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ORIGINAL RESEARCH ARTICLE

Metaverse in Conjunction with Telemedicine: A Review of Trends

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ABSTRACT

The current research aims to investigate the process of publishing resources related to metaverse in connection with telemedicine. The current research is of applied type and uses the Scientometric method. A descriptive review of the available resources with related keywords such as logistics, knowledge logistics, medical knowledge logistics, telemedicine and knowledge logistics in telemedicine was done in Google, Google Scholar, and SID databases to determine the relationship between the two concepts. The findings of this research showed that the sources of this area have a history of about two years. Ammar A, Fournier, Stephane, Muller, Olivier, and Skalidis, Ioannis are among the most used authors. India, Italy, the United Arab Emirates, UNAV, and the United States were among the busy countries. Also, most organizational affiliations were related to the University of Crete, Center Hospitalier Universitaire Vaudois, Imam Abdulrahman Bin Faisal University, Symbiosis International Deemed University, Symbiosis Institute of Digital and Telecom Management and CATHOLIC UNIVERSITY OF THE SACRED HEART. The analysis of the occurrence of keywords also showed that telemedicine, metaverses, virtual reality, augmented reality, artificial intelligence, and telerehabilitation were among the most frequent keywords. Reviewing the subject literature in this research showed that these two concepts are closely related. As far as it can be claimed that the metaverse is a general concept that can cover various aspects of human life and transform human interactions. This research can be the basis for conducting more studies regarding the connection between the medical field and the metaverse through telemedicine.

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Introduction

Telemedicine is a new concept that has been created in the era of digital transformation and as a result of the emergence of the digital environment and its effects on human life. Telemedicine, or the provision of remote health care services using information and communication technologies, is a concept in which information and communication technologies have great potential for use. Recent studies on the application of telemedicine in various fields such as emergency have shown that these applications include providing specialized services to rural areas, reducing overcrowding in health service providers, providing specialized services to rescuers, and better crisis management. , and reducing the time between accidents and patients arriving at the hospital (Sharifi Kia, Rafizadeh, & Shahmoradi, 2023).

The field of medicine and health care, for example in the case of pancreatic cancer, requires a multidisciplinary approach in a high-volume center for all stages of the diagnostic-therapeutic period. The most experienced centers are not evenly distributed across countries, causing a "health migration" that exposes patients and families to the associated financial, time, and energy costs, as well as the COVID-19 pandemic that has had a profound impact on surgical and oncological care, and travel restrictions due to Covid-related restrictions have delayed care for cancer patients who live far from referral centers. It provides the possibility of quick and effective access to care even for patients who are far from referral centers. Some of the successful applications of telemedicine in patients with pancreatic cancer include remote rehabilitation and nutrition assessment, remote symptom control, and remote evacuation after pancreatic surgery, remote education, and medical guidance about pancreatic disease, it also mentioned remote pathology (Tripepi, Pizzocaro, Giardino, Frigerio, Guglielmi, & Butturini, 2023).

In the digital age and especially after the coronavirus epidemic, the trend of using technology for remote consultation in thematic areas, especially in the medical field, has become widespread. It emerged especially for the pharmaceutical management of medical emergencies and is constantly evolving due to its undeniable advantages, including time and cost-effectiveness. Recently, the concept of metaverse has opened new opportunities for this field in the field of remote medical consultations (Dagli, 2022).

The importance of the health system can be understood as an important factor in the life of humanity and as one of the indicators of development (Jamshidi and Jamshidi, 2016). Computer-aided medical diagnosis is one of the most important research fields in biomedical engineering based on clinical characteristics. In this approach, which is common to DDS, profiles are created that associate the input data, which includes clinical and genomic data along with diagnosis, treatment, and specific recommendations, with several types of outcomes. (Giannakeas, Exarchos, Goletsis, Papaloukas, Fotiadis, Akhgar, Gulissano, 2007). With the emergence of computer networks and the globalization of the Internet, we have witnessed the emergence of electronic health. To provide better services to all people. Electronic health and the provision of health services is one of the fields of science and technology that has an increasing growth in the field of health and treatment in the world. Electronic health is a new term that refers to the combined use of information technology. Electronic communication in the health and treatment sector is emphasized as a new method in health care, diagnosis, and treatment, with electronic and communication processes. In this system, all health services, including electronic patient records, telemedicine, evidence-based medicine, Information to citizens, information to specialists, and virtual medical teams are provided (Iranian Telemedicine Association website, 2021).

Telemedicine is a new concept that is related to electronic health and refers to the provision of health care services between service providers and service recipients remotely using information and communication technology. The British Telemedicine Association considers telemedicine to be the provision of medical services using information and communication technology by professional experts to exchange information in the field of diagnosis, treatment, prevention of diseases, and

conducting research telemedicine is the intersection of medicine with information technology and telecommunications (Ahmadi, Meraj, and Mashauf, 2017).

On the other hand, today the virtual space has undergone tremendous changes and is developing and progressing. For many years, digital interactions have become an integral part of human life, and day by day it is changing the lifestyle and creating new concepts. Metaverse is an emerging concept that marked the fourth technological revolution and is a kind of alternative digital virtual reality that connects the physical world with digital life. The metaverse has been rearranged in formats such as Second Life as a Meta world where users work, study, and socialize (Akefi Ghaziani, Milani, and Akefi Ghaziani, 2022). Metaverse is an innovative educational tool that introduces new ideas to educational environments and overcomes the limitations of time and space. Metaverse or Meta world refers to the integration of modern technologies such as virtual reality, augmented reality, mixed reality, artificial intelligence, and cloud computing (Pour Mohammad Baqer Esfahani and Safarabadi, 2022).

What happens in the metaverse is a three-dimensional simulation of environments, objects, people, and their connections, and based on this, it is possible to experience phenomena and create interactions with an experience close to reality as an immersion experience. The term metaverse was first proposed in 1992 by Neil Stevenson in the book Falling Snow, and according to the Oxford definition, it is a space based on virtual reality in which users can interact with the environment created by the computer as well as with other users through Avatars interact. This concept has recently been at the center of attention with the new approach of Meta Company, and it is a hypothesis of the future of the Internet, which consists of decentralized and stable online 3D virtual environments. In such an environment, by using technologies such as augmented reality and virtual reality, immersion in interaction with the environment can be well experienced (Davarpour, 2022).

Through Metaverse, people can easily communicate with different people from different countries, and easily become members of different societies and foundations. To attract the cooperation of others to create new activities. On the other hand, individuals can, after the construction and development of Metaverse, benefit from legal acts like other acts and material behavior. Things like buying and selling goods and concluding other contracts and such things are among the things that can be done in Metaverse (Akefi Ghaziani, Milani, and Akefi Ghaziani, 2022).

Considering the short history of the formation of the concept of metaverse, the literature of this field is still not rich enough due to its novelty. The field investigation shows that the history of the publication of sources in this field goes back to 2022 in thematic databases. Therefore, much research is still needed so that this concept is well known to the scientific and popular community. On the other hand, telemedicine is a new concept that, with a history of nearly half a century, has not yet been widely used. If we examine the definitions and limits of these two concepts, we will notice the close connection and link between these two areas. Therefore, in the present research, we decided to have an overview of the publication process of the sources of these two fields and examine their connection.

Literature Review

Metaverse is a simulation of the real world and its root is derived from the two words meta and world. Therefore, it describes a digital virtual environment that combines the features of the digital and physical world with augmented reality and virtual reality. Technologies in this field can revolutionize remote health care and also provide the possibility of remote consultation in 3D virtual clinics. The way it works is that digital images, known as avatars, represent a person in virtual environments. This technology has eliminated geographical boundaries, as people can meet each other in the digital space and interact through avatars using headsets regardless of their location in the real world. In the field of medicine, patients can access healthcare providers at the global level through virtual clinics (Dagli, 2022).

