

## INNOVATIONS IN THE AREA OF HEALTH IN SELECTED COUNTRIES OF THE EUROPEAN UNION ON THE EXAMPLE OF POLAND AND GERMANY

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**Purpose:** The aim of the article is to identify and compare various types of product innovations and business processes in the area of health in selected countries of the European Union. The rationale for undertaking research on this subject resulted from the lack of scientific studies on innovation in the health sector.

**Design/methodology/approach:** The analysis was carried out on the basis of two countries, namely Poland and Germany. For this purpose, an analysis of domestic as well as foreign literature was used aimed at proving the originality of the problem undertaken. In addition, the method of comparative analysis aimed at searching for similarities and discrepancies occurring in the phenomena under consideration in the article was used. An analysis of selected indexes and rankings on the implementation of innovations in the field of health globally was also carried out.

**Findings:** The article provides insights into the implemented innovations in the field of health. The results obtained show that innovations in the area of health care are more developed in Germany than in Poland, and also most of them are product innovations.

**Originality/value:** Implementation of innovations in the field of health care is important due to the permanent changes that are taking place on the technological, social and economic levels - not only in a specific country, but all over the world. Most of the findings presented in the article can be used to improve the operation of medical facilities in many areas, as well as to increase the quality of service to patients and improve the comfort of their lives.

**Keywords:** innovation, research and development activities, health care.

**Category of the paper:** A literature review.

## 1. Introduction

The environment in which organizations currently operate is undoubtedly undergoing many dynamic changes. Thus, it is important that appropriate measures are taken to encourage both scientists and entrepreneurs to conduct all kinds of research and seek innovative solutions involving the creation of new products, ways of doing things, improving productivity and improving the technologies used.

It is worth noting that innovations are used in every sector of the economy, which undoubtedly has a positive impact on the development of countries. They are of particular importance in the area of healthcare (Grenier, Oiry, 2021; Condry, Quan, 2021). Statistics published by the European Patent Office (EPO) show that innovation in healthcare is the leading field of inventions in terms of quantity, while pharmacy and biotechnology are considered the fastest growing disciplines (EPO, 2020). This situation is due to the fact that today's medical sector is constantly faced with various problems, especially in the context of an ageing population (Vaportzis, Clausen, Gow, 2017; Eze, Mateus, TCO Hashiguchi, 2020; Alzahrani, Hunt, Whiddett, 2021; Irmén, Litina, 2022; Extermann et al., 2022). The increasing number of chronically ill patients, the upward trend in the incidence of cancer, the rising costs of diagnostic and therapeutic procedures and the underfunding of health care services have a significant impact on the health of the sector. Therefore, the implementation of innovation is one of the solutions that can be used to reduce or avoid some of the problems mentioned.

Many authors emphasise that innovation activities in this field encompass different aspects of it, such as medical products and procedures used, medicines, or e-medicine. In addition, innovation may refer to the organisation and management of health services, advances in technology, medical products in a broad sense, and the pharmaceutical sector (Tyszka, Lubos, 2009; Dymyt, M., Dymyt, T., 2016; Barlow, 2016). It can be concluded that innovations in this sphere should not only refer to internal improvements of medical facilities, but, above all, they must concern and have an impact on the patient.

The theoretical and cognitive analysis showed that although the literature extensively addresses the issue of innovation, there is a certain shortage of the scientific studies on innovation in the area of health, especially innovation implemented in other countries. The identified cognitive gap was reflected in a research gap relating to the identification and comparison of innovations in the area of health in selected European Union countries. In addition, the focus of the research on the medical sector resulted from the researchers' conviction about the importance of this area, which should be characterised by a high degree of innovation. The analysis of the literature did not reveal such studies in the context of comparing the innovations implemented in different countries. In order to fill the identified gaps, the aim of the study was to identify and compare different types of product innovation and business processes in the area of health in selected European Union countries.

For the health sector, innovation is particularly important for several reasons. Firstly, they result from the specificity and role of fulfilling a social mission for society through the provision of health services. Secondly, due to the constant changes taking place at technological, social and economic levels, it is important to develop new forms of service provision, products and system solutions, as this builds trust and a sense of security in society.

The main research problem is focused on finding an answer to the question: is there a difference between the amount of implemented innovations and their type in the area of health in Poland and Germany?

The research presented in this article responds to a cognitive and research gap identified in the literature. As part of the research undertaken, product and business process innovations were identified. The results of the research confirmed, i.a. that innovations in the field of health care are more developed in Germany than in Poland, and that most of them are product innovations.

## 2. The essence of innovation

The literature so far has not developed a single universal definition of innovation, there are various approaches to it proposed, but they are often not consistent with each other. This is partly due to the fact that the development of the concept of innovation has been significantly influenced by various sciences. The table 1 presents selected definitions of the term.

