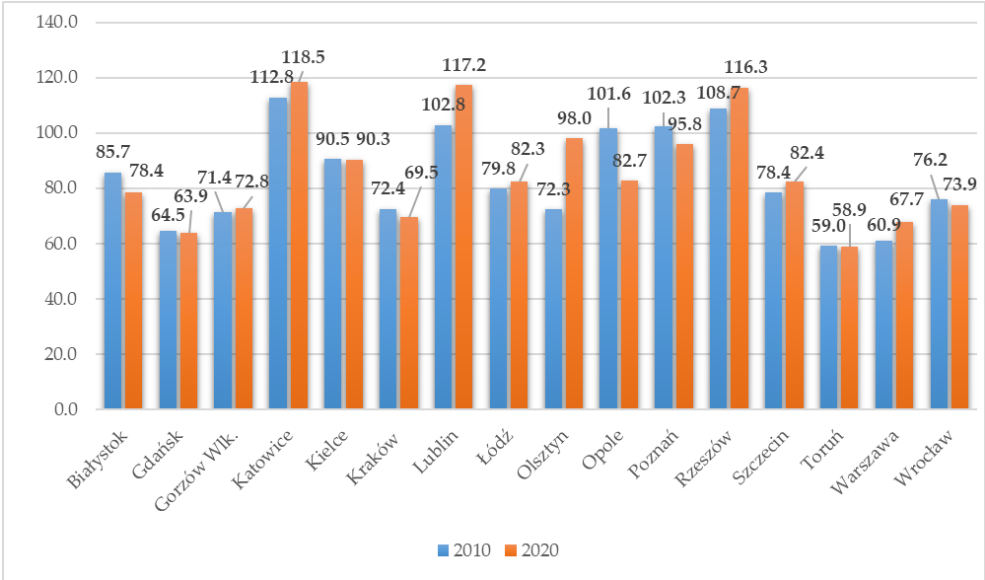

Figure 7. The hospital beds per 10,000 residents in the surveyed Polish cities in 2010 and 2020.

The number of hospital beds between the surveyed cities varied quite a bit, but changed little over time. In 2010, it ranged from 59.0 (Toruń) to 112.8 (Katowice), and in 2020 it varied from 58.9 (Toruń) to 118.5 (Katowice). Unlike the number of doctors and

nurses, the studied indicator did not show an upward trend in all analyzed city units. Indeed, the number of hospital beds decreased in: Białystok, Kielce, Kraków, Opole, Toruń and Wrocław. On the other hand, the largest increase in hospital infrastructure was recorded in Lublin and Olsztyn. The declining number of hospital beds may be due to the shrinking population. Nevertheless, it should be borne in mind that the elderly population has an above-average risk of disease, so an increase in the number of seniors in the future may result in a greater need for long-term hospitalization.

Table 3 summarizes the medical data described in this section. They show that the number of physicians per 10,000 residents grew the fastest in all the cities studied during the analyzed period. The leaders in this regard were Olsztyn and Szczecin. The number of nurses and hospital beds also grew fastest in Olsztyn. It is worth recalling that Olsztyn is a city that is seriously threatened by unfavorable demographic changes, so the pace and direction of changes in the analyzed indicators should be evaluated very positively. They are a proof of a conscious adjustment of medical resources and infrastructure to the rapidly growing number of seniors.

Table 3. Average annual rate of change in medical indicators between 2010 and 2020 in surveyed Polish cities.

Cities	Medical Indicator		
	Physicians per 10,000 Residents	**Nurses per 10,000 Residents**	**The Number of Hospital Beds per 10,000 Residents**
Białystok	2.01%	0.72%	−0.88%
Gdańsk	2.37%	0.55%	−0.09%
Gorzów Wlk.	0.67%	−0.48%	0.19%
Katowice	2.92%	1.20%	0.49%
Kielce	2.50%	2.47%	−0.02%
Kraków	2.45%	2.02%	−0.41%
Lublin	1.50%	2.72%	1.32%
Łódź	2.25%	2.28%	0.31%
Olsztyn	4.94%	4.06%	3.09%
Opole	1.65%	0.62%	−2.04%
Poznań	3.03%	0.86%	−0.65%
Rzeszów	3.06%	2.41%	0.68%
Szczecin	4.27%	1.87%	0.50%
Toruń	3.64%	0.08%	−0.03%
Warsaw	1.95%	1.37%	1.07%
Wrocław	4.07%	2.31%	−0.29%

