The Redefinition of mHealth Applications in the Metaverse

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***Abstract*— The term "mobile health" (sometimes spelled "mHealth" or "m-Health") refers to the delivery of medical services via smartphones, tablets, PDAs, and PCs. The metaverse combines the real world and the virtual world, allowing people to interact with their avatars in a setting supported by cutting-edge technologies like high-speed internet, virtual reality, augmented reality, mixed reality, extended reality, blockchain, digital twins, artificial intelligence (AI), all of which are enhanced by practically limitless data. This paper discusses how these technologies might be used in digital medicine in the future, as well as the potential of the medical metaverse. This qualitative study examines and evaluates past articles and websites. The healthcare business depends heavily on physical connection, eye contact, facial expressions, and gestures, which the metaverse can simulate virtually. However, the metaverse may be viewed as a tool to improve the effectiveness of the healthcare system in terms of intervention and treatment, worldwide education, assuring consistent training, and assisting in the development of global databases for research. Finally, the metaverse may be a location where young people can start practicing and acquiring new skills considering how much time they spend in front of screens.**

Keywords—metaverse, mHealth, mobile health, applications, medical metaverse, Internet of Medical Things

I. Introduction

The term "mobile health" (sometimes spelled "mHealth" or "m-Health") refers to the delivery of medical services via smartphones, tablets, PDAs, and PCs. The metaverse combines the real world and the virtual world, allowing people to interact with their avatars in a setting supported by cutting-edge technologies like high-speed internet, virtual reality, augmented reality, mixed reality, extended reality, blockchain, digital twins, artificial intelligence (AI), the internet of medical devices, robotics, quantum computing, etc. Tthrough which new approaches to delivering high-quality healthcare treatments and services can be investigated [1][2].

The quality and delivery of healthcare services have considerably improved due to the continuous development of mobile health applications. The market for mHealth mobile applications is quickly developing, offering flexible alternatives for the comfort of both patients and caregivers. The global mHealth application market is anticipated to reach US$102.35 billion by 2023, according to a report released by Research and Markets [3]. In addition, 53,054 mHealth applications were accessible through the Google Play store within the first quarter of 2021, according to Statista. In the first quarter of 2021, there were 53,979 iOS medical apps available in the Apple Store [3]. These figures demonstrate both the growing acceptance of mHealth mobile apps among consumers and the rising popularity of mobile health technologies.

For example, chronic disorders including chronic obstructive pulmonary disease (COPD) and obstructive sleep apnea-hypopnea syndrome (OSAHS) are still challenging to manage in the present healthcare system due to issues like unequal resource distribution, poor follow-up, overworked specialists, etc. These problems might be solved by metaverse medical platforms that use cutting-edge AI technology, like large-scale digital twins [4].

Several cutting-edge technologies are entering the healthcare sector. However, the development of creative mHealth applications can be greatly aided by the following three technologies: Blockchain Technology, Artificial Intelligence (AI), and the Internet of Medical Things (IoMT) [5]. In this article, we talk about how these technologies might be used in digital medicine in the future, as well as the potential of medical metaverse applications. We will also provide examples of applications already implemented or in the process of being implemented and discuss their integration with the metaverse as well as the challenges and limitations of these applications.

The paper presents a literature review of state-of-the-art research in medical health related technology in section II. In section III we will define the methodology of the process for acquiring and filtering the papers under consideration in this research. Section IV presents the results and findings, followed in section V a full discussion summarizing these findings. Later in section IV a final conclusion is provided.