**Table 1.**  
*Choosing definitions of innovation*

Author	Definition of innovation
C. Leadbeater	"A long, interactive and social concept, involving different people from different backgrounds with different competencies" (Leadbeater, 2003, p. 30)
J.P.J. de Jong, D.N. Den Hartog	"Creating new ideas, products and processes that have a simultaneous impact on productivity" (De Jong, Hartog, 2007, pp. 41-64)
J. Schumpeter	"(...) Innovation is divided into five types: 1. introduction of a new product or a new grade of an already known product. 2. The use of new methods for producing or selling a product. 3. The opening of a new market. 4. Acquiring new sources of supply for raw materials or intermediate products. 5. A new industry structure, leading to the creation or destruction of a monopoly position" (Śledzik, 2013, pp. 303-312)
J. Baruk	"It is a deliberate human-designed change in product, manufacturing methods, organization of work and production, and management methods, applied for the first time in a community to achieve specific socio-economic benefits, meeting specific technical, economic and social criteria" (Baruk, 2006, p. 102)
A. Pomykalski	"(...) innovation is an activity that gives resources new opportunities to create added value for shareholders, consumers and other interest groups" (Pomykalski, 2001, p. 9)
D. Smith	"Innovation is a new idea, practice or object" (Smith, 2006, p. 6)
J. Wyrwa	"A learning process that has a social and territorial reference and a cultural and institutional context" (Wyrwa, 2014, pp. 15-16)

Cont. table 1.

R. Knosala, A.M. Deptuła	The authors define innovation as "any idea transformed into a concrete action/thing, which is characterized by a deliberately designed change of a novelty nature, both sensu stricto and largo, which is intended to bring certain benefits". (Knosala, Deptuła, 2018, p. 18)
D. Cropley, A. Cropley	"Innovation is the process of generating novelty and then implementing it in organizations". (Cropley, D., Cropley, A., 2014, pp. 21–59)
Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation	"An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)". (OECD/Eurostat, 2018, p. 20)

Source: own study based on literature.

Based on the above definitions, it can be concluded that innovation is a concept treated by researchers very broadly. It is commonly regarded as the introduction of a new product, technology or solution or a significant improvement of an existing one. It should be noted that today the popularity of innovation is constantly growing, as new or improved solutions are used in every area of human life.

Due to the difficulties associated with defining innovation clearly, many types of innovation are distinguished in the literature. The most up-to-date typology is presented in the Oslo Manual and lists among others business process and product innovations.

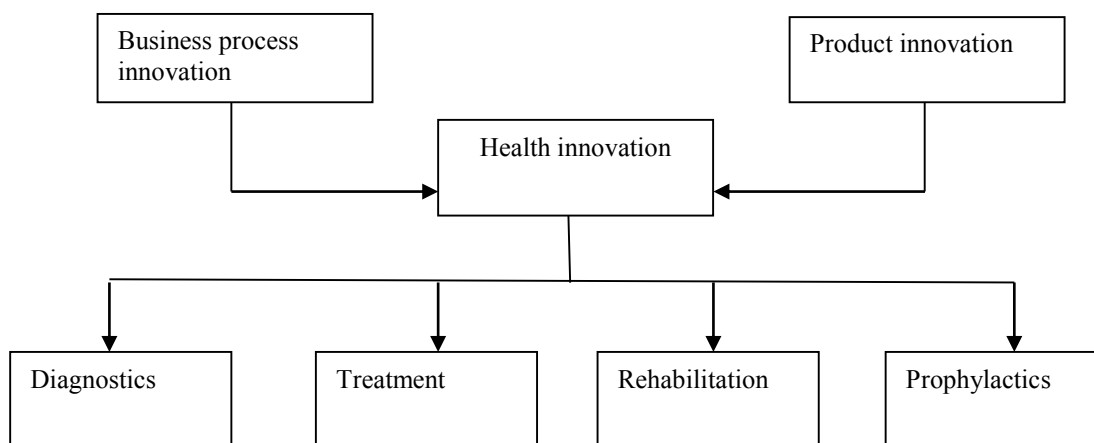
**Table 2.***Types of innovation*

Type of innovation	Definition
Business process innovation	"(...) a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm".
Product innovation	"(...) a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market. Product innovations must provide significant improvements to one or more characteristics or performance specifications".

Source: Own study based on OECD/Eurostat (2018), Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg.