Unfortunately, the number of nurses has grown far more slowly in the cities surveyed than the number of doctors. This may be a matter of concern, since in the care of the elderly this resource is engaged on a long-term basis, both during their hospitalization and during stays in nursing homes or family homes. In addition to Olsztyn, as mentioned above, the number of nurses increased by more than 2% per year in: Kielce, Kraków, Lublin, Łódź and Rzeszów. In some cities significantly burdened by the threat of urban aging, that is in: Gorzów Wlk. and Toruń, the described indicator was decreasing or increasing minimally, which indicates the lack of provision for the systematic growth of people requiring medical care. In the case of these cities, this is also confirmed by the value of the rate of change in the number of hospital beds per 10,000 residents, which in Gorzów Wlk. did not exceed 0.2% per year and in Toruń was negative, which means

a systematic decrease in key hospital infrastructure. The number of hospital beds was also decreasing in: Białystok, Gdańsk, Kielce, Kraków, Opole, Poznań, Toruń and Wrocław, that is in most of the surveyed cities. The identified changes depend, of course, on the initial level of the number of hospital beds. Their decreasing number is also influenced by the shortening of time of post-operative hospital care and the general trend toward population decline, as well as by the indebtedness of hospitals in Poland in the end resulting in their liquidation. However, these circumstances are prolonging waiting times for planned treatments, and—in the future—may result in a lack of expert care for the growing number of ailing seniors. The observed trends will be felt by all cities due to the progressive aging of urban communities. Nevertheless, they will be particularly acutely felt by those entities that do not currently care about developing and improving the quality of medical care. These certainly include: Gorzów Wlk., Toruń and Opole. In Olsztyn, Łódź, Kielce and Szczecin—also heavily exposed to the aging of the urban population—the situation was better, as these cities sought to increase medical resources during the period under review.

In the final stage of the analysis, a comparison of the cities under study was conducted. The results of this comparison in descriptive form are included in Table 4. In conclusion, the level of selected indicators and the level of demographic and medical risk, a descriptive scale (low; average; high) was used. In each case, the point of reference of such description was the average value of the parameter in the study group in 2020, also included in Table 4. Such an aggregated assessment does not reflect all the details presented in the earlier analyses, but synthesizes the data with respect to the two groups of conditions studied, namely demographic and medical.

Table 4. Summary of demographic and medical assessment of the surveyed cities.

Cities	Demographic Indicators		Medical Indicator			
	Elderly Burden Ratio Level	**Elderly Burden Ratio Growth Rate**	**Physicians (Level/Rate of Change)**	**Nurses (Level/Rate of Change)**	**Beds (Level/Rate of Change)**	**Demographic Risk/Medical Resources**
Average Value for the Cities under Analysis (2020)	32.80%	4.87%	59.60/2.70%	115.2/1.56%	85.5/0.2%	Not Applicable.
Białystok	low	average	average/low	low/low	average/negative	low/high
Gdańsk	average	average	low/average	low/low	low/negative	average/high
Gorzów Wlk.	average	high	low/low	low/negative	low/average	high/high
Katowice	high	average	high/high	high/low	high/high	high/low
Kielce	high	high	high/average	high/high	average/negative	high/high
Kraków	average	low	average/average	average/high	low/negative	low/average
Lublin	average	average	high/low	high/high	high/high	average/low
Łódź	high	high	average/low	average/high	average/high	high/average
Olsztyn	low	high	high/high	average/high	high/high	average/low
Opole	average	high	high/low	high/low	average/negative	high/average
Poznań	low	high	low/high	low/low	high/negative	average/high
Rzeszów	low	average	high/high	high/high	high/high	low/low
Szczecin	average	high	high/high	low/average	average/high	high/average
Toruń	average	high	low/high	low/low	low/negative	high/high
Warsaw	average	low	low/low	low/average	low/high	low/high
Wrocław	average	average	average/high	low/high	low/negative	average/average

According to the data in Table 4, in most of the surveyed cities, the level of elderly burden in 2020 was average (as compared to the average and maximum in the surveyed group), but already the rate of change of this level in many cities turned out to be high. This is a result of the acceleration of the aging process in urban communities. The level of medical and nursing care in most cities was high or average (relative to the average and maximum in the study group), and the rate of change increased over time, which should be evaluated positively. The situation was different in terms of the number of hospital beds. It was low or average in most of the analyzed city units and decreased over time or grew insignificantly. This could raise serious problems for hospital care of the elderly in the future, especially since large urban hospitals most often also treat other residents of the region not included in this analysis.

