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The Metaverse Technology in Medicine, Public Health, Nursing, and Dentistry: A Comprehensive Review

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ABSTRACT

Introduction: *There is a lack of direct investigations on metaverse technology in the health area. Metaverse technology comprises several technologies that collaborate and continually improve. Some of the technologies mentioned include artificial intelligence, augmented reality, virtual reality, social networks, blockchain technology, , and avatar.*

Aim of work: *To provide an in-depth assessment of the metaverse application in the field of health.*

Methods: *The MEDLINE database's electronic literature was searched using the provided search terms: Health, medicine, nursing, dentistry, metaverse, and technology. The search was limited to publications between 2021 and 2024 in order to identify relevant material. Relevant search terms were utilized on Google Scholar to locate and explore relevant scholarly articles. The selection of papers was guided by certain inclusion criteria.*

Results: *The publications included in this study were published from 2021 to 2024. The study was organized into several sections with particular headers in the discussion section.*

Conclusion: *Virtual and augmented real[1]ity technologies are acknowledging themselves as part of the metaverse under the heading of augmented reality. Such applications are particularly useful for complex processes that need trial and error, like those that come up in the medical field.*

The mechanical resolution of touch is a significant advancement in the field of metaverse technology, and it was honored with the 2021 Nobel Prize for its contributions in physiology and medicine. This is on top of the incredible technical advancements that are linked to it, such computer networks, haptic devices, sensors, computer vision, blockchain, and computer vision. There may be many real-world uses in the metaverse, based on past experiences and projected

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advancements in the field. Among the industries most affected by this link is the health care sector.

Keywords: *metaverse, technology, medicine, health, nursing, dentistry.*

INTRODUCTION

The burden caused by chronic diseases, growing health-care costs, an aging global population, a shortage of workers for high-demand health services, and few resources make the health system unsustainable in the long run. We must be able to use cutting-edge technology to transport health services from hospitals to our homes, rather than only utilizing it for conventional health care. Significant changes in the medical field have been brought about by the Covid-19 epidemic, which has inspired physicians to look for innovative approaches to provide remote treatment to outpatients (Thomason, 2021).

The essential and vital technology for the Metaverse structure include , augmented reality (AR), artificial intelligence (AI), virtualreality (VR), computer vision, blockchain, edge comp uting, computer networks, and the internet of things, hardware infrastructure, and robotics. The metaverse, which has the ability to significantly alter every sector in some manner because to the technology it integrates into health care and the vast technical breakthroughs that are its stakeholders, could potentially bring about a revolution and a big transformation. Experts across several domains might use VR and AR technologies to ready themselves for unforeseen circumstances or refine their existing abilities and proficiencies. One crucial sector where this technology is being used widely and successfully is the health sector (Damar & Damar, 2021).

Governments in America, Asia, and Europe invest a great deal of money in R&D. In the months following the outbreak of pandemics like COVID-19, the need of integrating these innovations into educational procedures has increased. Communicating face-to-face becomes harder when Covid-19 spreads, yet formerly offline activities quickly transform into VR and extend to the education, healthcare, fashion, and other sectors (Kye et al.,2021).

According to Jeon (2021), universities are working to prepare students for the demands of the fourth industrial revolution by creating curricula that are relevant to the requirements of society and that foster problem-solving skills. They said that they are making an effort to use the best teaching-learning strategies. In this sense, Seoul National University's anatomy course used metaverse as a teaching tool, requiring students to use VR and AR technologies to learn about and practice human anatomy. The advancement of technologies including mixed reality (XR), VR, AR in addition to wearables, immutable tokens (NFT), blockchain, and the internet of things, according to Türk et al. (2022), planted the metaverse's seeds. They said that there will be no limits to inventiveness in the metaverse. It's also crucial to note that we don't sure whether the metaverse will consist of a single universe or several. Facebook is already making rapid progress in creating its own metaverse. It's possible that Microsoft and Google will create their own Metaverses in the same way. In the Metaverse, any significant tech corporation could own distinct platforms, product families, formations, and product groups (AĞIRMAN & BARAKALI, 2022).

