



Analysis of patents and scientific publications in the field of telemedicine

Analiza patentów i publikacji naukowych w dziedzinie telemedycyny

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Abstract

Introduction and Objective. Telemedicine is a method for delivering health care services between health-care professionals and patients, where distance is a critical factor. With the development of technology and digital transformation, telemedicine will be used even more effectively. To understand the developing trends, a study was carried out to review patents and systematic reviews.

Review Methods. Data about systematic reviews were collected from Scopus, after which the Bibliometrix R package and Biblioshiny app for the quantitative analysis were used. The data about patents was collected from the PatSnap® access platform.

Brief description of the state of knowledge. Analysis of the systematic reviews showed an increase in interest in the discipline due to COVID-19, but the increase in the number of patent publications was noticeable even before the pandemic in 2019, and a decrease is observed after 2021. The lack of artificial intelligence among patents was also noticed. However, it should be taken into account that the differences between the life cycle of the research process are shorter than that of the patent publication process.

Summary. The examination of patent filings and scientific publications serves as a valuable indicator for assessing the level of research activity in an area. Typically, an increase in investment and research in an area correlates with an increase in the number of patent applications. Telemedicine is a rapidly evolving field that relies heavily on technological advancements. By comparing publications of patents and systematic reviews, insights can be gained into the latest technological developments and trends in telemedicine. Patents provide information about new inventions, designs, and technologies that have been protected, indicating areas of innovation and potential future developments.

Key words

telemedicine, e-health, digital health, patents, technological trends

Streszczenie

Wprowadzenie i cel pracy. Telemedycyna to świadczenie przez pracowników służby zdrowia usług opieki zdrowotnej na rzecz pacjentów, gdzie czynnikiem krytycznym jest odległość. Wraz z rozwojem technologii i transformacji cyfrowej telemedycyna będzie wykorzystywana jeszcze skuteczniej. Aby zrozumieć rozwijające się trendy, przeprowadziliśmy badanie w celu przeglądu patentów i przeglądów systematycznych z tej dziedziny.

Metody przeglądu. Dane dotyczące przeglądów systematycznych zostały zebrane z bazy Scopus, a następnie wykorzystaliśmy pakiet Bibliometrix R i aplikację Biblioshiny do analizy ilościowej. Dane dotyczące patentów zostały pozyskane z platformy dostępowej PatSnap®.

Opis stanu wiedzy. Analiza przeglądów systematycznych wskazuje na coraz większe zainteresowanie telemedycyną ze względu na COVID-19, ale wzrost liczby publikacji na temat patentów zauważalny był jeszcze przed pandemią w 2019 roku, a spadek obserwowany jest po 2021 roku. Zauważyliśmy również, że w patentach nie wykorzystuje się sztucznej inteligencji. Należy jednak wziąć pod uwagę, że proces badawczy jest krótszy niż proces publikacji patentu.

Podsumowanie. Badanie zgłoszeń patentowych i publikacji naukowych pozwala dokonać oceny poziomu aktywności badawczej w danym obszarze. Zazwyczaj wzrost inwestycji i badań w danym obszarze koreluje ze wzrostem liczby wniosków patentowych. Telemedycyna jest szybko rozwijającą się dziedziną, która w dużym stopniu opiera się na postępie technologicznym. Porównując publikacje patentów i przeglądy systematyczne, badacze mogą uzyskać wgląd w najnowsze osiągnięcia technologiczne i trendy w telemedycynie. Patenty dostarczają informacji o nowych wynalazkach, projektach i technologiach, które zostały objęte ochroną, wskazując obszary innowacji i kierunki potencjalnego przyszłego rozwoju.

Słowa kluczowe

telemedycyna, e-zdrowie, patenty, zdrowie cyfrowe, trendy technologiczne

INTRODUCTION

Telemedicine, as defined by the World Health Organization, is the delivery of health care services between health-care professionals and patients, where distance is a critical factor

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[1]. The situation of the Covid-19 pandemic has made this method of contacting a doctor the safest and fastest option to get medical help. The outbreak of the virus changed people's lives worldwide, influenced global trade, the world's economy, and travel. To limit the spread of infection, it was necessary to start socially distancing ourselves from each other and take advantage of technology. The pandemic of COVID-19 can be considered as the first global epidemic in the digital era and, as telemedicine has shown us, digital tools can effectively support patients, medics and institutions [2]. With the development of technology and digital transformation, telemedicine will be used even more effectively. Although systematic reviews on telemedicine have been a topic of interest over the past few years, no comprehensive study has reviewed and compared the results between patents and systematic reviews.