5. Discussion

The results of the study confirm a clear trend toward population aging in Polish cities, reflecting the trend observed in many European economies. Nevertheless, it is worth noting that in the cities analyzed, this process is proceeding more slowly than in the region or the country. In addition, in cities that are more often cited in the literature as smart, the rate of aging is significantly slower than in cities considered "less smart". This confirms the general claim about the attractiveness of cities, especially the smart cities [1–6].

The identified trends—without anticipatory measures taken up by local and regional authorities—in the future may cause the accumulation of problems of social, technological, and economic exclusion [7–10] of a significant part of the urban community. This may adversely affect the image of cities and exacerbate the criticism of the smart city concept already present in the literature, as expressed by, among others: [96–98]. Finally, it may give rise to social tensions that are difficult to resolve, related to, among other things, the health care described in the article.

In this context, it is worth once again clearly emphasizing the necessity of balancing the smart cities concept, not only in the widely described environmental [29,30,67–70] or participatory [32–34,63–66] aspects, but—above all—in the aspect of a balanced urban community structure, in which each resident has equal access to opportunities to improve their quality of life.

Accordingly, the concept of smart cities still needs to improve the threads relating to humanistic and social aspects of quality of life [39,41,50]. Moreover, it is not only about the participation of residents, but primarily about creating such living conditions, that absolutely all residents feel taken care of, safe and important in a smart city.

The characteristics of the next generation of smart cities increasingly emphasize the importance of urban stakeholders in the process of creating and developing smart cities [51–53]. However, in the context of the results of the study, one gets the impression that, in practice, too little is still being done for those struggling to meet basic social needs. This is all the more important because the group of seniors is growing significantly and constitutes a significant percentage of the urban population. Therefore, every effort should be made to ensure that the Human and Sustainable Smart City is not only available to young and healthy people, who can easily use modern technologies.

Given the above, we should also emphasize that smart health care solutions cannot be limited to health monitoring gadgets [113–120] or to offering various leisure activities [128–135], although these are undoubtedly important issues for seniors (however, those who are largely still fully functional). Indeed, the aging of urban communities is also associated with the less attractive side associated with illness and geriatric and palliative care. Therefore, cities must also improve and develop their medical and nursing staffs, as well as their hospital and social infrastructure, in order to fully meet the needs of that part of the urban community that is unable to take full advantage of smart city benefits related to health problems. Meanwhile, virtually no research and analysis are being carried out in the above area, which further emphasizes the exclusion of the seriously ill part of the senior community and the utopian nature of the smart city concept, as pointed out by Hatuka and Zur, [103] Wang [104] and Ivan et al. [105].

The problems of aging urban communities can be particularly acute in developing and emerging economies, which face economic problems that make it difficult to develop human resources and medical infrastructure. The results of the research conducted in the article clearly confirm this. In the future, Polish cities—as well as the Polish economy—will face a shortage of qualified nurses (necessary for senior care) and a shrinking number of hospital beds. In the context of an aging population, this could mean a serious health care collapse.

For these reasons, it is necessary to draw the attention of local and regional authorities to less image-attractive problems that cannot be solved in the short term due to the requirements of the medical training process and the duration of infrastructure investments. Representatives of these authorities—according to the recommendations articulated by Clement [87] and Anand [88]—should play the role of decision-maker and coordinator of urban health care and direct the actions of business stakeholders not only to technological areas, but also to key social problems. This will allow avoiding the political decision-making described by Engelbert [92] and enable real rather than fake creation of sustainable smart cities.

Practical use of the results of the presented diagnosis allows assessing the demographic situation of a given city. It also provides a basis for comparative analysis over time and in space—in relation to other analyzed cities. In turn, confrontation of the rate and scope of aging of the urban community with the level of medical care can be the basis for developing plans for the development of medical staff and infrastructure, so that, in the future, it can be fully adapted to the needs reported by seniors. This is, according to contemporary SC development trends, a prerequisite for improving the quality of life of all urban stakeholders and responsibly creating smart cities.

The results of the study also provide a basis for theoretical implications. The increasing rate of aging of urban communities raises the need for deeper study of the situation of seniors and the adaptation of smart city solutions to the needs of this social group. It also points to the growing risk of exclusion of senior citizens from urban life, which is pointed out by opponents of the SC concept as one of its most serious drawbacks. The considerations undertaken are complementary to, but also expose the need to study the aspirations of cities to be smart in emerging economies, which, although less successful in improving the quality of life, cannot be overlooked due to the socio-economic distance already separating them from developed countries [54].

