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The Internet of Things through Internet Access Using an Electrical Power Transmission System (Power Line Communication) to Improve Digital Competencies and Quality of Life of Selected Social Groups in Poland's Rural Areas

Wioletta Knapik [1,*], Magdalena Katarzyna Kowalska [1], Monika Odlanicka-Poczobutt [2] and Marek Kasperek [3]

[1] Department of Statistics and Social Policy, Faculty of Agriculture and Economics, University of Agriculture in Krakow, 31-120 Krakow, Poland; magdalena.kowalska@urk.edu.pl
[2] Department of Management, Faculty of Organisation and Management, Silesian University of Technology, 44-100 Gliwice, Poland; monika.odlanicka-poczobutt@polsl.pl
[3] Department of Economic Logistics, Faculty of Management, University of Economics in Katowice, 40-287 Katowice, Poland; marek.kasperek@uekat.pl
* Correspondence: wioletta.knapik@urk.edu.pl; Tel.: +48-608-473-424

Abstract: In the 21st century, society has been undergoing a technology-driven transformation which heralds a new revolution that has potential to strengthen the position of an individual and community but may also lead to the marginalization of certain groups. The Internet of Things takes advantage of the technology's potential to improve digital competencies and the quality of life in society. The purpose of this paper is to obtain information about the digital competencies and needs of contemporary seniors and pre-senior age people, as well as socially sensitive groups from Poland's rural areas. To strength the level of internet infrastructure in rural areas, power line communication (PLC) systems that utilize high-voltage line(s) between transformer substations are presented as a cost-effective communication tool. PowerLink IP has made PLC systems today more attractive and efficient than ever before. Based on nation-wide representative surveys conducted in deliberately selected groups, we collected information on digital competencies and formulated recommendations pertaining to the structure and contents of an innovative internet portal as regards offering, sharing, and the availability of commercial and social services targeted at seniors and other dependent groups. The recommended portal combines the needs of target groups with interests of entrepreneurs, self-government authorities, and NGOs.

Keywords: Internet of Things; PLC system; innovative portal; Poland; rural areas; elderly people; socially vulnerable groups

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1. Introduction

For over a decade, we have been experiencing a "technological revolution" that has, to a large extent, changed our way of living, thinking, and communicating, while, at the same time has posed new challenges that are bigger and bigger [1]. As a result, new challenges and postulates of a contemporary society in various fields have been emerging to improve the quality of life and the functioning of entire societies in order to effectively adapt to global requirements, trends, and strategies. More and more frequently, innovative solutions need to be introduced that are revolutionary rather than evolutionary changes [2].

A wide range of contemporary and also modern technologies, computer systems, communication systems, and smart robotic and automatic solutions are continuously being developed that create the bases for building and developing modern systems [3] that are viewed from a broad perspective of activities involving the use of the internet or smart IT systems employing modern electronic technologies from a special angle of the so-called Internet of Things (IoT) or smart sensory networks.

One definition of the Internet of Things refers to devices that can be directly connected to the internet or other devices using wireless networks or, less frequently, cables. This definition of the IoT includes contemporary telephones, cameras, movement sensors, weather stations, even dishwashers, vehicles, industrial machinery, and daily outfits. Almost any object can get connected to the internet even if it was not manufactured as intended for the IOT, because in the majority of cases its functionality can be extended. The IOT has been growing dynamically, offering smart technological solutions. IoT-based applications are client-server operable which requires a specific communication protocol that can be used to determine a client-server communication model, allowing all clients to perform specific tasks thanks to communications via the internet [4].

It seems that the concept of the IoT should be used more broadly because of its possibilities to satisfy the needs of the elderly and the disabled. Limited mobility of those social groups resulting from their health conditions and access to basic services is a challenge faced by the IoT. The purpose of this paper is to present opportunities that have opened for the IoT with respect to satisfying daily necessities of life and social needs of the elderly, disabled, and other socially sensitive groups. Because the internet infrastructures in some rural areas in Poland are insufficient, the use of power line communication (PLC) systems has been proposed. PowerLAN has also been described as the "internet in an electrical outlet", and recently, this technology has become popular in companies and in private houses. Poland's rural areas that are diversified in terms of economic development are poorly equipped with basic infrastructure, which is a barrier to the functioning of people with limited mobility. Here, we attempted to collect all the required information that was required to develop an internet portal, i.e., Senior-net, as a tool equipped with functionalities adapted to the possibilities and expectations of seniors, the disabled, and other people in difficult life situations as representatives of social groups at risk of exclusion. Social research that has been conducted has involved three IoT levels: (1) a spatial and technical dimension securing direct relations, transport of people, and required products; (2) digital communication with the environment and social support institutions as a tool facilitating fulfillment of their needs; (3) a cultural dimension related to digital competences of seniors, the disabled, and other social groups requiring support that is important to their readiness for social interactions. Furthermore, to ensure the project's completion (Senior.net portal), accounting for internet access among the inhabitants of rural areas, power line communication (PLC) technology was offered as a recommended source of access to the internet.

2. Literature Review

2.1. The Internet of Things: Approach and Definitions

The origin of the Internet of Things (IoT) is associated with a British expert in digital innovations, Kevin Ashton, who used the term, "Internet of Things", for the first time, in 1999, at a presentation for Procter & Gamble. In that approach, the IoT is a "network of devices that exchange data with other devices instead of with their users" [5] (p. 2). As Kevin Ashton stated, the difference between the devices used to date and those from the 21st century lies in the fact that data required by the previously used devices had to be fed by human beings, whereas now the devices are capable of collecting and sending data on their own. Hence, the "essence of the Internet of Things" is the fact that data are collected, processed, and sent by devices without the necessity of involving humans in the process [5]. Such an approach was a starting point for the development of the IoT concept.

However, in practice, it was not developed until 2008–2009, when the number of devices connected to the Internet exceeded the global population. That moment marked the beginning of the concept of the IoT [6].

The term Internet of Things is not easily defined, mostly related to failure, by various environments, to accept what the IoT is in reality. It has been defined differently by researchers and scientists versus developers and corporate workers. However, based on its universal definition, it is assumed that it is an "an open and comprehensive network

of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment" [7] (p. 165). According to another definition of the IoT, it "is the interconnected sphere of physical devices with the Internet and other networks through uniquely identifiable IP addresses, whereby data is gathered and communicated through embedded sensors, electronics and software" [8].

Mocnej, J. et al. drew attention to the diversity of approaches to the IoT linked to developments in that field and the multidimensional nature of the related research [9] (p. 2), providing another two definitions for the term. The first definition by ITU is: "The Internet of Things is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies." The other definition by ISOC is: "The term Internet of Things generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention. There is, however, no single, universal definition." [9] (p. 2).

Additionally, the European Commission referred to the concept of the IoT in its document entitled "Internet of Things. Position Paper on Standardization for IoT Technologies" dated 2015; they defined the IoT as "a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network" [10,11] (p. 57).

Regardless of the approach and the definition's level of detail, it should be concluded that the IoT has revolutionized the internet. Its primary task is to develop possibilities for connecting objects in any way, at any place and time, and using any network or service; therefore, those objects can communicate and provide information not just about them but also can access any other information. However, the essence of the IoT is merely something more than that as, apart from computers, that notion (the "thing") refers to objects used on a daily basis which are controlled online. The above refers to technologically advanced devices such as vehicles, household appliances, radio and TV appliances, buildings, industrial systems, and many other objects connected to and communicating with each other, as well as such "things that we do not ordinarily think of as electronic at all—such as food, clothing, chair, animal, tree, water, etc." [12] (p. 6122).

It is a very broad approach to the implementation of the assumptions of the concept of the IoT and in such a broad context the Internet of Things is defined as "a concept and a paradigm that considers pervasive presence in the environment of a variety of things/objects that through wireless and wired connections and unique addressing schemes are able to interact with each other and cooperate with other things/objects to create new applications/services and reach common goals" [12] (p. 6122). From that perspective the IoT allows virtually unlimited scope of research and implementation related to the establishment of a smart environment, also in the context of, for example, effective management of energy in households [13].

Diversified approaches to the IoT are provided in the Report of the Working Group for the Internet of Things of the Ministry of Digital Affairs entitled "The IoT and the Polish economy" dated 2019. The report assumed that the Internet of Things could be defined depending on the area within which it was analyzed. Hence, the IoT was presented from three angles: technological, architectural, and business.

According to a technological definition, the Internet of Things is a "wired or wireless network used to connect devices which work autonomously (without any human interaction) to collect, share, and process data, or to interact with their surroundings on the basis of said data". Such an approach assumes that distributed IT systems are built along with telecommunication networks that can be used publicly. As the report's authors stated, they

can be found in almost every area of life, including science, and applied in practice in the economy (e.g., control systems or smart control systems and metering).

According to the architectural definition of the Internet of Things, "the IoT is a concept of information architecture which enables cooperation (interoperability) between various information and communication systems supporting a wide variety of field applications, based on the following layers: hardware, communication, software, and integration". Regarding hardware, it is important that the devices are capable of communicating and processing data without or with limited human interaction (e.g., smartphones, computers, tablets, etc. that are equipped with sensors or controllers). The second layer is communication, namely, a telecommunication infrastructure and network (wired or wireless) based on a range of data transmission standards (in this case, the internet). REgarding software, IoT devices mostly use IT systems and software used for data exchange and processing as well as managing the system and its security.

The final IoT element is integration, i.e., "groups of defined IT services which ensure software interoperability at all levels of the architecture" [14] (p. 5).

From a business perspective, the Internet of Things is "an ecosystem of business services using devices capable of collecting and processing information (interaction), forming a network in order to ensure the interoperability and synergy of applications". That kind of networking IoT products and services results in broad possibilities of improved market operations. The above mostly allows better understanding of consumers (e.g., thanks to more accurate personalization), environment, products and "as well as identification of relevant events and reacting in order to immediately optimize or ensure more precise customization" [14] (p. 5).