II. Literature Review

Internet-based applications for mobile devices that assist medical and health-related tasks are known as mobile health applications. Mobile health has been shown to affect consumers' health behaviors, including physical activity, diet, alcohol, sexual behavior, and medication adherence. It can also help manage health conditions, including diabetes, asthma, depression, hearing loss, anemia, and migraine. However, the market of mobile health applications is still developing, even with their recognized benefits [6]. The term "metaverse" refers to a new version of the internet that combines the real and virtual worlds through the use of avatars, blockchain technology, and virtual reality headsets

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[7]. The launch of Horizon Worlds by Meta Platforms in 2021 and the idea that the metaverse may influence many aspects of our work and social lives has sparked a growing amount of discussion and debate among academics and practitioners about the many societal implications for many people all over the world [8]. Avatars and holograms may be used to work, engage, and socialize via simulated shared experiences in the new metaverse idea, according to Mark Zuckerberg. This ecosystem is described as a seamless integration of the real and virtual worlds for users. Organizations are beginning to evaluate the metaverse's potential and how to incorporate it into their current business structures [9]. Marketing, tourism, leisure and hospitality, citizen-government engagement, health, education, and social networks are just a few of the industries that may drastically change if organizations were to adjust their business models and operational capabilities to operate in the metaverse. The seamless movement between the physical and virtual worlds and the multimodal augmentation of our experiences and interactions enables an infinite range of options for anyone who chooses to interact with the metaverse in the future, many of which may be beyond our current understanding [7].

The pandemic condition made actual life difficult; as a result, online versions of activities like education, healthcare, fashion, and shopping replaced solely offline ones. According to us, the metaverse is a location where people will spend a portion of their lives using services and amenities, not only a haven to escape the bustling world and enjoy a leisurely existence. New technologies that enable us to be a part of this online world around the clock and from anywhere have made it possible for us to connect with the metaverse. These include smartphones and smartwatches, the latter of which offers the potential for self-management of chronic conditions, nursing or home-based care, as well as healthcare education and physical activity tracking [10].

The management of CVDs such atrial fibrillation, heart failure (HF), and myocardial infarction as well as rehabilitation are made easier by mHealth interventions. With the combination of mHealth technologies and ECG monitoring made possible by technological advancements, patients with myocardial infarction can now get close treatment and emergency care. In terms of lowering the rates of CVD events (2/3), hospitalization (6/10), death (4/7), and exercise capacity (3/4), telemonitoring for HF has been found to be superior to conventional treatment. It may also encourage behavioral changes or medication adherence. A different comprehensive analysis found that telemonitoring significantly lowers the chances of all-cause death (RR=0.60, 95% CI: 0.45-0.81) and HF-related hospitalizations (HR=0.86, 95% CI: 0.61-1.21). From several comparisons, the absolute RR ranged from 1.4% to 6.5% and from 3.7% to 8.2%, respectively. A growing body of research exploring the health economic effects of mHealth treatments for the management of CVD has revealed that these interventions can prolong years of quality-adjusted life compared to traditional therapy [14].

Technology	CVD risk factors*	CVD events	Hospitalization	Mortality	QoL	Exercise capacity	Adherence
Multicomponent mHealth interventions	1/2 (+)	-	1/1 (+/-)	-	1/3 (+)	1/2 (++)	1/3 (++)
	1/2 (+/-)				1/3 (+/-)	1/2 (+/-)	1/3 (+)
					1/3 (-)		1/3 (+/-)
Web-based technologies	2/3 (++)	3/3 (+/-)	1/5 (++)	4/4 (+/-)	2/3 (++)	2/2 (++)	1/1 (++)
	1/3 (+)		4/5 (+/-)		1/3 (+/-)		
Mobile applications	2/2 (+/-)	-	-	-	-	-	2/2 (++)
Telecom services (SMS, telemonitoring program, etc.)	1/6 (++)	2/3 (++)	6/10 (++)	4/7 (++)	2/6 (++)	3/4 (++)	13/15 (++)
	3/6 (+)	1/3 (+/-)	4/10 (+/-)	3/7 (+/-)	1/6 (+)	1/4 (-)	2/15 (+/-)
	2/6 (+/-)				3/6 (+/-)		

Fig. 1 (+/-): No distinction; (-): inferior to control group; (+): superior to control group with significance (P 0.05); (+ +): superior to control group without significance. include low-density lipoprotein, body mass index, weight reduction, and quitting smoking. cardiovascular disease (CVD), mobile health (mHealth), and quality of life (QoL); Short Message Service (SMS) [14].

