INNOVATIONS, R&D AND KNOWLEDGE TRANSFER IN THE HEALTHCARE SECTOR

Dominika Gadowska[1]
e-mail: dgadowska@wne.uw.edu.pl

Agnieszka Różycka
e-mail: arozycka@wne.uw.edu.pl

University of Warsaw, Poland

[1] Corresponding author

Abstract. The efficiency of the healthcare sector is highly determined by its ability to conduct innovative industrial research and development practices as well as to achieve effective knowledge transfers between the scientific world and the economy. The article presents the analysis of the current situation of the medical industry in Poland as well as abroad, describes factors and barriers influencing the advancements in innovative activities, and determinants of successful research and knowledge transfer. The main part of the article is a presentation of own research based on one of the basic innovation indicators – patent publications – whose analysis, taking into account type, time range and location, allowed for pointing out the most innovative areas with the best growth potential. Faced with a lack of comparable analyses, both in scope and specificity of data, we believe this research paper may carry substantial scientific value and could be of use in further studies.

Key words: R&D, innovations, knowledge transfer, medicine.

Introduction

The term 'innovation' comes from Italian *'innŏvātĭo'* and is used to describe new ideas, appliances, mechanisms or ways of developing them (Aronson 2008). In economics, innovation is often regarded as a precondition for higher productivity and sustained competitive advantage, as well as a prerequisite for boosting growth, especially during financial crises (Ciani et al. 2016). Product innovation is crucial for every single enterprise since it helps generating additional revenue. Process innovation aims at both increasing internal potential of a company and improving quality of products and services offered to the public (Omachonu, Einspruch 2010). In health policy innovation it's often equated with introducing new pharmaceuticals (Webb 2011; Bouvenot 2007).

The efficiency of the healthcare sector is highly determined by its ability to conduct innovative industrial research and development practices as well as to achieve effective knowledge transfers between the scientific world and the economy. Innovations are among the key factors enabling companies to

succeed on the market, influencing the development of the economy in regions, countries and worldwide.

The aim of this article is the analysis of innovative activities in the healthcare sector. Both current situation of the medical industry and future prospects of the sector are being discussed, with particular regard to Poland. The article presents the scale of innovation across selected countries, describes factors and barriers influencing the advancements in innovative activities, discusses determinants of successful research and knowledge transfer, as well as analyses the scale of innovation in medical sector as measured by patent publications data.

The essay compiles numerous scientific works, information and data from several analyses and reports on the innovation topic, as well as Central Statistical Office of Poland (*Główny Urząd Statystyczny*, GUS), Eurostat, OECD and Espacenet statistics on the subject in question.

1. The protection of human health and innovations

1.1. Innovations in the healthcare sector

Medical sector is said to be one of the most innovative fields, one that requires the use of advanced technologies and the newest science achievements. These aspects, paired with high expectations when it comes to life lengthening, enhancing diseased people's condition and introducing n ew medicines, make the collaboration of the scientific world with the business area absolutely crucial. Pharmaceutical companies very seldom decide to conduct basic research that is the first stage in the development of a new medicinal product. It's not only a very time-consuming step but a very risky one since only one among thousands of molecules being examined is qualified for further research, with the rest of the compounds never transcending to the next phase. Looking for ways to shorten the implementation path, pharmaceutical companies get interested in a specific research project only after it succeeds in having a positive preclinical experience. All that indicates that a new idea in the medical sector, its development and the beginning of the testing phase is usually conducted in scientific units and at universities.

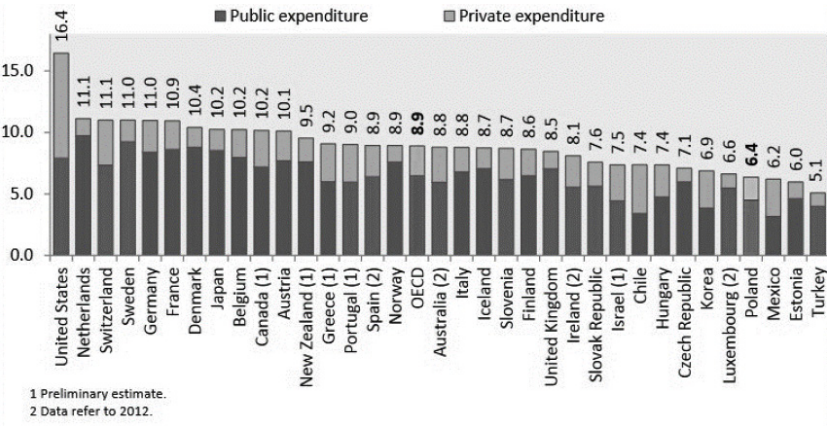
Characteristic to the medical sector are elevated hopes concerning the fulfillment of the basic needs of patients, fighting long-term suffering, illnesses and premature deaths. These expectations are the driving forces of the pharmaceutical market and lead to a continuous will to innovate and engage in research on new medicines, developing better methods of fighting pain, introducing supplements or providing access to cutting-edge diagnostic equipment.

Implementing innovative solutions in the medical sector is very costly. According to data gathered in 2012 by a Forbes.com journalist, bringing one medical product to the market, if we take into account the failures of numerous research projects, cost around 4 billion US dollars. Average expenditures for

a single medicine varied between 3.7 and 11.8 billion US dollars (Herper 2013). One needs to remember that this amount is spread over many years since the average time for a new medical product to be brought to the US market is about 12 years. Therefore, the commitment of different people and entities from both the scientific world and the business sphere is prerequisite for conducting research in this sector. Entrepreneurial environment can not only introduce the new products to the market but also offer financial support.

One of the basic indicators of the medical sector is the ratio of health spending to GDP. According to OECD statistics, the USA is the unquestionable leader of the ranking with health spending accounting for 16.4% of GDP in 2013, paired with a high level of private sector spending (8.5% of GDP). Figure 1 presents the situation for all OECD countries.

Figure 1. Health spending (excluding capital expenditure) as a share of GDP, 2013



Source: OECD Health Statistics 2015.

Since 2004, the average health spending as a share of GDP has risen by ca. 0.5 percentage points in OECD countries, mostly due to the growth in health spending, reaching 8.9% in 2013. In Poland the ratio of health spending to GDP is only 6.4% which is still significantly lower than the OECD average and ahead of only three countries: Mexico, Estonia and Turkey. When it comes to public spending share in total health spending, the OECD average is around 73% and this level was relatively stable over the last 10 years. Poland with its result of 71% doesn't differ much from that average. Among OECD countries, only two – the United States and China – reported the prevalence of private over public health spending. It's worth noting that in Poland, regardless of the slowdown caused by the economic and financial crisis, the growth rate of health spending was much higher than in the majority of OECD countries. In 2013 health spending per capita grew by 3.8%, significantly more than the observed increase of

ca. 1.0% in OECD countries. Total health spending growth slowed down mostly due to a decline in pharmaceutical spending. The latter was partially caused by changes in law introducing profit margin limits to wholesalers and retailers and cutting pharmaceutical spending within the social security budget. In 2013, expenditures on pharmaceutical products reached in OECD countries ca. 800 billion US dollars what accounts for around 20% of the average total expenses on healthcare (OECD Indicators 2015).

Now let us look at the data gathered in the Eurostat database concerning the scale and scope of innovation in the medical sector in selected European countries. The analysis takes into account the following statistics of *Medical and health sciences* (FOS07): total intramural R&D expenditure in medical and health sciences, total R&D personnel and researchers in medical and health sciences as well as medical or veterinary science and hygiene patent applications to the *European Patent Office* (EPO). The study takes into account only these EU countries for which complete data entries in the Eurostat database for the most recent five-year period were available.

Table 1 presents total intramural R&D expenditure in medical and health sciences per inhabitant. The countries were ordered by scale of spending in 2013. Poland came in second but last on that list with expenditures of 9.5 Euro per capita, preceding only Cyprus. The highest expenditures in this group are observed in Malta (34.2 euro per capita) who stayed the leader of the ranking even though the 2013 R&D spending fell by more than 7 euro per inhabitant as compared to the previous year. The Czech Republic and Bulgaria are the countries that are consistently demonstrating an increasing trend of spending. In Poland the expenditures were gradually rising as well, except for 2013 when the spending fell by 2 Euro per inhabitant. It's worth noticing that the situation in Slovenia changed significantly – between 2005 and 2007 the country was spending on R&D much more (e.g. 63.3 Euro per capita in 2007) than in subsequent periods.

Table 1. Total intramural R&D expenditure in medical and health sciences in selected European countries in 2009-2013 (EUR per inhabitant)

Country	2013	2012	2011	2010	2009
Malta	34,2	41,3	25,4	20,9	12,6
Portugal	26,5	28,5	30,9	29,5	27,5
Czech Republic	22,4	22,2	19,4	18	18,1
Bulgaria	15,9	15,1	13	11,1	3,6
Croatia	13,3	12,4	10,6	5,7	9,9
Slovenia	12,6	11,9	11,2	11,3	10,8
Turkey	12	12,3	11,4	11,6	10,9
Hungary	10,4	10,7	9	8,4	7,2

Slovakia	10,1	9,2	6,9	5,5	4,3
Poland	**9,5**	**11,7**	**8,4**	**7,1**	**5,8**
Cyprus	3,5	4,2	4,4	4,1	4

Source: Eurostat statistics

If one looks at the total R&D personnel and researchers in medical and health sciences presented in the Table 2, it becomes apparent that the leader is Turkey with almost 36 thousand employees in 2012, almost double the number observed in Poland who is the second on the list (18865 people engaged in R&D activities). The comparison of data proves that over the years countries try, if not to increase R&D employment (the case of Portugal, Bulgaria and Slovakia), then to keep it at a stable level (in Slovenia and Croatia). In Poland R&D personnel numbers seem to be steady, except for 2007 and 2008 when they declined significantly.