Due to the complexity of the term Internet of Things, sources in the literature highlight several characteristics of the IoT, which present a complex approach to the IoT technology and include:

- ✓ **Connectivity** Anything that qualifies as the IoT can be connected with the use of sensors and controls, and thus, forms global IT and communications infrastructure;
- ✓ **Things/things-related services** The IoT includes all things/objects that can be connected (e.g., household appliances or livestock tagging), additionally, the IoT can be used for service performance, for example, in interactions between physical objects and virtual ones connected to them;
- ✓ **Communication** This ensures network availability and compatibility so that the devices are capable of connecting and transmitting data, communication can be short or long distance with the use of Wi-Fi or LPWA such as LoRa or NB-IoT;
- ✓ **Heterogeneity** IoT devices are heterogenic which is particularly important due to their possible operations based on different hardware platforms and different networks (they interact with different devices or service platforms via diverse networks);
- ✓ **Dynamic changes** This refers to both the change of the number of devices and the device status (e.g., operations in different modes);
- ✓ **Enormous scale** There is an enormous number of devices (which keeps growing) which interact and need to be managed;
- ✓ **Safety** Ensuring safety mostly means securing access to personal data and also safety-engineered devices [8,12,15].

Moreover, describing the Internet of Things one should also recognize the following vital characteristics: data (being the basis of the IoT and treated as "the first step towards action and intelligence"), intelligence (among other things, artificial intelligence), action (e.g., designing smart factory elements), and ecosystem (the IoT from the perspective of other technologies) [8,15].

The concept of the Internet of Things has been frequently associated with the term Industry 4.0. This term was used for the first time at the Hannover Trade Fair where it was promoted as a new idea strengthening Germany's manufacturing industry's competitiveness through associations of business, political, and academic representatives. The German government announced that it was going to be an integral part of the initiative entitled

"High-Tech Strategy 2020 for Germany". An Industry 4.0 Working Group was established for that purpose and developed preliminary recommendations on the implementation of the strategy, which were published in April 2013 [16]. The concept of Industry 4.0 was quickly applied all across Europe, building a world in which virtual and physical systems could work together in a completely flexible way, designing products more in line with consumer demands and developing new operating models [17].

In turn, Industry 5.0, also known as the fifth industrial revolution, is a new development path set out by the European Commission. Industry 5.0 is neither a development nor an alternative to the concept of Industry 4.0. It can be seen as a kind of correction of the course taken by Industry 4.0.

Society 5.0 proposes the concept of a modern, future-oriented and human-centred society. The integration of cyberspace and the real world is to be realized by means of state-of-the-art technologies such as artificial intelligence, the Internet of Things, robotics, or big data. Necessary goods and services will be provided to everyone at any time and place, regardless of region, age, gender, language, or other limitations. The goal of society 5.0 is to simultaneously achieve economic growth and prosperity [18] (p. 22).

One might assume that the IoT is a network of unique cyber-physical systems working together towards common goals. The IoT allows companies to supervise each product in real time and manage it in a logistic architecture. Companies can supervise information in a supply chain, and they can also analyze data and forecast in order to determine trends or likelihood of events, which improves early responses to market needs. The IoT, together with the Internet of Services, can develop complex supply chain processes and, in that way, implement the philosophy of smart logistics [19,20]. Sources in the literature differentiate between the consumer Internet of Things (CIoT) and the industrial Internet of Things (IIoT). Such a distinction is important as the two elements overlap [8]. The Industrial Internet of Things is defined by the Industrial Internet Consortium as "machines, computers, and people enabling intelligent industrial operations using advanced data analytics for transformational business outcomes" [8]. Whereas the Consumer Internet of Things is a term used to refer to "connected devices designed for the consumer market, such as smartphones, smart wearables, and the increasing number of smart home devices that collect and share data through an internet connection" [21].

Due to the ambiguous terminology, the Internet of Things and other concepts related to the concept of smart systems in a broad understanding of the term are used interchangeably. As M. Malucha stated [11] that the above was related to "the concept and terminology standards being not quite fully developed". In the United States and in the English language source literature, the term "Internet of Everything" (IoE) is frequently used [8,11,15]. However, the term IoE is definitely broader than the term IoT, both with respect to infrastructure and the impact of a large number of devices connected to the internet and with respect to the quality of data transmission, data security, and privacy. According to a common definition of the Internet of Everything: "it is a network of people, processes, data, and objects allowing so-far the most valuable transformation of information into specific actions that create new, enhanced experiences, and unprecedented economic opportunities for companies, people, and countries" [6,8,11]. The comparison of the Internet of Things and the Internet of Everything results in clear differences, namely, the IoT focuses on physical objects and their interaction, whereas the IoE "taking into account people and processes, mostly relies on communication based on content, so-called content-centric networking (CCN)".

Furthermore, depending on the degree of automation and the manner of interaction between individual elements, there are other concepts that are used interchangeably with the Internet of Things, such as Machine-to-Machine (M2M), Edge computing, and Cloud computing. However, terminology differences between these concepts are significant enough that a clear distinction should be made [11].

2.2. The Internet of Things in Poland

The Internet of Things (IoT) refers to all devices with access to the internet that are capable of communication. Therefore, this includes the mass use of modern technologies and an extremely diversified range of IoT consumer, corporate, and industrial products. The latest forecasts related to the development of the IoT cover the next few years. IHS Markit that delivers analytics and intelligence for industries and markets, including in economy and finance, and supports decision processes of business and institutional clients [22] forecasts that the number of connected IoT devices is going to grow at 12% per year from 27 billion in 2017 to 125 billion in 2030. On the other hand, according to a survey conducted by Statista, one of the largest global platforms with statistical and market data [23], it has been estimated that the connected IoT devices could total USD 75 billion worth of investments in 2025 [24]. The global IoT market in 2018 was valued at USD 190 billion, and is predicted to amount to USD 1.1 billion in 2026 (an increase of approximately 24% per year). On the other hand, by 2022, IoT spending in all industries worldwide will have approximated USD 4 billion [25].

In Poland, it is also anticipated that in the near future the IoT technology and solutions will show high-growth pace, i.e., approximately 13% every year, resulting from the development of new communication technologies, including 5G [14]. The market of the Internet of Things in Poland in 2019 totaled over USD 2.2 billion (an increase by more than 6 percentage points vis-a-vis 2018). It is projected that by 2023 the growth rate of that market will have reached 23.9% [25].

The Digital Economy and Society Index (DESI), in 2020, showed that, as compared with other countries, Poland was ranked low, at the 23rd position. However, the data show that Poland is a leader in the EU with respect to the widespread access to mobile broadband services, which, undoubtedly, effects research results, according to which Polish consumers are "enthusiasts of digital services" and above all appreciate their convenience, speed, as well as the possibility of using them at any time and place. It should be noted that smart home technology is the fastest growing market segment in Poland as well as other countries. It is estimated that by 2022 its global value will have reached USD 123 billion. However, in Poland, consumers are not as interested in the application of IoT technology in their homes; as many as 42% of Polish people have stated that they are not interested in such solutions [25].

The latest document that discusses the IoT status in Poland and its prospects for development over the coming few years is the Report of the IoT Working Group of the Ministry of Digital Affairs entitled "The IoT and the Polish economy", dated 2019. The report's authors present the Internet of Things as a wave of innovations that takes advantage of networks of smart objects having significant importance to the "emergence of new areas of use, unexpected consumer behaviors, and new business models" [14] (p. 2).

The Report contains the characteristics of the current IoT market in Poland and presents the opportunities for the Polish economy in the context of those technologies. Furthermore, the report's authors have identified problems and barriers to the development of the IoT and have proposed related solutions. Importantly, the report contains a review of global trends with recommendations for the future for Poland that pertain to the most important issues related to the functioning of the Internet of Things, namely, aspects such as education, legislative regulations, and ethical issues. It should be recognized that the analysis of experiences of global IoT development leaders and drawing conclusions based on the observed phenomena and then their skillful adaptation to the needs of the Polish economy is now particularly important. In the face of the dynamic growth of modern technologies, the report's authors postulate the need for regular IoT data updates in Poland and the preparation of comprehensive reports on a cyclical basis, which should "remain to be valuable guides and material supporting the formulation of technological strategies that will manage the development of the Internet of Things in Poland". The reports should be comprehensive, especially in the context of coordination with areas related to the Internet of Things, i.e., national plans pertaining to the growth of artificial intelligence

and the program of the development of the 5G network. Such a holistic approach to the development directions is particularly important in the context of the plans of Poland's economic growth [14].

Taking into consideration the trends and structure of the Polish economy, the authors of the report selected nine key industries associated with the possibilities of developing the IoT in Poland, which included:

Safety and certification

Due to the widespread use of the IoT and massive data processing, both for the country's economy and defense and for each citizen, cybersecurity should be particularly important. Security is a sine qua non condition for the growth of the IoT, whereas proper certification of IoT products guarantees a proper level of security. Therefore, Poland must have appropriate legal and certification regulations. Security in IoT systems takes several forms: product safety (accounting for standards related to hygiene, toxicity, ergonomics, etc.); product cybersecurity (resistant to ICT risks); data security (e.g., as processed by the product); physical safety (the impact of the IoT technologies on a physical world, direct influence on the daily lives of citizens); legal and regulatory safety; and national and military security.

Finance and insurance

In the finance and insurance industry, the IoT is mostly related to payments for services. Transformations that are bound to occur in that area in the near future will be very dynamic and will require far-reaching changes in the attitudes of customers and partners towards information sharing (e.g., biometrics and tokenization). In Poland, the changes in the financial and insurance sector must, above all, include changes in legislation and supervisory regulations. Thus, the authors of the report recommend, among other things, the establishment of a cohesive legislative framework, development of clear legislation allowing unambiguous classification of the IoT data, protection of data processing and transfer, as well as adapting the provisions of the Insurance Activity Act and GDPR to enable IoT data processing.

Smart metering

The IoT is used to support the implementation of smart metering and monitoring corporate infrastructure. It is also related to the growing awareness of end customers about the possibilities of using data to streamline their household spending, for example, data collected from IoT meters in industry sectors are to be made available online on end-customers' smartphones.

Industry

The IoT has created new opportunities for industry, as the manufacturing process of the Industrial IoT devices (IIoT) is frequently based on innovative solutions. The scope of possible IoT applications includes: the Offline IIoT type, i.e., solutions which support data collection and allow their further processing in order to optimize the processes, and the Online IIoT, i.e., tools and systems that work operationally and influence the operations of an industrial plant on an ongoing basis. Recommendations provided by the report's authors mainly refer to the necessity of developing a National IoT Growth Strategy for the Industry to include all important assumptions underlying the growth of the industry.