The internet of things, artificial intelligence, VR, AR, edge computing, and other technologies will make it possible to use metaverse technology in the medical field. Numerous industries, including education, research, healthcare, rehabilitative services, and clinical applications, employ these technology. Integration of the metaverse has numerous prospects and will be advantageous (YILMAZ et al., 2022).

The importance of VR and AR is growing daily, thus it's critical that health professionals discuss them. Furthermore, it is obvious that students, trainers, professionals, and researchers in a range of medical fields, including medicine, dentistry, and nursing, would find studies that

include contemporary technology and demonstrate how they connect to and benefit the sector helpful. The research examines the potential impacts of metaverse technology on health education and its fields of application, with a particular emphasis on health studies. as it will illustrate the state of technological advancement in the metaverse as it is now in the field of healthcare, the research is regarded to be significant. From the perspective of scientific research, people are curious about how technology may impact health processes and what possibilities it may provide. They are additionally interested to know what this industry's prospects are.

AIM OF WORK

To provide an in-depth assessment of the metaverse application in the field of health. The scope encompasses current metaverse technologies, future prospects, and the implications of these innovations on healthcare delivery.

METHODS

Using various keywords (Health, medicine, nursing, dentistry, metaverse, technology), scientific websites (Google Scholar and Pubmed) were searched to retrieve all relevant publications. A set of selection criteria was used to determine which papers were chosen. After reviewing each paper's abstracts and significant titles, we eliminated case reports, duplicate articles, and articles without complete text. The reviews that this study looked at were released between 2019 and 2024.

RESULTS

Studies on the metaverse technologies and the implications on healthcare delivery between 2021 and 2024 were considered in the current investigation. Consequently, the review was published under several topics in the discussion section, including **The Metaverse Platform, Current Metaverse Platforms in Healthcare and Metaverse Technology in Public Health, Medicine, Nursing, and Dentistry.**

DISCUSSION

The Metaverse Platform

The metaverse is a digital replica of the actual world, according to Koo (2021). According to Lee & Kwon (2022), it has progressed beyond state-of-the-art technology, allowing users to experience lifelike VR and computer-generated virtual environments. Werner et al. (2022) claim that the idea of a "metaverse," which is a network of virtual spaces where individuals may interact with digital items, adds a lot of new components to medical communication. Eight components were used by Matthewball & Ball (2021) to map the evolution of the metaverse: digital platforms, hardware, networking, computation, exchange technologies and standards, metaverse content, products and services, payments, assets, and user behavior patterns. The following are the layers that make up the Radoff (2021) model: Decentralized governance; infrastructure; user interface (VR tools, mobile devices, blockchain, wearables, etc.); spatial computing (VR, AR, spatial mapping, motion recognition, etc.); producer economy (digital exchanges, design tools, commerce); and exploration.

The Metaverse is a realistic-looking, artistically rich virtual world where people may play, shop, work, and socialize. It's a network of virtual settings in three dimensions with a social interaction hub. A metaverse platform is a virtual environment that enables developers to create anything from AR to VR. The technology category known as Metaverse has come a long way,

and it is continuing to develop as a result of investments from significant players in the industry including Microsoft, Epic Games, and Meta Platforms (Kim & Kim, 2024). According to Damar (2022), the blockchain technology powers the Metaverse VR platform.

The word "metaverse" describes a network of three-dimensional virtual environments that people may access via AR and VR (Mick, 2023). Applications for VR and AR have dubbed themselves inside the metaverse, especially in key medical settings for treatments that are too important and complicated to be completed by trial and error. As on Ağırman & Barakalı's 2022 forecasts, The market for metaverse is anticipated to grow from a value of $45.5 billion by 2019 to a total of $1.5 trillion in 2030. The firms that introduced the Metaverse and guaranteed its quick expansion were Decentraland, The Sandbox, Roblox, Cryptovoxels, Bloktopia, Somnium Space, and Meta Platforms. For instance, Roblox is a well-liked platform for both kids and adults, and it has over 20 million games created on it. Decentraland, a 3D VR environment, is powered by the Ethereum blockchain. To create the SAND money and a virtual Mega City in Sandbox, it is working with many partners in the banking, real estate, gaming, entertainment, and Hong Kong film industries (Schöbel & Leimeister, 2023).