In the virtual, digital, and three-dimensional world of Metaverse, various technologies and virtual places are integrated and it provides the possibility to transform the way people interact and perform their daily tasks. Musamih, Yaqoob, Salah, Jayaraman, Al-Hammadi,

Omar, & Ellahham, (2022) discussed in their article how to use metaverse in health care and focused on the concept of the universe and its main enabling technologies. Potential applications of the metaverse in healthcare, such as telemedicine and telehealth, medical education and training, medical marketing, healthcare supply chain, healthcare facilities, and fitness and wellness are also explored.

According to Chen and Zeng (2022), with the development of the digital economy and the emergence of Metaverse as the infrastructure of the next-generation Internet, medical informatics and future health have a promising path ahead. Their study used a bibliometric analysis of more than 34,000 metaverse-related publications over 22 years to propose a new concept called the Health Metaverse. They used Zipf's Law, Bradford's Law, and Lotka's Law methods, respectively, to explore the research framework, challenges, and applications of the Health Metaverse. Their results show four perspectives, namely knowledge, socialization, digitalization, and intelligence. Their proposed framework mainly focuses on multimodal medical information standards, integration of medical and social data, telemedicine and online health management, and medical artificial intelligence. It also provides a valuable innovative stimulus in medical education, surgical procedures, and communication between service providers and patients. However, their study found that there are challenges in promoting technology, gamification of medical services, protecting patient privacy, and preventing people from escaping reality.

Dagli (2022) listed the main advantages of Metaverse in the field of telemedicine and health as follows:

- Creation of virtual clinics: routine consultations can be replaced with consultations in virtual clinics, and this eliminates the need to travel to hospitals and clinics and wait hours in waiting rooms for consultations. Therefore, both time and money are saved. Another advantage of virtual clinics is that physical visits are reduced and therefore the risk of infection for patients and doctors is reduced, especially during outbreaks of diseases and during pandemics.
- People's fear, anxiety, and embarrassment sometimes make many patients avoid consulting doctors and other healthcare professionals. But with Metaverse, people can consult with any health care professional, sometimes sitting at home, using headsets that reduce anxiety and fear. The digital environment can be designed and applied in a more suitable way for the patient.
- Ability to provide access to healthcare experts globally: Different specialists from different institutions can join a common virtual meeting place to study patients' files and share views. Therefore, better access to timely and cost-effective global healthcare providers.
- Community health education programs: It will be possible to provide various education and public health to the disadvantaged and those living in remote areas through the digital environment and metaverse. Public health awareness training programs in a digital environment can be even more interactive and cost-effective than in the real world.
- Virtual educational models: Virtual education can also use 3D educational models in virtual classrooms for students of the relevant field to better understand anatomy and surgical procedures. In this context, a study showed that local anesthesia application skills improved after VR training. On the other hand, the curriculum becomes more standardized because the same virtual study content can be provided to all students regardless of their geographical location and institution.
- Virtual and augmented reality assistance methods: In an advanced state, surgeries can be performed more accurately using headsets that provide an X-ray view and allow seeing the internal anatomical structures of the body. In the field of dentistry, various procedures, including randomized controlled trials, periodontal surgeries, and implant placement, can be performed using similar techniques with greater accuracy.

According to Bhattacharya, Obaidat, M. Savaliya, Sanghavi, Tanwar, & Sadaun (2022), we can now see that smart healthcare has shifted to 5.0 generation healthcare, in which patient tracking, telemedicine, remote surgery, health monitoring, virtual clinics, and personal care are provided. Hence, the metaverse has become a potential tool for leveraging digital connectivity through improving the healthcare experience in virtual environments. But despite its potential benefits, sensitive patient information is captured and digital avatars are created and interact with healthcare stakeholders for virtual care. Due to the decentralized nature of the metaverse components, blockchain (BC) has created a potential solution to instill transparency and immutability in the transactions stored in the metaverse, which is used to support clinical decision-making for accurate and interpretable diagnosis. Therefore, explainable artificial intelligence (xAI) constitutes another important component that builds trust in healthcare informatics. In their research, they investigated the interaction between patients, virtual hospitals, and doctors through a telesurgery plan. Next, they discuss potential challenges and present a test case of the advantages of their proposed architecture over traditional telesurgery systems.

Randazzo, Reitano, Carletti, Iafrate, Betto, Novara, & Zattoni (2023) believes that in particular, urology patients and urologists can benefit from Metaverse facilities. They conducted a non-systematic

review of the literature and recently published studies on the metaverse. The database they used was PubMed, and the identified studies served as the basis for a qualitative analysis of the literature examining the use of Metaverse in urology. Their results showed that virtual consultation can increase access to health care and reduce distance and costs, and pain management and rehabilitation can find incredible support in virtual reality, which can reduce anxiety and stress. and improve treatment adherence. According to them, Metaverse has great potential in urological surgery and can revolutionize both surgical planning with 3D modeling and virtual surgeries, and during surgery with augmented reality and artificial intelligence. Also, Med Schools can provide anatomy and surgery lectures and an inclusive environment for learning, and residents can use this platform to learn in a safe environment at their own pace. However, there are also potential challenges and ethical concerns associated with using metaverse in healthcare.

Kim and Kim (2023) stated that the emergence of digital therapies has attracted much attention in recent years as a new approach to managing situations and crises. In this approach, the use of evidence-based therapeutic interventions is facilitated by high-quality software programs to treat, manage, or prevent medical conditions. This issue has increased the possibility of implementation and application of Metaverse in all fields of medical services. In urology, they believe, significant digital therapies including mobile apps, functional bladder devices, pelvic floor muscle trainers, smart toilet systems, augmented reality-guided surgery and education, and telemedicine and education for Urology consultations are being produced and researched. They provided an overview of the current impact of Metaverse on the field of digital therapy and identified its current trends, applications, and prospects in the field of urology.

Despite the positive results and advantages that Metaverse has, this technology also faces its challenges. The most important challenge that can be mentioned is the issue of ownership. Because everything is immaterial and the connection between the physical world and the virtual world is in the process of being fixed, the discussion of properties and economic activities is facing a challenge.

Metaverse can also negatively affect physical and mental health. For example, excessive use of digital space, sedentary lifestyle, addiction, and physical pressure may be created among people. Privacy and cyber security are also among the factors influencing the success of Metaverse projects. Therefore, guidelines and regulations are needed to ensure safety limits before allowing widespread use. Other challenges in using this technology include its availability and affordability. If Metaverse is affordable and convenient, it will be widely used and will revolutionize the entire healthcare system. Also, remote counseling is as effective as face-to-face counseling. On the other hand, diagnostic tools based on artificial intelligence can be designed to help in the remote diagnosis of various diseases (Dagli, 2022).

Khowaja, Dahri, Jarwar, & Lee (2023) believe that with the growing trend of digital technologies, such as augmented and virtual reality, the metaverse has gained significant popularity, and among the important areas that benefit from the metaverse are the medical fields through Distance and health are electronic. However, the data and techniques used to understand the medical side of the metaverse are vulnerable to data leakage attacks and so on. According to them, most of the existing studies focus on each of the problems through coding techniques or adding noise, and the use of coding techniques affects the overall performance of medical services and hinders its realization. In this regard, they proposed generative adversarial networks and spike learning-based convolutional neural networks (GASCNN) for medical images that are resistant to data leakage and class attacks.

According to Athar, Ali, Mozumder, Ali, & Kim (2023), the metaverse is redefining the way humanity communicates. Rapid technological innovation has revolutionized all market industries, including the healthcare sector. After being announced by Meta CEO Mark Zuckerberg, Metaverse has received widespread attention from the medical industry. Overall, Metaverse can be considered a big game changer in the medical industry in 2022 and 2023. With the manufacturing opportunities in the medical industry, Metaverse technology has become one of the most profitable and promising technologies. This modern technology can address numerous issues in the healthcare industry, including virtual health and fitness, mental health, access to health without geographic restrictions, and connecting with friends and family members. In their study, they explored the use of metaverse and its future directions in the healthcare industry and also provided explanations about the main challenges we may face when using metaverse technology in the future.