Agriculture and environment protection

The Internet of Things is a key technology that shows huge potential for supporting the management and optimization of agricultural processes. When it comes to environment protection, the IoT offers opportunities for improving control of the environment, for example, by increasing the number of measurement stations. The above is related to growing civilizational challenges and environment protection, for example, climate changes, smog, draughts, polluted waters, adverse changes in the habitat of animals and plants, etc. The Internet of Things is a key technology for monitoring these phenomena and supporting rapid action.

Telecommunications

The telecommunications sector plays a key role in the implementation and development of the Internet of Things. Based on the services provided by the telecommunications industry, it is possible to quickly implement IoT concepts on a large scale. The above refers to, for example, wireless telecommunications for the IoT that make it easier to integrate IoT devices into networks, and therefore, make them available virtually anywhere.

Transport, logistics, and autonomous vehicles

The IoT can be used in different kinds of transport, but given the prevalence of their use, land and air transport are currently key areas for its implementation, for example, in traffic management systems, prioritizing public transit, accident or collision identification, and automatically informing emergency services (eCall), traffic prediction, driving times, traffic density, etc. From the logistic perspective, the IoT is essential, for example, to the development of integrated supply chains—it can facilitate the optimization of how people, systems, and resources work together, and can also co-ordinate actions.

Healthcare

The IoT solutions in the area of health protection may help to reduce treatment costs, to improve the quality of medical services, and also, as part of an integrated emergency medical system, to help improve survival rates. Moreover, the data collected through IoT solutions are used by manufacturers of medicines and medical devices to supervise the use of products after they are marketed. It should be noted that IoT solutions also improve the well-being of the ageing population, as well as the length and quality of life for patients. Recommendations of the report's authors mostly focused on legal regulations related to patients' data processing, preventative, and educational activities and, of particular importance, from the perspective of the presented report, those that pertained to senior care, for example, financed by self-governments.

Smart cities and buildings

The key element of the Smart Cities concept is the digitization of urban space, and its purpose is to build cities that are more citizen-friendly, eco-friendly, and more economical The Internet of Things technologies that cover, among other things, urbanistic areas such as transport and mobility, waste management, street and city infrastructure lighting, provision of utilities or health, are required to that end [8,14].

The IoT also covers technologies that are friendly to seniors and the disabled. It is a particularly important challenge in the era of an ageing society. Proper adjustment of technical solutions aimed to support the functioning of senior citizens in the society requires comprehensive knowledge of many fields such as cognitive psychology, AI, neurobiology, and engineering in a broad understanding of the term (e.g., IT, electrical engineering, and communications), as well as antropotechnology, i.e., the knowledge of the relations between a human and a computer [26]. Activities as part of gerontechnology cover many levels. Therefore, it has been observed that gerontechnology helps solve many problems of the elderly individuals with the following main exemplary areas being:

- ✓ Cognitive-inspired computing and supporting technologies and devices;
- ✓ Cognitive-inspired computing and accompanying technologies and devices;
- ✓ Cognitive-inspired computing and detection of household accidents;
- ✓ Emotions (controlling them), mood recognition, and regulation;
- ✓ Environment personalized adaptation;
- ✓ Social/care cognitive robots and agents;
- ✓ Cognitive-inspired computing and technologies providing entertainment to adults;
- ✓ Cognitive-inspired computing and fitness and sports for seniors;
- ✓ Smart telehealth, telemedicine, and communications services;
- ✓ Social networks for seniors;
- ✓ Lifelong learning for mental health [27] (pp. 358–359).

Telecare is remote care of the elderly, physically less able people, and the disabled, is an example of gerontechnology applied in practice. To that end, ICTs are used to provide remote care, in an automated manner with the possibility of remote control. They allow seniors and other persons in need to safely function in their own homes. Another example is a telemedicine wristband which is being used more and more often for remote health monitoring. It is mostly intended for people who live independently or require constant monitoring and care. The wristbands have multiple functions, which include calling for help by pressing an SOS button; providing reminders about the necessity to take medications; and enabling cyclical pulse, temperature, and blood pressure measurements. There are also bands for detecting falls or those equipped with a GPS to locate their user, etc. Other innovations dedicated to the elderly and disabled individuals are smart home solutions, which can be remotely supervised by a consultant who informs a caregiver once they have noticed something alarming. Smart home solutions can help to control household appliances with, for example, a gesture or voice. In addition, they can remind individuals about turning off water or lights or taking medicines. They can also be used to monitor falls [26,28]; the more advanced designs of smart homes make the lives of seniors and the sick much easier. Numerous activities that previously had to be done manually have been gradually automated for convenience [29].

Other technological examples include, for example, Beacon, that is, micro-location technology (up to 100 m) that uses Bluetooth Low Energy (BLE) to connect with smartphones to exchange information. The application of Beacon technology has been considered in medicine, for example, in hospitals for the purpose of developing "centralized patient information" and also in the manufacturing of devices dedicated to seniors. For example, an electronic "life chart" is one such solution which is a device transmitting data about health condition and diseases that can be easily accessed by a doctor or a paramedic. Such solutions are particularly important as the process of improving devices that can monitor health 24/7 can save lives [29].

2.3. Power Line Communications (PLC)

Power line communications (PLC), also referred to as PowerLAN or dLAN is a communication technology that enables sending data over existing power cables. Power line communications is a solution that has been known in the telecom industry for years, however, technological limitations have prevented its broad application. Nevertheless, currently, thanks to different improvements, PLC has been increasingly popular both in homes and in small- and medium-sized businesses [30].

The application of PLC technology involves transmitting internet data utilizing power line infrastructure, with an electrical outlet becoming a communication port (e.g., in a home or office) [31]. As a result, PLC technology has become an attractive alternative to standard solutions that utilize network cables or Wi-Fi (especially where, e.g., reinforced concrete walls block Wi-Fi signals). Thus, PLC technology avoids problems related to cable network development, mainly problems involving laying down wires. A PLC solution is the most economically viable as it helps avoid expenses related to such installations. PLC technology enables connecting to the internet virtually, from anywhere in a room without the necessity of installing network cables. The only barrier that prevents the use of PLC is multi-outlet power strips which can significantly slow down or even interfere with data transmission. Therefore, one should always remember to have PLC adapters plugged into electrical sockets [32].

PLC technology makes it possible for a signal to be sent with the use of at least two adapters, i.e., a transmitter and a receiver. Thanks to their filters, high-frequency energy waves can be properly filtered, modulated, and encrypted, thus, transforming an analogue signal into a digital signal that can provide the internet to a TV set, a computer, a tablet, and other devices. Importantly, research has shown that power line adapters do not interfere with other devices at home or with their operations [30,31].

PLC technology has numerous business applications. It can be used, for example, for remote energy consumption reading in real time, the automation of industrial processes, and the implementation of security systems.

The most important advantages of PLC technology are:

✓ It is easy to install and set up;
✓ A high level of network security—it is well protected against unauthorized access;
✓ It enables fast and stable access to the internet in an entire building;
✓ Its adapters are small [31].

3. Materials and Methods

The purpose of the survey was to obtain information about digital competencies and the use of internet tools by seniors and sensitive social groups inhabiting rural areas in Poland. The results were used to facilitate the development of a Senior-net portal dedicated to social groups experiencing difficulties on a daily basis. The tool should enable them to place orders for basic necessities as well as provide smooth access to social and commercial services such as medical, rehabilitation, administrative, care, gastronomic, and tourist services offered to seniors and other persons that require support due to their disability or social dysfunctions. A purposive sample of the inhabitants aged over 60 who inhabit rural areas of Poland along with additional representatives of sensitive groups (the disabled, unemployed, and single mothers) were selected to undergo computer-aided telephone interviews (CATI). In total, 521 interviews were conducted.

The following research questions were formulated:

1. What sociodemographic characteristics distinguish respondents representing socially vulnerable groups?
2. What is the level of support for dependent people—institutional and non-institutional—from family, social environment, and institutions?
3. What is the level of digital competencies of representatives of socially vulnerable groups, including older people?

4. Results

Just like elsewhere in Europe, the infrastructure in rural areas in Poland is much poorer as compared with urban areas. Although the number of internet users has been growing year by year, access to the internet in the countryside far from cities is still difficult. The elderly or other persons that require support in their everyday life suffer the risk of double exclusion, i.e., exclusion because of their health, age, or social dysfunctions and also because of their place of residence (country) and limited access to the internet.

4.1. Sociodemographic Characteristics of Respondents

Persons aged 61–70 accounted for the largest group of respondents (211), followed by people aged 71–80 (128). The group of people aged 51–60 consisted of 78 respondents. There were 50 respondents aged 41–50; whereas there were 33 young respondents aged 31–40, with the 12 youngest respondents aged 18–30. Summing up, the largest group of respondents (53%) were people aged over 60, every fifth respondent was disabled (21.3%), 16.1% of respondents were unemployed, and one in 10 respondents was a single mother (9.6%). Figure 1 below shows the detailed data.

Women accounted for 52.8% (275) and men accounted for 47.2% (246) of the respondents.

The number of respondents aged over 60 was 276 (55.1% men and 44.9% women). There were 111 disabled respondents, 84 unemployed respondents, and 50 single mothers (Table 1).