The current version of the Oslo Manual does not distinguish between the basic types of innovation - marketing and organisational - because, along with process innovation, they are mostly included in business process innovation. A single innovation may consist of a combination of types of product innovation and business process innovation. Therefore, the typology of innovations according to their subject matter is not a classification whose categories are mutually exclusive (OECD/Eurostat, 2018). In the area of health, it could be distinguished, among others, innovations related to the treatment process, often referred to as pharmaceutical-medical innovations, technological-information innovations, organisational innovations, as well as marketing innovations (Pawłowska, 2015). Another division is medical innovations - related to the evolution of medical knowledge, which is a result of the achievements of biomedical engineering, information and communication techniques and

changes in the pharmaceutical market. A distinction is also made between innovations related to the provision of healthcare services - these are innovations relating mainly to the organisation and functioning of the healthcare system, as well as other entities that constitute the environment for this system (Dymyt, M., Dymyt, T., 2018). Innovations in healthcare can be classified as social innovations. Their main purpose is to try to solve social problems, related to poverty, education, health and other aspects of human development, which cannot be solved by the use of appropriate technology alone (Dubé et al., 2014; Kimble, Rashad Massoud, 2017; Niekerk, Manderson, Balabanova, 2021). A typology of health innovations is presented in the Figure 1.



**Figure 1.** Typology of health innovations.

Source: own study.

It can be concluded that innovations in the area of health are innovative solutions that contribute to positive outcomes, including the provision of quality services, but also the effective functioning of the organisation itself and translate into diagnostics, treatment, rehabilitation and prophylactics, increasing patient satisfaction and quality of life.

### 3. Innovation in health care - a global perspective

In the literature, there is a lack of scientific studies addressing the topic of innovation in health comparing the situation in more than one country. In particular, the topic of the health system (Döring, Friedemann, 2010; Hofmarcher, 2013; Ioberman, 2013; Globerman, 2013), costs of this system (Saksena et al., 2018), as well as innovations in individual countries (Gerke, Stern, Minssen, 2020; Lipowicz, Nojszewska, Sikorski, 2020; Kokocińska, 2020; Stern et al., 2022; Lantzsich et al., 2022) are discussed. Most articles in the literature refer to the health system as a whole, while there are no studies comparing the situation of innovation in Poland and Germany.

Reviewing the literature on the subject, one must conclude that globally, health innovation has the potential to relate to saving lives, improving health outcomes (both for individuals and societies), making the best use of limited financial resources allocated by countries to health care, and setting, achieving and supporting both national and international health goals.

It should be emphasised that the emergence of innovation in the field of health, is important within the framework of actions taken by the EU institutions. The Horizon Europe Programme, which is scheduled to run from 2021 to 2027, aims to fund research and innovation, being build on three main pillars.

**Table 3.**  
*Structure of the Horizon Europe Programme*

	<b>Pillar I</b>	<b>Pillar II</b>	<b>Pillar III</b>
<b>Name</b>	Excellent science	Global challenges & European industrial competitiveness	Innovative Europe
<b>Aim</b>	Reinforcing and extending the excellence of the Union's science base	Development of key technologies and solutions that are the basis of EU policies and sustainable development goals	Stimulating market-creating breakthroughs and ecosystems conducive to innovation
<b>Institutions</b>	<ul style="list-style-type: none"> <li>• European Research Council;</li> <li>• Marie Skłodowska-Curie;</li> <li>• Research Infrastructures.</li> </ul>	<ul style="list-style-type: none"> <li>• Clusters:               <ul style="list-style-type: none"> <li>○ Health;</li> <li>○ Culture, Creativity &amp; Inclusive Society;</li> <li>○ Civil Security for Society;</li> <li>○ Digital, Industry &amp; Space;</li> <li>○ Climate, Energy &amp; Mobility;</li> <li>○ Food, Bioeconomy, Natural Resources, Agriculture &amp; Environment.</li> </ul> </li> <li>• Joint Research Centre.</li> </ul>	<ul style="list-style-type: none"> <li>• European Innovation Council;</li> <li>• European Innovation Ecosystems;</li> <li>• European Institute of Innovation &amp; Technology (EIT).</li> </ul>

Source: Own study based on [https://ec.europa.eu/info/funding-tenders/find-funding/eu-funding-programmes/horizon-europe\\_pl](https://ec.europa.eu/info/funding-tenders/find-funding/eu-funding-programmes/horizon-europe_pl), 22.10.2022.

The above-discussed pillars have a significant impact on the development of innovation in the area of health. From the perspective of the analysed issue, activities undertaken within the framework of the cluster of pillar II referring to health, whose main aim is to deepen knowledge in order to develop and implement innovative solutions in the subject of broadly understood health and disease management, seem to be extremely important. Within this cluster, the following areas of action are distinguished (KPK, 2022):

- a. Health at different stages of life,
- b. Environmental and social factors,
- c. Non-communicable diseases and rare diseases,
- d. Communicable diseases,
- e. Tools, technologies and digital solutions in health and care,
- f. Health systems.