Current Metaverse Platforms in Healthcare

Technologies related to VR, AR and XR have promise for raising the efficacy and standards of health education. By using these tools, healthcare professionals may practice in a safe setting without worrying about negative outcomes. It provides its customers with high-quality, reasonably priced interactive learning (Logeswaran et al., 2021). Metaverse has great promise for use in medical care. Surgeons may get real-time advice in their range of vision using immersive surgical process simulators. AR improves surgical accuracy and adaptability by projecting information into a sterile area of the operating room. Concurrent teaching, training, and planning as well as cooperative medical procedures will be made possible by metaverse (Thomason, 2021).

It is possible to successfully digitize and implement a large number of healthcare service apps across various platforms, owing to the Metaverse ecosystem. Future XR application integration with the metaverse in health institution service delivery will allow institutions to identify potential issues early and do proactive evaluations to prevent damage (Yılmaz et al., 2022). Future applications of the metaverse to augment, refine, and perhaps revolutionize health care are explored. The five subjects covered are profit, clinical treatment, education, collaboration, and well-being (Thomason, 2021). According to Sandıkçı's (2022) predictions, VR is expected to have a noteworthy impact on the health industry in terms of medical applications. Additionally, it is expected to create a sizable market in the healthcare sector. They also said that as technology developed, costs will go down and more research might be done in this area. Hawks & Krasniansky (2022) categorize digital applications of health into two classes inside the metaverse ecosystem.

Metaverse Technology in Public Health, Medicine, Nursing, and Dentistry

In their study, Ifdil et al. (2022) noted that the metaverse has gained popularity, that mental health specialists can benefit from its opportunities, and that VR in the metaverse could provide an alternate means of addressing the COVID-19 pandemic's mental health issues for future mental health assistance professions. Post-traumatic stress disorder (PTSD), fear-associated disorder, nervous system disorders, and anxiety and other nervous medical difficulties are the four key study areas for VR-assisted treatment. Liu et al. (2022) used the bibliometric methodology to analyze the approaches and results of these therapies. He emphasizes the

promise of VR in healthcare, stressing its benefits in terms of simplicity of use, cost, accessibility, reward, and customization. Additionally, he mentions the benefits of VR-assisted treatment for a variety of illnesses. The aforementioned advantages facilitate the integration of VR technology into various therapeutic approaches and aid traditional treatments in surmounting the limitations imposed by physical factors, which have particular significance in the current COVID-19 pandemic. They stated that Health 4.0 and possibly the exciting future vision of the Health Metaverse will be simpler to attain because to VR's potential.

It has long been believed that a student's feeling of presence—their sensation of being there—is crucial to both effective learning and appropriate patient care, according to Locurcio (2022). He argued that a more comprehensive version of the "old" telemedicine experience might be implemented, especially considering the last two years of forced social isolation. Furthermore, according to his study, dental education in the metaverse is a way for individuals to interact with one another and their environment by extending the use of the internet. They stated that the application of other technologies, including VR and AR, also makes this engagement feasible. He underlined that even though these circumstances could seem remote from our everyday educational experiences or limited to research facilities, they are a reality for addressing challenging scientific problems.