As the review of research sources and literature shows, metaverse is a new concept that has officially entered the literature in the last two years, and its thematic resources are being published in thematic and dedicated databases. On the other hand, telemedicine is a new concept that is closely related to

digital fields with its decades of history. These two concepts can be considered among the outputs of the digital age. On the other hand, a review of sources shows that metaverse and telemedicine are also very close. It may be considered that telemedicine is providing care and providing health services through the metaverse and its technologies. That is, the metaverse is a more general concept that can include the communication and interaction of different societies through the digital world and the virtual world. In this regard, one of the subject areas that can provide some of its services virtually is the field of medicine, where this process is carried out through telemedicine, and it is telemedicine. Therefore, since the sources of this field are limited and no research was found that investigated the process of publishing resources in connection with the two mentioned fields, in the present research we decided to investigate the process of publishing resources related to metaverse in connection with telemedicine. In this regard, the research questions are as follows:

1. What is the process of publishing resources related to Metaverse and telemedicine in Scopus and PubMed databases?
2. Who are the most active authors in the field of metaverse and telemedicine in Scopus and PubMed databases?
3. Which are the most active organizations in the field of metaverse and telemedicine in the Scopus and PubMed databases?
4. What is the co-occurrence of keywords between the two domains of metaverse and telemedicine?

Method

The current research is a cross-sectional review and was carried out using the scientometric method. To conduct the research, a review of the sources of this field was done first. Then, the term "Metaverse AND Telemedicine" was searched in Scopus, Web-of-Science, or Clarovit Analytics, and PubMed subject database. Then, the required output was taken from the recovered results, and using VOSviewer software, knowledge maps and communication networks related to the resources of this field were drawn. It should be noted that the analyses provided by the databases themselves were also used. It should also be noted that to answer the first question, the analyses provided by the Scopus and Web of Science databases were used, and to answer the other questions, the outputs extracted from the Scopus and PubMed databases were entered into the VOSviewer software, and the maps A co-occurrence was drawn.

Findings

First question: What is the process of publishing resources related to Metaverse and telemedicine in Scopus and PubMed databases?

The search results indicate that until September 19, 2023, 30 sources were retrieved in the Scopus database and 13 sources were retrieved in the Web of Science database with the words metaverse and telemedicine. Figure 1 shows the search results of the mentioned term in the Scopus database and Figure 2 shows the number of documents per year in the Web of Science database.

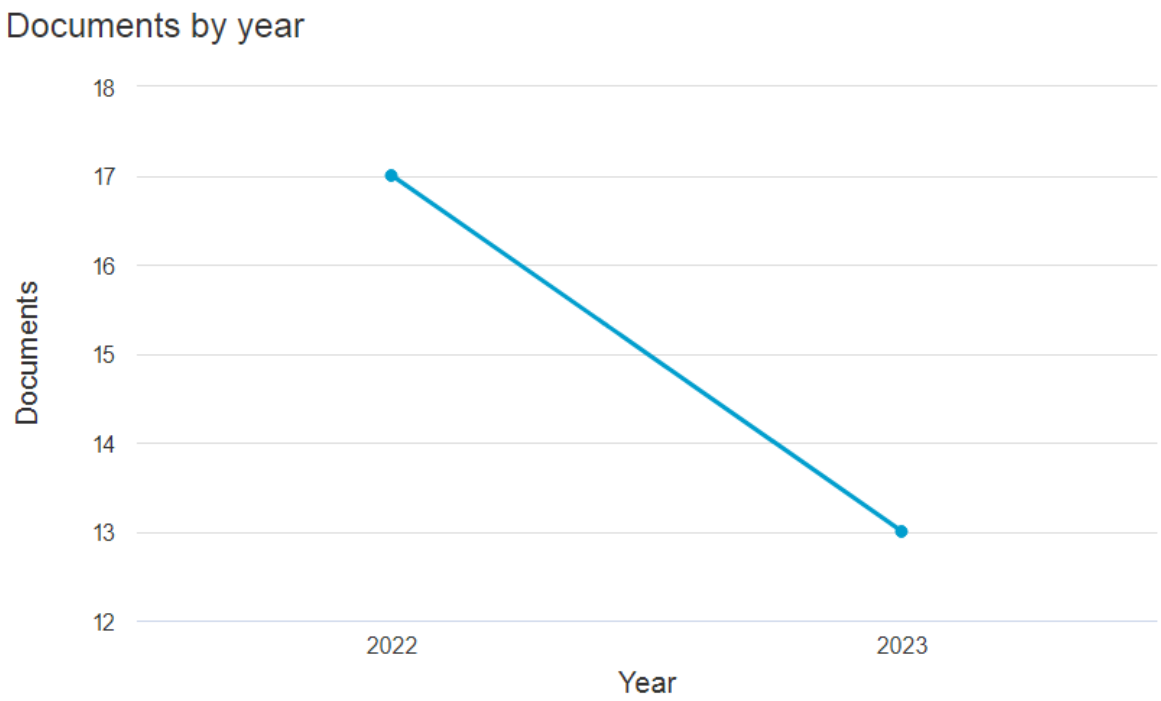

Figure 1. *Number of documents per year in the Scopus database*

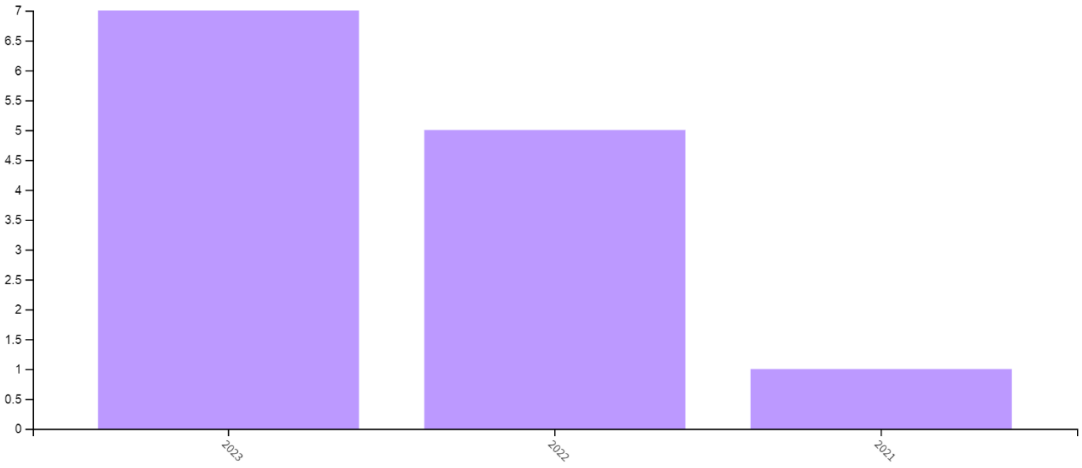

Figure 2. *Number of documents per year in the Web of Science database*

As Figure 1 shows, the history of the publication of sources in this field goes back to a year ago, i.e. 2022. This year, 17 sources and 13 sources in the field of metaverse and telemedicine have been published in the Scopus database.

But as it is clear, according to Figure 2 in the Web of Science database, the history of the publication of sources in this field is more than one year so in 2021, 1 source was published in this field. In 2022, 5 sources, and in 2023, 7 sources were published in this field in the Web of Science database.

Figure 3 shows the organizational affiliations of this field in the Scopus database and Figure 4 shows the organizational affiliations in the Web of Science database.