The activities of the European Institute of Innovation and Technology (EIT, 2022) should not be overlooked either, as the main task of this institution is to promote innovation activities undertaken by EU countries by facilitating cooperation between the three most important sectors - business, research and education.

A study conducted by The U.S. Agency for International Development (USAID, 2020) indicate that 70 to 90 percent of global health innovation relates to improving products, services and practices that already exist, while only about 10 percent of innovation activities relate to inventing something entirely new that can meet the health needs of communities. An interesting perspective on health innovation is presented by The Foundation for Research on Equal Opportunity, which created the FREOPP World Index of Healthcare Innovation (FREOPP, 2021). The index ranks countries not only by traditional indicators such as affordability of health care facilities and health outcomes, but also by characteristics such as the degree to which patients have a choice of doctor and insurer, patents in health care, scientific impact and Nobel Prizes in chemistry and physiology or medicine, access to new treatments and digitization of health. The index also measures the fiscal sustainability of countries' health care systems, meaning the degree to which a country is able to maintain public health care spending without punitive taxes or a debt crisis. All components use a scoring method on a scale of 0-100 to assess each country's performance relative to others. Therefore, it should be inferred that the index uses a data-driven approach to identify the leading health systems in 31 countries based on four equivalent categories, which are quality, choice, science and technology, and fiscal sustainability. The ranking of the FREOPP World Health Innovation Index 2021 is presented on the Figure 2. in a tabular form.

Overall Rank	Country	Overall Tier ▲	Overall Score	Quality	Choice	Science & Technology	Fiscal Sustainability
1	Switzerland	Excellent	65.15	65.39	68.25	53.92	73.06
2	Netherlands	Excellent	62.99	62.65	73.31	42.56	73.43
3	Germany	Excellent	59.79	52.73	70.25	37.69	78.48
4	Ireland	Excellent	56.67	58.16	61.48	32.52	74.50
5	Israel	Excellent	55.72	63.21	59.67	38.38	61.62
6	United States	Excellent	54.78	56.33	54.53	73.93	34.35
7	Australia	Good	50.76	60.07	65.44	25.27	52.25
8	Hong Kong	Good	50.72	40.56	61.58	24.96	75.77
9	Belgium	Good	50.51	48.84	56.23	35.43	61.53
10	United Kingdom	Good	50.21	52.15	57.04	47.18	44.46
11	Denmark	Good	49.87	49.20	52.20	45.37	52.70
12	Singapore	Good	49.71	46.83	66.44	32.63	52.95
13	Taiwan	Good	49.26	50.22	60.10	17.75	68.96
14	South Korea	Good	48.36	51.81	63.35	18.14	60.16
15	New Zealand	Good	48.28	58.47	54.61	25.47	54.56
16	Czech Republic	Good	47.58	38.84	56.84	15.58	79.06
17	Portugal	Good	46.92	63.15	58.83	15.78	49.93
18	Sweden	Moderate	45.35	48.72	53.87	40.99	37.82
19	Austria	Moderate	45.33	50.86	55.45	29.84	45.16
20	United Arab Emirates	Moderate	45.19	46.72	45.86	22.41	65.79
21	Finland	Moderate	44.64	50.45	42.34	36.99	48.78
22	Spain	Moderate	44.53	47.13	56.85	23.52	50.63
23	Canada	Moderate	44.31	53.26	54.05	27.63	42.29
24	Norway	Moderate	44.17	57.10	48.59	33.76	37.22
25	France	Moderate	42.60	53.25	54.04	32.79	30.34
26	Greece	Moderate	41.55	38.72	58.67	19.66	49.14
27	Hungary	Moderate	40.31	32.34	48.82	17.72	62.34
28	Italy	Poor	37.90	44.22	44.21	19.37	43.80
29	Slovakia	Poor	37.70	28.75	48.66	14.32	59.06
30	Japan	Poor	37.52	57.20	56.09	36.76	0.04
31	Poland	Poor	35.52	25.23	44.01	8.40	64.45

Figure 2. Ranking of the World Health Innovation Index 2021 FREOPP.

Source: FREOPP World Index of Healthcare Innovation, <https://freopp.org/key-findings-from-the-freopp-world-index-of-healthcare-innovation-cda78938c047>, accessed 07.01.2022.

Figure 2 allows us to observe that six countries received an overall score of "Excellent": Switzerland, the Netherlands, Germany, Ireland, Israel and the United States. In contrast, Italy, Slovakia, Japan and Poland are the countries that received an overall score of "poor" in the FREOPP World Health Innovation Index 2021. In doing so, however, it should be noted that it is possible to create a classification of the countries presented based on the individual categories that make up the overall rating obtained by each country.