According to Kurian et al. (2022) study on dentistry in the metaverse, dentistry will soon be more heavily involved in medical health applications inside of metaverse technology. We could soon have dental telemedicine discussions in a virtual metaverse where patients get dental advice from avatars. We may also see in your real-time perspective that you have completed a root canal, the placement of the implant, and the precise location of the implant of bone in surgery because of x-ray or 3-D images of the canal structure. Among the metaverse technology's greatest benefits according to Kurian et al. (2021), is increased accessibility. It can make it easier for those with low incomes to access dental care, and it also has the added benefit of allowing participants to attend sessions from any location in the world without having to pay for travel. A number of dental education situations may be created, which is advantageous for enhancing teaching models. Second Life took on the role of the virtual world, while Google Earth performed the role of the mirror reality. The researchers evaluated the practicality of a project like creating virtual situation rooms for public health and emergency management and disaster management using Second Life and Google Earth in real time. Through the usage of the deployed apps, it enables users to see, engage with, and even navigate the built environment. In the near future, many applications would be interested in the strategy of integrating the virtual world and the three-dimensional environment on such platforms, particularly in view of Mark Zuckerberg's declaration and meta rebranding (Photiadis & Papa, 2023).

The pleasure of living in a three-dimensional virtual setting is the same as that of being in real life, claim Garavand & Aslani (2022). Furthermore, they asserted that two individuals or avatars could easily recognize and appreciate one other's presence in this virtual setting. They claimed to be able to understand other people's capacities. Using period-appropriate technologies, researchers examined how to develop Web GIS apps for infectious disease monitoring. Millions of dollars are spent by social VR users on virtual products and services every year, however there are significant issues with reliability, confidentiality, and safety, according to a study by Shen et al. (2021). Employing metaverse technology, an experimental evaluation of alpha generation consumers who try on and buy cosmetic products in-person in the cosmetics industry was conducted by Lee & Kwon (2022). The goal is to make use of the metaverse as a notable tool for marketing by understanding how customer wants are changing in large markets, such as the cosmetics sector.

According to Koo et al. (2021), the global coronavirus pandemic has made it more challenging to provide medical education across international boundaries. In particular, it is now almost hard to see surgeries in order to witness and get knowledge about advanced medical technology that is brought from outside. They used AR and metaverse to perform an educational practice study in pulmonary cancer operation at Seoul National University Bunag Hospital in Korea's smart operating room. In their research, they spoke about possible future uses for this technology in the field of medicine and detailed a metaverse training course that happened in Korea. This training course offers an example of XR implementation by combining AR and VR. They said that COVID-19 has reduced the opportunities for students to engage directly with patients and that it is difficult to give appropriate surgical training using currently accessible video conferencing tools like Zoom.

Kim (2022) discovered via their research that there is hardly any historical precedence for this kind of intense interest in a newly developed technology. The rapid development of information technology over the last several decades is said to have persuaded society that the metaverse may emerge swiftly. VR, AR, NFT and spatial networks are some of the fundamental ideas of the metaverse. The Metaverse seeks to enable interaction among many people by constructing a virtual three-dimensional environment that closely mimics the real world via the use of specialized devices. Huh (2022) looked at how the Korean Medical Licensing Examination used computerized assessment in the metaverse. They assert that the application of mirror universes, AR and VR and lifelogging has skyrocketed in the last few years. Kye et al. (2021) divided information into four distinct groups: AR, lifelogging, mirror world, and VR with the goal to highlight the potential and constraints of the metaverse for applications in education. The most popular and actively used technology among the four interrelated areas of metaverse education is a form of VR. The latest era of nonface-to-face communication has been characterized by the broad adoption of VR, which can be accessible from any location. Furthermore, he maintained that there are many opportunities in the emerging field of social communication known as the metaverse. Understanding head movement is important for modern problems such as virtual reality, metaverse systems, and non-contact systems.

In their investigation, Ionut-Cristian & Dan-Marius (2021) examined the technical literature published over the preceding 10 years about head motion tracking devices that use inertial sensors. An overview of head motion tracking systems that use inertial sensors is given in this publication. The relevant literature offers applications for wearable device-based head activity and movement detection in a range of domains, such as medical, recreational activities, sports education, and health surveillance. Human behavior recognition and categorization is a major aspect of the metaverse. The healthcare sector, which is currently using AR resources, would greatly benefit from this next technology advancement (Castro et al., 2022).

