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Digital social innovation based on Big Data Analytics for health and well-being of society

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Abstract

Background: Any nation's health policy aims to properly care for its citizens and the society's quality of life. Since in the healthcare system, the population's health is the essential component of national wealth, health is treated as a public good and a social value. Therefore, in recent times, in addition to traditional instruments for promoting healthy lifestyles, health policy has increasingly turned to information instruments and digital technologies.

Aims: The paper aims to recognize the role of Big Data Analytics (BDA) in developing Digital Social Innovation (DSI) in the healthcare field. The proposal of the author's Individual Health Plan Platform (IHPP) solution is presented as an example of Digital Social Innovation.

Material and methods: The research is based on a critical analysis of the literature, followed by a Focus Group study aimed at determining the potential of Big Data Analytics, including especially analysis based on data from wearables, to help manage one's health and improve the society's well-being. The focus research also included verification of the research model presented in the article and evaluation of the proposed solution, the Individual Health Plan Platform, including the possibilities of its implementation as a solution to complement healthcare provided by medical facilities in Poland.

Results: The results of the focus group interviews show that analysing data from wearables and the proposed IHPP could be helpful in managing one's own health and helping to level important problems in healthcare.

Conclusion: One of the goals of this paper was to determine the role of BDAs in the development of social innovations in healthcare. From the analysis of the literature, results of the focus group study and discussion, it was concluded that Big Data Analytics has the potential to develop social innovation in healthcare.

Keywords: Digital social innovation, Healthcare big data, Big data analytics, Society health, Social well-being, Wearables

Introduction

Innovation has become a key resource to all sectors of the economy, and the health sector is not an exception. The importance of innovations in the health sector is undeniable. Over the years, healthcare innovations have been an essential source of improving people's health and well-being. This includes innovations in the field of new medical

solutions, new drugs, treatment methods, new clinical procedures, and the robotization of healthcare [14, 81]. Moreover, social innovation is becoming increasingly important in modern society and economies. Social innovation is seen as a better opportunity to meet social needs than existing solutions resulting, for example, from working conditions, education, community development or health [73, 81]. However, it should be noted that innovations are implemented on already existing structures, which become the basis and a prerequisite for any innovation and development. Therefore, the basic/existing structures are of paramount importance, and should be taken care of first, and if they work poorly (or do not work at all), even innovative approaches cannot replace them and enable citizens to meet their social needs. Social innovation can compete with an existing standard solution. Potential users will have to analyse whether the innovative alternative offers added value compared to the existing, known solution [66]. They will use it if it satisfies their needs to a higher extent than the old solution, and if this benefit is worth the financial and non-financial cost [28]. Other innovations offer a completely new solution, service, product or meet a need that was previously completely uncovered. There is a noticeable development of research on social innovation and implementation of solutions (products, services, models) aimed at improving and supporting all social changes.

Social innovations differ from traditional innovations mainly in terms of generating value for the broadly understood environment of organizations, i.e., customers, suppliers and various stakeholders [77]. The values developed as part of social innovations can improve social relations, communication and cooperation. The inherent goal of social innovation is to improve people's quality of life, create and share these values, not only in the economic sense but, above all, in the social sense.

An essential part of social innovation is Digital Social Innovation (DSI). In the literature, there is much evidence that digital technology can play an essential role in various social processes, e.g., communication or cooperation [3, 14, 37, 65, 70, 72, 73, 80, 81] . However, there still needs to be more research aimed at exploring the issues of computer-aided social innovation. The research gap also includes illustrating the technological solutions that can be used in supporting social innovation.

In general, DSI is a young field of research, which needs to be addressed in more depth including examples of its specific use. Moreover, there is no research illustrating whether Big Data analyses can support Digital Social Innovation which determines their application and the ways of designing Digital Social Innovation solutions (systems, apps, websites) based on data stream analysis. For this reason, the paper aims to identify the possibilities of using Big Data Analytics to create Digital Social Innovation in society's health and well-being. The study focuses specifically on the following aspects: (1) specification and applications of Digital Social Innovation based on Big Data Analytics in healthcare, (2) the benefits and barriers of healthcare based on Big Data Analytics and wearables (3) the potential impact of Digital Social Innovation based on Big Data Analytics on eliminating the problems healthcare is currently facing. The research presented in the article will use such methodologies as world literature query and case studies in the field of sources of knowledge, Digital Social Innovation related to healthcare, and healthcare Big Data Analytics. The research methodology also consists of data collection methods, transcription, analysis, processing, and interpretation of results. The research

was exploratory and qualitative in its nature, as the issues addressed in the article are less widely studied. At the same time, it is complex and multidimensional. The conceptual framework presented in this paper has been subject to initial verification using the focus group interview method.

Related works

Contemporary approaches to health and well-being

From the perspective of health policy and its goals, it is essential to properly take care of the quality of life of citizens and society because in the healthcare system, the population's health is the most crucial component of national wealth. Thus, health is a public good and a social value [17, 63, 64]. The World Health Organization equates health with a state of "complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO).[1] Good health is a condition for the participation of individuals in various areas of social life. Health and illness are not only a problem of the human individual, but also a cherished value of the social environment [41]. Thus, the task of health policy should be to improve health, meet health needs or provide health services [11, 23, 75]. Terefore, the goals of health policy include prolonging life and eliminating premature deaths, minimizing deviations from physiological and functional norms through preventive measures and early detection of diseases, strengthening resistance to disease, minimizing discomfort and disability, strengthening health potential, and fostering a sense of well-being and self-realization [8, 34, 53].

To achieve these goals, it is necessary to take comprehensive measures involving the various stakeholders in the healthcare system, from the state to the members of society, to maintain and improve health. The effectiveness of health policy measures is considered from the level of dealing with the problems that arise in a particular area [60]. One of the most critical problems facing the healthcare system is the aging of the population, which affects both the epidemiological and economic situation.

There is also a lack of "preparing for old age" activities in Poland, as too little attention is paid to maintaining physical and social activity. not only in old age but also much earlier. This should be the axis of preventive and health promotion activities. We can feel the short-term consequences of this in the form of poorer health parameters for young adults and the further result for older adults and older people. Also, diseases undiagnosed and untreated in the early stages of life can generate high medical costs in the future.

Therefore, health policy in recent times has increasingly turned to information instruments and digital technologies in addition to traditional tools to support healthy lifestyles. Digital technologies offer new opportunities for identifying needs and delivering health care (from prevention and health promotion to treatment interventions and self-management).

Digital transformation of health services can ensure better health outcomes and contribute to the sustainability of health systems. In addition to digitally supported health services as part of digital transformation, we can manage our health through

[1] https://www.who.int/data/gho/data/major-themes/health-and-well-being.

self-care. The World Health Organization defines self-care as: "*the ability of individuals, families, and communities to promote their health, prevent disease, maintain health, and to cope with illness and disability with or without the support of a health worker*."[2] Self-care is everything one does to take care of oneself to maintain their physical, mental and emotional well-being [55]. Research suggests that self-care promotes positive health outcomes and can help prevent future health problems, but it is not a cure or treatment for diseases.

Moreover, in recent years, healthcare stakeholders around the globe have been looking for new, innovative, cost-effective ways to deliver patient-centred, technology-enabled "smart" healthcare. Healthcare organizations have been seeking to provide appropriate treatment offered at the appropriate time and place for the specific patient. Clinicians use technology, information systems, and analytics to diagnose and treat illnesses and deliver care more accurately. Healthcare is patient-centred, and it is based on patients' engagement. Patients are informed and actively involved in their treatment plans. The adoption of these assumptions requires decision support in five areas [30, 54]:

- the right way of life—the patient's commitment to a healthy lifestyle,
- proper medical care—application of appropriate medical procedures to patients at the right time and provision of access to all their data to optimize the treatment process,
- the right care provider—the implementation of medical procedures by highly qualified staff; engaging specialist doctors only in situations requiring their knowledge, and other medical personnel in the remaining cases,
- the proper value of medical care—improving the quality of medical services and eliminating economically unjustified expenses for healthcare providers and institutions,
- proper innovations—identification and implementation of new treatment methods and organizational solutions by new health system entities.

The implementation of this concept requires a new approach to human health as well as to the whole healthcare system. As mentioned before, a concept that is gaining in importance in this area is health culture connected with a more proactive approach to health promotion and maintenance [12]. In the culture of health, the latter together with well-being are priorities, while pro-health behaviour, prevention, and social justice are promoted. Citizens can make choices and contribute to a healthy lifestyle throughout their lives. The use of Big Data Analytics may be helpful for this purpose. Digital technology used to support prevention and a healthy lifestyle also plays a vital role. The use of information technology is aimed at creating integrated healthcare as a new driver to improve the society's quality of life. This involves individuals managing their health and well-being throughout their life. For this purpose, biological, physical, behavioural, environmental, and social factors should be monitored (assisted by digital technology). This includes everything related to the individual perception of illness or health. Therefore, innovations that are implemented in healthcare should

[2] https://www.who.int/news-room/fact-sheets/detail/self-care-health-interventions.

be focused not only on the healthcare system, but should also cover the conditions in which individuals are born and in which they live, work, and exist [18, 39, 44].