Another indicator for observing how advanced countries are in terms of innovation is the Global Innovation Index (GII), published annually since 2007 (WIPO, 2021). The Global Innovation Index measures the performance of a particular country by considering its innovation inputs and innovation outputs. Innovation inputs can represent a country's spending on R&D and higher education, while innovation performance is, for example, intellectual property. In 2021, 132 global economies were analyzed, and as in previous editions of the report, Switzerland ranked first. Second place belongs to Sweden, and third place belongs to the US. The top ten innovative countries also include the UK, South Korea, the Netherlands, Finland, Singapore, Denmark and Germany (WIPO, 2021).

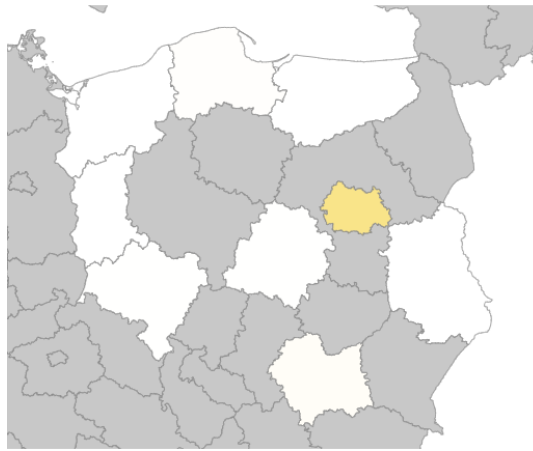
The above data indicate that there is a need for improvement measures in health care globally, which is a direct result of the need to adapt the methods and technologies used and the desire to improve the efficiency of health care systems to the dynamically changing environment and patients' expectations.

## **2.1. Poland**

According to the publication 'Health System Profile 2021' (OECD/European Observatory on Health Systems and Policies, 2021) which was developed thanks to cooperation between the Organisation for Economic Co-operation and Development (OECD), the European Observatory on Health Systems and Policies and the European Commission, for many years now, low financial outlays allocated to health care have resulted in a shortage of doctors and nurses, which strongly influences the problem of access to services, which is felt by patients in the form not only of long waiting times for specialists and medical procedures, but also incurring high own fees. In addition, the management of the health care system in Poland is dispersed, so that effective coordination of the measures taken is difficult. It should be emphasised that in 2019, the average total expenditure allocated to healthcare in the European Union was 9.9% GDP, while in Poland this figure was significantly lower – 6.5% GDP. Moreover, healthcare expenditure per capita was over €1,500 in Poland in 2019 (adjusted for differences in purchasing power), representing one of the lowest amounts within the European Union countries, while the EU average is over €3,500. In 2019, almost 39% of adults in Poland report suffering from at least one chronic disease, while for citizens over 65 this percentage rises to 70% - also for this reason, the implementation of health innovation should be a key issue in Poland.



In Poland, participation in Pillar II (Global Challenges and European Industrial Competitiveness) in the health area of Horizon Europe was reported by 25 entities, which received €17.62 million in funding from its budget to implement 33 projects.



**Figure 3.** Net funding [€] by NUT2 region in Poland.

Source: Krajowy Punkt Kontaktowy ds. Horyzontu Europa, Narodowe Centrum Badań i Rozwoju.

The analysis of Figure 3. allows to conclude that the Warsaw Capital Region is the beneficiary of the highest funding. In this region, the National Centre for Research and Development is the entity that has been granted the highest financial support, amounting to over €5 million. It should be emphasised that this organisation focuses its activities on providing support to organisations to create and implement innovative solutions (NCBR, 2020). The entity that also received funding under this programme, amounting to more than €2 million, is the Maria Skłodowska-Curie National Institute of Oncology - National Research Institute - which is extremely important in view of the growing trend of oncological diseases in Poland.

In the Global Innovation Index 2021, Poland ranked 40th, down two positions from before the COVID-19 pandemic. Despite this, it should be noted that innovation in Poland is developing, however not in such a dynamic and resilient way as in the world economies that top the ranking.

Bearing in mind the demographic situation in Poland - a decline in the number of births and fertility rates, as well as the aging of the population - innovative activities carried out in health in the broadest sense seem extremely important. This article presents only examples of implemented health innovations, however, it should be emphasized that more and more projects in this area are being developed in Poland every year.

One interesting example of a health innovation implemented in Poland is the Zeus bionic prosthesis for upper limb amputees. This product is controlled by the user using electrical signals sent by muscles (EMG). Admittedly, bionic prostheses are not a new product, but what makes the aforementioned model stand out among them is certainly the following (Aether Biomedical, 2022):

- a. one of the highest grip forces available on the market (greater than 150 N),
- b. speed and strength reflecting muscle strength to ensure a firm grip,
- c. innovative fingers that are resistant to damage without sacrificing grip strength.