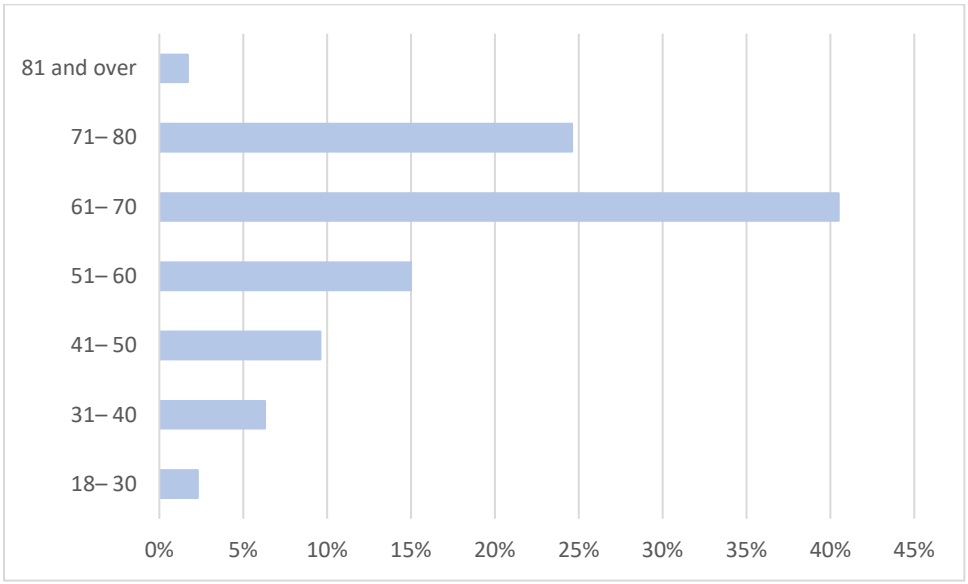

Figure 1. The respondents' age (n = 521) (source, own research).

Table 1. Characteristics of the survey population by sex and social status (n = 521).

Sex	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Female	50	100.0	50	59.5	124	44.9	51	45.9	275	52.8
Male	0	0.0	34	40.5	152	55.1	60	54.1	246	47.2
Total	50	100.0	84	100.0	276	100.0	111	100.0	521	100.0

Source: own research.

Respondents who were single mothers and those who were unemployed were most often young and middle-aged persons, under 50 years old. The disabled were most often seniors, aged over 60 (Table 2).

Table 2. Characteristics of the survey population by age and social status (n = 521).

Age	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
18–30	2	4.0	9	10.7	0	0.0	1	0.9	12	2.3
31–40	15	30.0	12	14.3	1	0.4	5	4.5	33	6.3
41–50	20	40.0	19	22.6	0	0.0	11	9.9	50	9.6
51–60	12	24.0	43	51.2	0	0.0	23	20.7	78	15.0
61–70	0	0.0	1	1.2	175	63.4	35	31.5	211	40.5
71–80	1	2.0	0	0.0	95	34.4	32	28.8	128	24.6
81 and over	0	0.0	0	0.0	5	1.8	4	3.6	9	1.7
Total	50	100.0	84	100.0	276	100.0	111	100.0	521	100.0

Source: own research.

The highest percentage of the respondents came from the south-western macro-region (119 persons) followed by the north-western macro-region (91 persons). Central Poland (the Central and Mazovian macro-regions) was represented by 18.1% of the respondents (94 persons). The following macro-regions were represented by the smallest percentage of respondents: eastern (68 persons) and northern (62 persons). Figure 2 presents the distribution of the respondents by macro-region (NUTS 1).

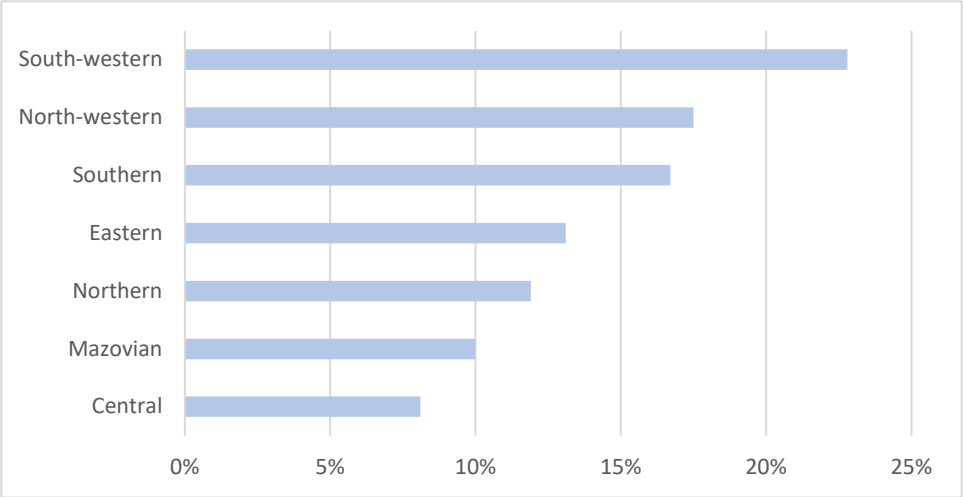

Figure 2. Characteristics of the survey population by macro-region (n = 521) (source, own research).

The largest group of the respondents were those with secondary education (35.3% of all respondents, 184 persons) and tertiary education (29.8%, 155 persons). As part of different social groups that were surveyed, the highest number of persons with tertiary education was found in the group of seniors and the lowest number of persons with tertiary education was found in the group of single mothers. One of five respondents had basic vocational education (Table 3).

Table 3. Characteristics of the survey population by education and social status (n = 521).

Age	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Basic	3	6.0	2	2.4	8	2.9	9	8.1	22	4.2
Basic vocational	11	22.0	13	15.5	49	17.8	27	24.3	100	19.2
Secondary	22	44.0	29	34.5	90	32.6	43	38.7	184	35.3
Postsecondary	9	18.0	15	17.9	28	10.1	8	7.2	60	11.5
Tertiary	5	10.0	25	29.8	101	36.6	24	21.6	155	29.8
Total	50	100.0	84	100.0	276	100.0	111	100.0	521	100.0

Source: own research.

The main source of respondents' income was old-age pension, as indicated by 322 respondents. Forty-two respondents were on a disability pension, 24 respondents specified that farming was their main source of income, 97 persons earned their income from sources outside agriculture, 34 respondents received benefits/allowances, 39 persons were engaged in casual work, only 4 respondents earn their income abroad, and 14 respondents marked "other".

In summary, the main sources of respondents' incomes were old-age/disability pensions, specifically in the case of seniors and the disabled, as well as employment outside agriculture and benefits/allowances, especially in the case of single mothers and unemployed persons (Table 4).

Over one out of five respondents were disabled; 17 respondents refused to provide details of their disability, if any (Table 5).

Table 4. Characteristics of the survey population by sources of income and social status (n = 521).

Source of Income	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons	
	No.	%	No.	%	No.	%	No.	%
Old-age pension	2	4.0	11	13.1	243	88.0	66	59.5
Employment outside agriculture	19	38.0	27	32.1	40	14.5	11	9.9
Disability pension	5	10.0	7	8.3	5	1.8	25	22.5
Casual work	9	18.0	14	16.7	10	3.6	6	5.4
Benefit/allowance	14	28.0	12	14.3	0	0.0	8	7.2
Farm	7	14.0	10	11.9	5	1.8	2	1.8
Other	0	0.0	9	10.7	3	1.1	2	1.8
Employment abroad	3	6.0	0	0.0	1	0.4	0	0.0

Source: own research. Note: adds up to 100% as respondents were free to indicate more than one source of income.

Table 5. Characteristics of the survey population by disability and social status (n = 521).

Disability	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Yes	0	0.0	0	0.0	0	0.0	111	100.0	111	21.3
No	43	86.0	79	94.0	271	98.2	0	0.0	393	75.4
Refusal	7	14.0	5	6.0	5	1.8	0	0.0	17	3.3
Total	50	100.0	84	100.0	276	100.0	111	100.0	521	100.0

Source: own research.

Among 111 respondents with disabilities, those with physical impairments made up the largest group of respondents (71) followed by 17 respondents with visual impairments and 13 respondents with hearing impairments. Four respondents declared intellectual disability; 8 respondents specified "other", whereas 11 respondents did not indicate their type of disability.

The sample comprises 14% of persons who experience problems with daily tasks. Naturally, the highest number of such people can be found among the disabled (nearly every other person declared the above), however, a high percentage of such people was recorded among single mothers (7 out of 50). Regarding the disabled, 10 respondents found it difficult to state whether daily tasks were a problem (Table 6).

Table 6. Difficulties with daily tasks by social status of the respondents (n = 521).

Difficulties With Daily Tasks	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Yes	1	2.0	2	2.4	3	1.1	21	18.9	27	5.2
Rather yes	6	12.0	5	6.0	9	3.3	26	23.4	46	8.8
Rather no	10	20.0	26	31.0	47	17.0	29	26.1	112	21.5
No	30	60.0	47	56.0	207	75.0	24	21.6	308	59.1
Difficult to say	1	2.0	3	3.6	6	2.2	10	9.0	20	3.0
Refusal	2	4.0	1	1.2	4	1.4	1	0.9	8	1.5
Total	50	100.0	84	100.0	276	100.0	111	100.0	521	100.0

Source: own research.

The respondents rather moderately tend to rely on the assistance of others—in total 106 persons accounting for 20.3%. The greatest number of persons who report that they require support in daily tasks is the disabled (62), accounting for 55.9% of that group. Only 25 persons of 276 people aged over 60 rely on the assistance of others. In the case of the unemployed, 11 out of 84 respondents, and in the case of single mothers, 8 out of 50, are helped with daily tasks.

In summary, every fifth respondent stated that they rely on the assistance of other people in their daily tasks. The beneficiaries of such support are most often the disabled and also, to a much smaller degree, single mothers. Interestingly, only every 10th senior stated that they benefit from such support.

4.2. Support for Dependent People: Institutional and Non-Institutional

Family is the greatest support group, especially in the case of people aged over 60 (22 out of 25) and the disabled (52 out of 62). It is mainly the disabled who can rely on the assistance of their neighbors (6 of 62 people). Friends or organizations such as Caritas provide hardly any assistance to the people in need. Community nurses are surprisingly not helpful at all, and regarding social workers, only three respondents stated that they benefit from such kind of assistance.

Hence, the respondents most frequently benefit from the help of their family members, especially in the case of the support for the disabled and seniors. Apart from the support lent by family members, the group of single mothers indicated that they benefit from the help of their neighbors or friends (much more frequently as compared with other survey social groups (Table 7).

Table 7. Relying on the assistance of other persons by social status of the respondents (n = 106).

Persons Providing Assistance	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Family	4	50.0	8	72.7	22	88.0	52	83.9	86	81.1
Neighbors	3	37.5	3	27.3	2	8.0	6	9.7	14	13.2
Friends	1	12.5	0	0.0	1	4.0	0	0.0	2	1.9
Charity organizations, e.g., Caritas, etc.	0	0.0	0	0.0	0	0.0	1	1.6	1	0.9
Social worker	0	0.0	0	0.0	0	0.0	3	4.8	3	2.8
Community nurse	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Other people	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	8	100.0%	11	100.0%	25	100.0%	62	100.0%	106	100.0%

Source: own research.