The overriding task of introducing a health culture is to improve the population's health, which requires a broader approach that considers, in addition to health factors, also social, economic, and environmental factors [10, 23, 46]. This is in line with introducing social innovation in the field of health.

Human health and a sense of well-being can be seen as a lifelong process, not just as a biological good. In everyday life, people begin to perceive life as a value, analyse the determinants of health and constantly evaluate it. The degree of the sense of one's influence on the surrounding reality has been recognized in this model as an essential variable determining health-related behaviours. Therefore, health and well-being should be considered as a unique resource that can be adequately managed. This management essentially involves identifying determinants of health and well-being that can be modified over time and changing one's lifestyle or living conditions that directly or indirectly impact health and well-being.

Among these determinants, some can and others cannot be influenced. Determinants that can be directly or indirectly influenced include [32]:

- health behaviours and lifestyle,
- employment and work performed,
- income and social status,
- education,
- social status,
- family status,
- place of residence and physical environment,
- access to appropriate health services.

Determinants beyond control include the physical conditions of each person, genetic conditions, or environmental threats.

Proper management of health and well-being can influence the shaping of individual health paths. In turn, this makes it possible to control, to a significant degree, the modifiable risk factors, and introduces preventive strategies that help to avoid the incidence of various diseases (including diseases associated with the progress of civilization) and minimize the risk of premature death [44].

The need to create a health culture as a standard "social good" is recognized. However, health and well-being are non-objective values as they relate not only to the well-being of a person and their health (constituting an objective value) but also to a subjective perception of health. The issue of well-being is also related to quality of life (QoL), which is a measure of the well-being of individuals, due to its ability to capture both individual expectations and objective health.

Big Data Analytics is a useful technology that can contribute to a more objective assessment of human health and well-being. Big Data information resulting from normalized data flow may represent an appropriate approach to future evaluation of well-being both at the population level and at the individual level. It can form the

basis underlying the development of adequate healthcare facilities but also for managing one's health.

Digital social innovation in healthcare

The world today is struggling with many social problems, including: an aging population, falling birth rates, diseases linked to the progress of civilization, and the impact of the COVID-19 pandemic on the health of society. Progressive demographic changes and modern-day diseases are a challenge for health systems worldwide. Aging societies are also visible as life expectancy increases and fertility rates decline. A worrying trend is also the increasing incidence of chronic diseases (cardiovascular diseases, cancer, diabetes, chronic respiratory diseases, mental health problems, skeletal muscle disorders) caused by unhealthy, urban lifestyles and inadequate service provision. Therefore, improving the healthcare system and introducing innovations to medical facilities or doctor's offices is not enough. For the entire system to be more efficient and prosper, it is necessary to treat the patient as a genuine partner.

Many authors point to the possibilities of using social innovations in various areas of socio-economic life. Social innovation focuses on issues such as "designing and implementing better ways to meet social needs", "new ideas that work to meet important, unmet needs", and "new ideas that solve existing social, cultural, economic and environmental challenges for the benefit of people and planets" or "ideas working for the public good" (Wronka-Pośpiech 2015). Therefore, although most definitions of social innovation present it as new ideas or solutions, they remain agnostic of the form it can take as new products, programmes, services, processes, activities, practices or social movements [81]. Such social innovations aim to improve the life of society in the areas of its functioning and to obtain lasting social value. Social innovation gives us a different perspective on strengthening healthcare and becomes an important element of innovative health policy that solves social problems and creates value in areas serving society. In the health field, it is indicated that social innovation can contribute to producing new knowledge and adapting existing knowledge better to meet social needs in terms of health and well-being.

The basis of this approach is the understanding that people of all walks of life can be competent interpreters of their own lives and they should know how to deal with the problems encountered. Social innovation is simply problem solving, and more specifically providing a creative and unconventional approach to solving complex problems that could not be solved otherwise.

Social innovation projects in healthcare can take many forms and are most often a combination of these forms. These can be [80]:

- processes (e.g., reorganized care pathways),
- products (e.g., applications for mobile phones),
- market mechanisms (e.g., social financing instruments),
- behavioural roles and practices (e.g., peer-to-peer services),
- new paradigms and policies.

In the literature, one can find examples of social innovation in different areas of healthcare, targeting diseases and different public health goals. Some of the implemented innovations include [81]:

- addressing the failures of the welfare state related to the inability of governments to sustain the increasing health expenditure of aging populations,
- increasing public participation in health care, often as a strategy to shift the burden of care from the state to individuals and other actors through social enterprises,
- solving problems with failures in the healthcare system,
- overcoming the vertical service delivery model, low satisfaction of health professionals and burdensome bureaucratic care processes,
- promoting standardized disease prevention and treatment programmes based on patient-centred principles.

In the area of healthcare, different types of social innovation can be identified. According to Mason et al., four types of social innovation in the field of healthcare can be distinguished: social movements (including networks of informal interactions between many people, groups and/or organizations to achieve a goal or solve a problem), services (social innovation aimed at improving services through collaborative and cross-sectoral design and delivery of services), social enterprises (innovative forms of social entrepreneurship—enterprises that exist to achieve a social goal and typically reinvest a significant portion of their profits or surpluses to achieve that goal), and digital products (Digital Social Innovation, based on collaboration between innovators, users and a society that uses digital technologies to co-create knowledge and solutions for a wide range of social needs) [47].

This research will focus on Digital Social Innovation (DSI). Mumford et al. [52] stated that social innovation is "*the generation and implementation of new ideas about people and their interactions within a social system whose success depends on developing new technologies. Social innovations may, at times, force the development of certain technologies, but at other times, technology may force the adoption of proposed social innovations*".

Thus, DSI refers to the design and implementation of new solutions that imply a conceptual, process-related, product-related or organizational change to improve the well-being of individuals and communities [14]. Digital innovation is the use of digital technology and applications to improve existing business processes, and workforce efficiency, improve customer service, introduce new products or business models or improve such products, such as mobile applications, information systems or websites that facilitate the connection between healthcare stakeholders. DSI can be identified as online platforms or applications that enable citizens to connect and collaborate [3, 37, 72, 73]. Nowadays, a connected world allows the development of various technologies that source crowd talent, creating value for individuals, groups and organizations [65]. The value of DSI from the point of view of public health policy is the ability to contribute to new health solutions, drawing on empirical and personal knowledge which can significantly complement that of experts or the process itself, leading to new forms of power, relations and empowerment.

The overriding goal of implementing digital innovations is to reorient technology towards social goals and use it to improve life and create value for society. The benefits that society can obtain include enabling citizens to take greater control of their own lives and to make positive use of their collective knowledge and skills. Along with the introduction of social innovation, special attention should be paid to preparing potential users for its exploitation. Citizens should be adequately informed, educated, trained to understand the importance of the social innovation. It is necessary to take care of adequate publicity of the project, education of potential users, or support development of competencies necessary to use this innovation to obtain the assumed additional values. Introducing social innovation in some cases will require the development of holistic programs to promote specific behavioral changes.

In the case of DSI, digital technology itself is seen as a tool, not as an outcome. Digital technology is a way to solve social problems. The term DSI largely overlaps with other terms, such as "technology for good", "citizen technology" and "social technology".

Creating DSI in the healthcare field enables the co-creation and exchange of knowledge and solutions for a wide range of social needs. Information and Communication Technology (ICT) solutions implemented to support social innovation make it possible to develop the concepts of open data, open equipment, open networks and open knowledge, and are aimed at creating online communities [72]. Using data and Internet solutions increases the variety of possible organizational activities for value creation. Data, especially Big Data, is becoming the driving force behind the development of DSI in healthcare.

Healthcare Big Data

In the literature, there is a lot of evidence that ICT can play an important role in various social processes [1, 2, 9, 21, 25, 29, 33, 42, 43, 48, 57, 67]. It is therefore clear that the demand for DSI is constantly growing. DSI may develop in the area of healthcare with the opportunities offered by Big Data analysts. With the rapid development of Internet technology, Big Data technology has been widely applied also in healthcare [43].

Healthcare has always generated huge amounts of data and, nowadays, the introduction of Electronic Medical Records (EMR), as well as the huge amount of data sent by various types of sensors or generated by patients in social media, cause data streams to constantly grow. Analysis of Big Data has penetrated the medical industry, and with the process of medical information digitalization, many electronic medical records, hospital information systems, medical imaging, genomic data, health behaviour data and other data has emerged. Proper use of such data will allow healthcare organizations to support clinical decision-making, disease surveillance and public health management. The challenge posed by clinical data processing involves the quantity of data and its complexity.

