



Metaverse phenomenon and its impact on health: A scoping review

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ABSTRACT

Introduction: Metaverse is a hypothesis of the next generation of the Internet, which consists of a decentralized and stable online 3D virtual environment and can be widely used in health. Due to the growth of Metaverse technology in various fields and the importance of using it in health, the present study has been conducted to review and identify the application areas of this emerging technology in the health field.

Methods: In this scoping review, an electronic search was done via scientific databases such as Web of Science, PubMed, and Scopus by combining topic-related keywords without time limits. Two authors independently gathered the data by a data extraction table.

Results: Of 46 articles found through the initial search, nine studies were eligible for review inclusion. Most of the studies (55.55%) were published in 2021, and South Korea was the country with the most published studies (44.44%). The main services for using Metaverse include educational services, interventional services, and communication services. Also, medical imaging was the most practical aspect of Metaverse used in healthcare.

Conclusion: The use of Metaverse in various healthcare fields is expanding rapidly. It is now used widely in other areas, such as medical interventions and the provision of health services; in medical images, it has many applications due to the fundamental change in the nature and quality of imaging.

1. Introduction

For decades, providing all types of health care has required face-to-face interaction between physician and patient. Some healthcare services that do not require the patient to be present, must go to a healthcare center and meet with their doctor [1,2]. It wastes time for the patient and the doctor and limits the provision of services to patients [2,3].

The advent of digital health services based on digital and Internet tools has affected physician-patient interaction [4]. Digital health solutions are on the verge of an unprecedented change due to augmented reality (AR) and virtual reality (VR) technology. Metaverse is a hypothesis of the next generation of the Internet that consists of decentralized and stable 3D virtual reality environments. This virtual world will be accessible through virtual reality headsets, augmented reality glasses, smartphones, PCs, and game consoles [5,6]. Thomason states in 2021 that the health care system has long been unsustainable under the pressure of chronic disease, rising costs, an aging population, inadequate health workforce, and limited resources. Digital health directly transforms care and becomes an important factor for change in health departments. The latest technology in facilitating health services is the

Metaverse phenomenon [7].

Metaverse has features that make it the next generation of the Internet. Due to this technology's three-dimensional space, users' real presence is associated, and the possibility of interaction and cooperation in its context is provided. Standardization is a vital feature of the Metaverse. The equipment and features are constructed according to a standard so that different Metaverse can interact with each other [6]. Metaverse has significant potential applications in the field of health care. For example, some of the most important applications are remote monitoring of patients needing intensive care, access to data, a better understanding of clinical outcomes (such as blood sugar and heart rate monitoring), and virtual follow-up of patients with COVID-19 [8].

Metaverse operated as virtual reality and augmented reality technology in cyberspace. It has great potential to improve surgical accuracy and therapeutic applications, facilitate social distancing, and more and more [9]. The main advantages of the Metaverse in healthcare and patient care can be placed in the following categories include virtual reality's growing role in medical training, digital therapeutic applications of the Metaverse, augmented reality in surgical procedures, how radiology can benefit from the Metaverse, using medical wearables in the Metaverse, mental health [10].