6. Conclusions

The study shows that in all 16 cities being surveyed, the aging process of urban communities deepened over time. This was reflected in an increase in all demographic indicators analyzed (post-working-age population per 100 working-age people; the demographic elderly burden factor; percentage of people aged 65 and over in the total population). Nevertheless, the process has progressed more rapidly in cities that are less attractive economically or touristically and less often considered smart, such as Gorzów Wlk., Olsztyn, Toruń, and Kielce. In Gdańsk, Kraków, Warsaw, and Wrocław, urban entities that often appear in rankings of smart cities, the rate of aging of urban communities is lower. Good economic conditions and a better image of these cities had a favorable impact on the quality of life rating and made the unfavorable demographic processes progress more slowly in these cities.

In the context of health care, the best indicator was that of medical care. Except for Gorzów Wlk. its value exceeded the EU average and steadily increased in all the analyzed cities. Far worse was the indicator for nursing care, which was lower than the EU average and, in addition, grew slowly over time, which may cause serious problems in the future in providing a sufficient number of mid-level medical personnel. The number of hospital beds was also declining in half of the cities surveyed, and the rate of growth in this parameter was low in the others, implying a shrinking of basic medical infrastructure and a reduction in hospitalization options for aging urban and regional communities.

In comparing demographic risk with medical care, the worst performing cities were such as: Gorzów Wlk., Toruń, Kielce, Łódź, Opole, and Szczecin. These are cities where demographic risk is high, and the level of medical care is poor or average. The best ratings, on the other hand, were given to: Warsaw, Białystok, Kraków, and Rzeszów. They have a low level of demographic risk and high or average medical security. These are cities that are economically attractive regional capitals and tourist destinations, which certainly attract people of working age and improves the demographic structure. Nevertheless, they are also cities that, according to medical data, are making efforts to secure medical and nursing staff and hospital infrastructure. Still, undoubtedly, due to a more favorable economic situation, they are able to offer doctors and nurses better pay conditions than the other units surveyed. It is worth noting that these are also the cities most often classified as smart cities. Their "smartness" in this case lies in forward-looking management that takes into account the process of aging of the urban community in the process of developing medical care.

In light of the above observations and conclusions, the surveyed cities aspiring to fully implement and develop the smart city concept are recommended to:

- monitor the aging process of urban communities and take measures to reduce its pace and effects;
- adjust the level of health care to demographic processes well in advance, including, above all, increase the number of nurses and reduce the rate of decline in hospital beds;
- identify the needs and expectations of seniors so that they can become full members of urban communities and have the desired quality of life;
- plan organizational and infrastructural social solutions aimed at providing long-term health care for a steadily growing group of seniors.

The results of the present research contribute to studies and smart cities in the following areas:

- assessing the current and prospective quality of life of seniors in smart cities from the perspective of adverse demographic processes and health care;
- filling the research gap on problematic aspects of quality of life in cities;
- addressing the issue of social exclusion of seniors in smart cities;
- identifying the scale and scope of aging of urban communities in Polish entities considered smart or aspiring to the title of smart cities;
- diagnosing the quality of health care in cities considered smart in the context of demographic conditions;
- assessing the effectiveness of measures to adapt health care to the increasing aging of urban communities.

The main limitation of the research conducted in the article is its concentration on the territory of a single country (Poland). Nevertheless, this allows obtaining consistent conclusions on the development of health care in the context of population aging in a rather large geographic region, representing one of the largest developing economies in the European Union. Research limitations also arise from the indirect analysis of the relationship between demographic processes and health care quality. This is because the article—due to lack of data—did not analyze medical indicators exclusively for the elderly; they applied to the urban community in general. However, it is worth adding that the methodology of the analysis carried out is universal and can also be used in other economies and international comparisons.

The results suggest the need for further research and efforts to improve the social and humanistic strands of smart city development. They receive far too little attention, both in the literature and in practice. Fundamental aspects of shaping the quality of urban life are also often overlooked, including such aspects as the medical care described in the article and its adaptation to demographic processes. Meanwhile, without real action to meet the basic needs of all residents, the idealistic assumptions of the Human and Sustainable Smart City concept will remain just a list of theoretical postulates and wishes. This may lead to a deepening of exclusion processes and a deterioration of the quality of life of some stakeholder groups at the expense of others, more privileged in terms of age or health.

Therefore, further studies on the aging of urban communities and the health care options offered by cities may involve comparative analyses over time and space. They can also be expanded to include qualitative analyses based on the opinions and expectations of seniors. Finally, they may be aimed at formulating guidelines for local, national and regional governments on improving the quality of urban health care with special attention paid to the aging of urban communities.

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