The concept of Big Data has evolved in recent years; however, it is still not clearly understood. Big Data can be treated as a large amount of digital data, large data sets, technology, a tool or a phenomenon (cultural or technological). Therefore, instead of defining this phenomenon, more authors are describing Big Data by giving it characteristics combined into a "collection of V's" related to its nature [1, 2, 21, 25, 29, 57].

- Volume (refers to the amount of data and is one of the biggest challenges in Big Data Analytics),
- Velocity (the speed with which new data is generated, the challenge is to be able to manage data effectively and in real time),
- Variety (heterogeneity of data, many different types of healthcare data, the challenge is to derive insights by looking at all available heterogeneous data holistically),
- Variability (inconsistency of data, the challenge is to correct the interpretation of data that can vary significantly depending on the context),
- Veracity (how trustworthy the data is, quality of the data),
- Visualization (ability to interpret data and resulting insights, challenging for Big Data due to its other features described above).

Value (Big Data Analytics aims to discover the hidden knowledge from vast Big Datacan be defined as a collection of data elements whose size, speed, type, and/or complexity require one to seek, adopt, and invent new hardware and software mechanisms to successfully store, analyse, and visualize the data [9, 33, 42, 48]. Big Data is a large amount of data generated swiftly and containing much content,. collected from various sources with different data properties and processed by different organizational units, resulting in a Big Data chain [35]. This data comes from unstructured sources, such as streams of clicks on the web, social networks, video recordings, recordings of calls, real-time information from various sensors, RFID, GPS devices, mobile phones and other devices which identify and monitor various aspects.

Big Data can also be defined as an information asset with high diversity, volume, velocity and variety, which requires specific technology and method for its transformation into value [21]. Undoubtedly, Big Data differs from the data sources used so far by organizations. Therefore, organizations must approach this type of unstructured data in a different way and start to see data as flows and not stocks—this entails the need to implement the streaming analytics. These features make it necessary to use new IT tools that make it possible to use new data to the fullest extent [57]. The above features make it necessary to use new IT tools that allow the full use of further data and treat it as flows, not stocks. Big Data requiring new forms of processing in order to support decision-making, discovering new phenomena and process optimization. The Big Data concept is constantly evolving and does not focus on vast amounts of data but on creating value therefrom [49].

The Big Data problem in healthcare is not limited to the overwhelming volume, but is also related to the unprecedented diversity in terms of types, data formats and the speed with which it should be analysed to provide the necessary information on an ongoing basis [2]. In the healthcare sector, Big Data streams consist of various types of data, namely [5, 6, 45]:

- clinical data, for instance data obtained from electronic medical records, data from hospital information systems, image centres, laboratories, pharmacies, and other organizations providing health services, patient-generated health data, physician's free-text notes, genomic data, physiological monitoring data [7],

- biometric data supplied from various types of devices that monitor weight, pressure, glucose level, etc.,
- financial data, constituting a complete record of economic operations reflecting the conducted activity,
- data from scientific research activities, e.g., results of research, including drug research, design of medical devices and new methods of treatment,
- data provided by patients, including a description of preferences, level of satisfaction, and information from systems for self-monitoring their activity: exercises, sleep, meals consumed, etc.,
- data from social media.

An interesting classification of big data that takes into account its source is presented by [13], dividing Big Data into molecular Big Data (obtained by means of wet-lab techniques and OMICS-based approaches, such as genomics, and post-genomics specialties, including proteomics, and interactomics), imaging-based Big Data (such as radiomics or the massive data-mining approach to extract clinically meaningful, high-dimensional information from images), sensor-based Big Data (wearable sensors) and digital and computational Big Data (with an incredible wealth of data produced by the internet, smartphones, and other mobile devices).

This paper will pay particular attention to data from medical systems, transactional systems and data from wearables. In traditional systems, patient data, including vital signs, is routinely collected manually by standalone medical devices. The introduction of the Internet of Things (IoT) and BD technologies has made it possible to continuously monitor patients' health and vital signs through smart devices, smart sensors, as well as smart wearable devices. Thus, wearable devices have the potential to transform medicine, enabling an increasing number of diagnostic and health monitoring processes. Combining BDA with wearables technology can definitely bring new opportunities to healthcare, as it makes it possible to effectively use Big Data to support a wide range of healthcare functions, including disease surveillance, clinical decision support systems and personalized health management [78]. Wearables devices provide first-hand data and real-time monitoring [84], can help transform traditional healthcare systems into proactive systems capable of continuously monitoring and controlling the health of patients to manage their care at an early stage, offer personalized services to patients and physicians and can be also used for patients and diseases management [50]. Wearable devices include any device that can be worn by humans (such as wristwatches, glasses, chest straps, rings, earrings, shoes and clothing) and can capture non-invasive signals from the human body through the use of different types of sensors. Sabry et al. [67] described numerous well-known signals from the human body and the technology (sensors) used to capture them. The full characteristics of the most popular wearables with a list of capabilities, functions, accuracies and uses were described by Aroganam et al. [4],Chakrabarti et al. [16] and Nahavandi et al. [56].

The main purpose of wearable technologies is to continuously monitor a person's physical activity and behaviour, as well as physiological and biochemical parameters during daily life [79]. Most commonly measured data include vital signs such as heart rate, blood pressure and body temperature, as well as blood oxygen saturation, posture and

physical activity via electrocardiogram (ECG), sleep quality and stress levels. Wearable devices belong to the Internet of Medical Things (IoMT), together with the implantable, ambient, and stationary devices used in hospitals [67]. Wearable devices can collect very large amounts of personal data due to their ability to continuously record data at high frequency combined with potential use by a large population. The data collected fits into the domain of Big Data, meeting the "four Vs" (volume, variety, veracity, velocity) characteristics of the latter [79]. Since wearables can collect highly personalized data among large populations, the collected information can not only be used to improve personalized intervention, but also to discover population patterns.

The availability of large health data sets collected by these devices has a significant impact on the accuracy of predictions related to the health status of individuals. It has also enabled access to applications that offer preventive healthcare tools, which in turn has increased the likelihood of early diagnosis and reducing the risk of serious diseases [38]. With wearables, we can continuously monitor the vital signs (heart rate, saturation, temperature, number of steps, location, weight, sleep quality, stress, ECG, etc.), lifestyle, behaviour and well-being of each user. Medical wearable devices with sensors collect extensive information about our physical and mental health. This gives us entirely new opportunities to draw conclusions on the uploaded data in the form of trend tracking, capture anomalies, and predict the future health and life of the user being analysed. Several technologies provide benefits for preventing or managing chronic diseases. These include devices that continuously monitor health indicators, automatically deliver treatment, or monitor health data in real time as the patient self-administers therapy. With the rise of high-speed Internet access and smartphones, many patients have begun using mobile apps to manage their various health needs.

Therefore, there is potential in healthcare Big Data analyses, especially in terms of improving the quality of medical care, saving lives or reducing costs [31]. Disentangling this complex network of association rules, patterns and trends will allow health service providers and other stakeholders in the healthcare sector to offer more accurate and more insightful diagnoses of patients, personalized treatment, as well as better quality of medical services and patient care, while at the same time making it possible to reduce costs. Due to the growing diversity and quantity of data sources, advanced analytical tools and technologies and Big Data analysis methods, which can meet and exceed the possibilities of managing healthcare data, are needed [2]. Big Data has great potential in healthcare as an opportunity for epidemiologists, physicians and health policy experts to make judgments based on data that will ultimately develop patient care and help, based on the medical records, for example to predict diseases before they emerge [68]. Nonetheless, the healthcare sector demands data-driven decisions in clinicians' daily work and at the organizational level [62]. Adopting the Big Data approach would make it possible to implement personalized and precise medicine based on personalized information, delivered in real-time and tailored to every individual patient [5].

Expected changes in healthcare should make it possible to move from a system driven by averaged statistical results and generalizations to one based on defining individual requirements in real time [74]. It would be possible to offer personalized and precise medicine services based on a person's unique behavioural, biological, and social characteristics, thus personalizing patient treatment anywhere, anytime. This leads to better

results and makes healthcare cost-effective and efficient. These solutions should report positive outcomes on enhancing affordability and improving effectiveness on disease or wellbeing indicators. The supported service focuses on the early detection of diseases and home care, not clinical exclusivity.

Also, issues related to health monitoring and management would become more individualized. They would be provided on time because modern web and mobile technologies could enable individuals to monitor routine patient health and respond to emerging issues. Network technologies introduced in patient healthcare would enable omnipresent access, improve connectivity, ad hoc service arrangement, alteration systems, and even the integration of patients, caregivers, and medical workers. The development of mobile technologies and the introduction of artificial intelligence systems and intelligent algorithms would allow healthcare to become more comprehensive-monitoring and helping people suffering from chronic diseases that require constant care, special attention or intervention.