Table 2. Total R&D personnel and researchers in medical and health sciences in selected European countries in 2008-2012

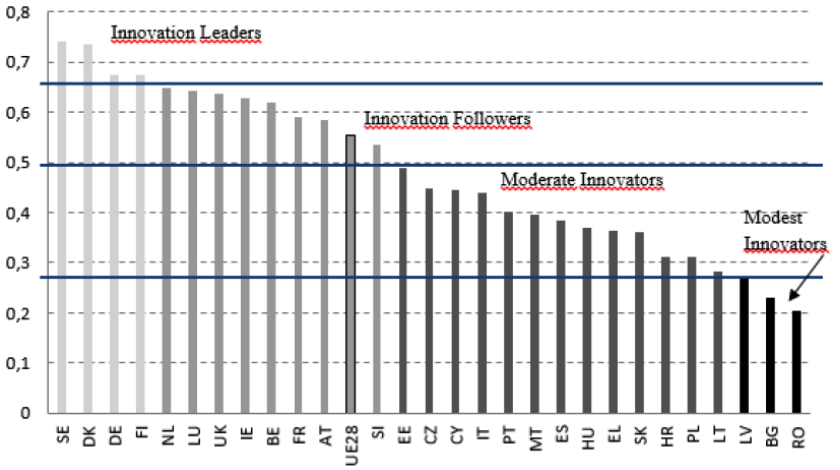
Country	2012	2011	2010	2009	2008
Turkey	35846	31890	30298	30527	28764
Poland	**18865**	**19283**	**18840**	**18702**	**6013**
Portugal	14094	13633	12701	12017	11536
Czech Republic	9269	9970	9798	10385	9380
Hungary	7231	8215	7771	8458	7925
Romania	3723	3741	3605	4935	3871
Slovakia	3641	3544	3590	3237	3139
Croatia	3378	3295	3940	3425	4140
Bulgaria	2546	2277	1921	1969	1683
Slovenia	2218	2327	2322	2125	2038
Malta	316	272	231	220	356
Cyprus	123	137	114	158	185

Source: Eurostat statistics.

When taking into account medical sector, Poland seems to be placing itself in the middle of the league table, outrunning a lot of countries that are getting much better results in overall innovation rankings. If we look for example at the *Summary Innovation Index* (SII) computed within *Innovation Union Scoreboard* developed by the European Commission in collaboration with Maastricht Economic and Social Research and Training Centre on Innovation and Technology (MERIT), Poland found itself in the group of moderate innovators (Figure 2) leaving behind only Lithuania, Latvia, Bulgaria and Romania (Hol-

landers, Es-Sadki, Kanerva 2015). It may imply that Poland's ability to innovate is greater in medical sciences than in other fields of expertise.

Figure 3. EU member states' innovation performance as measured by SII



The above finding is confirmed by the data gathered by the Central Statistical Office of Poland. In 2012-2014 the pharmaceutical companies were the most innovative ones since up to 45.6% of them introduced innovations (Table 3).

Table 3. Innovative enterprises in industry by type of introduced innovations, sections and divisions of NACE in 2012-2014

Specification	Enterprises that introduced innovations (%)		
	Total	New or significantly improved products	New or significantly improved processes
Total	**17.5**	**11.7**	**12.9**
Mining and quarrying	**14.7**	**8.5**	**10.7**
Manufacturing	**17.4**	**12.3**	**12.6**
Manufacture of food products	11.2	8.4	7.9
Manufacture of beverages	34.9	22.7	26.7
Manufacture of tobacco products	26.7	20.0	26.7
Manufacture of textiles	14.1	9.2	10.4
Manufacture of wearing apparel	6.2	3.3	4.5
Manufacture of leather and related products	9.6	8.6	4.8
Manufacture of wood and of products of wood and cork, except furniture	11.4	7.1	9.7
Manufacture of paper and paper products	18.4	12.0	15.5
Printing and reproduction of recorded media	18.8	11.4	16.4

Manufacture of coke and refined petroleum products	38.6	28.1	33.3
Manufacture of chemicals and chemical products	38.9	30.2	26.8
Manufacture of basic pharmaceutical products and pharmaceutical preparations	45.6	41.9	27.9
Manufacture of rubber and plastic products	22.7	17.6	17.4
Manufacture of other non-metallic mineral products	20.3	13.2	13.9
Manufacture of basic metals	26.1	16.0	21.8
Manufacture of fabricated metal products, except machinery and equipment	17.3	10.1	12.8
Manufacture of computer, electronic and optical products	33.0	28.6	19.8
Manufacture of electrical equipment	36.7	30.5	27.0
Manufacture of machinery and equipment n.e.c.	28.0	22.6	18.0
Manufacture of motor vehicles, trailers and semi-trailers	34.3	24.2	25.9
Manufacture of other transport equipment	29.7	27.8	15.1
Manufacture of furniture	13.6	8.4	10.3
Other manufacturing	24.2	20.4	14.0
Repair and installation of machinery and equipment	10.8	6.2	8.8
Electricity, gas, steam and air conditioning supply	**28.5**	**4.5**	**26.8**
Water supply; sewerage, waste management and remediation activities	**16.6**	**4.8**	**14.7**

Source: Own elaboration based on Główny Urząd Statystyczny, 2015.

1.2. Factors and barriers influencing the innovation capabilities in the medical sector

One can identify numerous factors and barriers affecting innovative processes in the medical sector. The major constraints can be classified into the following categories: financial, procedural and efficiency issues connected with the production and delivery methods.

The major impediment to developing innovations in healthcare are financial matters. The producers of pharmaceuticals or medical devices are rarely capable of covering high operational costs, not to mention those attributable to new research projects or patent protection fees. The main reasons for that are the elevated expenses linked with carrying out research, including specialized laboratory equipment, reagents and qualified personnel. Within financial barriers limiting the development of the medical sector, it's worth mentioning insufficient private healthcare spending in less developed countries, like Poland (OECD 2015).

The second group of barriers limiting the growth of innovative activities are procedural ones. Its significance is growing given the rising requirements of the medicine certification authorities: the number of procedures that need to be accomplished is mounting, and clinical tests need to be conducted on bigger groups of participants.

Healthcare market is one of the most regulated ones in view of the necessity to assure that the medical treatment is not harmful to patients' health and it doesn't have a negative impact on the environment. All the existing regulations significantly slow down the process of implementing innovations. Unfavorable bureaucratic arrangements impeding the functioning of companies are not helping either. Poland is among the most bureaucratically burdened systems in Europe. And, as international research carried out during the last 20 years in 40 countries around the world by Grant Thornton (one of the world's leading organizations of independent audit, tax and advisory firms) for International Business Report shows, excess of formalities leads to limiting the innovative initiatives and hinders entrepreneurship (Bariery rozwoju... 2013).

The third group of barriers is formed with efficiency issues. The assessment of the degree of economic effectiveness is crucial for formulating adequate health policy and is laying ground for effective management on different levels (Nojszewska 2011). The medical assessment of the efficacy of conducted research is yet another essential element since in order to be implemented, innovative solutions in the medical sector have not only to provide a high standard of healthcare and prove not be harmful to patients, they also need to fit the policy of minimizing costs. Moreover, accomplishing the assessment of medical efficacy can be a real challenge in the face of limited access to qualified doctors having acknowledged experience and expertise in the necessary areas.

The next impediment to implementing medical innovation is the difficulty in performing a thorough market analysis. When it comes to innovative healthcare products it's hard not only to get trustworthy information concerning the effectiveness of treatment but also to foresee how the market would react to the introduction of a new medicine and how this would fit the delivery chain (Grajewski 2015). The mechanisms of developing new solutions in the area of human health and life protection mostly promote innovative medications that are aimed at curing diseases affecting the world population (e.g. anybody can go on to develop cancer, regardless of the region or prosperity of the country). Pharmaceutical companies, encouraged by a chance to set up a price monopoly provided by the patent protection, are more likely to invest in such area of research rather than, say, in curing filariasis observed in some regions of Africa and Asia (Nathan 2007). Such a race to maximizing profit may be a barrier to innovation since it prioritizes solutions offering the best revenue perspectives before those with highest scientific potential.

Another group of limitations is formed by production and distribution factors that are particularly important in healthcare. Manufacturing problems are quite common in all high-technology sectors and can include difficulties in switching to a new production cycle when a new medication is introduced, as well as technical or financial aspects of production itself. The distribution of an innovative healthcare product can be another substantial hurdle given the specificity of the medical sector and its complicated delivery chain including producers of medical equipment, distributors, doctors and nurses, as well as government bodies. A lot of difficulties arise from intellectual property rights law – because enforcing a patent is very pricey, the procedure of getting protection requires the support of patent attorneys, and the risk of having to prove in court that one hasn't stolen an idea for a medical invention is relatively high (Grajewski 2015).