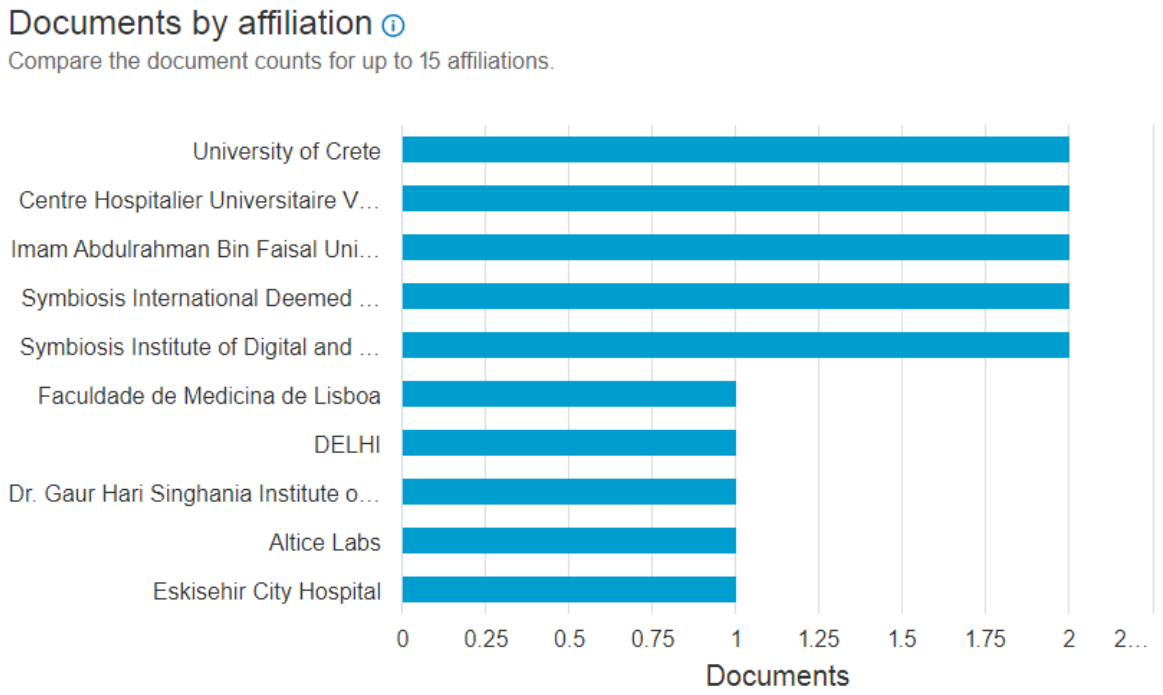

***Figure 3**. Organizational affiliations of documents published in the Scopus database*

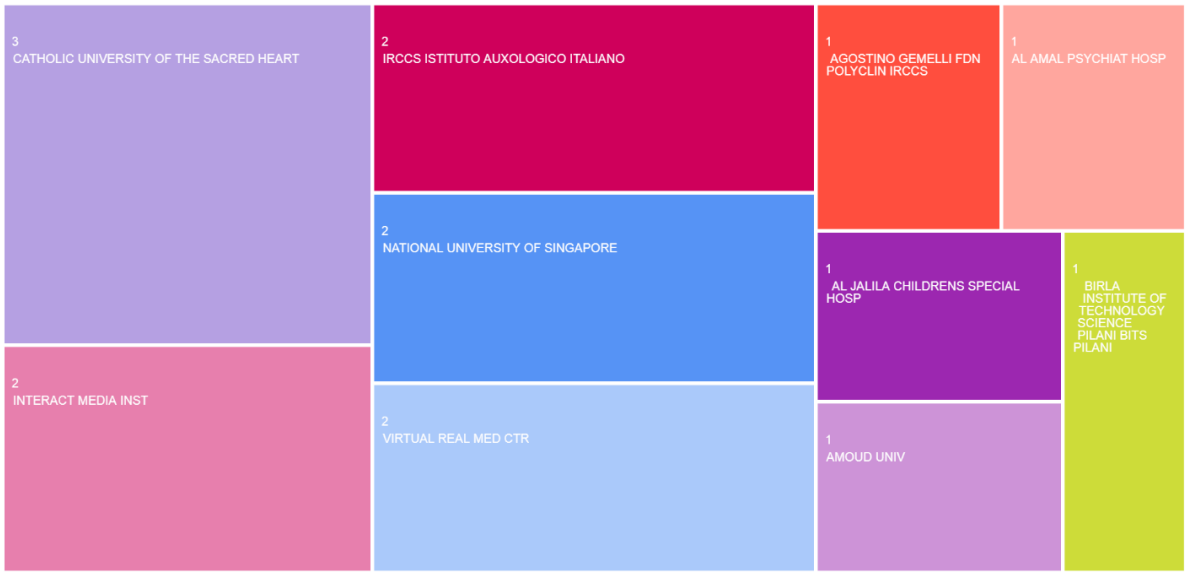

***Figure 4.** Organizational affiliations of documents published in the Web of Science database*

As Figure 3 shows,The University of Crete, Center Hospitalier Universitaire Vaudois, Imam Abdulrahman Bin Faisal University, and Symbiosis International Deemed University, Symbiosis Institute of Digital and Telecom Management, with the publication of two sources, are ranked first in the publication of sources in this field in the Scopus database have.

But according to Figure 4 on the Web of Science database, the CATHOLIC UNIVERSITY OF THE SACRED HEART published three sources, and INTERACT MEDIA INST, IRCCS ISTITUTO AUXOLOGICO ITALIANO, NATIONAL UNIVERSITY OF SINGAPORE and VIRTUAL REAL MED CTR ranked next with publishing 2 sources.

Figure 5 shows the position of the countries in terms of the publication of resources in this field in the Scopus database, and Figure 6 shows the position of the countries in the Web of Science database.

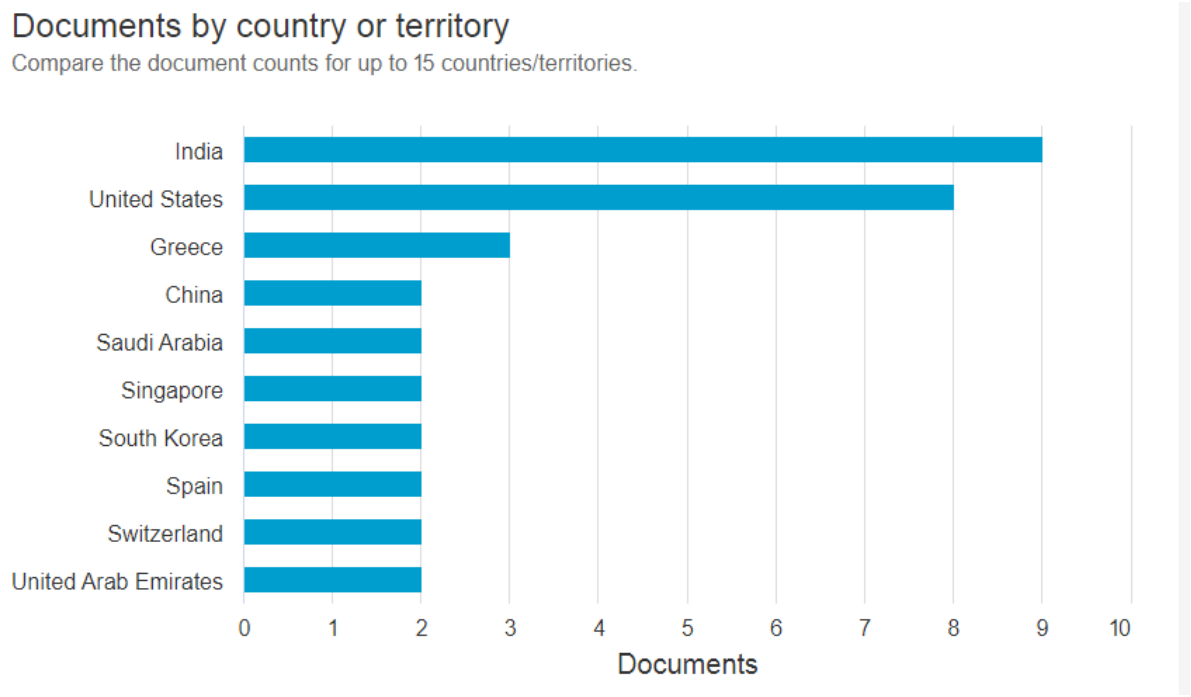

Figure 5. *The position of countries in the Scopus database*

Figure 6. *The position of countries in the Web of Science database*

As Figure 5 shows, India, the United States, and Greece are in the first to third positions with 9, 8, and 3 sources, respectively, and other countries are in the next positions with less than three sources.