The use of mobile technologies and wearable devices is becoming increasingly common, and people have started to use such devices and mobile applications for health reasons. Mobile and wearable device data are recorded to quantify patient results, supporting clinical trials and clinical practice [26]. The combination of mobile, handheld technology and other connected health devices has at least a few potential applications in the health field. However, it may be beneficial to monitor lifestyles, results reported by patients, patient behaviour, prevention and management of many diseases by analysing daily habits. This could transform data from mobile devices into practical knowledge that can support decision-making by specialists and patients.

Personalized patient care is one of the forms of healthcare that is possible to implement thanks to the use of Big Data Analytics. The use of Big Data Analytics can contribute to increased understanding of disease mechanisms and better healthcare. Big Data Analytics involves examining large and complex data sets (i.e., big data) and selecting veiled information that can help organizations with efficient decision-making [51, 69]. BDA refers to the process, methods and technologies for analysing such large data sets and discovering valuable information using non-traditional advanced methods such as: association rule learning, classification analysis, genetic algorithms, machine learning, regression analysis, sentiment analysis, and social network analysis [5]. In the creation of personalized healthcare, analytical tools are necessary because the combination of factors that need to be considered is so complex that the individual doctor is unable to fully analyse them (in real time) during the interaction with a patient [15].

Therefore, the concept of BDA can improve and facilitate a common approach to easy-to-manage health for patients. The use of BDA can contribute to an increased understanding of disease mechanisms and better healthcare based on data generated by individuals. However, there are several challenges that are associated with the use of Big Data in healthcare, especially in terms of diagnosing and treating patients.

The first one involves the reliability and quality of the data. This is an issue that has been considered both important and controversial for years now due to problems with the completeness, accuracy, reliability, consistency and validity of the data [36]. Much of the big data produced in healthcare is massive and is usually considered "dirty data", meaning that much of it is irrelevant to the specific topic of interest (e.g., a specific

disease) [76].There is no place in healthcare for decisions based on poor-quality data, especially these related to the disease. Therefore, a very important part of the process of using Big Data in healthcare is the pre-processing of raw data, including data cleaning, transformation and reduction of missing and noisy data to provide clean and reliable data [59]. It is furthermore very important to take care to constantly update and adjust the information, which is also necessary for reliable predictions and simulations. Data from wearable devices, and healthcare data in particular, should be treated with respect and caution. Unless they have been clinically tested, the accuracy of measurements is not uniform even among devices designed specifically for this purpose, but with respect to changes over time, trends, the results are more reassuring—the consistency of the measurement is much more reliable [71]. To obtain truly accurate data, at least at the level required by clinicians, it would be necessary to use certified medical devices. However, data from medical devices remains in the minority, and medical grade devices are both expensive and usually cumbersome to wear. Thus, the use of data in the treatment process is not possible, confirmation of detected abnormalities by additional testing is necessary. However, the data certainly shows trends, revealing holistic data on a specific individual over time, on their habits, behaviours, lifestyle and vital parameters, and makes it possible to capture anomalies.

Among the challenges, security and privacy are important issues, as large data sets often contain different types of sensitive information, especially health-related information. It is worth noting that with the rapid growth of healthcare data, the incidence of data privacy and security issues is increasing, with significant concerns related to confidentiality. There are privacy and reliability issues that hinder the full transfer of healthcare monitoring data to a cloud service platform [40], as well as data privacy breaches and information leakage [20]. The privacy of patients, doctors, and healthcare providers is extremely important, and to look after it, it is necessary to both introduce a secure data processing technology and find risk indicators that can be quickly identified to improve the privacy protection of healthcare patients, as well as establish strict compliance and management rules for data and data sharing, while encryption protocols should ensure the security of healthcare data transmission [43]. Managing the data of patients and other users of wearable technology as well as ensuring security of such data are very important issues. Many researchers have focused on identity protection and concealment procedures to anonymize private data [19, 58, 61] and ensure its security [82, 83, 85]. There are various solutions and techniques used to maintain the confidentiality of data and private information. Examples include the combined use of matching theory and coalition game to secure mobile social networks with large data sets, the use of reinforcement learning to design a security-sensitive algorithm for a smart grid system, or blockchain technology as a registry technology providing an attractive solution to ensure security and privacy in Big Data systems [22].

Other challenges include: the technical dimension (difficulties in data capture, data storage, data analysis and data visualization), data structure (Big Data should be user-friendly, transparent, and menu-driven, but it is fragmented, dispersed, rarely standardized and difficult to aggregate and analyse), data standardization (data is stored in formats that are not compatible with all applications and technologies), storage and transfers (especially costs associated with securing, storing, and transferring

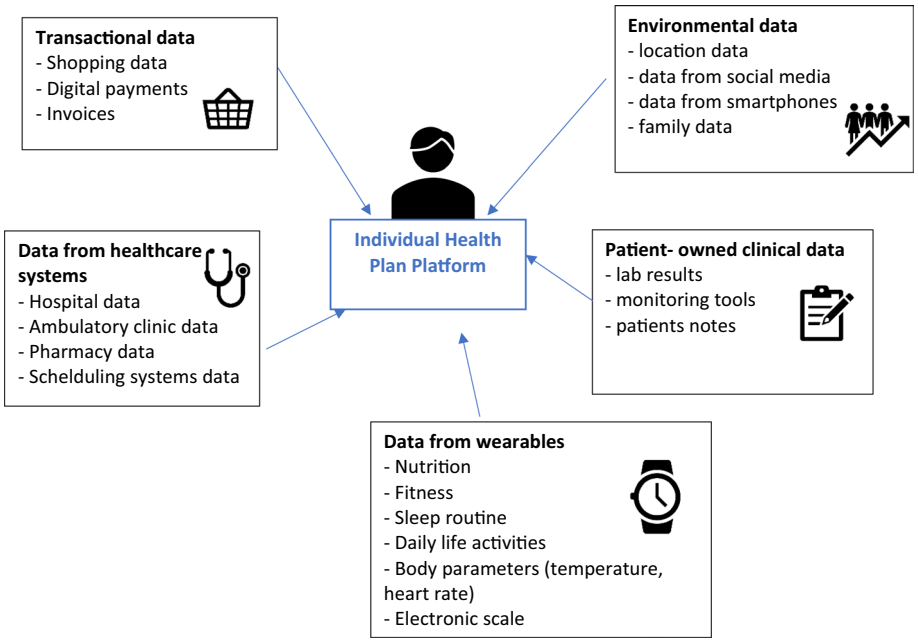

Fig. 1 Individual Health Plan Platform—Digital Social Innovation based on Big Data Analytics in the healthcare area. [70] Source: Own compilation based on:

unstructured data), managerial skills, such as data governance, lack of appropriate analytical skills and problems with Real-Time Analytics (healthcare is to be able to utilize Big Data in real time) [5].

Summing up, it can be concluded that BDAin the field of healthcare can be very beneficial to the latter, but there are still some challenges to overcome. This paper is a continuation of research that was published in an article on the use of Big Data and Big Data Analytics in healthcare [5].

Model of Digital Social Innovation based on big data analytics

The analysis of digital solutions in Polish healthcare indicates that there is a lack of a platform that would support the entire process of managing the health of an individual member of society. Therefore, based on the literature analysis, the author's model of the Individual Health Plan Platform (IHPP), a Digital Social Innovation based on Big Data Analytics in the healthcare area, was proposed.

Figure 1 presents the model of using Big Data to support Digital Social Innovation. Individual members of society, often identified with patients, are the key beneficiaries of DSI based on BDA. BDA can help provide personalized patient care based on data streams supplied to the system (application, online system): transactional, environmental, wearables data, data from hospital systems and clinical data provided by the patient.

Healthcare platforms supported by wearables connect everything anywhere, anytime, with anyone using any network and service [24]. Built-in or worn network sensors are designed to gather information about the health and vital parameters of people wearing them. The availability of such data along with intelligent procedures is aimed at providing personalized and precision healthcare. It would allow a patient (individual) to manage their own health as well as enable precise treatment and

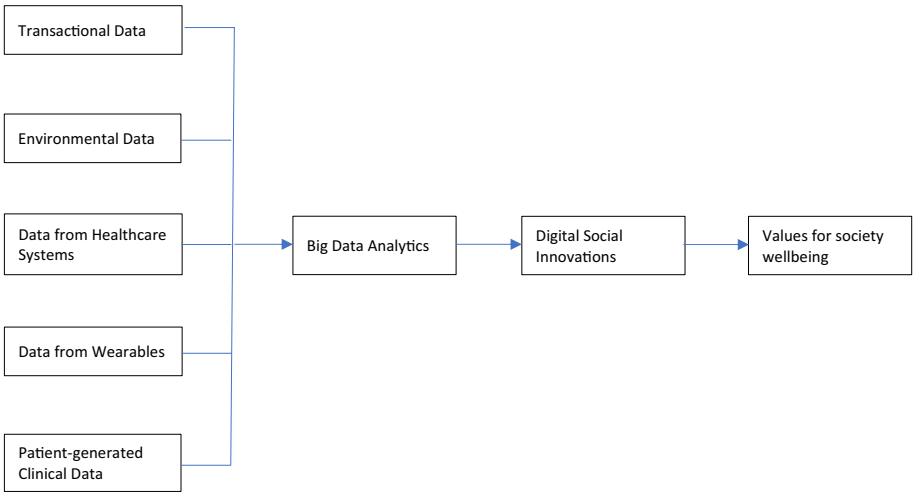

Fig. 2 Model of Digital Social Innovation based on Big Data Analytics. Source: Own compilation

reduce healthcare costs through improved results [27]. Data from wearables include remote monitoring and clinical care, which can support personalized care services. Remote monitoring enables easy access to accurate health monitoring using wearable devices (connected via the Internet of Things) to monitor patients. Data is collected, analysed, and then sent to obtain health recommendations for medical specialists remotely. This clinical care system uses sensors to collect physiological information stored and analysed in the cloud. It provides continuous automatic information flow, which improves the quality of care at a lower cost.