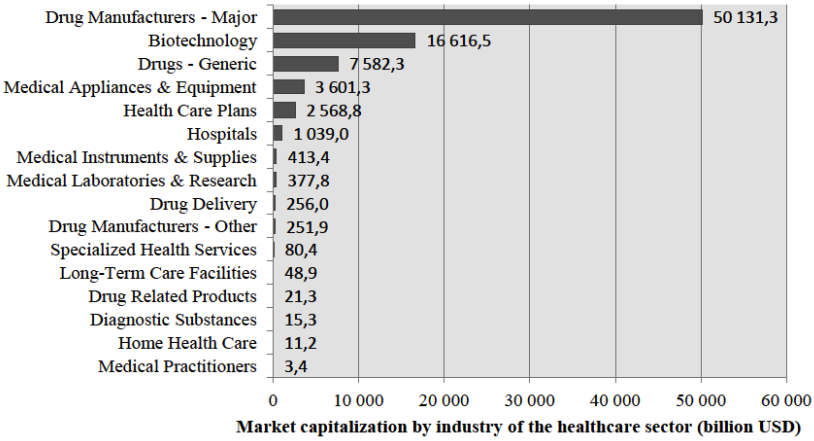
The list of barriers limiting innovation in the medical sector can be very long, not only confirming how unique this area is but also pointing to some common elements, such as: lack of centralized knowledge base, limited resources and fast developing industry. Inventors and companies or institutions engaged in research and development in every single area need to face numerous challenges but the institutional, industrial and knowledge-based ones the medical sector encounters are unique. The optimization of innovative processes in the medical sciences requires surmounting various difficulties and cooperation of many parties: producers, service providers, conductors, doctors and patients. Among other, not yet enumerated, barriers, it's worth noting that the medical sector is characterized by high risk aversion. Doctors familiarized with specific procedures and methods of treatment, are reluctant to switch to use new pharmaceuticals. Their day-to-day focus on caring for patients may not be helping either since they don't have enough time to follow new therapy methods. The situation gets even more complicated by the level of stress of medical personnel and frequent exhaustion caused by working long hours. These factors may limit innovative thinking and decrease creativity of the staff involved (Grajewski 2015).

1.3. The opportunities and perspectives of the medical sector

The medical sector is constantly developing as a consequence of rising customer needs resulting from growing population, population ageing, higher chronic diseases morbidity, infrastructure development, technological progress and emerging markets growth. Global healthcare spending is constantly increasing. In 2013 it reached 7.2 trillion USD (10.6% of global GDP) which is 2.8% more than in the previous year. The growth rate is expected to accelerate in the following years (with an average of 5.2% a year), and spending reaching 9.3 trillion USD between 2014 and 2018 (*2015 Global Health Care Outlook* 2015: 1).

The value of all companies active in the healthcare, as measured by market capitalization, surpasses now (as of April, 25th 2016) 83 billion USD, with ca. 60% of this amount generated by major drug manufacturers. The biotechnological companies come in second with a result of 16.6 billion USD, followed by entities operating in generic drugs area (7.6 billion USD) and medical appliances & equipment – 3.6 billion USD (Industry Browser – Healthcare Sector). The market capitalization of the healthcare sector by industry is presented in Figure 4.

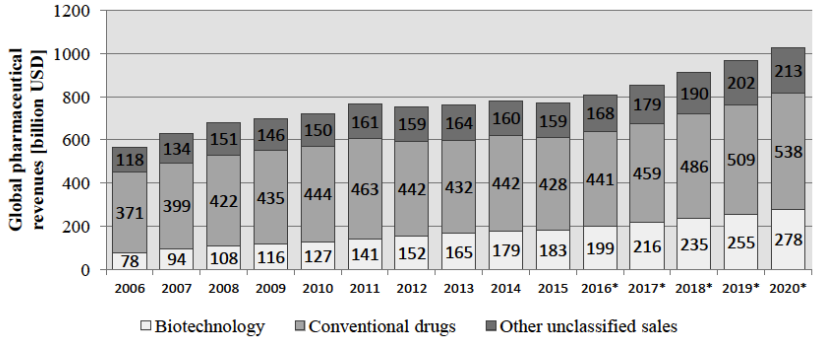
Figure 4. Market capitalization of the healthcare sector by industry



Source: Industry Browser, 2016.

The value of the world's pharmaceutical market, which can be considered representative for the whole healthcare sector because of its size, has been showing positive growth rates for years. The volume of sales grew from 567 billion USD in 2006 by a third, reaching 770 billion USD in 2015 (Figure 5). The forecasts show that it will surpass a trillion of dollars by 2020. It is anticipated that the role of biotechnological solutions will be increasing and the sales of conventional drugs will be declining. The latter accounted for almost two thirds of the sales volume in 2006 but estimates show that their market share in 2020 will shrink to around 52%.

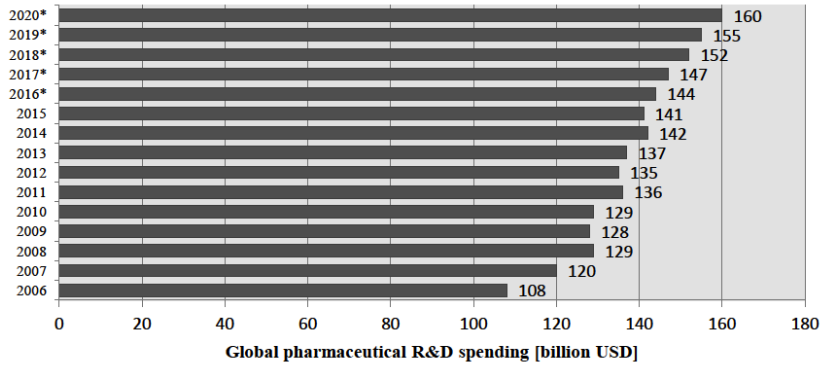
Figure 5. Global pharmaceutical revenues in 2006-2020 by type of product



* forecast
Source: Statista, 2016 a.

In 2015 R&D expenditures of the pharmaceutical sector reached 141 billion USD, more than 30% above the amount spent in 2006. According to the forecast, the value of research and development spending can grow by additional 19 billion USD until 2020, reaching 160 billion USD (Figure 6).

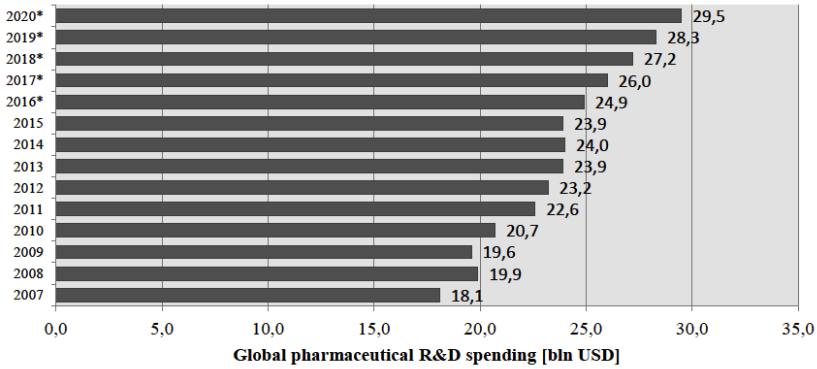
Figure 6. Global pharmaceutical R&D spending in 2006-2020



* forecast
Source: Statista, 2016 b.

As Figure 7 shows, a growth is also anticipated in the area of research and development spending in the medical technology sector which includes technological solutions designed to diagnose, monitor and treat all sorts of diseases. In 2007 investment in R&D in this area amounted to a bit more than 18 billion USD, was by 38% higher in 2015 and is expected to grow by additional 5.5 billion USD by 2020.

Figure 7. Global pharmaceutical R&D spending in 2007-2020



* forecast
Source: Statista, 2016 c.

The value of the Polish healthcare products market is estimated at 2 billion USD, out of which 85% is imports. According to Włodarczyk (2015), it should reach 3 billion USD by the end of the current decade. The pharmaceutical market is growing dynamically as its value increased in 2015 by 4.9% as compared to the previous year, reaching 29.9 billion PLN (Rynek Zdrowia 2015). With estimates indicating further growth, the volume of healthcare products sales may equal to 30.7 billion PLN (Frąckowiak 2016).

The reports mentioned present general forecasts of the healthcare sector development. It's worth noting that given how unique this area is, the reality may as well be different. It is a fairly atypical domain demanding high research inputs, calling for a substantial level of innovation, with further development conditioned by new discoveries. The medical sector will be evolving for sure but these factors may influence the dynamics or even the direction of the progress observed. The final outcome may surprise everyone.

2. The authors' research results

2.1. General outline

Literature studies show a lack of research papers similar in aim and scope to this article. In view of the scarcity of compound, cross-section analyses of innovation in medical sector, the following part of the essay is based on the authors' own studies. They take into account one of the main innovation indicators – patents. The analysis of the number of patents published, including their timeline and geo-positioning, allowed us to identify general trends in innovative activities in medical sector, as well as to delineate significant forecasts for the coming years. The categorization of patents enabled us to identify which areas of the healthcare sector are the most interesting to re-

searchers and those characterized by the highest innovation indicators. Faced with a lack of analyses comparable in scope and specificity of data, we believe this research paper may carry substantial scientific value and could be of use in further investigation.