Telemedicine solutions. Telemedicine is often described as the delivery of health-related services performed via electronic information and telecommunication technologies between medics and patients; however, it should not be limited only to these interactions [3], but expand to reliable websites that provide information, guidance, treatments and pharmaceuticals related to diseases [1]. The expansion extend to social networks which enable professional organizations to communicate with specialists, and also consists of web applications, wearables that monitor and collect data which helps determine whether the symptoms are worsening [3]. Artificial intelligence (AI) has also made significant contributions to telemedicine, and is used in information analysis collaboration, patient monitoring, and healthcare information technology [4].

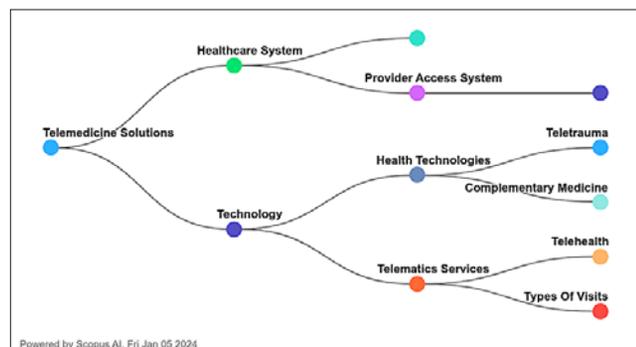


Figure 1. Telemedicine solutions.
Source: own elaboration based on Scopus AI

However, the digital technology used now by telemedicine dates back to the 1900s; for example, the cover of *Science and Invention* magazine published in 1925 shows a doctor giving a diagnosis by radio [5]. Even though innovations of telehealth were known for years and have been available at medical institutions for the past 30 years [6], the utilization of telemedicine in the USA was minimal [7]. In 2019, American Well [8] conducted a consumer survey about e-health the results of which showed that 66% of consumers were willing to use telehealth, but only 8% had actually tried it. The growth of telemedicine has been limited by lack of uniform coverage policies across insurers and States in the USA [5] involving problems with confidentiality, information security and data protection [9].

Nevertheless, the pandemic led many governments to use telehealth because it facilitated access to care and reduced the risk of transmission of the virus. In Argentina, the

number of telemedicine calls made during the pandemic increased by 230% and the number of first-time callers grew by 198%. The study [10] compared visit completion rates before and after the start of pandemic at an ambulatory rheumatologic care facility. Telemedicine during Covid-19 resulted in higher rates of completed appointments and lower rates of missed appointments, compared to in-person visits during and prior to the pandemic.

The influence of the pandemic on telemedicine can be also seen on publications trends. Figure 2 presents the distribution of academic publications from 2014 – 2023 with the search words ‘telemedicine’, ‘telehealth’, ‘e-health’ or ‘digital health’. Between 2012–2019, the number of articles grew very slowly, but in 2020 the number of publications abruptly increased and in 2023 the number peaked to over 200 thousand.

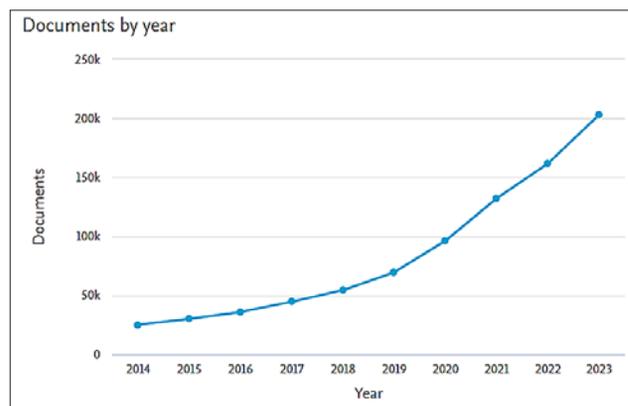


Figure 2. The distribution of academic publications between 2014–2023 containing the key words ‘telehealth’ and ‘telemedicine’.
Source: data downloaded from Scopus on 6 December 2023

In 2020, telemedicine solutions adapted quite rapidly and interest in virtual solutions was quite high. Telehealth is a promising health tool, not only among isolated and rural communities, but for everyone, as it reduces the cost and time for patients and medical workers [9] (Fig 2).