Based on such data, digital platforms can generate analyses used to create social innovations in the following forms [70]:

- an individual risk assessment of a patient suffering from specific diseases,
- risk assessment of falling ill with diseases associated with the progress of civilization,
- dietary suggestions,
- shopping suggestions,
- suggestions for physical activity,
- prioritization of patients based on the urgent need for medical attention,
- drug control,
- disease prediction,
- monitoring patients.

The IHPP supported by BDA can prepare individual health paths for patients (suggestions and recommendations on managing health and life parameters so that one can enjoy health and a high quality of life if possible). Drawing on the literature review and own observations, a model of DSI based on BDAwas proposed. This model can be used to determine whether Big Data influences DSI and what values it can create for society (Fig. 2).

Thanks to patients' involvement in managing their health and well-being, it becomes possible to create social networks and environments related to a patient's

holistic health focused on the social elements of unmet social needs. Thanks to health applications that can be a manifestation of implemented DSI, every person can:

- analyse their daily life activities,
- add and analyse their actions and habits that facilitate well-being and health, including fitness and nutrition,
- check the potential scenario and health paths configured based on information provided to the system.

The presented platform is intended to be a concept for a full cloud service system, i.e. a cloud-based information system that performs BD analysis and simulations to provide preventive medical decision support (for the doctor) and generate health pathways (for the patient). Data will be collected in real time to generate effective medical decisions. The system will collect, monitor and analyse clinical data provided from HIS and EHR systems (individual medical history), data on the patient's daily activities, as well as vital signs and transactional data, which are presented in Fig. 1. BDA will be used to analyse the data and generate treatment recommendations.

The IHPP thus represents a patient-centered health and well-being service framework in which wearables and cloud-based services are deployed to improve patients' lives and offer personalized healthcare. Physician dashboards and patient dashboards will be available, both through a web browser and as a mobile app. Smart applications, typically deployed on mobile devices, are also becoming more common. Mobile devices, in particular cell phones, have become important parts of our lives in recent years. Therefore, using them as platforms to monitor an individual's health status and process the data obtained seems to be an optimal solution.

Through their dashboard, the doctor will have access to:

- analysis (presented in the form of visualizations to minimize the time needed to review data during a visit),
- anomaly detection,
- diagnosis and prognosis—a decision support system (they will be able to compare data with model data developed in the form of model cases),
- simulation system (simulations due to changing data, changing selected parameters),
- multidimensional risk map of the patient (what diseases the person is exposed to with the current parameters).

The patient will have access to:

- monitoring of health status (presented in the form of visualizations),
- physical and mental condition tracking,
- dietary suggestion,
- shopping suggestions (e.g., replacing a sugar-containing yogurt one currently buys with a more protein-rich, sugar-free product),
- generation of health paths (due to a change in parameters, e.g. giving up sugar consumption, reducing body weight, introducing physical activity),

- disease support system (keeping a disease diary, contact with specialists, health packages and programs),
- incentive system (collection of points, rankings, redemption of points for prizes, etc.),
- alerts and reminders (information about alarming trends, anomalies)

Any analyses and conclusions generated will act as recommendations and will largely depend on the accuracy of the data set. Therefore, special attention will be paid to the accuracy and integrity of the data when developing the system. Digital Social Innovations based on Big Data Analytics have a huge impact on various aspects of public health systems. When considering systemic issues, they improve access to healthcare (e.g., through teleconsultation) and enable monitoring of population health. Advanced data collection and analysis systems make it possible to track population health, identify trends and predict health risks. In terms of human resources, they not only offer support in diagnostic and therapeutic decision-making, but also represent a relief to the healthcare system, as a healthier population requires less involvement of medical specialists. Analysing the financial area, it is worth noting that the introduction of BDA-based DSIs can contribute to the shortening of the diagnostic process, through access to real data, and thus make it possible to reduce the costs of unnecessary or duplicate diagnostic procedures. Very important aspects on the procedural level could include the improved availability of information and the ability to continuously monitor patients in real time. The social aspects that BDA-based DSIs could introduce are mainly better health education for the society (digital platforms can be used to educate the public about health, health promotion and disease prevention), fostering communities (online platforms enable the creation of patient communities and sharing of experiences and support), and offering shared responsibility for one's health. The solutions in question could also be useful in the field of insurance, as health risks could be assessed more precisely and insurance policies could be adjusted on the basis of digitally acquired data. This, in turn, could allow insurance companies to manage their customers' health costs and benefits more optimally. However, legal issues should not be overlooked, as special regulations governing the processing of data from wearables for medical purposes and the protection of patient data are needed for these systems to be part of the healthcare system in the future.

In conclusion, digital social innovations have a huge impact on public health systems, helping to improve access to healthcare, efficiency of procedures, quality of care, and financial and personnel management. However, their introduction requires appropriate regulatory and data protection measures to ensure patient safety and maintain patient privacy4.

Materials and methods

The article presents Digital Social Innovation and identifies opportunities for its use in healthcare. Moreover, the possibilities of using Big Data Analytics in creating a specific Digital Social Innovation related to health management and creating a culture of health and well-being in society are also described. The research and model of DSI based on BDA presented in this paper are supported by a critical analysis of the literature as well

Table 1 Structure of the focus group participants

The professional positions of the study participants	No. of participants
Hospital manager	2
Physician (doctor)	2
Owner of Medical Facility	3
Nurse	1
IT specialist in a medical facility	2

Source: Own compilation

as own observations and conclusions. This model can be used to determine whether Big Data influences DSI and what values can be created for society.

The research methodology also consisted of data collection methods, transcription, analysis, processing and interpretation of results. The conducted research was exploratory in its nature, as the issues addressed in the article were not subject to extensive studies. At the same time, the problems are complex and multidimensional. The conceptual framework presented in this paper has been subject to initial verification using the focus group interview method. This method was chosen based on the prolonged use of focus groups in the social sciences and design science. The focused interview was held on May 31, 2022. The group of respondents included 10 people. The participants were selected purposefully—the focus group consists of healthcare professionals who know what Big Data and wearable technology are, have mostly worked with them, and may benefit from the system proposed in the article. The participants include healthcare-related IT professionals, owners and directors of medical facilities, doctors and nurses.

The structure of the focus group is presented in Table 1.

In terms of the number of years of professional experience connected to healthcare, three people indicated more than 20 years; five people stated it to be between 20 and 10 years, one person had between 10 and 5 years, and one less than 5 years (3 years) of experience. It is important to note that the focus group participants are healthcare professionals who are familiar with IT systems and Big Data technology. Some of them have participated in projects that tested various types of IT systems and wearables technology. At the beginning of the survey, the researcher provided the participants with precise, consistent definitions and presented them with the assumptions of the solution described in the article, i.e. the Individual Health Plan Platform (IHPP).

The study aimed to determine the potential for using BDA (especially data from wearables) in terms of managing one's health and improving the well-being of society, as well as to assess the proposed solution- IHPP and the possibilities of its implementation as a complementary solution to the healthcare provided by medical facilities in Poland. The research made it possible to determine the rationale of the IHPP and evaluate its functionality, establishing whether analysing Healthcare Big Data (especially data from wearables) is legitimate in the process of diagnosing and treating patients or whether the solution is only recommended as a system for daily use by members of the public. The research made it possible to analyse the motives and purposes of using this type of data and its application. The study makes it possible to explain why various healthcare entities may not be interested in using the proposed IHPP.