Only every 10th respondent (52 persons) stated that they live independently—most often the disabled (17 of 111). More than 50% of the respondents live together with their spouse or regular partner, with the seniors being the largest group (208 of 276). Every third respondent lives with their children; in this case the above mostly applies to single mothers (almost all of them) as well as the unemployed (35 of 84) and the disabled (36 of 111) (Table 8).

The vast majority of the respondents (87.8%) believe that they can count on short-term assistance from their cohabitants. Only the group of single mothers who are most likely to live with small children, is characterized by a high percentage (36.0%) of the respondents stating that such assistance is not available to them. The highest percentage of the respondents from the groups that can rely on short-term assistance from their cohabitants was recorded in the case of people aged over 60 (92.9%) and the disabled (91.5%).

Table 8. Cohabitation with other people by social status of the respondents (n = 521).

Cohabitation	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Spouse/regular partner	0	0.0	57	67.9	208	75.4	69	62.2	334	64.1
Child	41	82.0	35	41.7	64	23.2	36	32.4	176	33.8
Lives independently	0	0.0	0	0.0	35	12.7	17	15.3	52	10.0
Grandchildren	3	6.0	4	4.8	25	9.1	12	10.8	44	8.4
Parents, in-laws	11	22.0	7	8.3	5	1.8	4	3.6	27	5.2
Siblings	4	8.0	6	7.1	7	2.5	1	0.9	18	3.5
Other family members	1	2.0	7	8.3	6	2.2	2	1.8	16	3.1
Refusal	1	2.0	0	0.0	5	1.8	1	0.9	7	1.3
Great grandchildren	1	2.0	1	1.2	0	0.0	2	1.8	4	0.8
Non-relatives	0	0.0	0	0.0	2	0.7	1	0.9	3	0.6
Total	50	100.0%	84	100.0	276	100.0	111	100.0	521	100.0

Source: own research.

4.3. Access to Facilities and Services

To people with limited mobility (the elderly, the disabled), access to facilities and services (within a walking distance) ensuring that their basic needs are met is of vital importance. The vast majority of the respondents stated that there is a grocery store near their place of residence, every other respondent has access to a pharmacy, a local health center, post office, and a hairdresser as well. Only one in three respondents stated that there is a market, a café, or a restaurant nearby (Table 9).

Table 9. Access to facilities and services by social status of the respondents (n = 521).

Access to Facilities and Services	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Grocery store	38	76.0	69	82.1	239	86.6	84	75.7	430	82.5
Pharmacy	24	48.0	34	40.5	148	53.6	59	53.2	265	50.9
Health center	18	36.0	28	33.3	148	53.6	58	52.3	252	48.4
Post-office	10	20.0	30	35.7	141	51.1	61	55.0	242	46.4
Hairdresser	13	26.0	28	33.3	153	55.4	50	45.0	244	46.8
Cafe, restaurant, bar	8	16.0	18	21.4	125	45.3	42	37.8	193	37.0
Market	10	20.0	13	15.5	109	39.5	35	31.5	167	32.1
None of the above	3	6.0	5	6.0	30	10.9	20	18.0	58	11.1
Total	50	100.0	84	100.0	276	100.0	111	100.0	521	100.0

Source: own research.

The research results show a very high percentage of the respondents declaring internet access (approximately 90.0%). The related highest percentage was recorded among the respondents aged over 60 (93.1%), whereas the lowest percentage was recorded among single mothers (88.0%). Access to the internet is generally equivalent to internet usage. Discrepancies related to a smaller number of people using the internet vis-a-vis the number of people with internet access was on average 2.6 percentage points. The largest discrepancy was recorded in the case of the disabled (5.4 percentage points) (Figure 3).

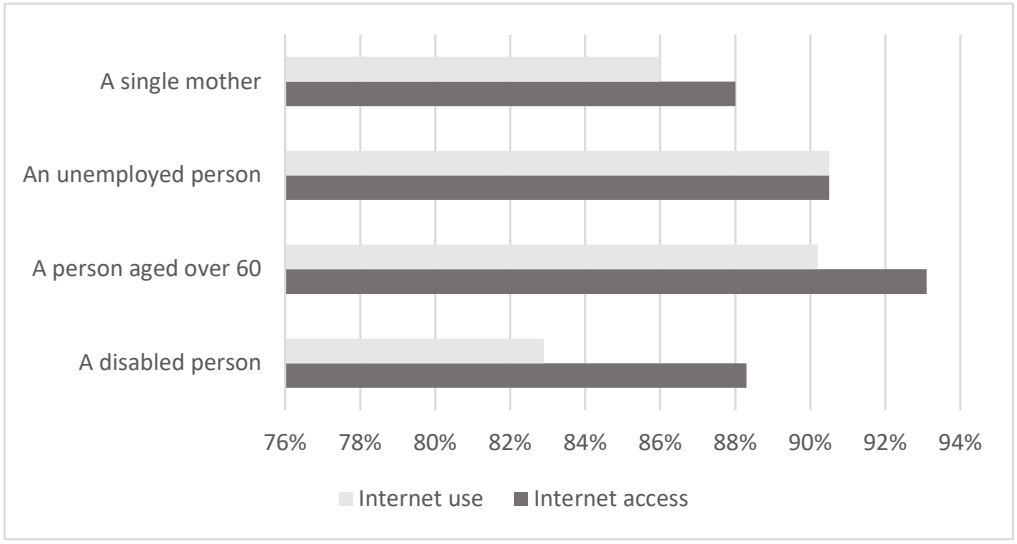

Figure 3. Internet access and usage by social status of the respondents (n = 521). Source: own research.

The respondents most frequently used laptops or computers to access the internet; in that category, the maximum percentage (90.8%) was recorded among the respondents aged over 60. Smartphone was the second most frequently used device among surveyed internet users. In this case, the discrepancies pertaining to the use of the tool by various groups of users are quite significant. For example, 72.1% of single mothers preferred to use the smartphone versus 55.8% of persons aged over 60. Tablets were the least popular devices chosen by the respondents. It was the most frequently used device by seniors (22.9%) and the least used device by single mothers (7.0%) (Figure 4).

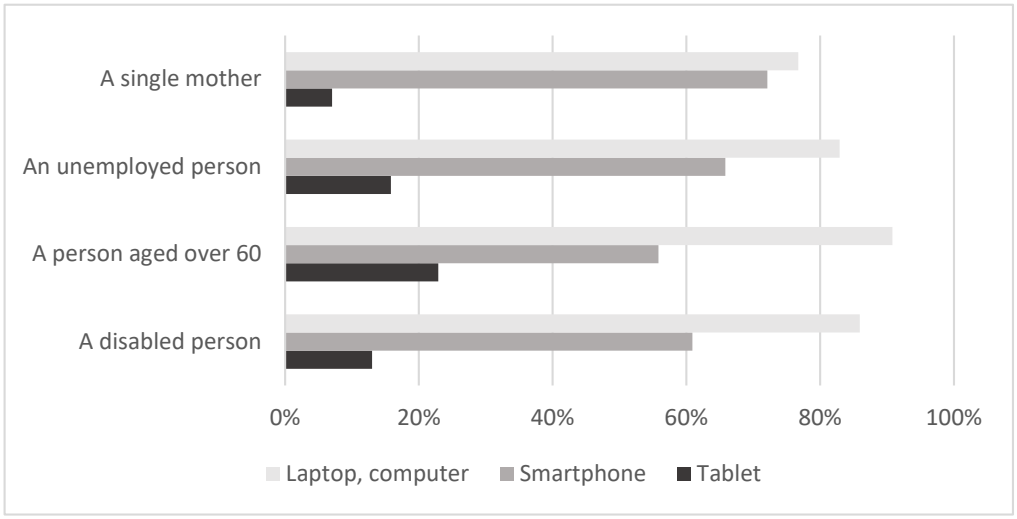

Figure 4. A device for access the internet by social status of the respondents (n = 521) (source, own research). Note: adds up to 100% as respondents were free to indicate more than one device.

Among 460 respondents who declared internet usage, the vast majority used it very frequently or almost daily, i.e., 80.7% of all respondents. The categories "once a week or less" and "if needed" were marked by 2.8% of the respondents; 16.5% of the respondents tended to use the Internet a few times a week (Table 10).

Table 10. Internet usage frequency by social status of the respondents (n = 460).

Internet Usage Frequency	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Very often	34	79.1	56	73.7	203	81.5	78	84.8	371	80.7
4–5 Times a week	5	11.6	10	13.2	23	9.2	8	8.7	46	10.0
2–3 Times a week	2	4.7	10	13.2	14	5.6	4	4.3	30	6.5
Once a week or less	1	2.3	0	0.0	3	1.2	1	1.1	5	1.1
If needed	1	2.3	0	0.0	6	2.4	1	1.1	8	1.7
Total	43	100.0	76	100.0	249	100.0	92	100.0	460	100.0

Source: own research.

Among the surveyed internet users, 50% indicated that their mobile phone operator was their internet provider, and only 25% of the respondents who were internet users had optic-fiber internet access. Wireless internet and cable internet access were indicated much less frequently (15.7% and 13.7%, respectively). Quite a large number of the respondents (31) indicated that other sources determined their access to the internet (Table 11).

Table 11. Internet access by social status of the respondents (n = 460).

Internet Access	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Mobile phone operator	24	55.8	43	56.6	113	45.4	46	50.0	226	49.1
Optic fiber internet	9	20.9	11	14.5	73	29.3	21	22.8	114	24.8
Wireless internet	9	20.9	12	15.8	37	14.9	14	15.2	72	15.7
Cable internet	3	7.0	14	18.4	29	11.6	17	18.5	63	13.7
Other	1	2.3	6	7.9	17	6.8	7	7.6	31	6.7
No information available	3	7.0	0	0.0	9	3.6	2	2.2	14	3.0
Total	43	100.0	76	100.0	249	100.0	92	100.0	460	100.0

Source: own research.