OBJECTIVE

The aim of the study is to understand the developing trends in telemedicine. A study was carried to review and compare patents and systematic reviews in this area.

REVIEW METHODS

A literature review was performed in December 2023 to retrieve articles from Scopus. We focus on the articles that were published before the pandemic in years 2018–2020 and during/after it in 2021–2023, using the ‘telemedicine’, ‘telehealth’, ‘e-health’ or ‘digital health’ MeSH term. General terms were chosen to describe telemedicine solutions in order to find articles providing an overview of trends in the discipline, rather than a detailed account of specific solutions. The search was limited to systematic reviews in English, and studies on human subjects. Preprints and articles without abstracts and without access to full text were excluded. Analysis of data was then performed using the Bibliometrix R package and Biblioshiny app [11].

STATE OF KNOWLEDGE

Before and at the start of the pandemic 2018–2020. In total, 2,031 articles were retrieved from the search in the Scopus database. Most of the articles were published in 2020, n=1292 (64%), 2019, n=411 (20%) and 2018, n=328 (16%).

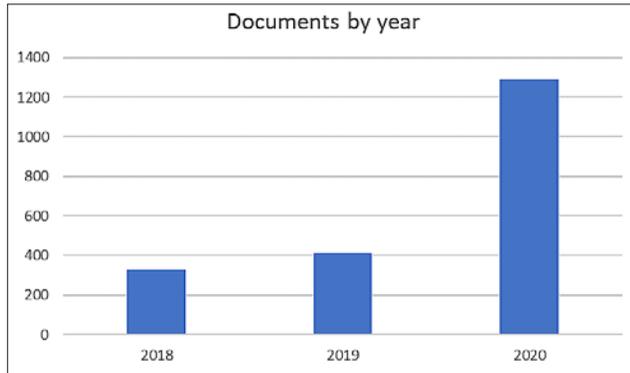


Figure 3. Published scientific reviews of telemedicine 2018–2020. Source: data from Scopus

Most papers were published in the USA (n=862; 42%), UK (n=382; 19%), Australia (n=203; 10%), and Poland (n=31; 1,5%). A Table with the exact numbers of publications in each country is shown in Figure 4.

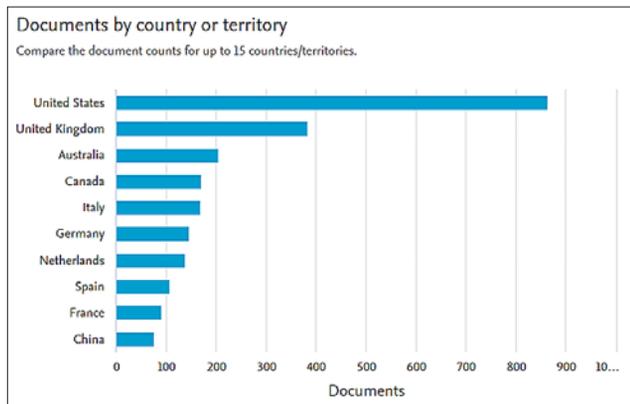


Figure 4. Publications by countries 2021–2023. Source: data and chart from Scopus

In 2018 – 2020, the most relevant words from the authors’ key words were ‘mobile health’ (n=74), ‘mental health’ (n=73), with ‘artificial intelligence’ in fourth place (n=61). (Fig. 5).