2.2. Methodology

The Espacenet database was the main source of data on patent publications used in this paper. The search was carried out with regard to the following criteria:

I. location – Worldwide Patents, European Patents, Polish (patents classified as Polish);
II. year – from 1996 till 2015 and a forecast until 2025;
III. category – limiting the search results to those IPC categories (International Patent Classification, www.web2.wipo.int) that are related to the healthcare sector. The following patent groups were included:
   A. Human necessities:
      A 61. Medical or veterinary science; hygiene:
      A61B. Diagnosis, surgery; identification;
      A61C. Dentistry; apparatus or methods for oral or dental hygiene;
      A61F. filters implantable into blood vessels; prostheses; devices providing patency to, or preventing collapsing of, tubular structures of the body, e.g. stents; orthopedic, nursing or contraceptive devices; fomentation; treatment or protection of eyes or ears; bandages, dressings or absorbent pads; first-aid kits;
      A61G. transport, personal conveyances, or accommodation specially adapted for patients or disabled persons; operating tables or chairs; chairs for dentistry; funeral devices;
      A61H. physical therapy apparatus, e.g. devices for locating or stimulating reflex points in the body; artificial respiration; massage; bathing devices for special therapeutic or hygienic purposes or specific parts of the body;
      A61J. containers specially adapted for medical or pharmaceutical purposes; devices or methods specially adapted for bringing pharmaceutical products into particular physical or administering forms; devices for administering food or medicines orally; baby comforters; devices for receiving spittle;
      A61K. preparations for medical, dental, or toilet purposes;
      A61L. methods or apparatus for sterilizing materials or objects in general; disinfection, sterilization, or deodorization of air; chemical aspects of bandages, dressings, absorbent pads, or surgical articles; materials for bandages, dressings, absorbent pads, or surgical articles;

A61M. devices for introducing media into, or onto, the body; devices for transducing body media or for taking media from the body; devices for producing or ending sleep or stupor;
A61N. electrotherapy; magneto therapy; radiation therapy; ultrasound therapy;
A61P. specific therapeutic activity of chemical compounds or medicinal preparations;
A62. Life-saving; fire-fighting:
A62B. devices, apparatus or methods for life-saving.

Multiple database inquiries were performed. A single search included: IPC patent category, date (1996-2015 period) and region (World, Europe, Poland). Since the search results in Espacenet database are limited to 10,000 records, sometimes – in order to obtain adequately detailed data – it was necessary to carry out searches covering monthly or even fortnightly data and then adding them for respective calendar year. Single patents may have belonged to more than one IPC category, e.g. a pharmaceutical product could be classified as A61K (the patent then included the method of production), as well as A61P (when the specific therapeutic activity was protected by the patent). These instances were not excluded from the database since each patent, even belonging to a few IPC categories described a different part of the discovery – its unique feature, a process or use – so constituted a separate component of each category, contributing to scientific progress achieved by a group of innovations.

The data gathered provided detailed information on those areas of the healthcare sector that are particularly interesting for research communities, allowed for assessing the scale of innovative activities in terms of localization and time, evaluation of the current situation, as well as indicating tendencies and generating forecasts for the coming years. For the latter the trend extrapolation method was used.

2.3. Data

Tables 4, 5 and 6 present the data on patent publications acquired from the Espacenet database classified by region (World, Europe, Poland) and IPC category (codes as mentioned in methodology section).

Table 4. The number of patents in the healthcare sector worldwide in 1996-2015

Year	IPC category											
	A61B	**A61C**	**A61F**	**A61G**	**A61H**	**A61J**	**A61K**	**A61L**	**A61M**	**A61N**	**A61P**	**A62B**
1996	19489	3055	14367	2903	3341	2856	66563	8280	11611	4166	35289	1358
1997	19481	3068	15522	3104	3497	3091	72121	8740	11806	4551	38234	1674
1998	21960	3779	17634	3214	3653	3156	81523	9882	13533	4820	43428	1576
1999	23812	3694	18957	3472	3910	3294	87648	10656	14295	5368	48053	1668
2000	26471	3972	20798	4071	4692	3634	99584	11970	15351	6052	60594	1785
2001	30362	4377	23373	4399	4720	3787	113012	13676	17219	6707	71803	1800

2002	36945	4821	26303	4515	4995	4589	133442	16191	19756	7851	86125	2189
2003	40597	4842	28503	4778	6071	5246	146094	18712	22354	8752	94806	2709
2004	46153	5900	30570	4969	6405	5321	153670	19964	24306	9829	96059	3311
2005	47972	5985	30788	5023	6896	5148	154574	19007	24584	10219	90755	3293
2006	45699	5630	27700	4816	6491	4339	141539	15529	21589	9615	80522	3106
2007	48533	5271	28592	4751	6253	4332	140686	15398	22597	9794	81331	2814
2008	50618	5686	27795	4931	6767	4613	141066	14746	23624	9755	90731	2648
2009	50348	5458	26635	4818	6552	4675	136867	14312	23279	9306	88540	2541
2010	52575	5608	26575	5588	7834	5665	129157	14792	25633	10080	86348	2973
2011	54747	5827	27661	6194	8340	5152	131420	15136	26920	10589	89564	3362
2012	61096	6167	28592	7419	9292	6404	129657	15401	30928	11240	88970	3115
2013	65124	6466	29144	9135	10550	6647	131259	16171	33293	11789	81504	3561
2014	68807	6568	29892	8466	10592	6389	144249	17097	33463	11941	88864	3576
2015	76242	6911	31179	12012	13486	7893	157571	19252	38792	13417	96986	3848

Source: Own elaboration based on Espacenet Patent Search, 2016.

Table 5. The number of patents in the healthcare sector in Europe in 1996-2015

Year	IPC category											
	A61B	**A61C**	**A61F**	**A61G**	**A61H**	**A61J**	**A61K**	**A61L**	**A61M**	**A61N**	**A61P**	**A62B**
1996	1504	207	1180	153	93	209	5124	703	1020	323	2795	72
1997	1545	225	1217	135	116	228	5609	705	995	386	3114	81
1998	1615	275	1301	158	88	183	6129	767	1161	371	3341	82
1999	2064	305	1627	187	111	206	6641	827	1268	481	3585	86
2000	2712	376	2096	246	159	251	9269	1104	1585	637	5390	119
2001	2769	390	2056	258	143	328	9742	1211	1500	662	6405	114
2002	3003	393	2148	228	168	345	10324	1392	1639	614	7170	133
2003	3263	361	2216	241	180	338	10802	1455	1793	639	7394	123
2004	4242	478	2777	291	247	446	12834	1794	2277	805	8658	178
2005	4173	493	2522	269	225	361	12158	1595	2086	918	6557	182
2006	4291	531	2697	243	255	330	12343	1552	2050	891	6094	184
2007	4546	473	2629	280	221	279	11886	1455	1934	823	6097	149
2008	4754	493	2691	269	253	294	12083	1398	2083	1032	6332	171
2009	4491	527	2427	265	225	289	10723	1408	2001	976	5800	137
2010	4576	508	2340	268	267	289	10906	1445	2185	935	6093	185
2011	5118	505	2595	277	270	336	12594	1454	2512	1067	7194	165
2012	5115	527	2596	291	210	312	10538	1405	2603	1052	5656	184
2013	4954	511	2519	282	240	346	9484	1237	2539	984	5113	192
2014	5348	502	2562	311	259	355	9260	1306	2735	967	4928	158
2015	5395	528	2361	294	307	322	9131	1108	2547	972	4871	157

Source: Own elaboration based on Espacenet Patent Search, 2016.

Table 6. The number of patents in the healthcare sector in Poland in 1996-2015

Year	IPC category											
	A61B	**A61C**	**A61F**	**A61G**	**A61H**	**A61J**	**A61K**	**A61L**	**A61M**	**A61N**	**A61P**	**A62B**
1996	54	9	89	35	30	15	638	42	43	11	169	18
1997	49	14	95	25	19	15	653	41	55	11	311	20
1998	68	20	85	27	22	12	864	32	59	8	387	17

1999	66	18	72	17	21	22	992	52	53	10	390	28
2000	69	13	113	17	14	15	1039	47	53	13	468	17
2001	51	13	81	15	22	7	1156	58	51	17	580	18
2002	48	9	81	14	25	17	946	52	45	11	564	10
2003	31	20	60	18	23	9	789	34	44	9	495	16
2004	78	26	141	19	25	27	1999	73	89	19	1430	16
2005	102	46	161	20	17	23	2776	69	102	26	1711	12
2006	70	16	74	13	23	13	610	21	34	13	343	38
2007	55	8	48	17	18	6	258	18	24	11	156	9
2008	81	16	57	31	18	10	409	34	43	13	267	14
2009	84	22	77	34	24	14	630	67	70	13	389	21
2010	104	17	101	41	28	17	731	61	85	17	470	21
2011	138	21	127	18	30	28	971	82	98	15	634	15
2012	139	16	150	36	37	21	1058	108	96	20	678	16
2013	139	31	152	38	18	21	1138	107	133	28	693	13
2014	198	31	179	54	38	22	1294	116	124	27	800	18
2015	231	34	170	31	36	14	1104	129	94	30	746	8

Source: Own elaboration based on enet Espacenet Patent Search, 2016.