Howere according to Figure 6 in the Web of Science database, the order is different. So India, Italy, United Arab Emirates, and America are in the first place with 3 sources each, China and Singapore are in the second place with 2 sources each, and the rest of the countries are in the third place with 1 source.

In terms of the type of published resources, Figure 7 shows the sources of this field in the Scopus database, and Figure 8 shows the type of resources published in the Web of Science database.

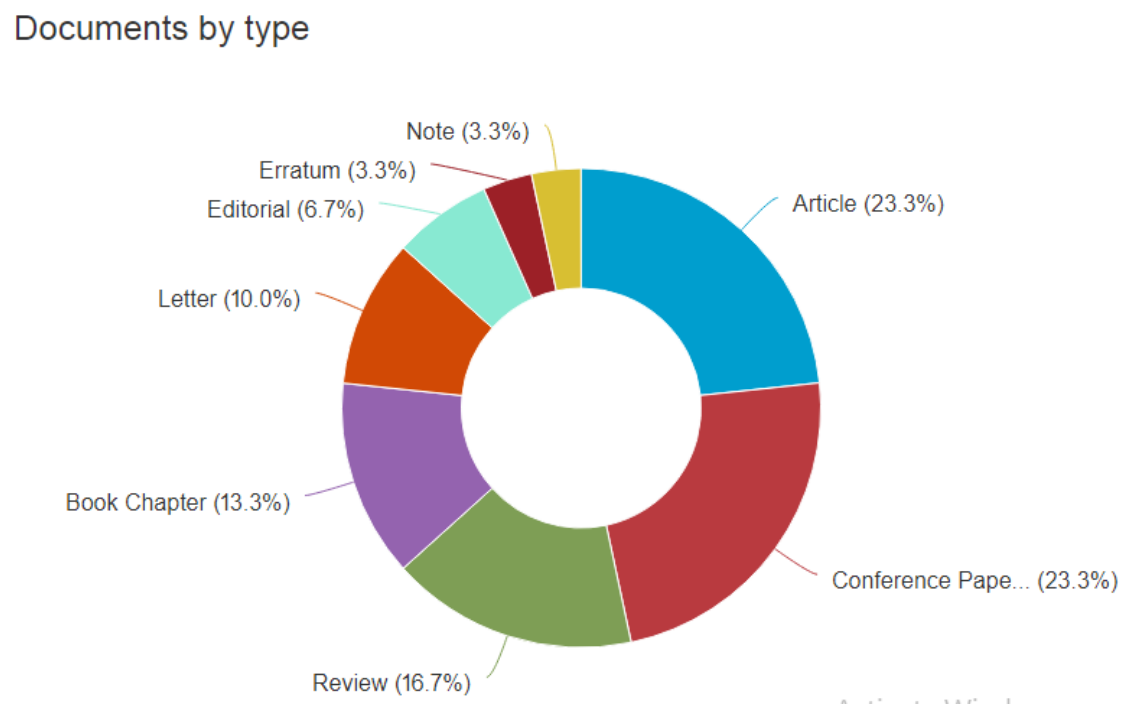

Figure 7. *Type of sources published in Scopus database*

***Figure** 8. The type of resources published in the Web of Science database*

According to Figure 7, it is clear that articles, conference articles, and reviews are the most popular types of published sources in this field, which is natural considering that articles are more up-to-date than other formats.

In the Web of Science database, according to Figure 8, articles are ranked first, and Editorial Material and Review Articles are ranked second. Next, Figure 9 shows the thematic coverage of the subjects under which the sources of this field are published in the Scopus database, and Figure 10 in the Web of Science database.

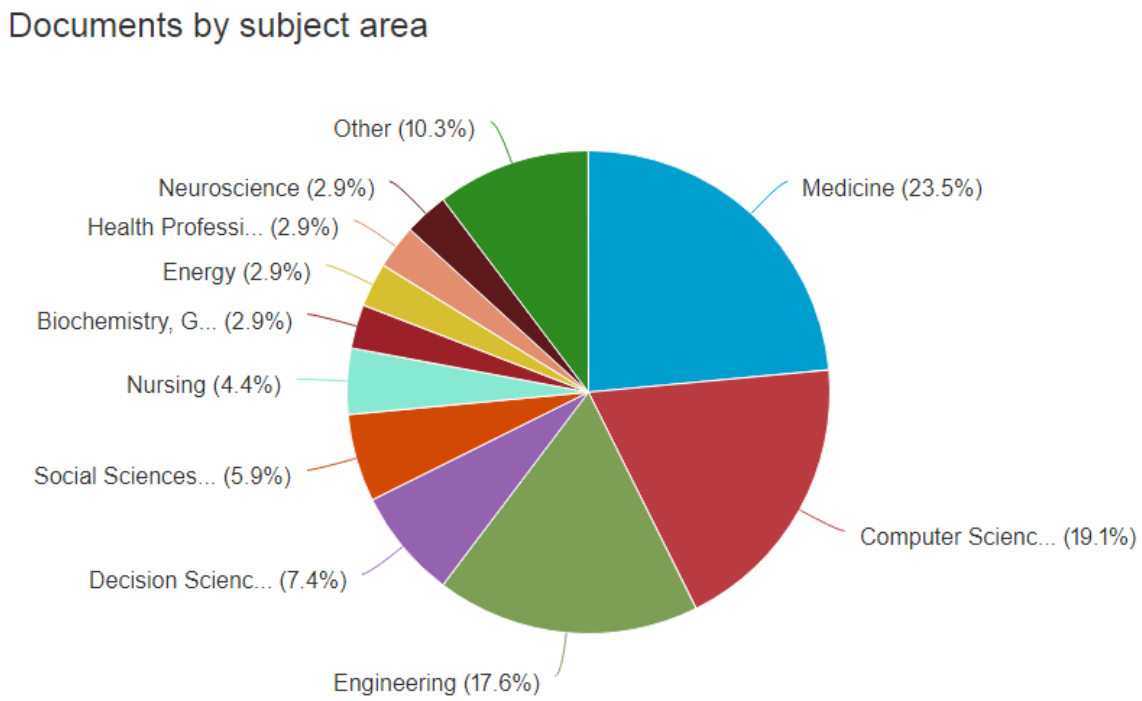

Figure 9. *Thematic coverage of sources published in the Scopus database*

Figure *10. Thematic coverage of sources published in the Web of Science database*

As Figure 9 shows, most sources related to the terms "metaverse" and "telemedicine" are located in the fields of medicine, computer science, and engineering, respectively, and according to the subject of the searched term, it is natural that the sources should first be in the field of medicine, and secondly, from In terms of technical aspects, they should be in the fields of computers and engineering.

According to Figure 10 in the Web of Science database, the resources related to computer science and Computer Science Cybernetics, Electrical Electronic Engineering, Health Care Sciences Services, Health Policy Services, and Medical Informatics are in second place.

Second question: Who are the most active authors in the field of metaverse and telemedicine in Scopus and PubMed databases?

To answer this question, the data output from the retrieved results was entered into the VOSveiwer software. Figure 11 shows the heating map related to the Scopus database and Figure 12 shows the map obtained from the data extracted from the PubMed database.