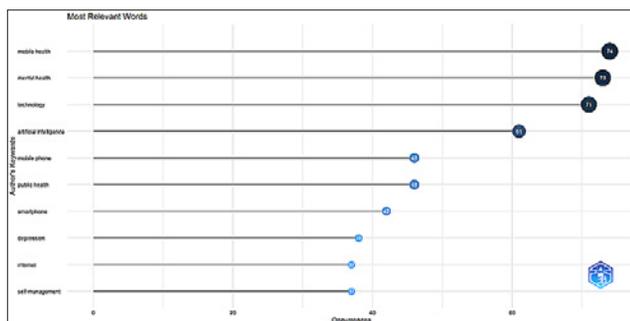


Figure 5. The most relevant keywords in articles from 2021–2023. Source: Data from Scopus, analysis and chart from Biblioshiny

During and after the pandemic 2021–2023. In total, 3922 articles were retrieved from the search in the Scopus database. Most of the articles were published in 2021 (n=1568, 40%), in 2022 (n=1333; 34%) and last year 2023 (n=1021; 26%) (Fig. 6).

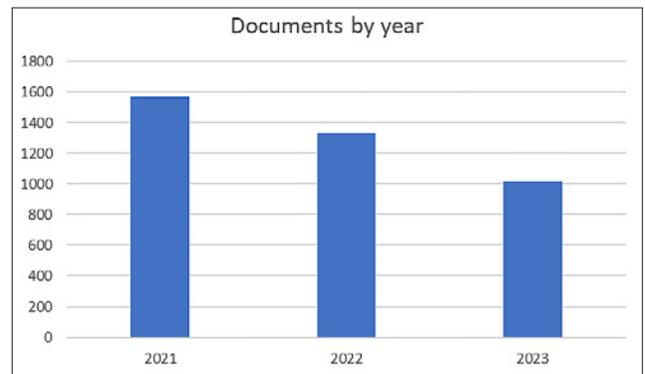


Figure 6. Publications of scientific reviews of telemedicine during 2021–2023. Source: data from Scopus

Most papers were published in the USA (n=1412; 36%), UK (n=635; 16%), Australia (n=379; 10%) and Poland (n=82; 2%) (Fig.7).

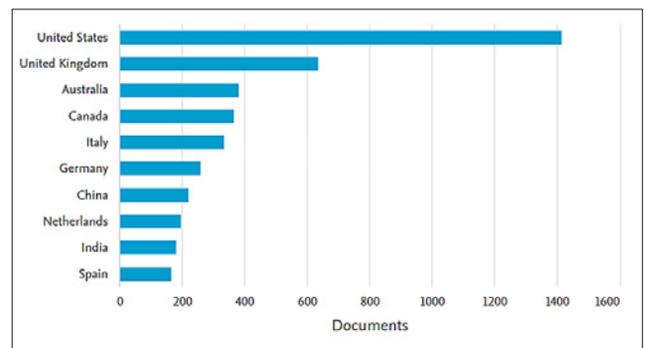


Figure 7. Publications by countries in 2021–2023. Source: Data and chart from Scopus.

The most relevant words from the authors’ key words were ‘artificial intelligence’ (n=199), ‘mobile phone’ (n=183), ‘mental health’ (n=142) and ‘mobile health’ (n=142) (Fig. 8).

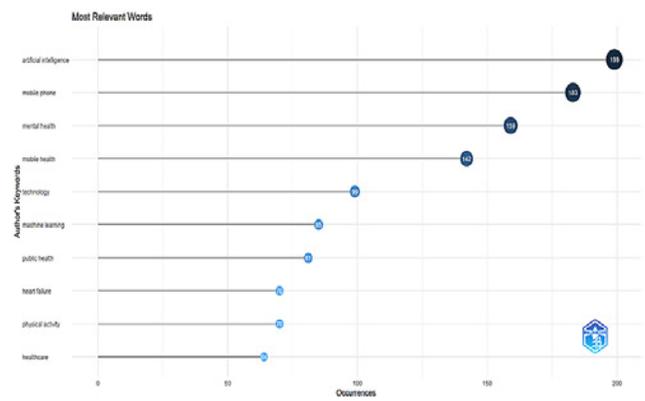


Figure 8. The most relevant key words in articles 2021–2023. Source: data from Scopus, analysis and chart from Biblioshiny