The majority of internet users (78%) are satisfied with the service's quality and speed. The highest number of dissatisfied users regarding the service's parameters was found to be among single mothers (34.9%). To illustrate, the percentage of users who were not satisfied with the quality and speed of their internet connection was 21.7% among the people aged over 60, 19.6% among the disabled, and 18.4% among the unemployed.

The majority of the respondents had never heard of "power line internet access". Only one in three respondents was familiar with such service. The disabled were the most informed respondents (37.8%) versus single mothers who were the least informed respondents (28.8%) (Figure 5).

According to the research results, half of the respondents use the internet through their mobile phone operator. Thus, the popularization of power line communication technology in the rural areas is a very important challenge.

Among 88.8% of e-mail users, the group of senior respondents aged over 60 stands out the most (90.8%). The same applies to home banking, i.e., on average the number of the respondents relying on home banking services is 78.7%, with seniors accounting for 83.5%. The same also applies for internet portals, i.e., seniors account for 83.9% of their users (an average number of users was 77.2%). The group of single mothers ranks above the average of 72.2% of social networking sites' users such as Facebook, accounting for 83.7%. Online shopping is mostly done by the disabled (69.6%) and seniors (68.3%). In addition, seniors (33.7%) are the largest group of users of online services with an average of 29.8%.

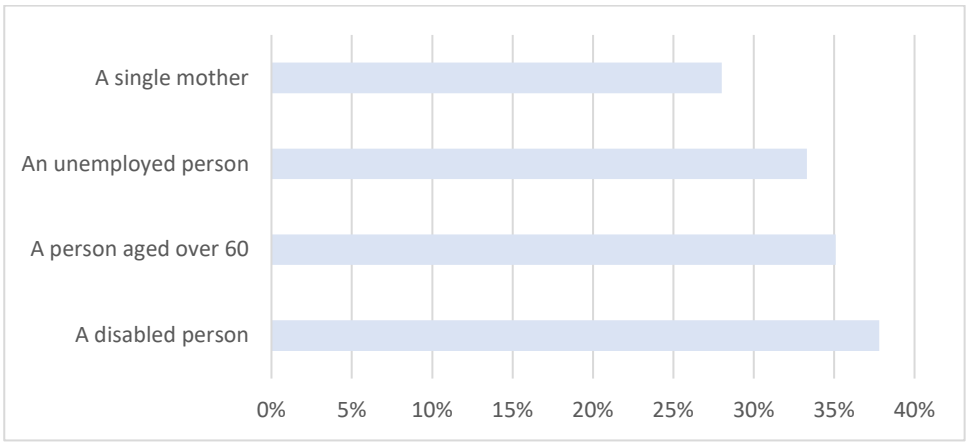

Figure 5. The awareness of respondents about PLC technology allowing them to use a power line at home or in an apartment for internet access (n = 521) (source, own research).

In summary, almost all internet users use e-mail, home banking, and visit news sites (portals) and social media. Slightly over 50% of the survey respondents using the internet use the option of online shopping, one third also benefits from online services (Table 12).

Table 12. The use of services, websites, and internet portals by social status of the respondents (n = 460).

The Use of Services, Websites, and Portals	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Electronic mail	36	83.7	65	85.5	226	90.8	78	84.8	405	88.0
Home banking	32	74.4	50	65.8	208	83.5	72	78.3	362	78.7
Internet portals	27	62.8	48	63.2	209	83.9	71	77.2	355	77.2
Social networking sites (e.g., Facebook)	36	83.7	52	68.4	176	70.7	68	73.9	332	72.2
Online shopping	26	60.5	47	61.8	170	68.3	64	69.6	307	66.7
Online services	9	20.9	19	25.0	84	33.7	25	27.2	137	29.8
Other	0	0.0	0	0.0	7	2.8	2	2.2	9	2.0
Total	43		76		249		92		460	

Source: own research. Note: adds up to 100% as respondents were free to indicate more than one variant.

Only 20% of respondents have access to fiber optic internet and report limited internet surfing (mainly e-mail). The majority of responders (80%) have other internet connections and cannot use other services that require large amounts of data flow, for example, movie streaming, online conferences (e.g., university of the third age), online conversations, or 24/7 monitoring.

Fifty per cent of the respondents said that they would be interested in an internet portal featuring information regarding services available near their place of residence targeted at seniors and the disabled (Figure 6). The social groups that were the most interested were single mothers (78.0%) and the unemployed (65.4%).

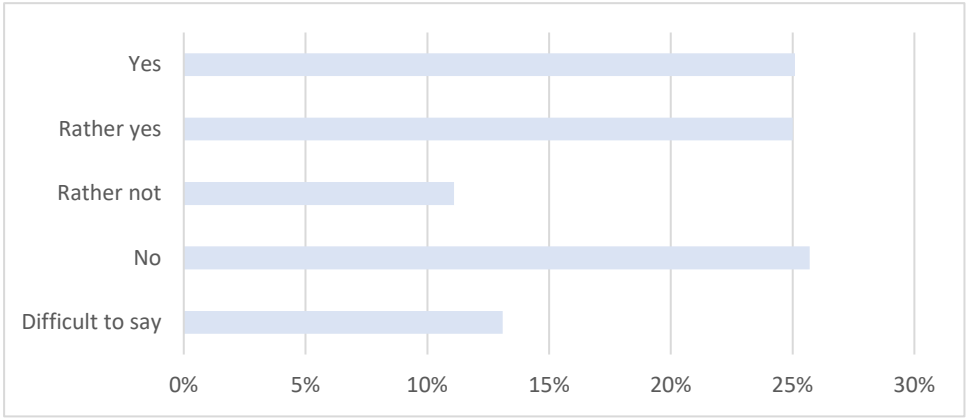

Figure 6. Interest in an internet portal featuring information regarding services available near their place of residence targeted at seniors and the disabled (n = 521) (source, own research).

The persons interested in the portal would mostly seek information about rehabilitation services and availability of specialist physicians (59.1% and 58%, respectively). The respondents would also be interested in leisure time possibilities (38.5%), legal and tax advisory services (38.1%), and transport services (37.7%). Among the respondents, the seniors and the disabled are more often interested in information featured on such a site as compared with the unemployed and single mothers. The last group of services in which the respondents were interested (30.0%) included: social services related to meeting new people (31.1%); educational services (30.0%); and ordering services of mobile sellers, and ordering shopping/meals with home delivery (29.6%) (Table 13).

Table 13. Interest in using services available as part of the portal addressed to seniors and persons with disabilities, by social status of the respondents (n = 521).

Services in Which the Respondents Are Interested In	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	% of N In Column	No.	% of N In Column	No.	% of N in column	No.	% of N In Column	No.	% of N In Column
Rehabilitation	23	59.0	29	53.7	57	55.9	43	69.4	152	59.1
Related to access to specialist physicians	18	46.2	22	40.7	70	68.6	39	62.9	149	58.0
Related to leisure, sports and hobbies	8	20.5	20	37.0	47	46.1	24	38.7	99	38.5
Legal and tax advisory etc.	11	28.2	25	46.3	45	44.1	17	27.4	98	38.1
Transport services, e.g., transport to a doctor	16	41.0	23	42.6	35	34.3	23	37.1	97	37.7
Related to meeting new people	6	15.4	18	33.3	37	36.3	19	30.6	80	31.1
Educational services	14	35.9	20	37.0	27	26.5	16	25.8	77	30.0
Mobile salespersons—ordering shopping/meals with home delivery	7	17.9	14	25.9	38	37.3	17	27.4	76	29.6
Hairdresser, beauty services	5	12.8	16	29.6	26	25.5	15	24.2	62	24.1
Related to psychological support	9	23.1	14	25.9	20	19.6	17	27.4	60	23.3
Offers of paid assistance in running the household, e.g., cleaning, shopping	4	10.3	13	24.1	27	26.5	12	19.4	56	21.8

Table 13. *Cont.*

Services in Which the Respondents Are Interested In	Single Mothers		Unemployed Persons		Persons Aged Over 60		Disabled Persons		Total	
	No.	% of N In Column	No.	% of N In Column	No.	% of N in column	No.	% of N In Column	No.	% of N In Column
Tourist services	4	10.3	11	20.4	27	26.5	13	21.0	55	21.4
Personal care services, e.g., help with bathing	10	25.6	11	20.4	13	12.7	11	17.7	45	17.5
Other	0	0.0	0	0.0	3	2.9	0	0.0	3	1.2
Total	39	100.0	54	100.0	102	100.0	62	100.0	257	100.0

Source: own research. Note: adds up to 100% as respondents were free to indicate more than one variant.

To realize the abovementioned services, an adequately efficient network capacity is required. Thus, power line communication technology seems to be a very favorable solution.

Only an app used for monitoring health condition scored higher (41.8%) than others. Other proposed conveniences for seniors and people with disabilities that should be available via portal achieved similar results (approximately 30.0%) (Figure 7). The seniors and the disabled are the most interested in the health condition monitoring service. The respondents also indicated the following: the possibility of using voice commands, a camera for video connections for the deaf, an app for processing text into speech, and a voice app for the mute.

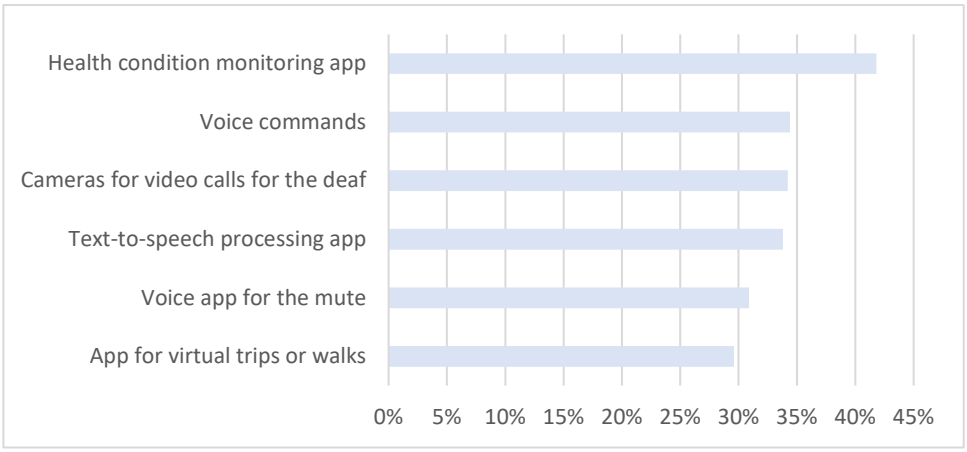

Figure 7. Conveniences for seniors and the disabled that should be available via the portal (n = 521) (source, own research). Note: adds up to 100% as respondents were free to indicate more than one variant.