An interesting study conducted in Ghana, showed how different illnesses are treated and managed with mHealth applications (*Fig. 1*). Only a small number of medical professionals, however, utilize mHealth to help treat other diseases such diarrhoea (17.9%), cancer (5.27%), chronic respiratory illness (2.1.08%), and stroke (0.0%). The majority of healthcare workers also use mHealth to diagnose diseases (182, 98.38%), treat and manage disease problems (162, 87.57%), and treat and monitor patients' health conditions (144, 77.84%) in addition to searching for medical information (117, 63.24%) [15].

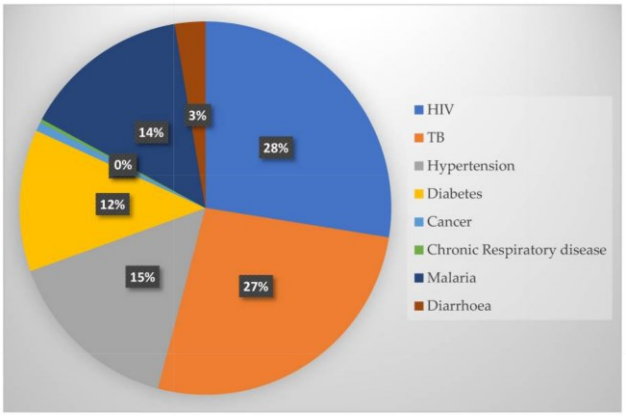

Fig. 2 Different illnesses are treated and managed with mHealth [15].

Critical uses of Health Metaverse include telemedicine and online health management. They place more emphasis on Health Metaverse privacy in the administration of individual diagnosis and treatment data than socialized openness. (*Figure 2*) displays an overlay visualization of five years' worth of writings on the Health Metaverse's digitalization viewpoint, with VR as the keyword. The picture identifies the major terms from the standpoint of digitalization, including VR, mental health, education, rehabilitation, and physical exercise. The studies on stress, anxiety, pain, depression, obesity, and stroke is where the keywords are most frequently found [16].

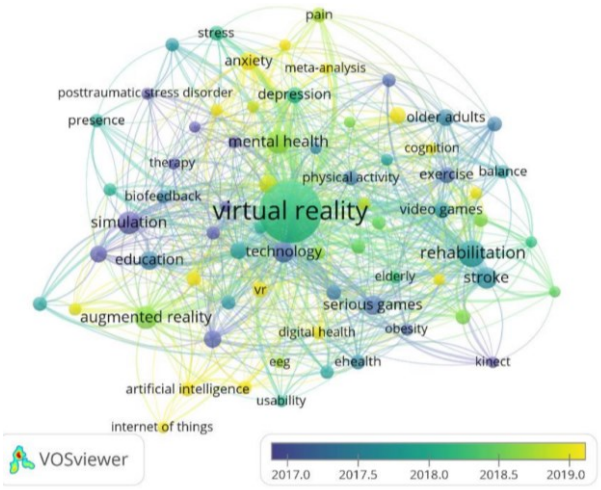

Fig. 3 Visualization of five years' worth of writings on the Health Metaverse's digitalization viewpoint, with VR as the keyword [16].

The complex developmental condition known as an autism spectrum disorder (ASD) is characterized by persistent difficulties with speech, nonverbal communication, social interaction, and limited or repetitive activities. ASD is characterized by impaired social functioning, which frequently needs lifelong therapy. A paper anticipates that doing the peer program in the metaverse will help children with ASD become more socially adept [11]. Studies have shown that PEERS programs dramatically reduce ASD symptoms while enhancing general social abilities, frequency of social interaction, and social skill knowledge. Additionally, earlier research has demonstrated the value of an additional 16 weeks of follow-up monitoring, suggesting that the program is successful in terms of both treatment efficacy and durability[11].