Patents. Recognizing evolving patterns in technology is important for developers and engineers involved in technology

research and forecasting. The understanding of trend development of technology is beneficial for policymakers, managers and scientists in making decisions regarding research and development [11]. Intellectual property (IP) refers to inventions, designs, symbols, names, and images used in commerce. IP is protected in law by patents, copyright and trademarks which enable inventors to earn recognition or financial benefits [12]. Although patents are often used as an indicator for measuring innovation development, there are few issues that influence the analysis. One issue is the time lag, it takes about 3.5 years for a full data set to become available from the filing of the patent [12], and the patent regulations differ in each country. In the European Union, computer-implemented inventions are not automatically excluded from patent eligibility, but they must demonstrate a technical character, e.g. an algorithm designed to improve video quality in teleconsultation may be considered eligible for a patent, while a generic data sorting method might not meet the criteria [13].

As telemedicine grows and develops, healthcare entrepreneurs and technology companies are looking for ways to gain a competitive advantage in the marketplace, and patent protection may increase the value of telemedicine companies. The US Patent Act allows the patenting of new and useful processes, machines, or improvements. Key considerations for patent eligibility include novelty: the invention must be new, and not publicly known prior to filing, usefulness: the innovation must have a specific, credible use, in telemedicine this involves enhancing patient care or system performance and unobtrusiveness: the invention must demonstrate a certain level of inventiveness beyond common expectations [13]. While patents may not receive extensive coverage in the media, they nevertheless play a crucial role in gauging technological progress within countries and, perhaps more significantly, in assessing their impact on development. Patents not only secure financial gains through technology marketing, sales or licensing, but also mirror a dynamic generation of knowledge and technologies that contribute positively to social advancement [14]. Consequently, the analysis of patents is an important indicator of trend development.

REVIEW METHODS

The patent data was collected from the PatSnap® access platform which is connected to 158 databases of national patent offices: EPO, WIPO and EAPO. The analysis included patents classified worldwide under the International Patent Classification (IPC), with legal status: active, inactive, or pending. Patent data was analysed for the period 2011–2023, with particular reference to the dynamics of change associated with the outbreak of the COVID-19 pandemic, to provide a picture of changes over time. However, it should be taken into account that patent procedures can take up to several years, depending on the country, so that more accurate changes in patent activity related to the COVID-19 pandemic outbreak will be observed with a time delay. Therefore, the Scopus and PatSnap data were quantitatively compared for the years 2014–2023. However, qualitative analysis of patent databases requires a more extended temporal perspective due to the time-consuming patenting process. As a result, the time frame for qualitative analysis of patent databases was defined for the period 2011–2021.

Previous analysis of scientific publications allowed the widest possible range of key words to be selected, which include: **‘telemedicine’**, **‘e-health’**, ‘biosensor’, ‘telediagnosis’, ‘telemedicine’, ‘personalised healthcare’, ‘e-health’ or ‘therapeutic chatbot’, ‘smart nursing’, ‘brain-computer-interface’, ‘teleradiology’, ‘telehealth’, ‘e-medicine’, ‘remote monitoring’, ‘gamification’, ‘self-monitoring’, ‘algorithm’, or ‘IoT’, whereby the words in bold words occurred in conjunction with any of the words listed.

STATE OF KNOWLEDGE

Analysis of the trend of patent publications between 2014–2023 reveals a clear peak in 2021, characterised by a significant increase of 178% compared to 2014. Subsequently, there was a discernible decline, with the number of publications decreasing by approximately 31% between 2021–2023. A comprehensive and precise analysis of this phenomenon may only become feasible with a certain time lag, considering the inherent time delays in patent-related processes.

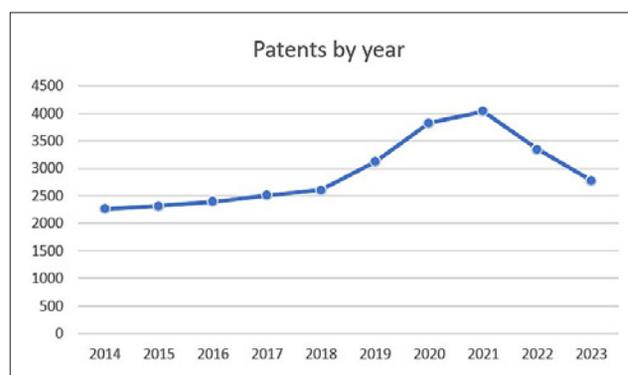


Figure 9. Distribution of patents publications between 2014–2023 containing key words ‘telehealth’ and ‘telemedicine’.