2.4. Results

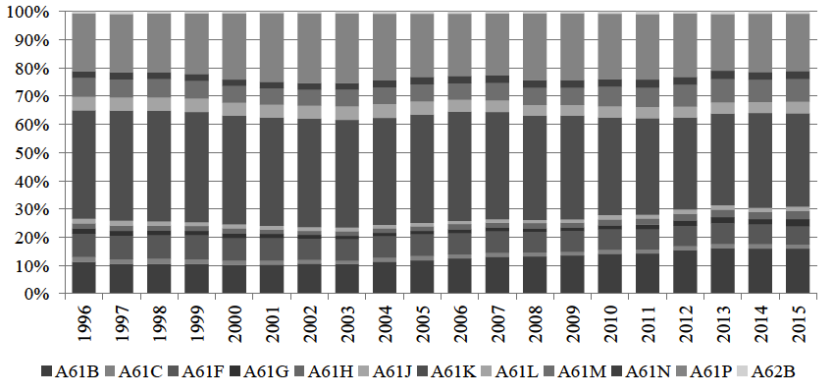
World

The analysis of global data indicates that almost 480 thousand healthcare patents have been published in 2015. It's almost three times as much as two decades ago. One can notice a significantly higher number of innovations appearing after 2005 when the number of patents surpassed 405 thousand. In the following years, especially in 2006 and 2007, there was a notable decline in the number of new findings which can be attributable to the world financial crisis, that had negative effects on the R&D sector. As a result, in 2006 there were only 367 thousand patents published. After the crises ended we are noticing again an upward trend that is particularly visible after 2010.

The most numerous group is formed by A61K category of patents that includes different types of drugs and cosmetics that – because of their active ingredients or specific form – are not included in other categories that are meant for typical body cosmetics. This particular category accounts for around 33% of all patent publications (157.6 thousand), a bit less than in previous years since between 1996 and 2007 it was 38-39% (Figure 8). Still, we can call this category the most innovative one. A61P category is coming in second. It includes specific therapeutic activities of chemical compounds or medicinal preparations that may also fall into previously mentioned category A61K. Whereas in A61K category the mixture of ingredients, ways of composing them or treatment methods are being protected, in A61P only therapeutic activities are being safeguarded. Since 2013 the A16P category accounts for ca. 20% of all patent publications (97 thousand patents). In previous years it was even more – 23-24%. The third

dominating category of patents is group A61B that makes up ca. 16% of all patents and is constantly increasing its share in the total number of patents. This category includes tools and equipment used in diagnostics and surgery. In 2015 76.2 thousand patents formed this group, almost four times as much as in 1996. The remaining categories account for less than 10% of all patents. Among them two are stepping out: A61M (including among others devices for introducing media into, or onto the body and devices for producing or ending sleep or stupor) and A61F (including among others filters implantable into blood vessels, prostheses, orthopedic, and nursing or contraceptive devices, and bandages) that account for 8.1% and 6.5% of all patents respectively.

Figure 8. The structure of patent publications worldwide by IPC category in 1996-2015



Source: Own elaboration based on Espacenet Patent Search, 2016.

Technological progress and a resulting growing research potential cause the total number of patent publications to increase. Between 1996 and 2015 there was a 176% rise worldwide. Categories that stand out substantially are: A61G (transport, personal conveyances, or accommodation specially adapted for patients or disabled persons), A61H (physical therapy apparatus) and A61B that rose by 300% in that period. As previously mentioned, years 2006-2007 were detrimental to all patent categories – each one of them recorded a decline in the number of patents. In the following years the situation started to get better, with the indicators getting back on a path of growth (Table 7).

Table 7. Average annual growth of the number of patent publications worldwide by IPC category in 1997-2015

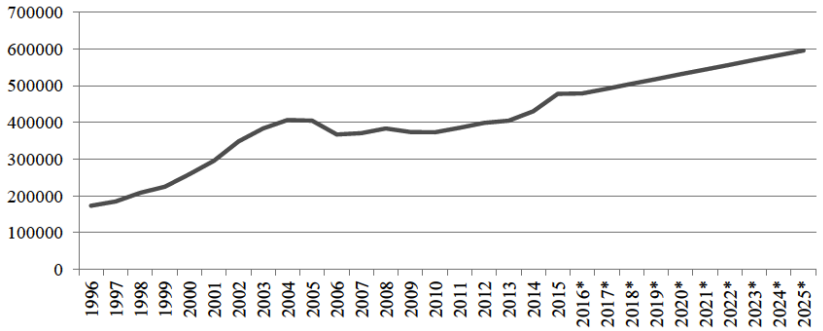
Year	IPC category											
	A61B	**A61C**	**A61F**	**A61G**	**A61H**	**A61J**	**A61K**	**A61L**	**A61M**	**A61N**	**A61P**	**A62B**
1997	0,0%	0,4%	8,0%	6,9%	4,7%	8,2%	8,3%	5,6%	1,7%	9,2%	8,3%	23,3%
1998	12,7%	23,2%	13,6%	3,5%	4,5%	2,1%	13,0%	13,1%	14,6%	5,9%	13,6%	-5,9%
1999	8,4%	-2,2%	7,5%	8,0%	7,0%	4,4%	7,5%	7,8%	5,6%	11,4%	10,6%	5,8%

2000	11,2%	7,5%	9,7%	17,3%	20,0%	10,3%	13,6%	12,3%	7,4%	12,7%	26,1%	7,0%
2001	14,7%	10,2%	12,4%	8,1%	0,6%	4,2%	13,5%	14,3%	12,2%	10,8%	18,5%	0,8%
2002	21,7%	10,1%	12,5%	2,6%	5,8%	21,2%	18,1%	18,4%	14,7%	17,1%	19,9%	21,6%
2003	9,9%	0,4%	8,4%	5,8%	21,5%	14,3%	9,5%	15,6%	13,2%	11,5%	10,1%	23,8%
2004	13,7%	21,9%	7,3%	4,0%	5,5%	1,4%	5,2%	6,7%	8,7%	12,3%	1,3%	22,2%
2005	3,9%	1,4%	0,7%	1,1%	7,7%	-3,3%	0,6%	-4,8%	1,1%	4,0%	-5,5%	-0,5%
2006	-4,7%	-5,9%	-10,0%	-4,1%	-5,9%	-15,7%	-8,4%	-18,3%	-12,2%	-5,9%	-11,3%	-5,7%
2007	6,2%	-6,4%	3,2%	-1,3%	-3,7%	-0,2%	-0,6%	-0,8%	4,7%	1,9%	1,0%	-9,4%
2008	4,3%	7,9%	-2,8%	3,8%	8,2%	6,5%	0,3%	-4,2%	4,5%	-0,4%	11,6%	-5,9%
2009	-0,5%	-4,0%	-4,2%	-2,3%	-3,2%	1,3%	-3,0%	-2,9%	-1,5%	-4,6%	-2,4%	-4,0%
2010	4,4%	2,7%	-0,2%	16,0%	19,6%	21,2%	-5,6%	3,4%	10,1%	8,3%	-2,5%	17,0%
2011	4,1%	3,9%	4,1%	10,8%	6,5%	-9,1%	1,8%	2,3%	5,0%	5,0%	3,7%	13,1%
2012	11,6%	5,8%	3,4%	19,8%	11,4%	24,3%	-1,3%	1,8%	14,9%	6,1%	-0,7%	-7,3%
2013	6,6%	4,8%	1,9%	23,1%	13,5%	3,8%	1,2%	5,0%	7,6%	4,9%	-8,4%	14,3%
2014	5,7%	1,6%	2,6%	-7,3%	0,4%	-3,9%	9,9%	5,7%	0,5%	1,3%	9,0%	0,4%
2015	10,8%	5,2%	4,3%	41,9%	27,3%	23,5%	9,2%	12,6%	15,9%	12,4%	9,1%	7,6%

Source: Own elaboration based on Espacenet Patent Search, 2016.

The forecasts for the coming years indicate that the number of patent publications in the area of human health and life protection will be constantly growing. In 2018 one can expect surpassing the barrier of 0.5 million, and in 2025 this number may exceed 0.6 million patents. As a result, the number of innovative solutions may triple during three decades (Figure 9).

Figure 9. The number of patents in the healthcare sector worldwide in 1996-2025



* forecasted values

Source: Own elaboration based on Espacenet Patent Search, 2016.

2016 may bring a significant drop in the number of patent publications in some categories, especially in A61G (-26%) and A61H (-17%). Other groups may experience smaller declines or even a slight growth. This may apply to A61P (+8%) and A61F (+6%). The situation should stabilize in the following years with the annual growth rates of around 2-4% (Table 8). It's worth noting

that the number of patents in all IPC categories will be growing but at a diminishing rate (usually smaller by 0.1% annually worldwide).

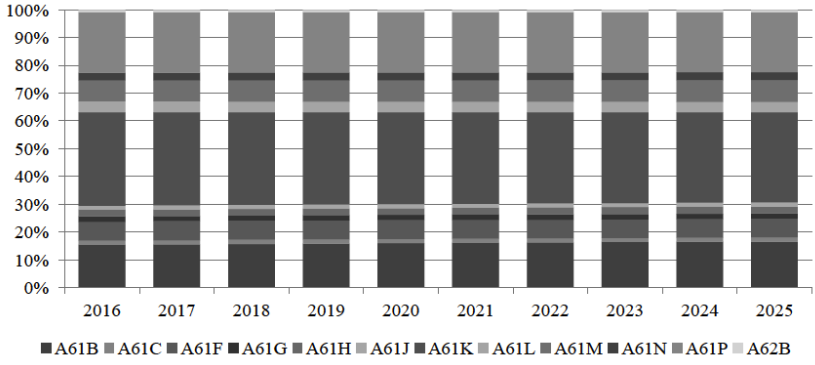
Table 8. Forecasted annual growth rates of the number of healthcare patents worldwide in 2016-2025

IPC category	Year									
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
A61B	-3,4%	3,8%	3,6%	3,5%	3,4%	3,3%	3,2%	3,1%	3,0%	2,9%
A61C	2,4%	2,6%	2,5%	2,5%	2,4%	2,3%	2,3%	2,2%	2,2%	2,1%
A61F	6,1%	2,2%	2,1%	2,1%	2,0%	2,0%	2,0%	1,9%	1,9%	1,9%
A61G	-25,9%	3,7%	3,6%	3,5%	3,3%	3,2%	3,1%	3,0%	3,0%	2,9%
A61H	-16,9%	3,8%	3,7%	3,5%	3,4%	3,3%	3,2%	3,1%	3,0%	2,9%
A61J	-11,9%	2,9%	2,9%	2,8%	2,7%	2,6%	2,6%	2,5%	2,4%	2,4%
A61K	2,6%	2,2%	2,1%	2,1%	2,0%	2,0%	2,0%	1,9%	1,9%	1,9%
A61L	-2,9%	2,0%	2,0%	1,9%	1,9%	1,9%	1,8%	1,8%	1,8%	1,7%
A61M	-8,3%	3,4%	3,3%	3,2%	3,1%	3,0%	2,9%	2,8%	2,8%	2,7%
A61N	-0,5%	3,3%	3,1%	3,1%	3,0%	2,9%	2,8%	2,7%	2,6%	2,6%
A61P	8,0%	2,5%	2,5%	2,4%	2,4%	2,3%	2,2%	2,2%	2,2%	2,1%
A62B	0,9%	3,0%	2,9%	2,9%	2,8%	2,7%	2,6%	2,6%	2,5%	2,4%

Source: Own elaboration based on Espacenet Patent Search, 2016.