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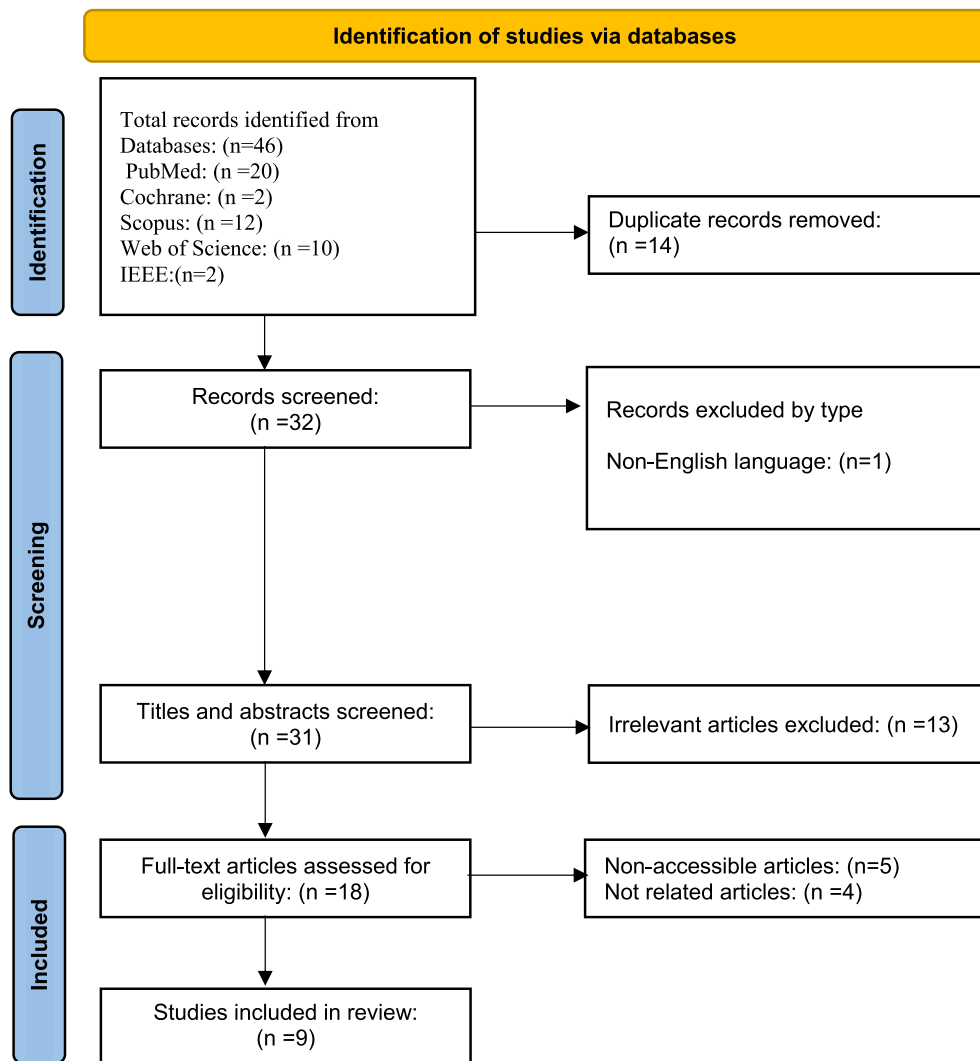


Fig. 1. Article selection process based on PRISMA.

Kye, in 2021 examines meta-transformers' characteristics: augmented reality, lifelogging, mirror world, and virtual reality. An example of augmented reality in medical education is the augmented reality shirt, which allows students to explore the human body as an anatomy laboratory. In addition, the spine surgery platform has been developed using augmented reality technology. The potential of the Metaverse as a new educational environment can provide a suitable space for establishing new social connections [10]. In 2021, in a study that analyzed and discussed Metaverse and sports rehabilitation information, Yang showed that sports rehabilitation that uses virtual reality and Metaverse games could activate the body and mind. It can help improve these people's brain and physical ability [11]. In their study, Holloway et al. cited Metaverse as the latest technology in the virtual world. These technologies show the results of interventions in the form of simulated tools and can increase knowledge of health, and they also ultimately improve the provision of care services. The main challenges to the wide acceptance of the virtual world in the healthcare profession are the lack of well-established privacy standards, interaction, and information distribution. This study provides recommendations for formal collaboration mechanisms, agreement on standards, future research approaches, and focusing on the virtual world [12].

Due to the growth of Metaverse technology in various fields and the importance of its use in health, the present study has been conducted to review and identify the application areas of this emerging technology in health, and it can be effective in the development of this field.

2. Methods

2.1. Search strategy and data sources

In this study, we tried to do a complete search by searching Web of Science, PubMed, Scopus, Cochrane, and IEEE scientific databases by combining topic-related keywords including "Metaverse" AND "health" OR "medicine" OR "medical," without time limitation up to March 2022. The study was based on scoping and systematic review guidelines [13]. The scoping review has three main parts: Population, Context, and Concept (PCC). Therefore, we formulated it based on the scoping review parts.

2.2. Inclusion and exclusion criteria

All types of studies about Metaverse applications and effects on health which their full-text published in the English language were included in the study. Studies about other technologies in health, such as virtual reality, articles about using Metaverse in other fields except for health, and other irrelevant articles were excluded from the study.

2.3. Data extraction

After selecting related studies, data extraction was done on a data extraction table designed in MS Excel 2019. This table has many data

Table 1

The features of included studies.