A recent description of the Metaverse in Medicine, put out by Professor Chunxue Bai and colleagues, describes it as the medical Internet of Things (MIoT) made possible by AR and/or VR glasses [12]. Applying a metaverse platform, made up of AR and VR glasses and the MIoT system, and integrated with the technologies of holographic construction, holographic emulation, virtuality-reality integration, and virtuality-reality interconnection makes it possible to implement the three fundamental MIoT functions, namely, comprehensive perception, reliable transmission, and intelligent processing. In other words, we will be able to conduct medical education, scientific popularization, consultation, graded diagnosis and treatment, clinical research, and even comprehensive healthcare in the metaverse through interactions between virtual and real cloud specialists and terminal doctors. Various medical services, such as disease prevention, healthcare, physical examination, disease diagnosis and treatment, rehabilitation, management of chronic diseases, in-home care, first aid, outpatient attendance, consultation, etc., could be facilitated by the interaction between virtual and real cloud experts and terminal users (including terminal doctors, patients, and even their family members). It is also important to highlight that security is a requirement for the Metaverse in Medicine and that a solid security system is a cornerstone for ensuring the smooth functioning of such a platform [12].

III. Methodology

We shall evaluate and assess earlier studies, publications, and articles that address the possibilities of clinical metaverse software and how such innovations could be applied in virtual care next. We also look at the development of mHeath and the increasing use of smart health technology to draw an opinion regarding whether it is beneficial for various organizations to modify their operational and financial strategies to function within the metaverse. To obtain pertinent data that will aid in developing our hypothesis, we shall investigate archives. This study is a qualitative one that examines, detects, communicates, and draws a verdict. Considering this work to be qualitative, it looks into and assesses earlier works and websites that are relevant to our subject.

To evaluate a website and make sure it presents its information in an unbiased manner to decide whether or not we should include it in our study, we looked at the 5 evaluating criteria. This criterion includes Accuracy, Authority, Objectivity, Currency, and Coverage. The papers we reviewed met those criteria. Accuracy was met in the sense that we know who the authors are, and we are able to contact them via forms and social media. The Authority of the websites proceeded because our articles and authors are credible. Our websites covered our subject in depth and satisfied the objective, therefore Objectivity was met. Currency is satisfied, since both of our articles were released in the second half of 2022. Our articles are current and don't include any dead links. The websites are accessible easily and without any fees or software requirement, therefor Coverage is fulfilled. According to our evaluation, the websites are credible and valuable to our research.

IV. Results

The article "Develop mHealth applications: mHealth applications development" covers all aspects of mobile health applications and provides crucial information regarding the benefits, kinds, and advancement of mHealth applications. mHealth applications raise both the standard of patient care and the effectiveness of medical institutions. 93% of specialists, based on a RubyGarage study that discusses how mHealth influences medical services, agree that mHealth applications may enhance an individual's well-being, as shown in Fig 3. mHealth has a variety of benefits, including the ability to gather clinical information effectively, assist caretakers in improving alertness, lowering medical fees, assist with remote observation, and many more [5].

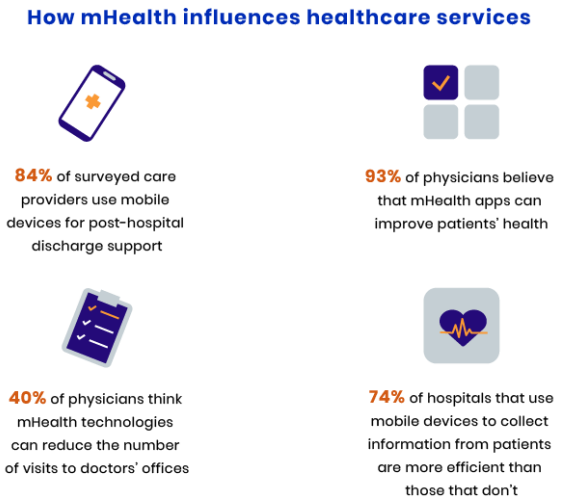

Fig. 4 A Statistical Study by RubyGarage [5].

The six primary categories of mHealth applications were thoroughly covered. Health Information Exchange Applications enable the safe communication of clinical images and information. Persons and physicians can communicate over video or audio using Telehealth Applications. Style of living, exercise, and diet can be monitored via Wellness Applications. Remote Healthcare Applications permit people to send their information to professionals. Clinical businesses may control a variety of duties, including appointment scheduling, observing patients, and stock control, with the help of Hospital Applications. Individuals can save and control their details, including health files, medications, and care options, using Personal Health Record Applications [5].