If one looks at the forecasted structure of patent publications, A61K group will still be dominating but its share will be gradually declining (from 33.7% in 2016 to 32.4% in 2025). Minor downturn may affect A61P and A61F categories (ca. 0.3% in 10 years). The most significant growth is expected in A61B group (1.19%). The second highest growth – 0.39% is foreseen in A61M category (Figure 10).

Figure 10. Forecasted structure of patent publications worldwide by IPC category in 2016-2025



Source: Own elaboration based on Espacenet Patent Search, 2016.

Europe

In Europe, between 1996 and 2015 there were around 537 thousand patent publications in the area of human health and life protection. The highest number of inventions was reported in 2004 (more than 35 thousand), and the following years – as it was worldwide – reflect the impact of the world financial crisis and its consequences. One can observe the lack of a constant trend in patent publications (see Table 9) – significant falls (reaching 20%) are alternately replaced by substantial growths (up to 35%). The highest increase since 1996 was noted in A61B (+259%), A61H (+230%) and A61N (+201%) categories.

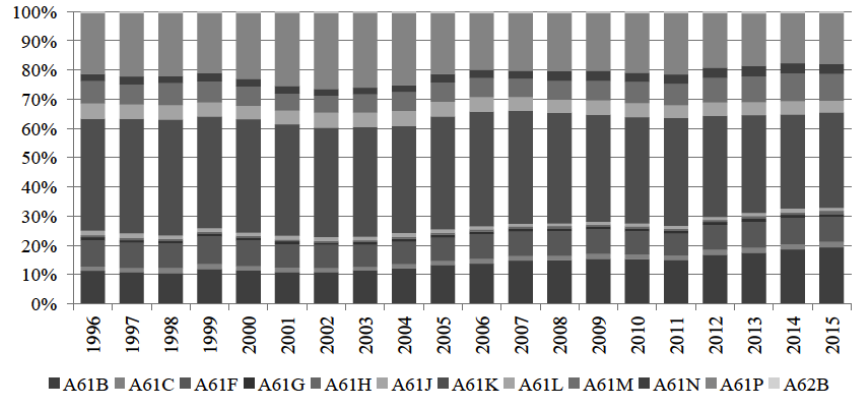
Table 9. Average annual growth of the number of patent publications in Europe by IPC category in 1997-2015

Year	IPC category											
	A61B	**A61C**	**A61F**	**A61G**	**A61H**	**A61J**	**A61K**	**A61L**	**A61M**	**A61N**	**A61P**	**A62B**
1997	2,7%	8,7%	3,1%	-11,8%	24,7%	9,1%	9,5%	0,3%	-2,5%	19,5%	11,4%	12,5%
1998	4,5%	22,2%	6,9%	17,0%	-24,1%	-19,7%	9,3%	8,8%	16,7%	-3,9%	7,3%	1,2%
1999	27,8%	10,9%	25,1%	18,4%	26,1%	12,6%	8,4%	7,8%	9,2%	29,6%	7,3%	4,9%
2000	31,4%	23,3%	28,8%	31,6%	43,2%	21,8%	39,6%	33,5%	25,0%	32,4%	50,3%	38,4%
2001	2,1%	3,7%	-1,9%	4,9%	-10,1%	30,7%	5,1%	9,7%	-5,4%	3,9%	18,8%	-4,2%
2002	8,5%	0,8%	4,5%	-11,6%	17,5%	5,2%	6,0%	14,9%	9,3%	-7,3%	11,9%	16,7%
2003	8,7%	-8,1%	3,2%	5,7%	7,1%	-2,0%	4,6%	4,5%	9,4%	4,1%	3,1%	-7,5%
2004	30,0%	32,4%	25,3%	20,7%	37,2%	32,0%	18,8%	23,3%	27,0%	26,0%	17,1%	44,7%
2005	-1,6%	3,1%	-9,2%	-7,6%	-8,9%	-19,1%	-5,3%	-11,1%	-8,4%	14,0%	-24,3%	2,2%
2006	2,8%	7,7%	6,9%	-9,7%	13,3%	-8,6%	1,5%	-2,7%	-1,7%	-2,9%	-7,1%	1,1%
2007	5,9%	-10,9%	-2,5%	15,2%	-13,3%	-15,5%	-3,7%	-6,3%	-5,7%	-7,6%	0,0%	-19,0%
2008	4,6%	4,2%	2,4%	-3,9%	14,5%	5,4%	1,7%	-3,9%	7,7%	25,4%	3,9%	14,8%
2009	-5,5%	6,9%	-9,8%	-1,5%	-11,1%	-1,7%	-11,3%	0,7%	-3,9%	-5,4%	-8,4%	-19,9%
2010	1,9%	-3,6%	-3,6%	1,1%	18,7%	0,0%	1,7%	2,6%	9,2%	-4,2%	5,1%	35,0%
2011	11,8%	-0,6%	10,9%	3,4%	1,1%	16,3%	15,5%	0,6%	15,0%	14,1%	18,1%	-10,8%
2012	-0,1%	4,4%	0,0%	5,1%	-22,2%	-7,1%	-16,3%	-3,4%	3,6%	-1,4%	-21,4%	11,5%
2013	-3,1%	-3,0%	-3,0%	-3,1%	14,3%	10,9%	-10,0%	-12,0%	-2,5%	-6,5%	-9,6%	4,3%
2014	8,0%	-1,8%	1,7%	10,3%	7,9%	2,6%	-2,4%	5,6%	7,7%	-1,7%	-3,6%	-17,7%
2015	0,9%	5,2%	-7,8%	-5,5%	18,5%	-9,3%	-1,4%	-15,2%	-6,9%	0,5%	-1,2%	-0,6%

Source: Own elaboration based on Espacenet Patent Search, 2016.

In line with worldwide trends, the most innovative IPC category in Europe are pharmaceuticals (A61K), accounting for 33% patents in 2015. However, the importance of this group is diminishing, especially in favor of A61B category with its 19% share of all patents compared to 11% in 1996 (Figure 11). Moreover, this category is the second biggest in Europe while worldwide it is the third. A61P, currently the third most significant patent group, is reducing its share from 21% in 1996 to 17% in 2015. The shares of other, less important categories (i.e. A61C, A61H, A61M and A61N) are slightly increasing, indicating growing research interest in these areas. This may imply a bigger innovative potential or higher expected demand in target groups that trigger researchers reaction.

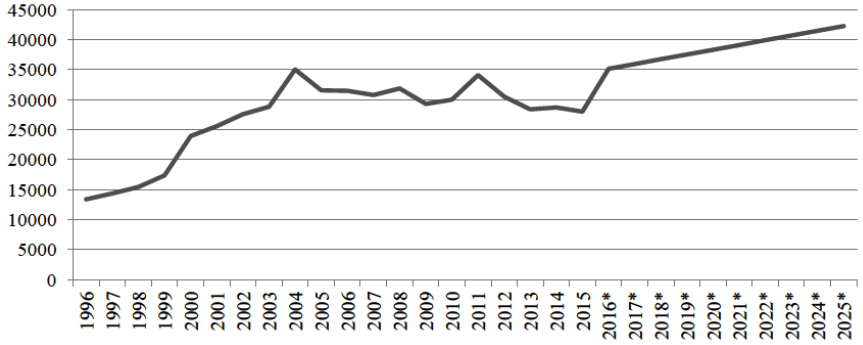
Figure 11. The structure of patent publications in Europe by IPC category in 1996-2015



Source: Own elaboration based on Espacenet Patent Search, 2016.

The forecasts for the coming years indicate a further growth of innovation in human health and life protection as measured by the number of patent publications. It will increase from 28 thousand in 2015 to more than 42 thousand in 2025 (Figure 12).

Figure 12. The number of patents in the healthcare sector in Europe in 1996-2025



* forecasted values

Source: Own elaboration based on Espacenet Patent Search, 2016.

IPC category A61B, as well as A61N and A61M will experience the highest growth rate (ca. 3% annually). The lowest growth (1.2%) will be observed in A61P group (Table 10). Similarly to global trends, one can expect in Europe a diminishing rate of growth (anticipated to be lower by 0.05-0.1% annually).