ROW	Author, year, country	Type of services	Application	platform	outcome
1	Xiaodan Yu et al. [14] 2012 USA	Improving the communication quality of telemedicine-based healthcare providers	the application of Metaverses for supporting effective collaboration and knowledge sharing in virtual teams. Virtual teams have been used in health/medical areas, such as home healthcare.	ICTs	With unique capabilities, Metaverses have great potential in supporting a socioemotional environment where effective collaboration and knowledge sharing can be achieved.
2	L. L. Locurcio [15] 2022 UK	Dental services training	1 Dental education in the Metaverse	–	This technology with more accessibility, no travel cost, and the benefit of moving from different sessions or booths are possible from anywhere in the world.
3	Bokyung Kye et al. [10] 2021 S. Korea	Providing dental services	2 Dentistry in the Metaverse 3 Pharmaceuticals	1Smartphones, vehicle HUDs	The Metaverse roadmap categorizes the Metaverse into 4 types: augmented reality, lifelogging, mirror world, and virtual reality.
4	Cho Hyun-Jae [16] 2021 S. Korea	Medical education	1Educational personnel	2Wearable devices, black boxes 3Map-based services 4Online multiplayer games	With the changes in perception and the advances in technology, non-face-to-face connections are possible, and the cost is very low.
5	Zhehui Wang [17] 2020 USA	oral health education	oral health education	1a Metaverse platform called Gether Town 2non-face-to-face platforms such as ZOOM.	The Metaverse roadmap categorizes the Metaverse into 4 types: augmented reality, lifelogging, mirror world, and virtual reality.
6	Huilyung Koo [18] 2021 S. Korea	Radiological imaging	Radiographic imaging and tomography (RadIT)	–	The latest thrusts of growth come from automation, machine vision, additive manufacturing, and virtual reality (the “Metaverse”). The fiveRadIT themes parallel their counterparts in optical IT. Synergies between different forms of RadIT and with optical IT motivate further advances towards multi-modal IT and quantum IT.
7	Zhen Liu [19] 2021 China	lung cancer surgery	Non-face to face training during the COVID-19 pandemic era	(an extended reality (XR) technology platform.) head-mounted display (HMD) and laptops	The Metaverse is expected to be actively used in medical education or education for residents and students in the future. The use of the Metaverse through tailored education and training in the COVID-19 era will be accelerated even in the post-COVID-19 period.
8	Maged N Kamel Boulos [20] 2008 UK	Aided therapy	Four major research areas of VR-aided therapy were identified and investigated, i.e., post-traumatic stress disorder (PTSD), anxiety and fear-related disorder (A&F), diseases of the nervous system (DNS), and pain management, including related medical conditions, therapies, methods, and outcomes.	–	This paper highlights that VR-aided therapy is effective for various medical conditions, and VR has advantages in customization, compliance, cost, accessibility, motivation, and convenience that highlight its potential in HC (Health care). These advantages enable VR technology to be integrated into a variety of therapies and help traditional therapies overcome the limitations of physical factors, which is important in the current context of the coronavirus disease 2019 (COVID-19) pandemic
9	Hyoseok Yoon [21] 2021 S.Korea	public health	Web 2.0 and GIS (Geographic Information Systems) for infectious disease surveillance’, ‘Web 2.0 and GIS for molecular epidemiology’	web	The web is rapidly evolving into a much more intensely immersive, mixed-reality and ubiquitous socio-experiential Metaverse that is heavily interconnected through various kinds of user-created mashups.
		Use in patient remote management	Medical and Surgical Telementoring applications	smart-glasses	This technology harmoniously fosters cooperation using the smart devices of mentors and mentees at different scales for collocated, distributed, and remote collaboration.

items such as type of services, application, platform, and outcomes of the Metaverse. Two authors compared the data extraction and the gathered data to identify the probable contradiction in extracted data.

2.4. Data analyses

After data extracting, we analyzed data through the content analyses method, and the results were summarized and reported in related tables

and figures.

3. Results

From 46 articles in the initial search, 9 were selected based on inclusion and exclusion criteria (Fig. 1).

Table 1 shows the selected articles’ specifications and features, such as the type of service, the platform, and the outcome of using Metaverse.