According to Werner et al. (2022), Metaverse is being used in gynecology and fetal medicine. With the objective of facilitating cooperative movement inside a three-dimensional organ and observing an imaging array of two-dimensional crosssections, the project trains specialists from many domains in interdisciplinary talks that occur in real time and across geographical borders. They claimed that they were interested to include adjustable features. According to Werner et al. (2022), the metaverse has great potential as a digital tool to assist students in developing their comprehension of intricate gynecological illnesses and prenatal abnormalities, in addition to enhancing their capacity for working in interdisciplinary teams. It may thus be effectively used as a teaching tool.

Liao and Kang (2022) assert that ambient assisted living (AAL) has garnered increasing academic interest over the last 10 years due to population aging and the proliferation of internet and mobile technology. In recent years, families and assisted living institutions have also come

to choose smart care. Additionally, they pointed out that "above science" represents the extreme of AAL, where scientific technologies significantly outweigh human functions. This not only puts older people's health at risk but it makes the dysfunctions worse by ignoring their demand for independence and value. Therefore, rather than creating a mix of computerized instruments that are linearly organized, making a web ecosystemshould be the goal of AAL.

Yilmaz et al. (2022) state that excessive use of metaverse applications may result in a number of negative outcomes, such as social isolation, virtual addiction, behavioral issues, and elevated anxiety and stress. Kuş (2021) claims that although metaverse technology presents a plethora of opportunities and strategies for collaboration, education, economic growth, and the arts and culture, it also poses a number of risks and raises a number of concerns that are reminiscent of those brought up by previous technologies. He listed the following risks: rapidly advancing technology; profit-driven technical initiatives; humanity's incapacity to keep up with these developments; and the veracity and quality of information in the social and virtual domains. Despite the fact that metaverse technology provides safety in the virtual economy, trust in the secure storage and display of data, and security in terms of the technologies it contains, there are, and likely always will be, questions because of its commercial nature. Additionally, after the arrival of Mark Zuckerberg, the inventor of Facebook (Damar, 2021), this idea has gained increasing traction (Milmo, 2021). Facebook's track record is concerning, however, because of the problems it has already caused its users (Story et al., 2021). The study's emphasis is on metaverse technology and the health sector. As a result, there is no question that data security in this industry is much more quality-sensitive. According to Mamun (2022), healthcare organizations will benefit more from private/proprietary blockchains than from publicly accessible blockchains since they need authorization to join the network.

Hawks & Krasniansky (2022) declared their optimism about the metaverse's potential to improve availability of therapeutic settings and estimate probability prior to treatment choices, therefore lessening the strain on patients' actual lives. Their specific areas of study were how these solutions may improve interactions among communities on the internet, remove barriers to social isolation for the elderly and handicapped, and enable research engagement. Tong et al. (2022) address a few of the various arguments in favor of incorporating emotional and social interactions into health-related technology. These communication strategies are crucial for improving both medical results and patient happiness, much like human-to-human encounters. Second, hitherto unthinkable opportunities for healthcare are presented by the development of patient-centered technology. It is possible to create systems that can negotiate daily treatment regimens, attentively listen to patients, give information and confidence, and be available from home. In addition, it may be possible to create technologies that track the hospitalization of a patient while offering them access to both the functional and psychological parts of human care. Technologies that closely mimic the methods of communication of medical personnel in certain contexts may be used in teaching and interaction studies. There are indications of early development and creativity in digital health, even if technological advances from the metaverse are not commonly used yet. For example, $198 million has been granted to eleven digital health projects in the United States that use VR or AR technologies. This represents around 1% of total medical costs. Eight agreements will benefit this area with 93 million dollars in 2020 (Hawks & Krasniansky, 2022).The wide range of settings and uses for digital healthcare in the sector may be seen as strong indications that the area will grow significantly in the next years. Metaverse-based technology is seen as both beneficial and essential, especially in studies where accurate student involvement is essential in a realistic setting yet student recurrence is challenging.