5. Analysis

5.1. Access of Inhabitants of Rural Areas to Technical and Social Infrastructure

Rural areas are diversified in many aspects. One of the factors determining access to technical and social infrastructure is a village's location in relation to a town/city whose size also matters. Large cities or urban agglomerations keep growing and their newly emerging suburbs partially annex rural areas, mostly for the purpose of housing developments for new inhabitants. Such highly urbanized villages are relatively well-connected with towns/cities and the level of the development of infrastructure is actually similar to that available in towns/cities. Hence, the quality of life of the inhabitants of urbanized rural areas, including elderly individuals and people with special needs, differs in a positive way from the standard of living in villages threatened with depopulation. Regions characterized by the concentration of the ageing population, the absence of non-farm jobs, and the presence of hidden unemployment are those places where it is particularly hard to live for the elderly, the lonely, the disabled, and people in difficult life situations.

Table 14 presents the demographic development in Poland by voivodship (NUTS 2), accounting for population density per km^2 and average population of one village.

Table 14. Poland's population in 2020 by place of residence (city/country).

Voivodships (a)	Area (b)		Urban Population and Rural Population (c)		Rural Population (d)		Percentage	Average Population Per Village
	In ha	In km^2	Total	Per km	Total	Per km^2	d/c	
POLAND	29,049,891	290,499	38,382,576	123	15,340,784	53	39.97	292
Dolnośląskie	1,778,196	17,782	2,900,163	145	916,119	52	**31.59**	**362**
Kujawsko-Pomorskie	1,714,222	17,142	2,072,373	115	851,929	50	41.11	238
Lubelskie	2,410,384	24,104	2,108,270	84	1,128,913	47	**53.55**	280
Lubuskie	1,311,096	13,109	1,011,592	72	355,031	27	35.10	274
Łódzkie	1,703,449	17,035	2,454,779	135	919,859	54	37.47	**184**
Małopolskie	1,352,387	13,524	3,410,901	225	1,766,729	131	51.80	**906**
Mazowieckie	3,336,310	33,364	5,423,168	153	1,926,413	58	35.52	226
Opolskie	856,439	8564	982,626	104	459,478	54	46.76	397
Podkarpackie	1,660,422	16,605	2,127,164	119	1,244,742	75	**58.52**	**750**
Podlaskie	1,926,118	19,261	1,178,353	58	461,430	24	39.16	**123**
Pomorskie	1,725,165	17,251	2,343,928	128	855,801	50	36.51	297
Śląskie	854,274	8,543	4,517,635	366	1,056,968	124	**23.40**	**817**
Świętokrzyskie	1,093,050	10,931	1,233,961	105	671,904	61	**54.45**	272
Warmińsko-Mazurskie	2,355,701	23,557	1,422,737	59	580,641	25	40.81	**150**
Wielkopolskie	2,828,042	28,280	3,498,733	117	1,609,340	57	45.10	295
Zachodniopomorskie	2,144,636	21,447	1,696,193	74	535,487	25	**31.57**	178

Source: Own study based on https://stat.gov.pl/ (accessed on 12 December 2021).

Poland's population in 2020 exceeded 38 million, with 40% being the inhabitants of rural areas (over 15 million). The average population density is 123 people per km^2 with less than 50% inhabiting rural areas (53 people per km^2). On average, village population was 292. The highest degree of urbanization measured by the percentage of inhabitants in rural areas by voivodship was recorded in the Śląskie, Zachodniopomorskie, and Dolnośląskie voivodeships. In those regions, the percentages were well below the national average (40%) totaling respectively: 23.40%, 31.57%, and 31.59%. In addition, the voivodeships with the highest share of rural population in the entire population included: Podkarpackie (58.52%), Świętokrzyskie (54.45%), and Lubelskie (53.55%). On the one hand, the voivodeships where the average number of the inhabitants in a village differs "negatively" from the national average of 292 are: Podlaskie (123 people), Warmińsko-Mazurskie (150 persons), and Łódzkie (184 persons). Those data suggest an advanced depopulation process in the rural areas of those voivodeships which is related to insufficient technical and social infrastructure. On the other hand, the voivodeships with the average population of villages being several times higher than the national average were: Małopolskie (906 people), Śląskie (817 people), and Podkarpackie (750 people). This phenomenon is, to a large extent, caused by the development of peripheral areas of big cities. In the Małopolskie Voivodeship the big cities include Kraków, Tarnów, Nowy Sącz, and Nowy Targ. In the Śląskie Voivodship, a metropolitan area with the capital city of Katowice, the big cities include Częstochowa, Wodzisław Śląski, Racibórz, Bielsko-Biała, and Tarnowskie Góry. In the Podkarpackie Voivodship, the big cities include Rzeszów, Przemyśl, Mielec, Sanok, and Krosno. High population density in the rural areas of those voivodeships has a positive impact on the development of infrastructure and also contributes to improved quality of living.

In the digitalization era, internet access is one of the most important factors affecting the quality of living. The above is particularly important to the inhabitants of rural areas where such access is diversified. Based on a publication entitled "Społeczeństwo infor-

macyjne w Polsce"/Information society in Poland" that presented the results of research conducted in 2015–2019 regarding the application of information and communication technologies (ICT) in enterprises, public administration, households, and by individuals, appropriate research results were presented.

In 2019 in Poland, 83.3% of total households had broadband access which means that the rate increased by 4.0 percentage points as compared with the previous year, and, as compared with 2015, the rate increased by 12.3 percentage points. In 2019, households with broadband access accounted for 96.0% of total households with internet access. In 2019, in all highly urbanized areas of Poland, the percentage of households with broadband access exceeded 86% (the highest percentage was recorded in Poland, i.e., 89.5%). The lowest share of households with broadband access was recorded in areas with low degrees of urbanization in central Poland, i.e., 77.5%. In 2019 in Poland, 78.3% of people aged 16–74 used the internet regularly (at least once a week) (vis-a-vis 74.8% in 2018). In 2018 in the European Union, that figure totaled 83% (two percentage points more than in 2017). The gap between Poland and the EU average was eight percentage points. The highest share of regular internet users was recorded in Norway (97%) and Denmark (95%), and the lowest in Bulgaria (64%). The share of regular internet users differs depending on age, professional activity, education, and place of residence. Taking into consideration the type of professional activity, in 2019, the highest percentage of regular users was recorded for students (99.6%) and self-employed (95.5%) and the lowest percentage of regular users was recorded for pensioners and other people who are not professionally active (4.3%). The share of regular internet users has grown in all age groups. In 2019, vis-a-vis 2018, the highest increase in the share of regular internet users was recorded for persons aged 55–64 (up by 9.5 percentage points). In 2019, there were 59.9% regular internet users in that group. The oldest group of the respondents aged 65–74 that uses the internet has been growing year by year: in 2015, 19.5%; in 2016, 23.1%; in 2017, 26.0%; in 2018, 29.8%; in 2019, 33.3%. In 2019, more than 15.7 million people aged 16–74 (53.9% of the population) shopped online (in the past 12 months). In 2015–2019, the percentage of individuals who placed orders or shopped online grew regularly and increased by 17.0 percentage points over that period. Regarding the criteria of age and professional activity, in 2019, the highest increases in the share of persons shopping online were recorded for the respondents aged 16–24 (by 9.3%) and the unemployed (by 10.7 percentage points). Regarding educational background, the highest share of individuals buying products and service online in 2019 was recorded for people with higher education (81.2%) and, in the case of the place of residence, for the inhabitants of large cities (61.8%). Analyzing the popularity of e-commerce by voivodeship, it can be observed that, in 2019, in the Opolskie Voivodeship, over 60% of persons ordered or shopped online for goods or services for private use. The lowest percentage of e-buyers was recorded in the Lublin Voivodeship (45.0%). Clothing and sports equipment are the most popular items bought online. In 2019, those products were purchased by 68.9% of buyers shopping online. Other accessories, food products, holidays, excursions, and tickets were also very popular. Films and music (9.2%) and software (including games) (9.4%) were the items that were least frequently purchased online [32].

In 2019, on the one hand, the inhabitants of large cities had the greatest access to the internet at home, i.e., 90.0%. In smaller towns, that figure was 4.4 percentage points lower. On the other hand, 84.6% of the rural population had access to the internet. Lower figures were recorded for regular internet users: 3.7 percentage points less vis-a-vis individuals with internet access in big cities; in towns, 5.9 percentage points less; and in rural areas, 13.2 percentage points less. Regarding online shopping for goods or services, the inhabitants of big cities (61.8%) shopped online more frequently than the inhabitants of towns (54.2%) and countryside (48.1%). The order of the ranking is slightly different in regards of individuals using mobile devices for internet connection outside their homes or places of work. In this case, the dominant category is "towns" (23.1%), followed by "rural areas" (21.7%) and "cities" (20.2%) [32]. Figure 8 below shows the detailed data.