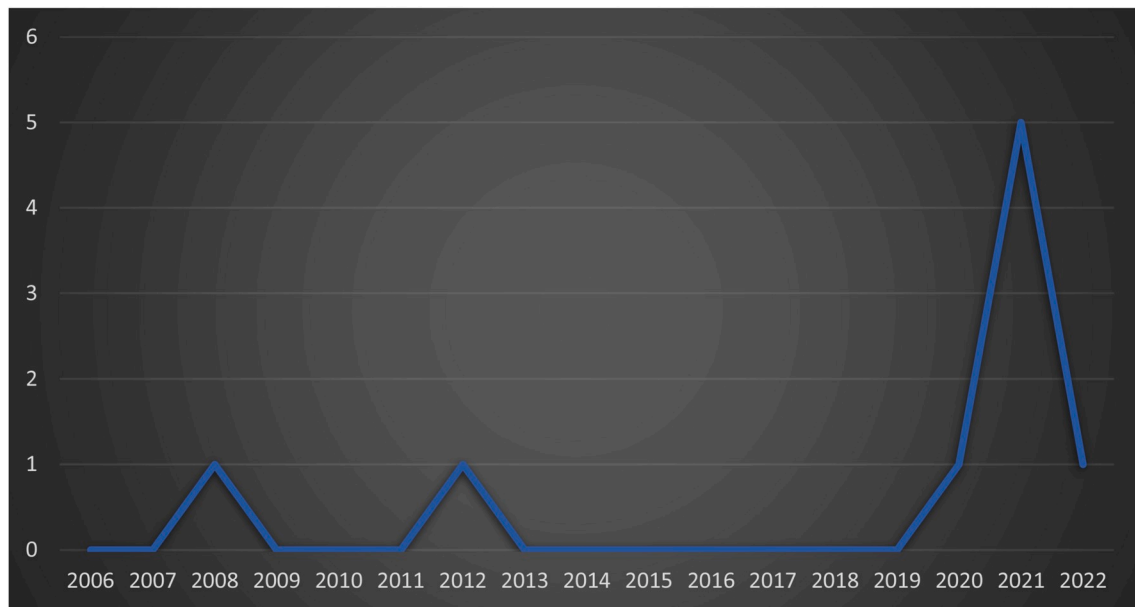


Fig. 2. Publication year trend of included studies.

Based on Table 1, the studies were designed in four countries, including South Korea had four articles (44.44%), and the UK, which with two articles (22.22%). The US has two articles (22.22%), and China has one article (11.12%).

Based on Fig. 2, most studies were conducted in 2021. This time trend shows a significant growth in conducting studies about Metaverse in health during recent years.

Based on Fig. 3, the main services that use Metaverse include educational, interventional, and communication services. Based on this figure, any service has some categories.

In Fig. 3, dentistry has the most use of Metaverse both in education and interventions. In dentistry interventions, dentists can use Metaverse in dental implants and other surgical interventions [16,17].

Other results show that medical imaging was the most practical aspect of Metaverse use in healthcare.

4. Discussion

Researchers have considered the use of Metaverse in health in recent years. Most studies were published in 2021. With this growing trend, it seems that we will see more use of this emerging technology in the health field in the coming years. Therefore, health system policymakers should consider expanding the infrastructure needed to use Metaverse in different areas. However, the study results indicate that many countries have not explicitly researched Metaverse in health or have not published the results of possible studies. It is suggested that other studies be conducted at different levels and in other countries to judge this technology more accurately.

The Metaverse is a step beyond education as a level above augmented reality. Beyond the capabilities, augmented reality can facilitate education for medical students by providing a three-dimensional environment closer to reality. In this context, there are possibilities beyond augmented reality, which is only a simulation of reality, and acts stronger in conveying emotions close to reality [10,16,22]. Therefore, it is suggested that in medical education, special attention be paid to the use of Metaverse, and that's why the authorities plan to use this technology.

One of the most valuable uses of the Metaverse is imaging. In this method, the specialists have prepared a 3D image of the desired limb or arm using the metatarsal capabilities, which the specialists can interpret much more quickly. This technology also needs more attention and use

in this field [17]. These images sometimes have a high volume, and sending them may be disrupted, so the dependency of usability on it is a faster platform than the Internet with the ability to transfer more information and radiological images at higher speeds that can be used.

One of the main challenges in providing remote health services is managing communication between service providers and recipients [23]. Metaverse can provide conditions that allow more effective and interactive communication through the ability to understand people's emotions more deeply. It is a matter of consideration for people to understand each other and the work done; the Metaverse provides the feeling of being closer to people at a distance by creating a space similar to the real environment [14,21].

The study results show that one of the areas in which Metaverse was used was dentistry, which teaches both students and dental professionals, and oral health education [16,22]. By providing the ability to provide 3D digital images, this technology in dentistry can provide the basis for improving the provision of dental interventions and be a proper response to the future needs of this part of health services. It is suggested that special attention should be paid to the use of Metaverse in the field of dental services, including diagnostic and therapeutic services and educational services. More studies should be done in this field as a new research field.

5. Conclusion

Metaverse technology, if accompanied by real innovation to meet people's perceptions and expectations, will revolutionize the performance of health care soon. Ultimately, institutions must understand how to create this technology safely for the patient and meet the human aspects. Also, the potential of the Metaverse in the topic of education can create a revolution in students' medical education and public health. While augmented reality technology has unlimited prospects in healthcare, it must be developed in a way that goes beyond the human relationship between patient and physician.

The use of Metaverse in various healthcare fields is expanding rapidly. It is now used in other areas such as medical interventions and health services. Metaverse in Medical images has many potential applications due to the fundamental change in the nature and quality of imaging.



Fig. 3. Type of Metaverse services.

Ethical approval

This study does not need any ethical committee approval and patient consent.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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