Before and at the start of the pandemic 2018 – 2020. In total, 9,554 patents were retrieved from the search in the PatSnap® database, most of which were published in 2020 (n=3826; 40%), in 2019 (n=3123; 33%) and 2018 (n=2605; 27%).

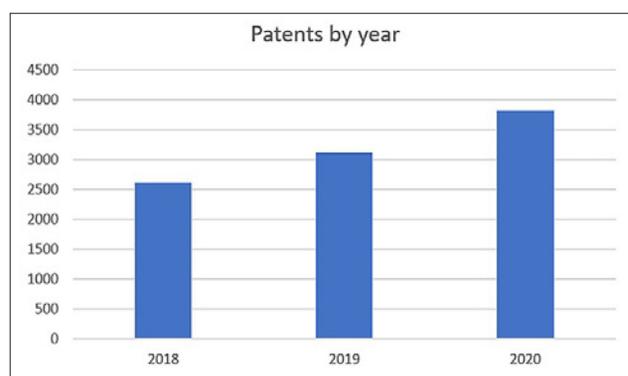


Figure 10. Publications of patents related to telemedicine during 2021–2023. Source: Data from PatSnap®

Most patents were published in USA (n=3234; 34%), China (n=2669; 28%), South Korea (n=1141; 12%), and Poland (n=31; 1.5%). There were no publications registered in Poland within the timeframe under review.

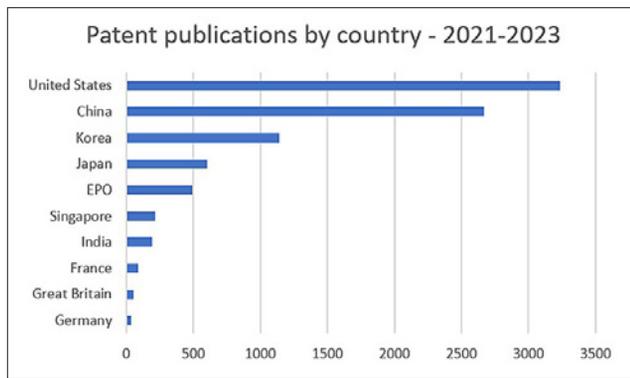


Figure 11. Qualitative analysis of patent databases in the context of IPC categories.

During and after the pandemic 2021–2023. In total, 10,171 patents were retrieved from the search in the PatSnap® databases. Most of the articles were published in 2021 (n=4040; 39.68%), in 2022 (n=3348; 32.92%), and last year 2023 (n=2783; 27.36% (Fig. 12).

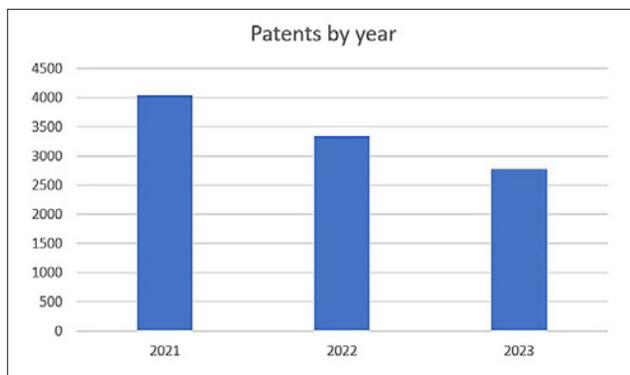


Figure 12. Publications of patents related to telemedicine during 2021–2023. Most papers were published in USA (n=2950; 29%), China (n=2627; 26%) and South Korea (n=747; 7%). There were no publications registered in Poland within the timeframe under review. Source: data from PatSnap®.