The stages that should be followed when designing mHealth applications are also covered in the article. This includes determining which type of application to be developed, picking the functionalities, having in-depth security, UI/UX designs, scripting and coding the software, quality assurance, and testing and debugging [5].

Several cutting-edge innovations are entering the health sector. The development of creative mHealth applications can be aided by the three main methods listed below. These techniques are Blockchain Technology, Artificial Intelligence (AI), and the Internet of Medical Things (IoMT). Blockchain Technology has seen a lot of interest lately, and the health sector is among this technology's most advanced developments. It is possible to guarantee proper security and transfer of healthcare records by combining blockchain with mobile health applications. Security attacks can be considerably reduced with the use of mHealth applications developed on the blockchain. Numerous firms have started utilizing blockchain after seeing its capability within the industry. After Market Research estimates that by 2026, the blockchain industry for medicine would be worth $5517.6 million. Artificial intelligence and mobile health applications can improve the medical sector in a variety of ways. Medical uses of artificial intelligence are expanding quickly. The industry for healthcare-related artificial intelligence is anticipated to exceed $31.3 billion by 2025, per a study by GVR shown in Fig 4. Healthcare gadgets, such as monitors, can communicate with one another, and share patient information thanks to the Internet of Medical Things (IoMT). IoMT and mHealth applications should work together to reliably and effectively gather large amounts of information. IoMT is currently being utilized by numerous medical companies. The Internet of Medical Things (IoMT) industry is expected to be worth $158.1 billion by 2022, as per Delloite, and shown in Fig 5. IoMT in conjunction with mHealth applications can aid to reach many new heights [5].

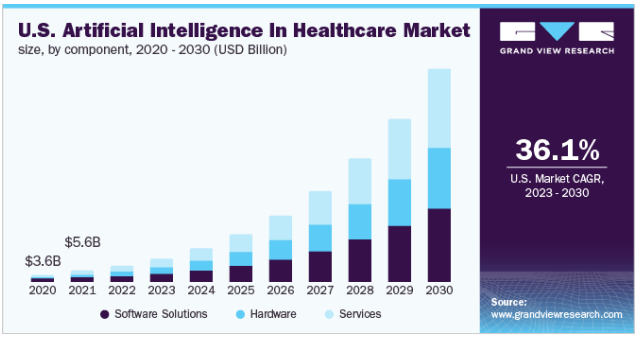

Fig. 5 U.S. Artificial Intelligence in Healthcare Market expected to reach 36.1% by 2030 [5].

Fig 6 Expected IoMT Market Growth [5].

The second article, "What is the Metaverse and Why Does it Matter to Healthcare?" by Dr. Emily Atkinson, explores the concept of the metaverse and how it relates to healthcare, as well as the opportunities, advantages, difficulties, and dangers associated with utilizing this cutting-edge innovation. It addresses how well the strength of the metaverse can be used to motivate and encourage electronically knowledgeable individuals for mutual learning whilst simultaneously empowering them to take charge of their wellness in fields like good nutrition as well as lifestyle [13].

VR teleconsulting offers several potential advantages. It could be challenging for individuals who reside in distant places or have disabilities to make it to consultations. It would be beneficial to provide these individuals with a somewhat more authentic encounter without requiring them to travel far from their residence. When a facility may be accessed digitally for non-emergency situations, service expenses might be decreased, and medical process effectiveness will potentially improve. Using the metaverse, settings might be customized for each individual to promote peace and tranquility. Through the multiverse, virtual interactions between persons and doctors might be facilitated, and doctors could gather information without being there. For individuals, this can mean having speedier access to data relating to their illnesses and outcomes. Every modern treatment breakthrough, even those that take place within the metaverse, must prioritize individuals' well-being. Any novel medical procedure or innovation should always be backed by solid medical justification and proof [13].