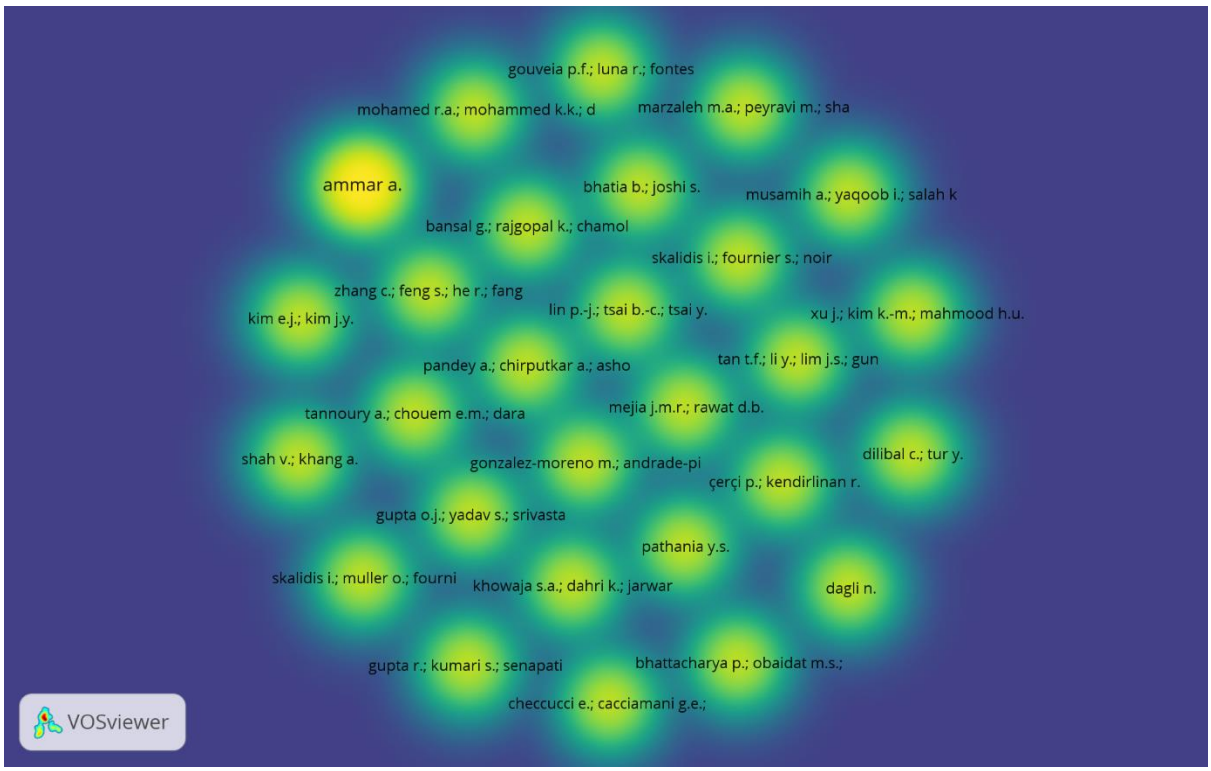

Figure 11. *Heat map related to data extracted from Scopus database regarding prolific authors*

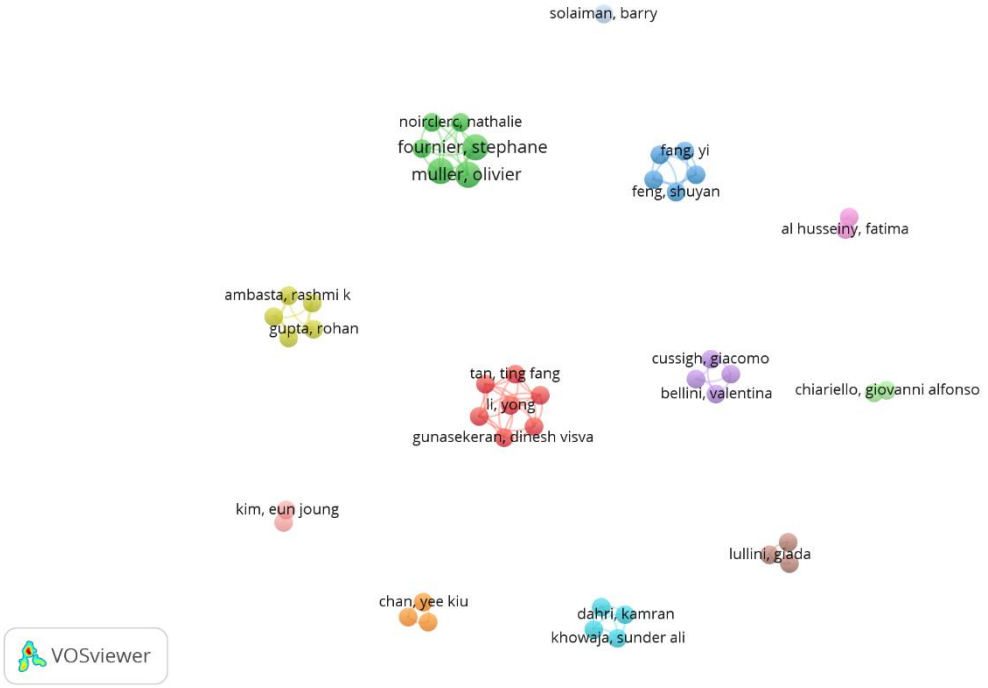

Figure 12. *The map related to the data extracted from the PubMed database regarding prolific authors*

According to Figure 11, in the Scopus database Ammar a. By publishing 2 sources, he has the most sources, and the rest of the authors have published one source each. But in terms of citations, Skalidis i.; Müller O.; Fournier s. with 66 citations, tan t.f.; li y.; Lim j.s.; Gunasekeran d.v.; Teo z.l.; ng w.y.; ting d.s.w. with 39 citations and Bansal g.; Rajgopal k.; Chamola v.; Xiong z.; Niyato d. They are ranked first to third with 20 citations.

According to Figure 12 in the PubMed database, Fournier, Stephane, Muller, Olivier and Skalidis, Ioannis each has the highest number of sources in this field by publishing 2 sources, and the rest of the authors have published one source each. In terms of the number of connections, these people have the most connections with other authors with 7 connections. Also, Gunasekeran, Dinesh Visva,

li, Yong, Lim, jane Sujuan, ng, Wei Yan, tan, ting fang, Teo, Zhen ling, and ting, Daniel sw are in second place with 6 connections.

***Third question: Which are the most active organizations in the field of metaverse and telemedicine in the Scopus and PubMed databases*?**

The findings related to the busy organizations in the field of resource dissemination in the field of metaverse and telemedicine are presented in the Scopus database in Figure 13 and the PubMed database in Figure 14.