The prosthesis makes it easier for users to perform activities of daily living - from holding sushi chopsticks to holding dumbbells. In addition, it is possible for buyers to customize the appearance of the device, which is undoubtedly another advantage.

The diseases of civilization in the 21st century, which are associated with the rapid development of civilization, lifestyle and physical activity, include diabetes (Ministerstwo Zdrowia, 2022). With the increasing number of patients, an extremely important example of health innovation is the GlucoStation portable and non-invasive glucose meters (Glucoactive, 2022), which use optical methods when measuring. The GlucoStation device provides a telemedicine solution, allowing limited contact between the patient and the doctor, which in the era of the COVID-19 pandemic seems to be an extremely important advantage.

Another example of a health innovation that responds, as it were, to the current pandemic situation is Neuroforma, which is an innovative online neurorehabilitation system prepared by rehabilitation specialists (Neuroforma, 2022). The premise of this project is a hybrid system that allows the patient to perform rehabilitation exercises both at the rehabilitation center and at home, as well as providing telerehabilitation. When exercising at home, the patient can take advantage of the support offered by a rehabilitation therapist, or exercise on his or her own by selecting exercises from an activity base, according to the area requiring rehabilitation. The developers point to Neuroforma's simplicity of use, as well as mobility and convenience. In addition, motivation to exercise at home is provided by collecting points and receiving rewards for regularity.

Professionals can use the TeleNeuroforma platform for hybrid rehabilitation. It not only contains sets of ready-made exercises, but also allows you to create your own using a wizard. In addition, it is also possible for a rehabilitation facility to purchase a stationary exercise device - Neuroforma PRO, which, combined with TeleNeuroforma, will make it easier for patients to perform stationary exercises at the facility and continue treatment at home.

Currently, many countries are emphasizing the emergence of smart hospitals, the main idea of which is to base health care management on modern information technologies and artificial intelligence. In Poland, an example of such a place is the Institute "Polish Mother's Memorial Health Center" in Lodz, which started the implementation of the "smart hospital" project in 2018. The hospital's management stresses that the idea of a smart hospital will not only improve the work performed by the employed staff, but patients will also notice positive effects in the form of, for example, shorter queues or waiting times for an appointment at a specialized clinic or procedures. In addition, the implementation of this concept should make it possible to generate 20% savings. Thanks to the IT solutions introduced at every level of the hospital, from clinics and outpatient clinics to administrative units and the unit's management, there is a noticeable improvement in the quality of work and the amount of time that is actually devoted

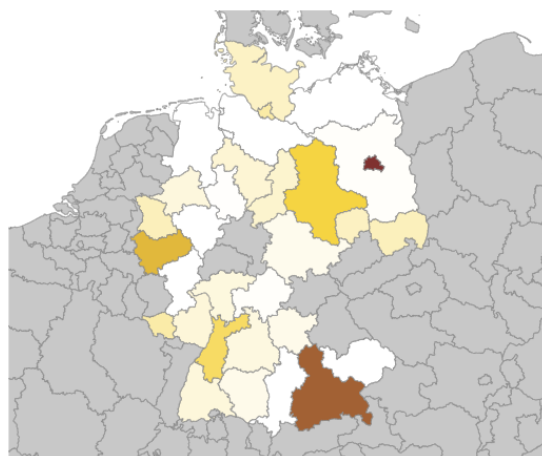
to each patient, as paper record-keeping has been reduced to a minimum (Centrum Zdrowia Matki Polki, 2020).

Based on the above, it can be concluded that in Poland, more and more attention is being paid to the implementation of innovations in various areas of broadly understood health, thus enabling not only the development of health care, but also increasing the quality of life of patients.

## 2.2. Germany

The publication 'Health System Profile 2021' (OECD/European Observatory on Health Systems and Policies, 2021) states that spending on the health sector in Germany, measured as a share of GDP, is the highest in Europe and that the health system offers a broad package of benefits, a high level of service and universal access to relatively high quality and effective care. The governance structure of the German healthcare system is complex, as decision-making is divided between the federal and national levels, together with strong local government bodies. The legal norms are defined by the federal government, while the regulatory details are the responsibility of the Gemeinsamer Bundesausschuss (Gemeinsamer Bundesausschuss, 2022), which is the decision-making body of the joint self-government of doctors, dentists, hospitals and health insurance funds in Germany. The federal states, on the other hand, supervise the self-governing units at regional level, are responsible for planning and investment in hospitals and also for medical education. In 2019, Germany spent 11.7% GDP on healthcare, which is the highest within the EU countries, as is its healthcare expenditure per capita of €4505. In addition, the country under analysis is also characterised by a high number of doctors and nurses, with their rates per population and growth rate significantly higher than the EU average.

In Germany, 179 entities applied to participate in Pillar II (Global Challenges and European Industrial Competitiveness) in the health area of Horizon Europe and received €207.79 million in funding from its budget for 137 projects.