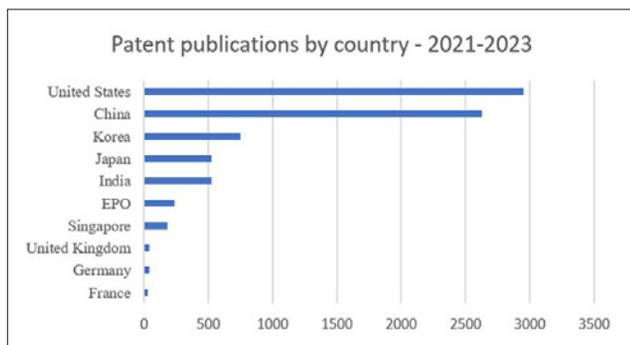


Figure 13. Patent publications by country in 2021–2023. Source: based on PatSnap®.

Qualitative analysis of patents in the telemedicine field 2011–2021. Based on the defined key words, 5,138 registered patents were identified in the PatSnap® databases between 2011–2021 related to the Key Technologies. These patents are classified according to the International Patent Classification (IPC) standard which is a hierarchical system for classifying inventions and utility models according to scope in eight fields of technology – represented by the symbolism of letters:

- A – human necessities;
- B – performing operations, transporting;
- C – chemistry, metallurgy;
- D – textiles, paper;
- E – fixed constructions;
- F – mechanical engineering, lighting, heating, weapons, blasting;
- G – physics;
- H – electricity.

The full IPC symbol is made up of division, class, subclass, group and subgroup (e.g. A01B1/00, where A represents division, A01 – class, A01B – subclass, A01B1 – group, and A01B1/00 – subgroup) [15].

Almost one-quarter of the reviewed patents were included in the group *Measuring for diagnostic purposes and Identification of persons* (A61B5). In a 10-year perspective, the number of patents registered annually – related to A61B5 classification – almost doubled, 56 patents in 2011 vs 105 patents in 2021. The peak in the number of registrations occurred in 2017, followed by a decline and a levelling-out of the trend. In conjunction with the decrease in the number of applications in the A61B5 group in 2017, there was a noticeable increase in the number of registered patents in class H04 – *Electric Communication Technique*. The relatively highest growth rates can be observed in patent subclass G16H – *Healthcare informatics*, i.e. information and communication technology (ICT) specially adapted for the handling or processing of medical or healthcare data. Table 1 summarizes the comparison of patent activity by group with the extreme years of 2011 and 2021, and the percentage of change.

A significant increase in activity in ICT-related categories (subclass G16H) was associated with a simultaneous extinction of activity in subclass G06F19 – *Digital computing or data processing equipment or methods, specially adapted for specific applications*. It is likely that this change was a result of the registration of increasingly well-defined patents with medical specifications. Moreover, as expected, due to the COVID-19 pandemic outbreak – the most spectacular increase in the number of telemedicine patents refers to the G16H50 group – ICT specially adapted for medical diagnosis, medical simulation or medical data mining; ICT specially adapted for detecting, monitoring or modelling epidemics or pandemics. The dynamics of change over time for each category are shown in Table 1.

Thus, the highest activity is observed in the area of various types of diagnostic measurements and ICT technologies, in particular, computational methods and processing of large volumes of medical data. Furthermore, an analysis of the innovation word cloud – built on the basis of the last 5,000 published patents – shows that the innovation trends are not only focused on terminal devices and wireless communication but also include the widely understood smart human environment, e.g. IoT, smart homes, smart buildings and smart cars.

DISCUSSION

Telemedicine is a rapidly evolving field that relies heavily on technological advancements. By comparing patents and systematic reviews, researchers can gain insights into the

Table 1. Comparison of patent activity by group with the extreme years 2011–2021 and the percentage of change