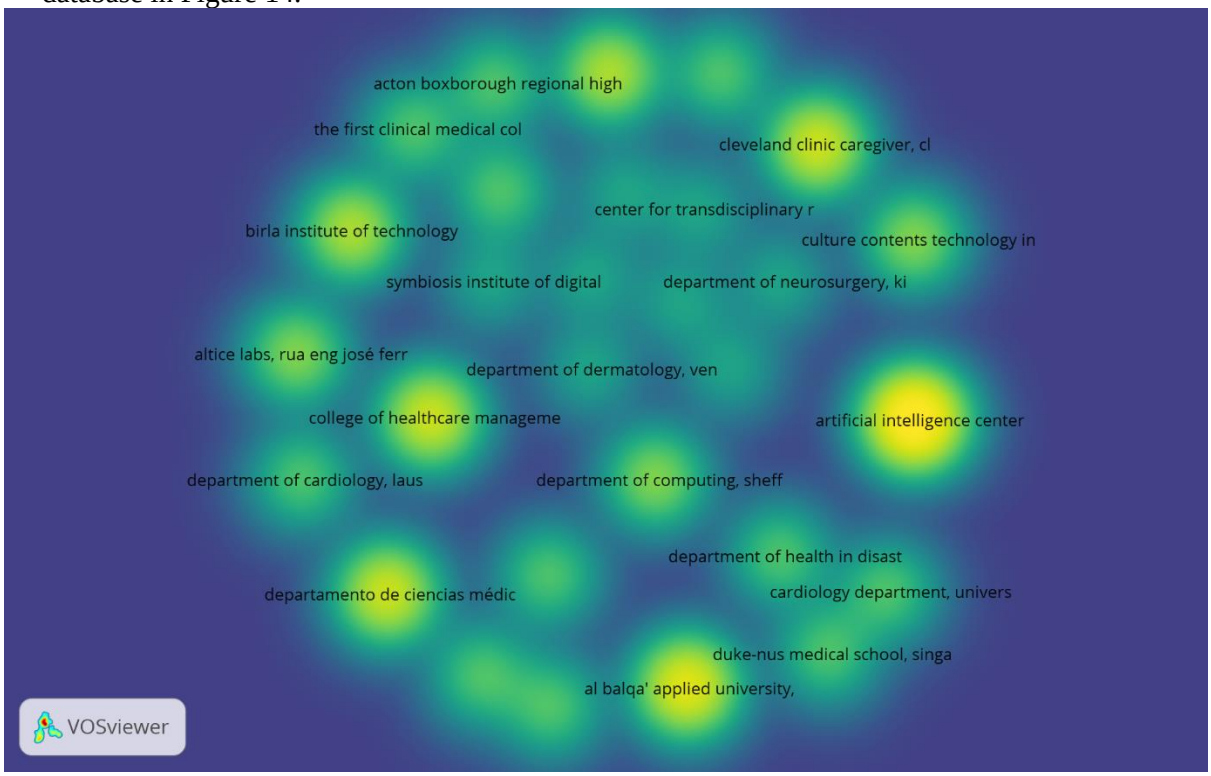

Figure 13. *Heat map related to the most active organizations in the field of publishing metaverse and telemedicine resources in the Scopus database*

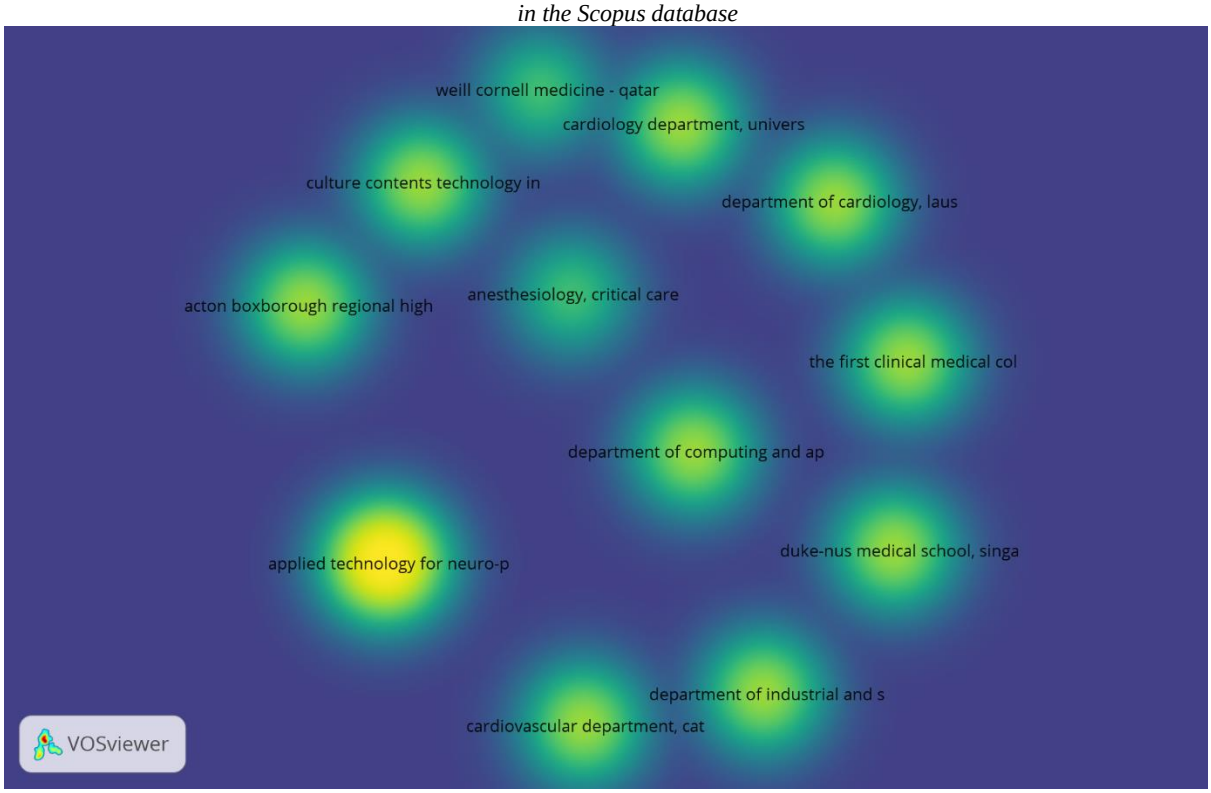

Figure 14. *The heat map related to the active organizations in the field of publishing Metaverse and telemedicine resources in the PubMed database*

According to Figure 13, in terms of the number of resources, all organizations are in the same position and each has published 1 resource. But in terms of the number of citations, the department of cardiology, Lausanne university hospital, Lausanne, Switzerland and Faculty of Medicine, university of Crete, Crete, Greece with 66 citations, duke-nus medical school, Singapore, Singapore and Singapore national eye center, Singapore eye research institute, Singapore, Singapore with 39 citations and Birla institute of technology and science (bits) Pilani, department of mechanical engineering, Pilani, Rajasthan, India; Nanyang Technological University, School of Computer Science and Engineering, Jurong West, Singapore; National University of Singapore, Department of Electrical and Computer Engineering, Queenstown, Singapore and Singapore University of Technology and Design, Information Systems Technology and Design, Tampines, Singapore, Singapore are in first to third place with 20 citations.

In the PubMed database, according to Figure 14, in terms of the number of sources, all organizations were in the same situation as in Scopus, but in terms of the number of connections, applied technology for neuro-psychology lab, Irccs istituto Auxologico Italiano, Milan, Italy; Department of Psychology, University of Bologna, Bologna, Italy; Human Technology Lab, Catholic University of Milan, Italy; Instituto Polibienestar, University of Valencia, Valencia, Spain; and Irccs Istituto Scienze Neurologiche, bologna, Italy with 4 connections were in the first position and other organizations were in the next position with one connection.

Fifth question: What is the co-occurrence of keywords between the two fields of Metaverse and telemedicine?

Findings related to the co-occurrence of keywords related to Metaverse and telemedicine in the Scopus database are presented in Figure 5 and the PubMed database in Figure 16.