The survey, in the form of a focus group interview, was designed to gather information from healthcare practitioners. As part of the survey, the participants were asked several questions:

- What are the benefits of healthcare functioning based on Healthcare Big Data? (benefits for medical facilities, benefits for the whole healthcare system, benefits for the patient, benefits for the doctor, benefits for society).
- In your opinion, what is the quality of data doctors use as the basis for diagnosing the patient and prescribing therapy? What data do they have at their disposal? What can be changed in this regard? Can data from wearables be helpful in this matter?
- Are we moving toward personalized medicine? Should patients share data collected by their wearables (e.g., smart wristbands) with a medical facility for better diagnosis? Can such data be relied on for diagnosis?
- What are the barriers to the use of wearables in healthcare and IHPP?
- What benefits can Big Data Analytics, wearables and the IHPP bring to the healthcare system?
- Can the use of wearables and of the IHPP have a positive impact on eliminating the problems healthcare is currently facing in Poland (problems with the aging population, obesity)?
- Should the platform be a complementary solution to the existing healthcare system, or should it be a part of it and be linked to healthcare IT systems?
- Should health promotion programmes based on Big Data, especially data from wearables, be created? Will the creation of a platform based on data analysis from wearables that support users in managing their own health and quality of life, contribute to the improvement of society's well-being?
- What will be the future of using wearable technology in healthcare?

The method for analysing the data from the focus group survey involved coding the written text of the survey—the so-called transcription. The transcription and coding were subject to the entire text, which included a total of about 90 pages intended for analysis.

Results and discussion

The results of the focus group confirmed the observations and previously constructed guidelines regarding both the use of BDA in healthcare and IHPP features.

Question 1 What are the benefits of healthcare functioning based on Healthcare Big Data? (benefits for medical facilities, benefits for the whole healthcare system, benefits for the patient, benefits for the doctor, benefits for society).

Survey participants were very eager to share their insights on the benefits of using real data in healthcare. They confirmed that real data could bring many benefits to various stakeholders in the health sector. They agreed with the statement that the use of Big Data in healthcare could have a positive impact on improving the health and well-being of patients, enabling long-term predictions regarding their health status, and implementing

appropriate therapeutic procedures. This is supported by the fact that through the collection of Big Data and its analysis within the healthcare system, it is possible to access a huge database for multi-cross-sectional analysis, including epidemiologically relevant morbidity prediction, determination of unit probabilities of diseases and infections, detection of trends that lead to improvements in the health and lifestyle of populations and analysis for the implementation of preventive programmes well in advance. Based on the parameters obtained, it would be possible to improve the quality and standards of healthcare.

"Yes, I have a full diagnostic (...) review spanning many years, actually at some point of data that we can provide every day, every couple of days, well I can imagine different scenarios. (...) so data, giant datasets (...) and I think any approach will be good with this amount of data." (P9)
"Well the more information, the better. It's always been known that preventive treatment prevention in general is cheaper than corrective treatment, so certainly also for health care in general. The organization from the point of view of just the payer, but also the way the information is sent and transmitted. I think it is. Well reliable knowledge definitely gives better results." (P3)
"Someone, for example, could, on that basis, (…) improve the quality, standards and quality of activities in medicine." (P4)

Big Data Analytics can also be important from the point of view of the patient who is the main beneficiary of medical services. The benefits that real data analytics can bring to patients include:

- full monitoring of vital parameters,
- real-time verification of one's health status,
- the ability to obtain individualized diagnosis and therapy,
- the impulse to contact the doctor in case of deviations, abnormal data,
- the ability to define target (achievable) indicators for patients and check the degree of their achievement.

The benefits shown for the patient in conjunction with the social determinants of well-being can contribute to greater satisfaction with life.

Data monitoring can result in avoiding illness and medicalization and, in this case, in obtaining better and personalized care. Participant 9 stated:

"From a doctor's point of view, it's certainly like it's seen by the patients, that these things are measured in some way and can somehow be assigned a number, for example (…)and a target range, you can see them, that it's so concrete for the patients and that it helps them (…) I would look more here not from the angle of such on-going verification of one's health status through these various telemedicine devices (...) I would focus more here on such significant deviations (...) If someone saw on some watch or device at home that he has significant deviations from the norm, then at this point he must come to us at the clinic and check, verify for himself his test results (…). At this point I would not rely on this (wearables) as the main source of treatment for patients, but more on such a personal

check and with significant deviations (...) this should be a sign to the patient that he should go to the doctor."

All data analytics activities are intended to serve the patients so that they can actively pursue good health, well-being and a better quality of life. Modern information systems of service providers supported by analytics should become essential for patients' health management.

Among the benefits for physicians, survey participants listed the following:

- access to complete patient data,
- the ability to check whether patients are adhering to recommendations such as diet,
- the ability to conduct preliminary diagnostic analyses based on such data,
- more concrete checking of the patient's health status,
- screening the health status of the population, risk groups, etc.

Therefore, it is necessary to provide analytical systems in medical facilities that enable medical professionals to access complete, high-quality patient health data, use automated analytical tools to understand this data, assist in clinical decision-making, and predict patient health. Providing doctors with access to Big Data analytics could positively impact the quality of patient care, as they would have access to complete patient data, they would be able to check whether patients are adhering to recommendations, e.g., diet, and it would be possible to conduct preliminary diagnostic analyses based on such data, making it possible to perform more concrete checking of patients' health and screening of population health, risk groups, etc. Access to complete data is important, because as Participant 2 and 3 stressed:

"The problem that I'm sure medical facilities are observing, doctors are observing as well, concerns the fact that patients very often fail during (...) visits to medical facilities to determine exactly how they manage, or perhaps don't even manage, their health. (...). If such information was sent from all sorts of devices, but also from automatic machines (...) It would certainly assist the diagnostic process maybe not exactly the therapeutic process." (P2)

"Most people confabulate because they need a prescription for something other than they should have or need to take a sick leave for work. Well, there is information juggling and questions such as do you follow the recommendations, do you follow the diet? Yes, they do , because patients are ashamed to admit, for example, that they do not follow such a diet. No way to verify that, and the results don't change." (P3)

An important aspect highlighted by the study participants, in terms of physician benefits, was the access to complete data. Participant 9 said:

"It's impossible to ask everything at a doctor's visit, and this is evident, for example, from lab tests, that often the patient is asked, for example, if there was a problem with diabetes or elevated blood sugar or high blood pressure in the past. Often patients say no, and then when reviewing the patient's laboratory tests

moments later, however, it comes out that yes, that there was a problem before, and for example there was diabetes, and the patient completely forgot about it, so this would certainly be helpful (...) if it were possible to collect a little bit more data about the patient, and you could go into an app of some kind (...) or a tab, just like laboratory tests, then whether before the visit or even during the visit there is something to refer to."

However, they pointed out several limitations associated with using such data in diagnosing patients and prescribing therapy. In the diagnostic process, the responsibility lies with the doctor, so the participants were concerned about the reliability of data from wearables. They emphasized the formulation of preliminary diagnostic conclusions which would need to be confirmed with further diagnostics.

Medical facilities, thanks to the ability to access Big Data analytics, would have access to the complete historical data of a patient and their recorded daily parameters, and they would be able to offer personalized service packages to patients.

Respondents also identified several benefits that society could gain from real data analytics. Among the benefits to society, they mentioned primarily the following:

- possible change in the lifestyle of society,
- the possibility of monitoring the elderly,
- the possibility of motivating lifestyle changes,
- personalized approach to each person (potential patient),
- detection of trends that lead to improvements in the health and lifestyle of society.

It is worth emphasizing that these are only possibilities, as whether these benefits will be achieved depends on the efforts of individual members of society and their commitment to care for their own health. As Participant 8 said:

"The benefits would be huge for everyone. In fact, both for the patient and for the doctors, as well as in general for society too, you can really say (...) the benefits would be if we could encourage right now, this society, people who are a little older... to change this lifestyle a little. (...) Such a system will be needed because society is actually getting less and less in touch somewhere. The fact that people now even as they work remotely, they do not leave the house, becoming more and more stupid, and they eat that fast food even more, because they have it delivered, so I think this is needed as much as possible. The only question is how to give them this information so that they understand it, so that they still want to change their habits or eating or exercise habits to get these benefits."

Question 2 In your opinion, what is the quality of data the doctors use as the basis for diagnosing the patient and prescribing therapy? What data do they have at their disposal? What can be changed in this regard? Can data from wearables be helpful in this matter?

The research confirmed that the quality and reliability of the data are essential to data analysis, especially if doctors were to diagnose patients or prescribe therapies based on

such data. The responsibility for the diagnosis rests with the doctor, as they are the one who makes the final decision, even when it is based on recommendations from the information system. One participant stated (P3):

"It's always two aspects (...) one aspect is (...) quality. And the other is responsibility. As for the quality aspect, I realize that it is not presumably dramatically difficult to produce a device that has the quality of collecting good, comparable information. Well, of course, these are such devices and medical and non-medical data. Well, in any case, here, we always have, for the time being, some confidence limit (...) On the other hand, well, when it comes to whether something is registered for medical use or not (...) for me, anything can be a medical device. (...) the certification is there so that the doctor can use it, rely on the data in a way that is also safe, safe not only for the patient, yes, but also for himself as a doctor and make these decisions (...) the patient may suffer harm (...) this is what happens in medicine well then the problem will be that a non-certified device was used and no one is going to get in trouble for this future goodwill. Therefore, in order to do something, this device should be certified (...) However, certification is one thing, and quality is another thing".