Medicine could be transformed by the metaverse, however technical, moral, and legal restrictions must be taken into consideration. There remains work to be done until automated developments make it convenient to provide treatment through the metaverse, although innovations like electronic medicines are transforming the nature of medicine. A significant quantity of private and confidential data will undoubtedly be accumulated as the metaverse develops, much of which will belong to the health sector. For the interaction involving individuals and physicians, client privacy is crucial. Increased legal protections will be required to lower hazards in light of private and cyber defense worries. Technology that will enable payers to change their processes of compensation and move away from cash-based systems is currently being developed [13].

The metaverse has emerged from the domain of sci-fi and is swiftly assimilating into the medical field. We've seen how this innovative and intriguing idea might be used in medical practices and how it might enhance individuals' quality of life. There are logistical and legal obstacles to be solved, however the doorway to the virtual world is currently accessible as a result of multiple businesses working on the required technologies [13].

V. Discussion

Consumer health habits such as physical activity, nutrition, alcohol, sexual behavior, and prescription adherence have been proven to be influenced by mobile health. Despite its apparent benefits, the market for mobile health applications is still emerging. The word "metaverse" alludes to a new version of the internet that merges the actual and virtual worlds via avatars, holograms, and virtual reality headsets. AR and VR glasses enable the medical Internet of Things (MIoT). The interaction between virtual and real cloud experts and terminal users could facilitate various medical services such as disease prevention, healthcare, physical examination, disease diagnosis and treatment, rehabilitation, chronic disease management, in-home care, first aid, outpatient attendance, consultation, and so on. It is critical to emphasize the importance of security in Artificial Intelligence in medicine.

mHealth applications improve the quality of patient care as well as the efficiency of medical institutions. According to a RubyGarage survey, 93% of specialists believe mHealth applications can improve an individual's well-being. The post thoroughly covers the six essential categories of mHealth applications. Some of the cutting-edge health sector advancements include Blockchain Technology, Artificial Intelligence (AI), and the Internet of Medical Things (IoMT). The three effective strategies outlined below can help develop innovative mHealth applications. Artificial intelligence and mobile health applications can improve the medical sector significantly.

The results imply that there are only a few editorials and book reviews in the literature on this subject. The presented experiments are recent, and different metaverse applications were adopted that will necessitate additional research shortly. Despite these drawbacks, the metaverse can be used for clinical condition prevention and treatment, it can be used for teaching and training, and researchers can utilize it to conduct studies more quickly and with larger, global samples. The paragraphs that follow in-depth present these features [10].

The application of the metaverse to clinical condition prevention and therapy is possible. It has positive effects on treating pain, stroke, anxiety, depression, fear, cancer, and neurodegenerative illnesses during diagnostic and surgical procedures as well as during rehabilitation. To connect the real world to the virtual one, various technologies can be used to monitor health issues at home. The smartwatch, which incorporates heart rate, blood saturation, pedometers, accelerometers, as well as Global Positioning System (GPS) data, is another device that has gained widespread adoption in recent years. These smartwatches might be used to bring a user to life in the metaverse [10].

Monitoring vital signs enables early detection and treatment of issues like atrial fibrillation. By using virtual reality to analyze the condition in 3D and solicit input from other experts linked via the internet, pre-operative planning might be created. Mirror therapy is one example of how it might be used as a rehabilitation strategy. An effective strategy can include virtual care models with psychological group support programs. Robotic end-user delivery units for virtual nursing care could also be beneficial [10].

The same approach can be used for this component of health promotion in classroom settings, similar to how it is used to educate students. We may see scenarios where individuals can interact and exercise together. The Peloton is a thing that already exists and is used. It is a virtual setting where individuals can compete or work out while riding bicycles. It is a sports simulator that makes use of virtual reality. In this workout apparatus, which is linked to a nearby computer via sensors and force feed-way, users can train outdoors and in a group. The user may wear either pajamas or a proper gym outfit, and sensors on the equipment will monitor their training alone. We believe that this is a simple technique to encourage everyday exercise, where members of fitness centers or athletic teams can compete [10].

Virtual reality is the metaverse's most widely used technology in a learning environment. Medical care personnel can receive a variety of training using virtual reality. Using extended reality technology, anatomical structures might be holographically displayed in a museum. Programs for behavioral and physical education are examples of practical components that might be included in distance learning. A massive amount of personal health data might be gathered using an online platform like the metaverse [10].