Dengel & Pirker (2021) separate their efforts in the VR space into two primary categories. Beginning with research to assist certain careers or pastimes, such virtual product development and medical simulation. Second, as with haptic feedback gadgets, attempts to improve and develop the technology itself are evident in the creation of pleasing, high-quality displays and quick, precise three-dimensional viewers. VR systems provide superior quality 3-D images, making them perfect for pre-operative planning, education, and medical imaging. Because VR apps completely cover the users' eyes, they are perfect for clinical settings where doctors do not need to inspect the state of the patient or surroundings (Morimoto et al., 2022). It will be useful in nursing education as well as other health-related disciplines. According to Barteit et al. (2021), virtual reality (VR) is a technology that enables users to communicate with and modify computer-generated, 3-D multimedia environments in real time, providing them with information relevant to their therapy requirements.

In their study, Pawassar & Tiberius (2021) pointed out that AR, or VR, has been the subject of extensive research in the field of health, and that during the past ten years, as cost reductions and advancements in technological innovation have come down, the VR technology use in healthcare has been growing over time. However, significant clinical databases like Medline and Psycinfo show that VR research is expanding rapidly. The use of Metaverse technology was suggested by Mozumder et al. (2022) in their investigation on smart hospitals and clinics. One may argue that countries like Turkey, who invest a lot of money in their health infrastructure, should give smart healthcare institutions top priority within the medical field and take proactive measures to fully use the technology of the metaverse.

Yilmaz et al. (2022) state that creating these technologies for the health sector requires extensive training for medical personnel, and that using them in the metaverse may need highly specialized training. An alternative strategy would be to include courses on metaverse technology into the curricula of health-related professions like medicine, dentistry, and nursing. The curriculum may include a wide range of subjects, including VR application creation, domains for health applications, and extended reality. The aforementioned could promote the quick adoption of new technologies by medical professionals should it become broadly accessible.

CONCLUSION

As part of the review, general trends in published research and metaverse investigations in the health field were provided. Only research pertaining to health was evaluated, and the articles that were received were related to the study disciplines of health. Applications specializing in virtual or augmented reality have positioned themselves as providing augmented reality inside the metaverse. These kinds of applications are common in the medical field and in challenging but important processes that need to be carried out via error and trial. One of the greatest accomplishments in the field has been the mechanical resolution of the sensation of touch, which was acknowledged with the Nobel for Peace in Physics in 2021. This is in addition to the amazing advancements made in a number of related fields over the past few years, such as computer vision, haptic devices, blockchain, computer networks and sensors . As the subject advances and on the basis of past experiences, many real-world applications may someday be translated to the metaverse setting. This discovery, for which the Nobel Prize was given, is thought to improve the degree of reality perception that haptic technology is able to capture as well as the feeling of reality in the metaverse domain. One of the sectors that this link will most likely have the most effects on is the health sector. Newly graduating health professionals' skills and capacities must be improved due to the ever-increasing need for health personnel and the rapid creation of new departments and programs to meet this requirement. Health care personnel have a lot of opportunities to improve their education because to the infrastructure

and opportunities that Metaverse technology offers. In particular, augmented reality technology has developed into an indispensable tool that functions as virtual reality and augmented reality together in the metaverse. It has been discovered that metaverse studies are usually conducted as simulation-based studies or in conjunction with augmented reality or virtual reality research in the health literature. This claim is backed up by virtual reality studies on nursing, one of the most important professions in the health sector, and Damar & Damar's (2021) assessment of augmented reality. They claim that a lot of study has been conducted regarding patient and student education, especially in the nursing area. Providing learners with access to educational resources that improve their learning processes as often as their area of study demands is the ultimate objective of this research. Additionally, technology has a significant impact on how competence and knowledge are developed. This contribution is done by observing their behavior and searching for process errors.

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