**Figure 4.** Net funding [€] by NUT2 region in Germany.

Source: Krajowy Punkt Kontaktowy ds. Horyzontu Europa, Narodowe Centrum Badań i Rozwoju.

An analysis of Figure 4. leads to the conclusion that the NUT2 Berlin and Oberbayern regions received the highest funding. In the first region, the project participant with the highest funding of over €16 million is the Charité - Universitätsmedizin Berlin, which involves around 5,000 researchers in the development of pioneering medical innovations (Charité - Universitätsmedizin Berlin, 2022). In Oberbayern, on the other hand, the recipient of the highest funding of over €10 million is the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V., which is a world-leading organisation in applied research, pioneering many innovative solutions (Fraunhofer-Gesellschaft..., 2022).

In the Global Innovation Index 2021, Germany ranked 10th, down one position from the previous year. Receiving high scores in all categories, enables the country to translate its efforts and investments into the implementation of innovations in many fields. With a large number of graduates in science, or engineering, Germany presents an excellent human capital and research system. In addition, they rank second in the world in terms of spending on research and development activities (WIPO, 2021).

An interesting example of a health innovation implemented in Germany is the EmergencyEye system, which allows emergency call centers and service centers responsible for communicating with victims to use more than just a phone call (EmergencyEye, 2022). The system was developed for use in emergency calls, but is now also in use in the energy, gas and water industries, chemical groups, logistics and service companies. The unquestionable advantage of the EmergencyEye system is that it improves the efficiency of emergency call centers and those tasked with communicating with the injured, as staff will be able to handle calls faster, more accurately and efficiently, and provide better support and care for the injured. The innovative technology is configured in minutes, and can be easily integrated into existing IT infrastructure.

Another interesting innovation that has been implemented in the German health field is Amparo's lower limb (below the knee) temporary prosthesis (Amparo, 2022). Its vision is to empower 90% of the world's 30 million amputees by providing them with access to affordable, high-quality prosthetics. Amparo's revolutionary prosthetic socket solution is now the fastest, easiest and most affordable on the prosthetic market. The prosthesis is designed so that fitting can occur anywhere and with optimal efficiency, so rehabilitation can begin almost immediately. In addition, by adapting to volume changes throughout the recovery process, it provides maximum comfort.

Amparo's product line also includes the Mobile Clinic, or "mobile prosthetic clinic," which includes, in addition to the custom-made prosthesis, the devices necessary for its placement. With the Mobile Clinic, there is freedom of choice in where amputees receive treatment.

Supporting people with disabilities in mobility and a sense of independence is provided by innovations created by the Munevo company (Munevo, 2022). Among the interesting product innovations offered by this company are:

- a. Munevo Drive - this is a head controller for electric wheelchairs, which serves as a platform for all other products. With this device, it is possible to control the wheelchair hands-free, as it is done using head movements. This product is available as a kit consisting of Smartglasses, an adapter and pre-installed software;
- b. Munevo Arm - with Munevo Drive, robotic arms from KINOVA and Assistive Innovations can be controlled, providing support for work, education, activities of daily living and hobbies;
- c. Munevo Phone - this is an application that allows you to control your phone (e.g., while listening to music, or for making calls) using your head movements.
- d. Munevo Monitor - is an application that allows you to display the image from your glasses on your mobile device;
- e. Munevo Home - with this product it is possible to control a smart home system.

It is predicted that digitization, in its broadest sense, will transform the daily operation of health care units. It is noted that German hospitals are at the forefront of the digital transformation taking place in many countries around the world. New technologies provide greater efficiency, while also reducing costs for the healthcare system. The Universitätsklinikum Hamburg-Eppendorf (UKE) was the first clinic in Europe to introduce a so-called electronic patient "file" in 2011, whose data is stored centrally by the hospital, allowing constant access to patient data by doctors, therapists, or nurses. In addition, thanks to the implementation of this solution, in the clinic's pharmacy the system packs more than 12,000 doses of medication for patients every day, and in the ward nurses check patients' wristbands before administering medications, further enhancing security. Another example of a smart hospital in Germany is the Universitätsklinikum in Essen, which in 2019 piloted algorithms that perform routine work in radiology, such as checking CT scans or evaluating examinations for signs of cancer. It should be noted that the algorithm implemented in Essen is a form of artificial intelligence that is constantly fed with data, so that it is constantly learning, as reflected, for example, by the rates of detecting cervical cancer metastases at an early stage with an accuracy of 95-97% (GTAI, 2019).