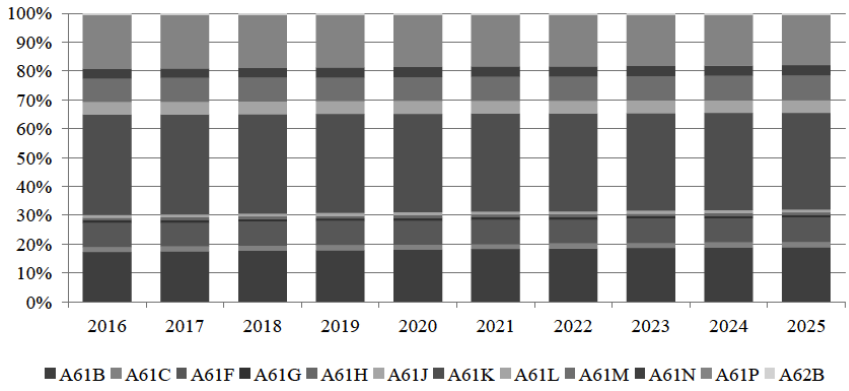
Table 10. Forecasted annual growth rates of the number of healthcare patents in Europe in 2016-2025

IPC category	Year									
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
A61B	12,4%	3,6%	3,5%	3,4%	3,2%	3,1%	3,0%	3,0%	2,9%	2,8%
A61C	13,4%	2,7%	2,6%	2,5%	2,5%	2,4%	2,4%	2,3%	2,3%	2,2%
A61F	23,9%	2,3%	2,2%	2,2%	2,1%	2,1%	2,0%	2,0%	2,0%	1,9%
A61G	10,0%	2,2%	2,2%	2,1%	2,1%	2,1%	2,0%	2,0%	1,9%	1,9%
A61H	-0,5%	3,2%	3,1%	3,0%	2,9%	2,9%	2,8%	2,7%	2,6%	2,6%
A61J	12,5%	1,6%	1,5%	1,5%	1,5%	1,5%	1,5%	1,4%	1,4%	1,4%
A61K	33,5%	1,8%	1,8%	1,7%	1,7%	1,7%	1,7%	1,6%	1,6%	1,6%
A61L	40,8%	1,8%	1,8%	1,7%	1,7%	1,7%	1,6%	1,6%	1,6%	1,6%
A61M	11,5%	3,1%	3,0%	2,9%	2,8%	2,7%	2,7%	2,6%	2,5%	2,5%
A61N	21,0%	3,2%	3,1%	3,0%	2,9%	2,9%	2,8%	2,7%	2,6%	2,6%
A61P	34,7%	1,4%	1,3%	1,3%	1,3%	1,3%	1,3%	1,2%	1,2%	1,2%
A62B	26,9%	2,7%	2,6%	2,6%	2,5%	2,4%	2,4%	2,3%	2,3%	2,2%

Source: Own elaboration based on Espacenet Patent Search, 2016.

The predicted structure of patent publications in Europe confirms the tendencies already observed in previous periods – A61P and A61K categories gradually give way to less popular groups of patents. The decrease of their shares in total number of patents, though, will happen very slowly, not threatening their dominant role (Figure 13).

Figure 13. Forecasted structure of patent publications in Europe by IPC category in 2016-2025



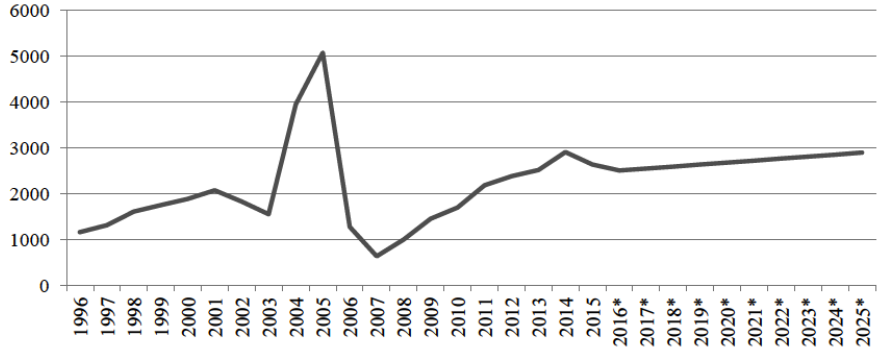
Source: Own elaboration based on Espacenet Patent Search, 2016.

Poland

The growth of innovation in Poland was very dynamic before the global financial crisis. The economic slowdown had an exceptionally negative impact on Polish research and development area. The annual number of patent publi-

cations was the highest in 2004 and 2005 surpassing 5,000. Till 2007 it fell to only 628, i.e. by 88% as compared to 2005. Since then it has been gradually growing. In 2015 there were more than 2,600 inventions registered and this number is forecasted to reach 2,887 in 2025 (Figure 14).

Figure 14. The number of patents in the healthcare sector in Poland in 1996-2025



* forecasted values
Source: Own elaboration based on Espacenet Patent Search, 2016.

Since some of the IPC categories contained only a few patent publications a year, there was no point in analyzing annual growth rates. That was the reason for calculating 5-year growth ratios that are presented in Table 11. What becomes apparent is the leading trend indicating an initial dynamic increase in innovation that has then slowed down after 2006, and a gradual recovery in the following years. The biggest changes were observed in A61P category with an intensive growth between 2001 and 2005 (+177%), a significant fall between 2006 and 2010 (-66%) and a notable improvement between 2011 and 2015 (+119%). Similar tendencies could be spotted in other innovation groups, e.g. A61L, A61K, A61F or A61M. Quite unusual is the A62B category, which in fact is not a medical one but includes devices, apparatus and methods used by rescue specialists and fire brigades, so directly connected to life-saving and thus taken into account in this study. This group experienced the opposite trend – a slowdown of innovations before and after the crisis and an increase of innovative activities during the crisis. One has to bear in mind that there were not too many innovations developed in this area so the results may be biased and disturbed. What is interesting is that not only A62B category resisted the difficult conditions of the crisis. Between 2006 and 2010 two more groups experienced a significant growth: A61G (+58%) and A61B (+27%).

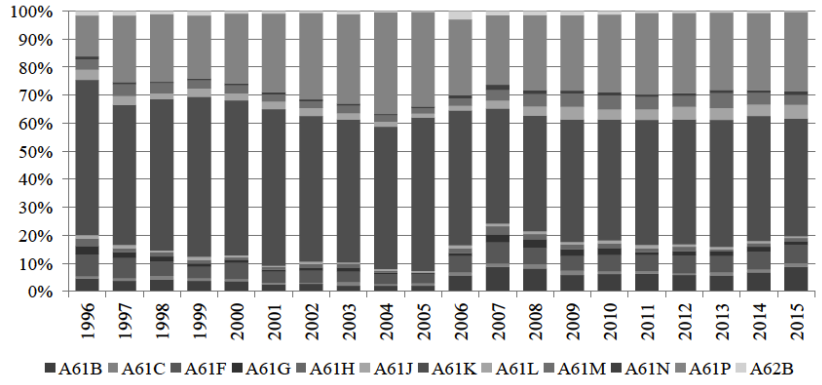
Table 11. Annual growth rates of healthcare patent publications in Poland in 2001-2015

IPC category	2001-2005	2006-2010	2011-2015
A61B	1,3%	27,1%	114,5%
A61C	54,1%	-30,7%	68,4%
A61F	15,4%	-31,9%	117,9%
A61G	-28,9%	58,1%	30,1%
A61H	5,7%	-0,9%	43,2%
A61J	5,1%	-27,7%	76,7%
A61K	83,1%	-65,6%	111,0%
A61L	33,6%	-29,7%	169,7%
A61M	25,9%	-22,7%	112,9%
A61N	54,7%	-18,3%	79,1%
A61P	177,1%	-66,0%	118,5%
A62B	-28,0%	43,1%	-32,0%

Source: Own elaboration based on Espacenet Patent Search, 2016.

The structure of Polish innovations (Figure 15) resembles more the global trends rather than the European ones, with an even stronger domination of A61K group (57% of all patents in 1999 and 42% now) and A61P category coming in second (28%). A61B group is third but its share in the total number of patent publications (8.8%) is significantly lower than globally and in Europe, not much higher than the forth category – A61F with a result of 6.5%. For years we have been observing a continuous decline of the group A61K in favor of smaller categories that are becoming more popular.

Figure 15. The structure of patent publications in Poland by IPC category in 1996-2015



Source: Own elaboration based on Espacenet Patent Search, 2016.

The forecasts for the coming years indicate a further growth of human health and life protection innovations in Poland (see Table 12). The number of innovations will be growing at a fastest pace in A61B, A61L, A61M and A61N categories (3-4% annually). An innovative downturn may be experienced in

A62B group (ca. 2% annually). In line with worldwide trends, growth rates will be positive but diminishing (they are expected to be lower by 0.05-0.1% annually).