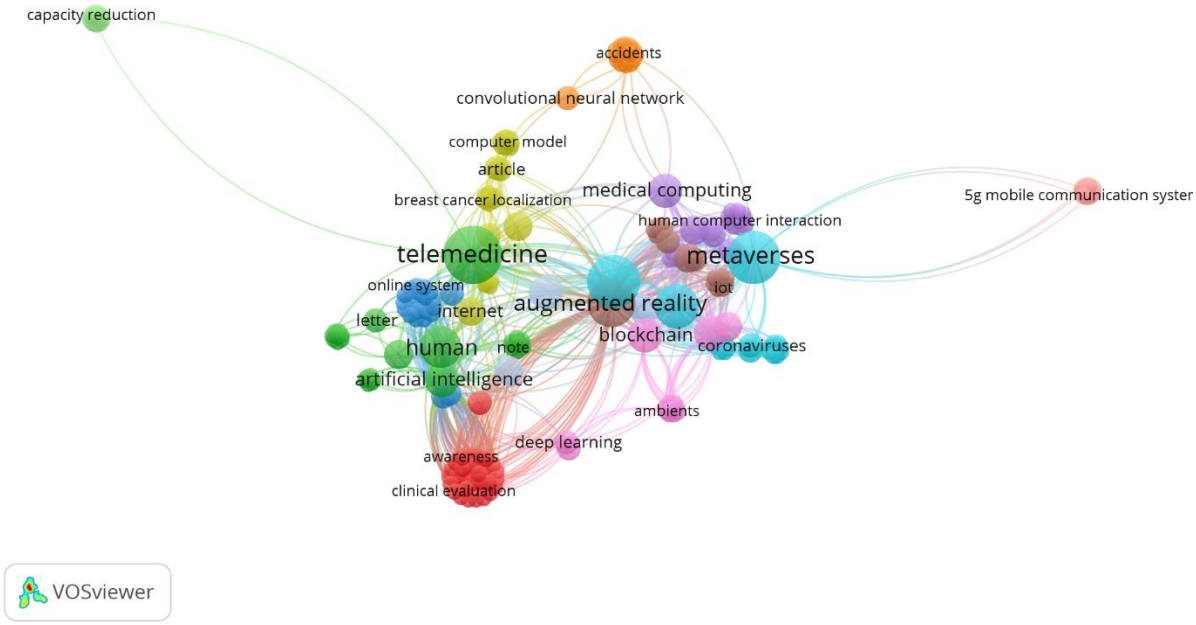

Figure 15. *Co-occurrence of keywords related to metaverse and telemedicine in the Scopus database*

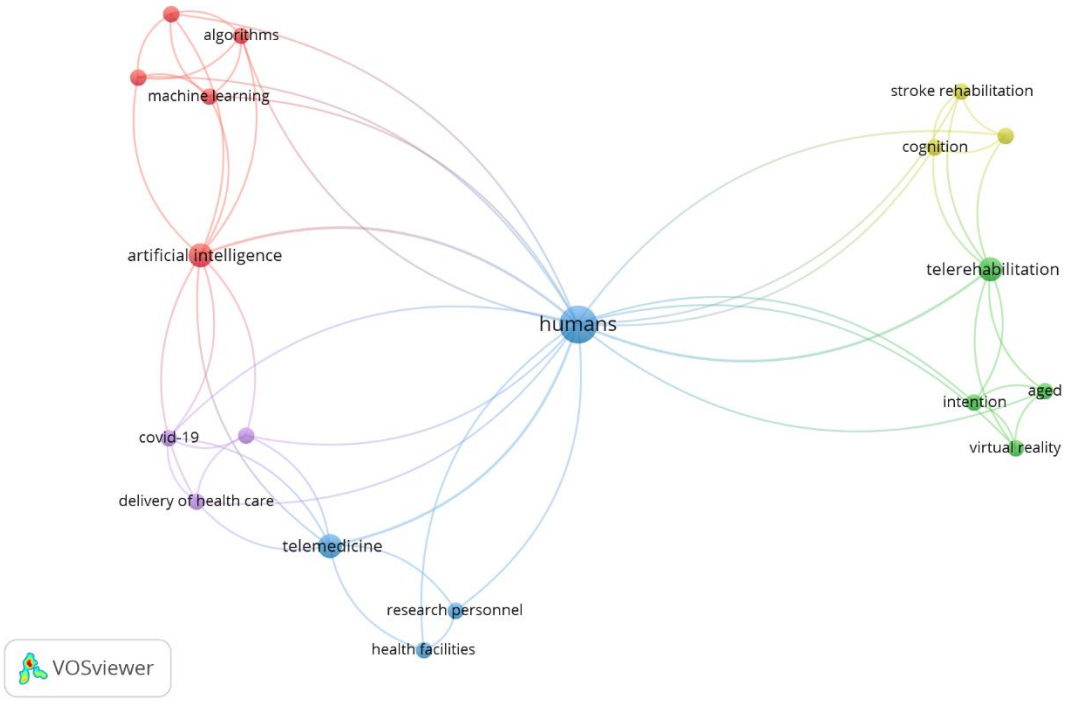

Figure 16. *The co-occurrence of keywords related to Metaverse and telemedicine in the PubMed database*

Finally, according to Figure 15, in the Scopus database, telemedicine with 12 occurrences, Metaverses and virtual reality with 10 occurrences, and augmented reality with 8 occurrences are in first to third place. In terms of the link power of the whole word telemedicine with 215, virtual reality with 164, and Metaverses with 155 were in the first to third place.

Also, in the PubMed database according to Figure 6, humans with 5 occurrences, artificial intelligence, telemedicine, and Telerehabilitation with 2 occurrences were ranked first, and other keywords were in the next position with one occurrence. In terms of total connection strength, humans with 21, Flan with artificial intelligence, and telemedicine and telerehabilitation with 8 connections were ranked first to third.

Discussion

The continuation of humanity's effort to give meaning to phenomena with the emergence of the Internet and the digital environment and the creation of networks has faced serious changes that have led to the emergence of virtual reality, augmented reality, metaverse and similar titles. The new spaces that have been created as a result of the advancement of information and communication technology have caused a representation of the physical environment in digital, multimedia and multifaceted formats with flexibility. This issue has transformed human interactions and pushed them toward virtual space (Hasanzadeh, 2022).

As the findings of this research showed the link between telemedicine and metaverse, the subject literature also shows this link, and various research, in line with the present research, confirm this link. For example, as previously mentioned, Kim and Kim (2023) stated that telemedicine is increasingly widely used in healthcare with the help of digital twins. Pusik et al [20] proposed a distributed digital twin implementation of a hemodialysis unit designed to help prevent the spread of the Omicron variant of COVID-19 and other infectious diseases. Another example in their paper is that Chung-Ang University's Gwangmyeong Hospital in South Korea used digital twin and metaverse technologies to create a virtual hospital called "Metaversepital" that allows users to visit the hospital without having to physically visit the hospital. Undergo medical treatment and advice.

Also, the research of Randazzo, Reitano, Carletti, Iafrate, Betto, Novara, & Zattoni (2023) showed that virtual consultation can increase access to health care and reduce distance and costs. Also, pain management and rehabilitation can find incredible support in virtual reality, reducing anxiety and stress and improving treatment adherence. They showed that Metaverse has the greatest potential in urological surgery for surgical planning with 3D modeling and virtual surgeries, as well as during surgery with augmented reality and artificial intelligence.

Turab and Jamil (2023) reviewed the current application of DTs in health care in the Metaverse, emphasizing the role of digital twins (DT) and their potential for health care in the Metaverse. Healthcare practitioners may use immersive virtual worlds to replicate medical scenarios, improve educational experiences, and provide personalized patient care, they believe.

Conclusion

Telemedicine is also a new concept that has been formed as a result of the developments resulting from the emergence of the digital environment. Since every organization must try to keep pace with the changes of its times and era, the field of health and medicine is witnessing the emergence and growth of telemedicine as a result of keeping pace with the digital age. Telemedicine can revolutionize the field of treatment, prevention, and identification of diseases through continuous and remote monitoring. Through telemedicine, changes have been made in access to medical services to the extent that deprived areas can also access medical services.

Reviewing the subject literature in this research showed that these two concepts are closely related. As far as it can be claimed that the Metaverse is a general concept that can cover various aspects of human life and transform human interactions. Maybe the time will come when people will entrust their interactions to their avatars in virtual space instead of physical presence, and a large part of people's lives will be managed without physical presence and only through virtual space. Health and medicine is one of the most important areas in human life, which is given a lot of attention. The literature review of this research showed how close the health field can be to the Metaverse through telemedicine. Also, the publication process of sources, and authors, busy countries and organizations were mentioned. This research can be the basis for conducting more studies regarding the connection between the medical field and the Metaverse through telemedicine.

In this regard, the following are suggested for future research:

- Conducting a systematic review of articles related to telemedicine and metaverse
- Researching to measure the effectiveness of telemedicine services through Metaverse
- Researching to identify telemedicine technologies in connection with Metaverse
- Researching to identify telemedicine components in Metaverse

Declaration of Competing Interest

The author declares that he has no competing financial interests or known personal relationships that would influence the report presented in this article.

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