Respondents also raised the issue of device certification. Opinions on this issue vary, as some respondents consider certification an expensive process and only partially indicative of the quality of approved devices.

Question 3 Are we moving toward personalized medicine? Should patients share data collected by their wearables (e.g., smart wristbands) with a medical facility for better diagnosis? Can such data be relied on for diagnosis?

The survey also showed that it is already a common claim that society is moving increasingly toward personalized medicine. The study participants indicated that it is very important for people to share data from their wearables (e.g., smart wristbands) with medical professionals and medical facilities. As P1 stated:

"Are we moving toward personalized medicine? Absolutely yes. In the near future, the Polish Ministry of Health will want patients not to be treated in the same way because, well, from a medical point of view, each patient is different, well, different needs have different requirements, this also concerns ailments. Treatment can be different and treatment needs are different. (...) of course, some guidelines will be prepared in advance, but yes for sure we are going in the direction of personalized medicine, because it is probably the most optimal. That is, not to measure everyone with the same yardstick just to prepare and treat diagnostics on the basis of individual parameters of a given person."

P3 added:

" The greater the amount of this data sent to the medical facility, the more reliable the result or the greater the quality (…) Everything is fortunately moving more and more toward an individualized approach to the patient." (P3)

Question 4 What are the barriers to the use of wearables in healthcare and IHPP?

However, there is also the issue of data sharing. Will the data be available for viewing only? Will they be saved in some database? Will they be saved in individual records under each patient, or only downloaded anonymously? P1 said:

> *"When it comes to sharing data, I think that, knowing the Polish society, some people may be outraged. It must also be some right of the patient, however, to keep this information, and it will certainly be helpful (...) but does the doctor, during the visit, have time to just review such patient data, to dig into it, or is he more simply going to rely on this data anyway, which is from the test results and what the patient says." (P1)*

This doubt also connects to respondents' barriers to analysing medical Big Data and implementing the author's original IHPP proposal. P1 stated that:

> *"The barriers are definitely going to be some kind of acceptance of such surveillance in a sense by some system, but a lot of people might agree, because I don't attach that much importance to it anymore."*

Among the barriers, respondents also point to the previously raised problem of data reliability and diagnostic decision-making based on this data type. Therefore, this problem can be treated as one that requires further exploration. P1 said:

> *"The barriers certainly include the reliability of the data that is being collected."*

P9 added:

> *"I wouldn't dare to diagnose patients on the basis of such data, because here it's like monitoring; there's a couple of different aspects that you can check for yourself (....) it's sort of just one element, some kind of diagnostic procedure, that is some kind of risk load there potentially. On the other hand, if it's strictly about the person's problems, some preliminary therapeutic decision may be possible on the basis of such data." (P9)*

The survey also pointed out technological barriers, especially if the users were to be elderly people. Potential problems were also identified by medical professionals who could access such data. The application would have to make the data available in an aggregated form, such as a dashboard, since there is not enough time during a medical visit to review all the data. P9 stressed:

> *"(...) the question is also how the data will be presented, because actually, it will probably be useful to have some kind of summaries or some kind of highlighting only, some kind of include dashboard with indicators (...) so that you can look at it and you can see some trends".*

The study also raised a problem related to the mentality of doctors and patients. It was pointed out that recommendation apps could be poorly perceived by doctors who believe they are the best ones to diagnose the patient and prescribe therapies. Therefore, as rightly noted, such a system could only be a recommendation and, as noted earlier, based on data from wearables, only preliminary diagnoses can be considered. It is necessary to verify the health status of a particular person fully. P1 stated:

"Doctors have a very strong resistance also to the fact that a machine can be better than them, and I know that. Doctors have a bit of a God complex. Yes, but they are also easy to approach, because I always say, listen, he won't be smarter than you, because you are the one who makes these decisions at the end of the day, the system only recommends, and you can still improve this recommendation and apply the final touch. The fact is that I've heard it a couple of times already, that it can't be a system that replaces the doctor, just a recommendation that the doctor can modify, improve, and he will then be satisfied, because it's not the system that did it, he just signed off at the end and said that's good."

On the other hand, when considering the mentality of patients, respondents pointed out that people don't want to know at all if they are sick, and when given unmeasured data, they may miss the truth. The fact that people need to take the data measured by wearables more seriously, or that they are not motivated to use these devices or apps, may also be a problem. P3 said:

"People don't want to know that they are sick. That's where the biggest problem is, but that's our society."

P1, in turn, commented and asked:

"We as a society know very well that we should eat well, that we should keep fit and so on and so forth. But do we do it, and what percentage of people do it? What is the only thing we can look at? How many people go for walks, how many people exercise? And so on and so forth. What do they eat? Unfortunately, fast food, it's popular and so on, and we know it all on the one hand, and on the other hand we don't apply it to you anyway (…). If I have such an app or if I have such a device, will I have anything extra? Because that would motivate me." (P1)

The link to transactional data was the most controversial feature of the IHPP solution presented by this study. Respondents pointed out potential problems with analysing shopping data, namely the inability to associate specific items on a shopping list with a specific person when shopping for a larger number of people, and the lack of willingness to share transactional data due to both fear of data security and possible negative reviews, catching fraud, or assessing a small food budget. As P3 stressed:

"There are some data that a large part of the population may not want to share. For example, the issue of these purchases may already be coming up. The problem is that this data is already too sensitive (...) Shopping is something else, health is health. It's as if we don't quite have control over health data (...) because no one chooses to get sick. No one wants to get sick. That's not people's goal, whereas shopping is. (...) Well, it could indeed be a problem because people may have different predispositions when it comes to food, as I understand it. It could stem from material issues. It could stem from different kinds of habits. It could be due to other issues that we're not talking about at the moment, and that's the kind of information that should rather be only in a limited scope, that is, that it should be accessed by, let's say, some kind of artificial intelligence that is able to handle it appropriately with the help of appropriate algorithms (…)." (P3)

A similar view is held by P4, P6 and P1:

"It will prove to you that you are eating badly, and you say the opposite, so I think also in this respect that patients would not quite want to share their information , when it comes to nutrition." (P4)
"I also don't think that such sharing of this data would be advisable, and patients would be interested in that, because I assume that I don't know a patient who would like to just have their purchasing data shared somewhere." (P6)
"If the application is to be linked precisely to the transactions with the analysis of the exact products we buy, for example food (...)we have a constant problem in Poland when it comes to sharing our detailed purchase history. Poles don't want to share, they don't want anyone to know what we do, what we buy, where we buy it, we have huge concerns about this, besides, the shadow economy exists all the time and a lot of people buy with cash, so this won't even be recorded (...) so I think that it would be very difficult to automate the process of investigating these purchases." (P1)

Question 5 What benefits can Big Data Analytics, wearables and the IHPP bring to the healthcare system?

As part of the applications, the participants were also asked to identify what benefits IHPP could bring to their potential users and what features it should have. Many respondents' indications overlapped with their indications when using Big Data analytics and data from wearables. They pointed to access to monitoring of one's health by individuals, and the ability to share data with a doctor who can draw certain conclusions based on it. The suggestions respondents made regarding the functionality and features of the analysed solution brought significant value. The suggestions are as follows:

- the system should be comprehensive so that it one does not need to use many different applications,
- there should be an option to boast about the results and to enter statistics (which can be achieved by adding social networking options),
- analysis of purchases in terms of nutritional and harmful substances should be available,
- the system should give recommendations on, for example, shopping,
- an extensive incentive system should be implemented based on the needs of users and their personality traits,
- the system should have a feature for monitoring elderly and disabled people by family members.

Question 6 Can the use of wearables and of the IHPP have a positive impact on eliminating the problems healthcare is currently facing in Poland (problems with the aging population, obesity)?

The survey participants felt that analysing data from wearables and the proposed IHPP could be helpful in mitigating essential healthcare issues, including, among others, the aging population and obesity.