Classification	Definition	2011	2021	%
G16H50	ICT specially adapted for medical diagnosis, medical simulation or medical data mining; ICT specially adapted for detecting, monitoring or modelling epidemics or pandemics [2018.01]	1	77	7,600%
G16H40	ICT specially adapted for the management or administration of healthcare resources or facilities; ICT specially adapted for the management or operation of medical equipment or devices [2018.01]	2	75	3,650%
G16H10	ICT specially adapted for the handling or processing of patient-related medical or healthcare data (for medical reports G16H 15/00; for therapies or health-improving plans G16H 20/00; for the handling or processing of medical images G16H 30/00) [2018.01]	5	75	1,400%
H04W72	Local resource management, e.g. selection or allocation of wireless resources or wireless traffic scheduling [2009.01]	9	79	7,78%
H04L29	Arrangements, apparatus, circuits or systems, not covered by any of groups H04L 1/00-H04L 27/00 [2006.01]	28	56	100%
A61B5	Measuring for diagnostic purposes (radiation diagnosis A61B 6/00; diagnosis by ultrasonic, sonic or infrasonic waves A61B 8/00); Identification of persons [2006.01]	56	105	88%
H04L12	Data switching networks (interconnection / transfer of information or other signals between, memories, input/output devices or central processing units G06F 13/00) [2006.01]	15	28	87%
H04W4	Services specially adapted for wireless communication networks; Facilities therefor [2018.01]	18	31	72%
G06Q50	Systems or methods specially adapted for specific business sectors, e.g. utilities or tourism (healthcare informatics G16H) [2012.01]	34	29	-15%
G06F19	Digital computing or data processing equipment or methods, specially adapted for specific applications (specially adapted for specific functions G06F 17/00; data processing systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes G06Q; healthcare informatics G16H) [2018.01]	27	0	-100%

Source: based on PatSnap®

due to the patent process, and the impact of the pandemic will be seen in the future.

The comparisons by country of publication show that the USA is dominant for publications and patents. The difference among patents is visible in the second and third places: the Asian countries, China, South Korea and Japan, and among publications in the English-speaking countries: UK, Australia and Canada. For example, less than 100 scientific reviews published and over 2,500 patent publications in China during 2021–2023. The high number of patents from China is not surprising because the patent applications are boosted by government subsidies [16], the publication of patents is easier, and the companies involved receive bonuses and lower taxes when they have more patents [12].

In public discussions on advancing technology, there is a noticeable focus on the utilization of AI (e.g. R. Girasa, *Artificial Intelligence as a Disruptive Technology: Economic Transformation and Government Regulation*. Springer Nature, 2020). This trend is also evident in the scientific publications analyzed, where the key words ‘artificial intelligence’ were popular both before and after the pandemic. Surprisingly, when examining patent publications, the incorporation of AI is not apparent. We are likely to see a change in this over the next few years as the process of publishing patents progresses. In addition, the use of AI can increase the likelihood of obtaining a patent, as the ‘intelligent’ nature of AI represents patent eligibility [16].

CONCLUSIONS

When summarizing both analyses presented, the following conclusions can be drawn:

1. The pandemic had a significant impact on the development of telemedicine technologies. This is evidenced by the dramatic increase in systematic reviews. The patent publication pattern does not accurately reflect this trend, likely due to inherent delays in the patent process. The impact of the pandemic on telemedicine patents will be more pronounced in future years.
2. The USA leads in both patents and publications. However, patent applications also indicate the strong presence of Asian countries, especially China, South Korea and Japan. This contrasts with the dominance of English-speaking countries in scientific publishing. This discrepancy reflects different national priorities, government mechanisms and R&D environments.
3. Despite the dominant discussion about artificial intelligence (AI) in public and academic circles, its presence in patents is not as clear. This gap suggests delays in translating theoretical and experimental advances in artificial intelligence into patented technologies in telemedicine.
4. While these hold promise for enhancing the effectiveness of telemedicine solutions, it also introduces challenges in formulating health policies and safeguarding patient privacy. The latter, already a commonly cited barrier in the adoption of telemedicine in the field of medicine, it is poised to become more intricate with the integration of artificial intelligence.
5. The comparative analysis of patents and systematic reviews within the telemedicine field underscores the intricate relationship between technological advancement and research trends. Patents reveal the trajectory of innovation and hint at future technological landscapes, while systematic reviews assess the efficacy and application of these innovations. The variance in patent procedure durations and the contrasting life cycles of research and innovation underscore the complexity of drawing direct comparisons.

In summary, comparing the results of patents and systematic reviews in the field of telemedicine provides valuable insights into technology development, informs policy and decision making, and facilitates innovation and competition. It helps researchers, policymakers, and industry professionals to stay updated with the latest advancements, and thereby make informed decisions about the adoption and implementation of telemedicine technologies.

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