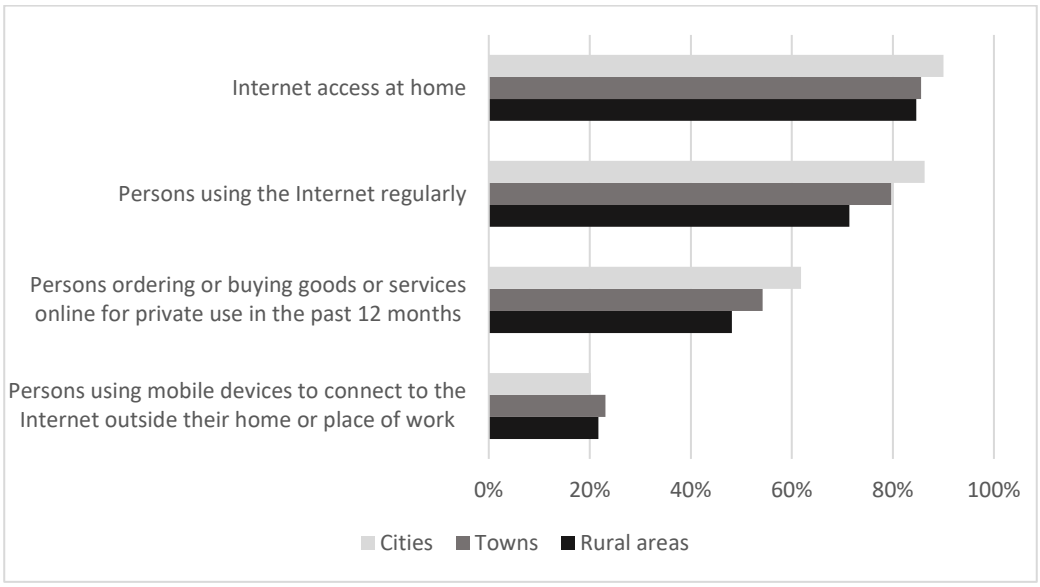

Figure 8. The use of the internet in 2019 by place of residence (source, own study based on information society in Poland, 2019).

5.2. IoT Technologies in the Face to Needs of Socially Sensitive Groups

In Poland in 2019, the most popular items purchased online were clothing and accessories (64.0%). Cultural goods and services (books, films, music, and cinema/theater tickets) ranked second and third. Over 40.0% of items bought via the internet were footwear, cosmetics, and care products. Consumer electronics, holidays, hotel bookings, and sportswear were the categories that were purchased by 36.0% of e-buyers. Mobile devices (smartphones, tablets, etc.) were ordered by 32.0% of internet users. The last three categories in the ranking, i.e., hardware, products for children and toys, and multimedia were bought by 29.9% of e-shoppers [32] (Figure 9).

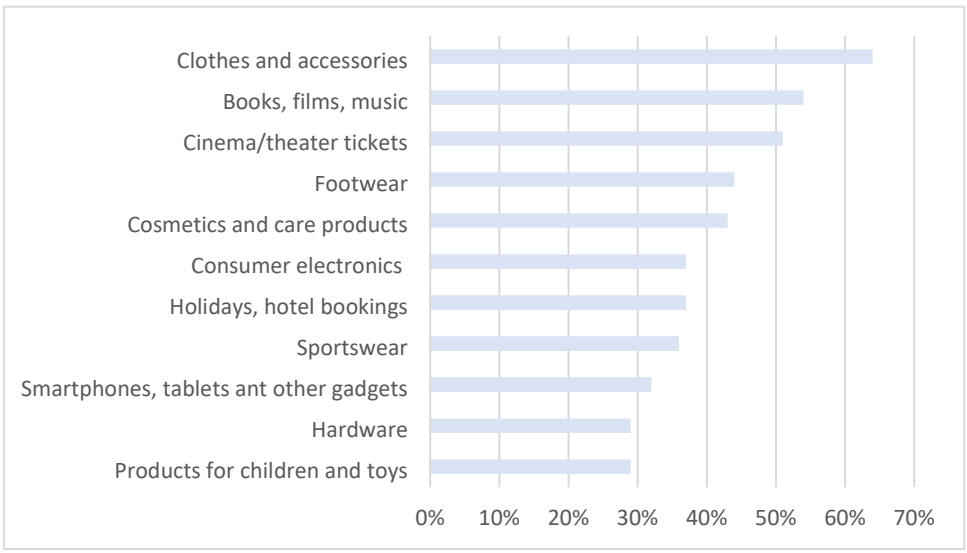

Figure 9. The most popular products e-shoppers bought online, in 2019 (source, own study based on information society in Poland). Results of statistical research in 2015–2019. GUS/Chief Statistical Office, Warsaw, Szczecin, Poland, 2019.

As mentioned above, seniors are the social group whose online activity has been growing year by year. Regarding trends and the structure of the Polish economy with respect to the development of the IoT, two areas are crucial from the perspective of seniors,

namely health care and smart cities/buildings which can also be considered in the context of contemporary demographic and social processes, including in Poland. The above refers to the progressing ageing of the population and, consequently, the growing share of the elderly in the society. One of the key challenges of modernity is definitely ensuring the well-being of seniors, inter alia, with the use of modern technologies. Progress in that area requires the deployment of systems and technologies that help monitor the condition of the surroundings and also collects data on seniors. The IoT may play a crucial role in that regard and its elements will gradually become commonplace both in the public space and in seniors' households [33].

The IoT technologies may also be convenient in the case of other socially sensitive groups, for example, people with disabilities. It has become increasingly important that people and groups that have been excluded and marginalized [34,35] must not be disregarded in the future in the process of the development of modern technologies; they must not be excluded from full participation in a public life. Unfortunately, research on the use of modern technologies by individuals with health dysfunctions, including those with intellectual disability, is irregular and insufficient. The above applies to, for example, research on access to digital technologies by such people, their activities online, or risk factors conducive to the abuse of new digital technologies by that group of customers [36].

A similar problem (the need of social inclusion of the disabled), however, in the context of 5G development, was discussed by the authors of the report entitled "(Nie)pełnosprawni w sieci"/"The dis/abled online" [37]. It is assumed that the connection of the components of modern technologies by 5G network will allow new apps to be created that will, in turn, facilitate daily functioning of the disabled. It will help eliminate obstacles in areas particularly critically assessed by people with dysfunctions such as problems with independent living (e.g., due to the absence of appropriate housing conditions) and trouble with transportation and movement. Currently, social assistants or nurses support such individuals, however, that could change thanks to IoT technology. The report also discusses 5G technology, specifically services that address people with all kinds of dysfunctions, namely, the services that ensure accurate location. They would help, for example, to find a person in a building that was not adjusted to the needs of the disabled, to prevent them from entering the road and getting hit by a car, and to help them freely move around the city. Another group of 5G solutions dedicated to the disabled includes medical care services that can, for example, help them remember taking medications, and in the future, will allow replacement of limbs with so-called smart prosthesis [37].

In the context of social participation, i.e., the participation of individuals with disabilities in the use of modern technologies, public space must be remodeled and there is a need for a comprehensive change in attitude towards a broadly understood social policy. Those changes must account for both subjective conditions (e.g., specific characteristics of disabilities) as well as objective ones (caused by external obstacles). There are several groups of problems that will determine the deployment of the IoT technology that should be mentioned. Firstly, one group of problems is related to access to high-speed internet, high-quality equipment, as well as software. Another group of problems pertains to skills required for the skilled use of the hardware and the use of cyberspace. The third group of problems involves adaptation of cyberspace (e.g., developed by public institutions and its adaptation to meet the needs of the disabled). Moreover, Polish legal regulations must be amended in order for such changes to be introduced [38].

According to the results of the research conducted for the purpose of this study and related to the opinions of seniors about the Senior-net portal, attention should be given to the application of modern technologies to meet the needs of the elderly generation, among which, the vast majority fits well with the concept of the Internet of Things. In that area, the term "gerontechnology" is used, being the science dealing with technology and aging for the purpose of improving the quality of daily lives of older people. An interdisciplinary approach consistent with the concept of sustainability and the combination of the research with design, production, and marketing plays an important role here [26].

6. Conclusions

The IoT technologies are one of the most dynamically developing segments of services in the world. In Poland, the value of the IoT market has been increasing at a fast pace, by approximately 13% per annum. The IoT also offers a number of solutions dedicated to the elderly and other social groups that require support. However, those smart technologies fail to satisfy all needs of those individuals due to the lack of access to specialized services (e.g., those related to the concept of a smart home) owing to their high costs. Given the processes related to the rapidly aging society, depopulation in rural areas, and deteriorating social ties, people need solutions that will make their daily functioning easier in relation to their limited mobility caused by age and disability. One such solution is the Senior.net portal, enabling them to place orders for basic necessities as well as providing smooth access to social and commercial services such as medical, rehabilitation, administrative, care, gastronomic, tourist, and other services. The purpose of this research was to obtain information about the digital competences of the elderly, the disabled, and other socially sensitive groups and their expectations related to the Senior.net. functionality.

With regard to the research questions formulated, the following conclusions were drawn:

1. What sociodemographic characteristics distinguish respondents representing socially vulnerable groups?
    - Despite their limited mobility or even disability, the respondents have been relying on the assistance of other people moderately (approximately 20% of all respondents);
    - The largest group of the respondents (53%) were people aged over 60;
    - Every fifth respondent was disabled and the disabled are most often seniors, aged over 60;
    - Respondents who were single mothers and the unemployed were most often young and middle-aged persons, under 50 years old;
    - The largest group of the respondents were those with secondary education and tertiary education;
    - The respondents' main source of income is old-age pension;
    - Every fifth respondent stated that they rely on the assistance of other people in their daily tasks.
2. What is the level of support for dependent people—institutional and non-institutional—from family, social environment, and institutions?
    - Family is the greatest support group, especially in the case of people aged over 60;
    - It is mainly the disabled who can rely on the assistance of their neighbors;
    - Friends or organizations, such as Caritas, provide hardly any assistance to people in need;
    - Community nurses are surprisingly not helpful at all, and similarly, only a few social workers provide help;
    - The group of single mothers indicated that they benefit from the help of their neighbors or friends.
3. What is the level of digital competencies of representatives of socially vulnerable groups, including older people?
    - The surveyed representatives of the social groups at risk of exclusion have access to the internet (approximately 90%);
    - Over 90% of the respondents use laptops or computers, whereas the second most frequently used device to connect to the internet is a smartphone followed by a tablet;
    - Over 80% of the respondents use the internet very frequently (almost on a daily basis);
    - 50% of the respondents use the internet and indicated their mobile phone operators as internet providers;

- The majority of the respondents have not heard of PLC technology allowing access to the internet using an electrical wiring at home or in an apartment;
- Seniors are a leading group among the respondents who have been using electronic mail (more than 90%), home banking (over 83%), and news sites (approximately 84%); single mothers mostly visit social networking platforms (approximately 84%); online shopping is the domain of the disabled (approximately 70%) and seniors (approximately 70%);
- 50% of the respondents stated that they would be interested in an internet portal featuring information regarding services available near their place of residence targeted at seniors and the disabled;
- The persons interested in such a site would like to obtain information about rehabilitation services and availability of specialist physicians (approximately 60%).

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