Newsweek magazine, in cooperation with Statista, has compiled a list of 250 hospitals around the world with the most advanced technology, artificial intelligence and broad telehealth solutions in 2021 (World's Best Smart Hospitals, 2021). The 10th place in the aforementioned ranking is held by Charité - Universitätsmedizin Berlin, which was also recognized in 2022 as the best hospital in Europe (World's Best Hospitals, 2022).

Analyzing the above examples of innovations in the field of health introduced in Germany, it can be concluded that innovative activities related to remote medicine are extremely important. In addition, solutions are also being implemented for the empowerment and sense of independence of people with disabilities, based on the use of modern technologies. It should also be emphasized that German hospitals are constantly striving to provide the best possible quality of patient care, which is reflected in the high positions held by these units in many rankings.

### 3. Conclusions

The analysis that has been carried out presents the identification and comparison of different types of product innovation and business process innovation in the field of health in Poland and Germany, but also the expenditure allocated to healthcare or participation of these countries in the Horizon Europe Programme.

**Table 4.**  
*Comparison of criteria in Poland and Germany*

Criterion	Poland	Germany
Population in 2019	37.97 million	83.09 million
Healthcare expenditures in 2019	6.5% GDP	11.7% GDP
Healthcare expenditures per capita	€1500	€4505
Rank in the Global Innovation Index 2021	40	10
Rank in the FREOPP World Index of Healthcare Innovation 2021	31	3
Type of innovation	Product innovation • Zeus - Bionic Hand, • GlucoStation, • Neuroforma, and others.	Product innovation • EmergencyEye, • Products of Amparo company, • Products of Munevo company, and others.
	Business process innovation • Smart hospital Instytut „Centrum Zdrowia Matki Polki” w Łodzi, and others.	Business process innovation • Smart hospital Universitätsklinikum Hamburg-Eppendorf, Universitätsklinikum Essen, Charité - Universitätsmedizin Berlin, and others.
Horizon Europe Programme – pillar II – area: health		
Funding received	€17,62 million	€207,79 million
Number of participants	25	179
Number of projects	33	137

Source: own study.

Based on the table 4, it can be concluded that:

- Healthcare expenditures in 2019, as well as healthcare expenditures per capita, were at a significantly higher level in Germany than in Poland, despite of almost three times higher population there;
- In both, the Global Innovation Index 2021 and the FREOPP World Index of Healthcare Innovation 2021, Germany ranked higher than Poland;
- Poland and Germany have both types of innovation included in the Oslo Manual 2018, i.e. product innovation and business process innovation. However, most of these are the first types of innovation, while within business process innovation, the concept of 'smart hospitals' is used more often in Germany than in Poland;
- The funding received under Horizon Europe Programme is almost 12 times higher in Germany than in Poland. Furthermore, the number of participants in Germany is more than 7 times higher and the number of projects more than 4 times higher than in Poland.

The analysis shows that innovation in health care is more developed in Germany than in Poland. This is also connected with the economic situation occurring in both countries and, consequently, to the expenditure they spend on healthcare each year.

#### **4. Summary**

The challenges that were posed to healthcare units in many countries during the COVID-19 pandemic made it clear how important the use of advanced technologies is in medicine. In addition, the pandemic accelerated a trend that could have been observed in the medical market for years - hospitals and other health care units are becoming more and more "smart". It is emphasized that "telehealth" in the broadest sense is an integral part of the current times. It should be noted that during the pandemic, the ability to provide services remotely, including patient monitoring and mutual communication proved invaluable. The introduction and improvement of solutions related to telemedicine is very important - not only because of the pandemic situation, but also because of convenience, the availability of the service "here and now" and the quality of the therapy provided. What's more, for many patients, the advantage of telemedicine is that it saves time and reduces the costs associated with traveling to the facility. It should also be borne in mind that this is a very beneficial solution for patients whose health condition does not allow them to move freely. In addition, the idea of "smart hospitals" seems to be extremely relevant in the context of telehealth, as it uses available IT solutions and artificial intelligence in its operation, which positively affects patients and employees of health care units.

Based on the examples of health innovation in Poland and Germany presented above, one must conclude that health innovation is more developed in Germany. Such a situation is probably related to greater state spending on research and development, as well as on the health care system. Unfortunately, the current situation in the medical market and the progressing economic crisis is undoubtedly not conducive to the growth of the implementation of innovative solutions in Poland. The solution to this problem could be not only the cooperation of the public sector with business based on the formula of public-private partnership, but first of all, increasing expenditures on R&D and the health sector.

Currently, it can be observed that many countries are affected by problems relating to the aging population, the increasing number of chronically ill people, or those suffering from cancer and other ailments. Therefore, it would be interesting to present innovations in other countries outside the European Union, such as Switzerland or the United States. Such an analysis would provide insight into the ways in which innovations are implemented and used both to improve the quality of life of citizens and the functioning of the health sector in other countries that are not connected with the European Union.

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