They emphasized that IHPP could give them access to monitoring data of, for example, parents who live separately, which was stressed by P4 and P3:

> *"(...) when parents live away from their children, for example, the latter would have access to this data to see that a parent is okay. Monitoring seniors who live alone and being able to just see if they're okay would also be exactly the kind of thing that such a platform could allow." (P4)*
> *(P4)*
> *(...) because still in the case of people who live in completely different places, then even more so, yes, they would do everything so that only such data flows to them there, that everything is ok and that there is contact, or that this person has the ability to quickly call for help, some kind of response, in a semi-automatic manner." (P3)*

IHPP could be a solution for parents of people with disabilities (e.g., autism, Down syndrome). This was stressed by P4 and P1:

> *"(...) people with Down syndrome are often on the level of a little bigger child (...) but they are able to learn some interesting basic such activities (...) There is not even such a device for them today, and this would also be a nice just to monitor, because they have seizures of epilepsy, for example, they get lost, sometimes they do not have fits of aggression, well different things". (P4)*
> *"In fact, the demand for such applications is gigantic. And it's going to get bigger and bigger, because more and more children are being diagnosed on the autism spectrum, for example. (P1)*

The respondents also pointed out the problems that can arise in monitoring the elderly, for instance, numerous health problems and ailments. It was pointed out that people should be introduced to such a system early to be more conscious and healthier seniors. For example, P3 said:

> *"With seniors it varies, because as far as prevention is concerned it is a simple matter, it will definitely help. If it works, it will help in the sense of being widespread and so on and so forth. (...) older people mostly get sick from something. Can such applications really help? (…) how much can it help, how much can it be a bother? Because older people have a lot of ailments, a lot of different things can appear, and every time you have to intervene in some way, and the older someone is, the more careful you have to be with different interpretations."*

Question 7 Should the platform be a complementary solution to the existing healthcare system, or should it be a part of it and be linked to healthcare IT systems?

The study showed that the proposed system should be linked to the healthcare system in Poland. It should be possible to integrate it with the Internet Patient Account, a nationwide e-health system, so that conclusions can be drawn about prevention, prophylaxis, and epidemiology with the help of artificial intelligence. Only then will it

be possible to fully utilize the potential of the various stakeholders and provide safe, user-friendly solutions making it easier for them to function in the healthcare system. In addition, during a visit, the doctor could collate data from the Individual Health Plan Platform with data collected in the Internet Patient Account (Polish EHR). P2 said: *"Well, of course it's better if it's connected." (P2).* A similar view is held by P10:

> *"It should be just such a platform that medical facilities join and at the same time make available to their patients. (...) to create such a nationwide health plan platform made available through the online patient account. As well as all the patients' data visible in the system at this point." (P10)*

P9 stressed that it would be a big loss if the data were not combined and aggregated, and subsequently used to analyse and predict population health:

> *"It would be a great loss if a lot of people used only their data, and it would not be possible to make some epidemiological estimates from this (...) access through an online account or (...) should be collected in databases (...) such data from such systems, which cover a wide range of different people, well necessarily they should be analysed. You can then observe in general some trends, going in this or that direction, or alarming ones , or you can also test, for example, the effectiveness of some actions so that they are taken on a global level (...) no longer in contact between doctor, patient, but at some higher, global level. And whether it affects some kind of behaviour or health-promoting behaviour." (P9)*

Question 8 Should health promotion programmes based on Big Data, especially data from wearables, be created? Will the creation of a platform based on data analysis from wearables that support users in managing their own health and quality of life, contribute to the improvement of society's well-being?

The study participants indicated that based on the data collected by wearables for the Individual Health Plan Platform, health promotion and prevention programmes could be created to improve their quality of life in the future. P1 said:

> *"Participating in a programme, a health-promoting style motivates the user a little more. When I go in, for example, I have some kind of health-promoting programme, like fighting obesity, and I have a 6-week programme laid out, for example. I'm supposed to use that 6-week programme at the end. It is just shown that I will lose so much weight my body fat will improve. I will lose this much; I will gain this much (...)" (P1)*

Participants also suggested that a reward model based on positive reinforcement could be implemented in this solution (along the lines of the normalized Chinese model). This view is shared especially by P7, P5, P1:

> *"This is such a platform for monitoring potential actions and checking to what extent they have effects. (...) If indeed a lot of people were monitored in such a platform, then a lot of things could be checked. Then it's already possible to introduce different things, for example, for specific cities." (P7)*

"That's not how it works, because if someone is motivated, it's just to help systematize (...) try to build a system just to motivate behavioural changes, nutrition, physical activity, but their identity is unknown, it's targeting random people.. (...) if someone needs it, maybe they will like it. Maybe it will be cool, he will use it, but the point is to stimulate that need to use it. But here's the problem: you would have to know the personality of the person at the beginning. That is, first to recognize, to diagnose their personality traits, build a profile, and on the basis of such a profile provide just this recommendation." (P5)
"For example, such a Chinese model (...) collecting points for different things and then rewarding (...) this new society (...) they don't really accumulate like the older society, (...) young people want rewards here and now, they can save for a month or two, maybe maximum three, if they don't get a reward here and now then they give up this option." (P1)

Question 9 What will be the future of using wearable technology in healthcare?

The respondents see the future of using data from wearables as positive. They believe that all the measuring devices we have at home (blood pressure monitors, thermometers, glucometers, even stethoscopes) will become connected to the Internet within five years. Based on the data analysis, they will create personalized services and products and offer discounts on healthcare (e.g., medicines, services, insurance) for people who live a healthy life.

"In 5 years, it's thought that c the devices we constantly use to measure our blood pressure, to measure our sugar (...) thermometer (...) will be digitized so much that they will probably automatically send this data to the cloud and the cloud will just give us a recommendation right away." (P2)
"Data is the future, well already healthcare probably can't function without data. (...) The acceleration was given by the pandemic. Here, let's not kid ourselves, if it wasn't for the pandemic, we would probably continue to deal with many things, but here is such a nice acceleration just after the pandemic." (P4)
"Members of the general public could be induced to give way to just such health data or transactional data so that they could get, for example, personalized products and services, that is, for example, we have results, we send all our data and based on the results of our activity, research is able to give us a recommendation, so to speak, and, for example, prepare a set of vitamins specifically for our needs. With the exact ingredients that we lack. She made the order and sent me an email, where I have to press only Buy Now." (P7)
"The future of analysing such data in the sense of seeing what is malfunctioning where, and how something can be improved or has it had an effect? Data from these devices can be analysed (...) and it would be possible to plan in a more precise and effective way certain measures, the big, strategic ones, related to the formation of health-seeking behaviour, so to speak." (P3)
"Perhaps someday it will be the case that, for example, people who are somehow able to confirm that they take care of their health, let's say by exercising or tak-

ing care of their diet or some parameters that they will be able to measure, using for example wristbands, could get some benefits in terms of healthcare. I don't know, faster access to a doctor or cheaper drugs. (...) What's happening in China, although I don't know about it exactly, but I know that there are some sort of, I guess, social points there, that citizens get points for sorting their waste, and they lose points if they don't do it properly (...)." (P1)

Conclusions

Digital transformation in the healthcare system in Poland is progressing intensively. The epidemiological situation in 2020–2021 has significantly increased the use of electronic services by patients and medical professionals. It has also accelerated the development of more health IT initiatives in Poland. This makes it possible to introduce new solutions for, among other things, prevention, diagnosis, the treatment process, management of broadly understood health, financing, financial settlement of health services, or conducting various types of analyses. At the same time, it should be remembered that the most crucial link in the healthcare system is the patient, which is why healthcare providers are focused on making the health of every Pole the best it can be.

To meet the growing demand for healthcare services, the healthcare system offers its citizens many digital services for research, faster diagnosis and health improvement. However, every person's physical, mental and social well-being depends not only on medical facilities. It is influenced by various factors including, among others, lifestyle, genetic conditions, available healthcare, and the physical environment. Therefore, health systems should involve the patient in managing their health, from adhering to prevention guidelines, motivating them to lead healthier lifestyles, to manage chronic diseases and provide feedback to healthcare providers. Such engagement can be achieved by providing patients with digital social innovation solutions based on BDA. Such digital solutions offer support to patients, with recommendations for healthy lifestyles and maintaining health based on analysis of data from various sources: wearables, other apps, or the healthcare system (data from medical facilities such as test results).

One of the goals of this article was to define the role (place) of BDA in developing social innovations in healthcare. The analysis of the literature made it possible to determine what DSI are, in which areas of health protection they can be applied, how BDA can contribute to their development and what values they can bring to the society. The findings show that Big Data Analytics has the potential to develop social innovations in healthcare.

The results obtained will be used as the basis for further research on the possibilities of using BDA in the development of social innovations in healthcare. The author's future research will focus on examining which values can win over different stakeholders of society (society, citizens, healthcare units) thanks to the implementation of DSI in the form of digital platforms supporting the monitoring of citizens' health and recommending health paths. Direct research will be performed based on the model of Digital Social Innovation, in turn based on Big Data Analytics as presented in this paper.

The results of the conceptual study and focus survey are important issues to consider when designing a health and well-being management system/application. It also has some practical implications for healthcare wearable device manufacturers and

community planners on what to look for in their design. Furthermore, our results provide insights for social planners on promoting better quality in healthcare services. The study provides guidance for health policy on how wearables and health-promoting platforms can contribute to the population's health, quality of life, early diagnosis and disease support, which should translate into strategies in this area.

However, the presented research has some limitations. It presents a holistic perspective and depicts the area of application, omitting the technical specification of the proposed platform, which will be developed after direct research conducted with potential users of the system (focus surveys and repertory sample interviews).

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