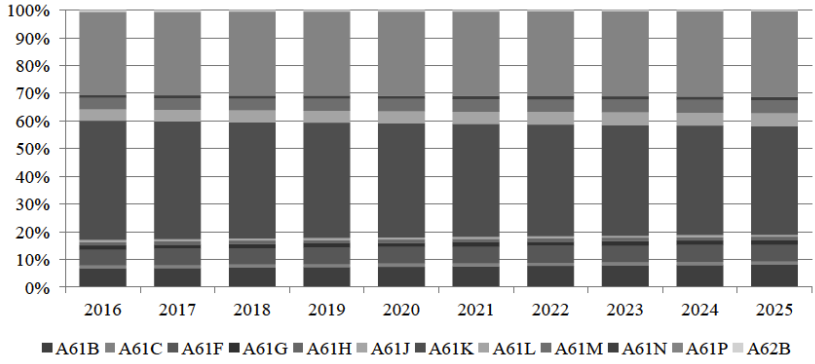
Table 12. Forecasted annual growth rates of the number of healthcare patents in Poland in 2016-2025

IPC category	Year									
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
A61B	-27,2%	4,3%	4,1%	3,9%	3,8%	3,6%	3,5%	3,4%	3,3%	3,2%
A61C	-17,6%	2,7%	2,7%	2,6%	2,5%	2,5%	2,4%	2,3%	2,3%	2,2%
A61F	-15,0%	2,6%	2,5%	2,4%	2,4%	2,3%	2,3%	2,2%	2,2%	2,1%
A61G	16,1%	2,6%	2,6%	2,5%	2,5%	2,4%	2,3%	2,3%	2,2%	2,2%
A61H	-15,4%	1,9%	1,9%	1,8%	1,8%	1,8%	1,7%	1,7%	1,7%	1,6%
A61J	37,8%	1,4%	1,4%	1,4%	1,4%	1,3%	1,3%	1,3%	1,3%	1,3%
A61K	-3,0%	0,6%	0,6%	0,6%	0,6%	0,6%	0,6%	0,6%	0,6%	0,6%
A61L	-20,7%	3,7%	3,6%	3,5%	3,4%	3,3%	3,1%	3,1%	3,0%	2,9%
A61M	12,2%	3,2%	3,1%	3,0%	2,9%	2,9%	2,8%	2,7%	2,6%	2,6%
A61N	-17,9%	3,3%	3,2%	3,1%	3,0%	2,9%	2,8%	2,8%	2,7%	2,6%
A61P	0,4%	2,1%	2,1%	2,0%	2,0%	1,9%	1,9%	1,9%	1,8%	1,8%
A62B	79,8%	-1,9%	-1,9%	-2,0%	-2,0%	-2,1%	-2,1%	-2,1%	-2,2%	-2,2%

Source: Own elaboration based on Espacenet Patent Search, 2016.

The structure of patent publications in Poland will gradually start resembling that of the global sector. A61K category will slightly lose its importance in favor of A61P (Figure 16). The researchers will increase their engagement in innovations from less popular groups (A61F, A61G, A61L, A61M and A61N). We may experience a decline in innovations in A61J and A61P but one can't be sure of these estimates since they were based on limited data.

Figure 16. Forecasted structure of patent publications in Poland by IPC category in 2016-2025



Source: Own elaboration based on Espacenet Patent Search, 2016.

Conclusions

Due to its specific characteristics, the medical sector is a fairly unusual area of the economy, requiring significant outlays, involvement of highly qualified research personnel, using specialized laboratory equipment and demanding lots of labor and time input. At the same time, it's a domain constantly under social pressure attributable to growing expectations pertaining to life lengthening, alleviating signs and symptoms of diseases and developing new generations of drugs. Additionally, there are very strict regulations in the medical sector concerning tests conducted on animals and people, and constantly changing procedures generate supplementary financial investments prerequisite for a new pharmaceutical to get across all research stages.

The analysis of the patent publications presented in this article proved that the healthcare sector is a very innovative one. In Europe the area of human health and life protection accounted for more than 21% of all innovations (20% in Poland). Given the fact that healthcare related patents constitute only one subcategory of the eight sections of IPC classification, this result is remarkable.

A closer look at the Espacenet data collected, lets us conclude that the most innovative segment of the healthcare sector is the division of medicinal products and some groups of cosmetics that in 2015 make up the biggest share of all patents across all three geographical regions, especially in Poland (42% as compared to 33% worldwide). This confirms a very good condition of drug manufacturing companies, whose market value was previously mentioned as being the highest in the healthcare sector (Figure 3).

The category including diagnosis, surgery and identification solutions is highly innovative as well. Its role is higher in Europe than globally, and – interestingly – significantly lower in Poland as patents falling into this category are 10% less than in Europe, where they account for 19% of all healthcare patents.

The third group standing out is the category of specific therapeutic activity of chemical compounds or medicinal preparations. In this case, the situation is exactly the opposite. While researchers' interest in this area is comparable globally and in Europe (20% and 17% of all patents respectively), in Poland the number of patents from this category is by 11% higher than the European average.

The analysis showed an easily identifiable trend in how the structure of patents changes. The share of traditionally predominant categories is diminishing in favor of those less popular till now. One can expect more patents published in the area of devices for introducing media into the body, devices for transducing body media and apparatus used in electrotherapy, magneto therapy, radiation therapy or ultrasound therapy.

As a result of continuous technical progress, the number of patent applications that are filed every year is rising. This situation is not going to change

in the foreseeable future but the barriers discussed in the paper will gradually slow down the growth rate of innovation indicators. Advancements in global research technologies increase R&D potential and simplifies the way experiments are being carried out. On the other hand, the more advanced the techniques used, the longer and more expensive the research process. Customers are getting more demanding, expecting innovative, scientifically proven and technologically advanced solutions. As a consequence, innovations are in greater demand than ever before. Regulatory authorities complicate the situation even further by imposing tighter regulations. As a result, innovation is and will be increasing but its growth rate is steadily declining (by ca. 0.05-0.1% annually). In the coming decade, the total number of patent publications will increase by ca. 25% with the quantities mounting up every year.

In Poland, both the medical sector situation and innovative activities trends are somehow different than those of other EU or OECD countries, but the observed growth rate of R&D spending, the use of EU funds, and the high level of expertise of Polish research personnel gives hope for the gradual creation of a level playing field. International innovation flow, knowledge transfer and cooperation of various groups of interest will be a key aspect allowing for breaking the boundaries existing in Poland, as well as abroad.

References

2015 Global Health Care Outlook. Common goals, competing priorities (2015), Deloitte Touche Tohmatsu Ltd.

Aronson, J.K. (2008), Something new every day: Defining innovation and innovativeness in drug therapy, Journal of Ambulatory Care Management, 31(1): 65-68.

Bariery rozwoju przedsiębiorstw, czyli co najbardziej hamuje wzrost polskich firm (2013), Raport z wyników ankiety przeprowadzonej podczas II Forum Przedsiębiorców Grant Thornton, grudzień 2013.

Bouvenot, G. (2007), The benefit provided by new medicinal products in 2005-2006 – the viewpoint of the French National Authority for health, Therapie, 62(5): 387-391.

Ciani, O., Armeni, P., Boscolo, P. R., Cavazza, M., Jommi, C., Tarricone, R. (2016), De innovatione: The concept of innovation for medical technologies and its implications for healthcare policy-making, Health Policy and Technology, 5(1): 47-64.

Espacenet Patent Search (2016), available at: http://worldwide. espacenet.com/advancedSearch (accessed 07 June 2016).

Frąckowiak, J. (2016), Dane Pharma Expert dotyczące rynku farmaceutycznego w Polsce, available at: http://www.pharmaexpert.pl/media-files/PharmaExpert_podsumowuje_ rynek _ farmaceutyczny marzec_2016.pdf (accessed 25 April 2016).

Grajewski, B. (2015), 10 barriers to healthcare innovation, The Guardian, Healthcare Network.

Herper, M. (2013), How much does pharmaceutical innovation cost, Forbes, 11 August.
Industry Browser – Healthcare Sector – Industry List (2016), available at: https://biz.yahoo.com/p/5mktd.html (accessed 25 April 2016).
Nathan, C. (2007), Aligning pharmaceutical innovation with medical need, Nature Medicine, 13(3): 304-308.
Nojszewska, E. (2011), Economic effectiveness as an analytical tool for health care, Management Problems, 9(3): 11-26.
OECD Health Statistics 2015 (2015), Country note: How does health spending in Poland compare?, available at: https://www.oecd.org/els/health-systems/Country-Note-POLAND-OECD-Health-Statistics-2015.pdf (accessed 31 May 2016).
OECD (2015), Health at a glance 2015, OECD Indicators.
Omachonu, V.K., Einspruch, N.G. (2010), Innovation in healthcare delivery systems: A conceptual framework, The Innovation Journal: The Public Sector Innovation Journal, 15(1): 1-20.
Rynek Zdrowia (2015), Wartość aptecznego rynku farmaceutycznego w IV kwartale 2015 r. wzrosła o 3,6 proc., available at: http://www.rynekzdrowia.pl/Farmacja/Wartosc-aptecznego-rynku-farmaceutycznego-w-IV-kwartale-2015-r-wzrosla-o-3-6-proc,158308,6.html (accessed 25 April 2016).
2007 to 2020, available at: http://www.statista.com/statistics/309297/ worldwide-medtech-research-and-development-spending/ (accessed 25 April 2016).
Webb, D.J. (2011), Value-based medicine pricing: NICE work?, Lancet, 377(9777): 1552-1553.
WIPO International Patent Classification (IPC) Official Publication, http://web2.wipo.int/classifications/ipc/ipcpub/#refresh=page (accessed 07 June 2016).
Włodarczyk, W. (2016), Rośnie rynek wyrobów medycznych, jego wartość już przekracza 2 mld dolarów, terMedia, available at: http://www.termedia.pl/mz/Rosnie-rynek-wyrobow-medycznych-jego-wartosc-juz-przekracza-2-mld-dolarow,19049.html (accessed 25 April 2016).