Researchers could utilize the data collected to build national or global monitoring and surveillance systems for their research. A doctor, other medical practitioners, or researchers may receive digital data directly from the customer, from services, or wearables [10].

The primary restrictions on the metaverse are those relating to data management and privacy, cyber-simulating, inside a lab, a different setting, like nature or a city, but also a par- security hazards. Blockchain technology is a way to manage and restrict access to a complicated network of data sets. Cardiovascular care is only beginning to use blockchain, thus there are still some implementation-related concerns. The main question is whether the metaverse should be run by the general population or by billionaire

corporations. This implies that the subject is novel and ground-breaking, necessitating further research. Future research should look into the viability of a health metaverse where individuals may learn about and receive guidance on healthy practices [10].

Overall, the current level of research in this domain is favorable because it is an intriguing topic with growing interest. Based on our analysis, the strengths of our topic are the generalizability and dependability of available information; however, some research lacks depth.

VI. Conclusion

To conclude, physical interaction, eye contact, facial expressions, and gestures are crucial components of the healthcare industry and cannot be replaced by normal technology but this is possible when entering the metaverse. Accordingly, the metaverse can be seen as a tool to enhance the quality of the healthcare system in terms of intervention and treatment, global education, ensuring standardized training, and aiding in the creation of global databases for research. Finally, given how much time young people spend in front of screens, the metaverse might be a place where they can start playing sports and learning new skills. Sports groups and facilities could benefit those persons who want to train independently, at their convenience, and home, expanding opportunities for physical activity.

References

[1] G. Wang, A. Badal, X. Jia, J. S. Maltz, K. Mueller, K. J. Myers, C. Niu, M. Vannier, P. Yan, Z. Yu, and R. Zeng, "Development of metaverse for Intelligent Healthcare," *Nature News*, 15-Nov-2022. [Online]. Available: https://www.nature.com/articles/s42256-022-00549-6#citeas.

[2] R. Chengoden, N. Victor, T. Huynh-The, and G. Yenduri, "Metaverse for Healthcare: A Survey on Potential Applications, Challenges and Future Directions," *ResearchGate*, Sep-2022. [Online]. Available: https://www.researchgate.net/publication/363479167_Metaverse_for_Healthcare_A_Survey_on_Potential_Applications_Challenges_and_Future_Directions.

[3] D. Gupta, "MHealth app development: Know benefits, types, and cost," *Appinventiv*, 27-Sep-2022. [Online]. Available: https://appinventiv.com/blog/everything-need-know-mhealth-apps/.

[4] M. Sun, L. Xie, Y. Liu, K. Li, B. Jiang, Y. Lu, Y. Yang, H. Yu, Y. Song, C. Bai, and D. Yang, "The metaverse in current Digital Medicine," *Clinical eHealth*, 09-Jul-2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S258891412200017X.

[5] A. Takyar, "Develop mhealth apps: Mhealth apps development," *LeewayHertz*, 26-Sep-2022. [Online]. Available: https://www.leewayhertz.com/develop-mhealth-apps/.

[6] Y. Wang, T. Wu, and Z. Chen, "Active Usage of Mobile Health Applications: Cross-sectional Study," *Journal of Medical Internet Research*, vol. 23, no. 12, p. e25330, Dec. 2021, doi: 10.2196/25330.

[7] Y. K. Dwivedi *et al.*, "Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy," *International Journal of Information Management*, vol. 66, p. 102542, Oct. 2022, doi: 10.1016/j.ijinfomgt.2022.102542.

[8] C. B. Fernandez and P. Hui, "Life, the Metaverse and Everything: An Overview of Privacy, Ethics, and Governance in Metaverse." arXiv, Mar. 24, 2022. doi: 10.48550/arXiv.2204.01480.

[9] M. Damar, "Metaverse Shape of Your Life for Future: A bibliometric snapshot," *Journal of Metaverse*, vol. 1, no. 1, Art. no. 1, Dec. 2021.

[10] L. Petrigna and G. Musumeci, "The Metaverse: A New Challenge for the Healthcare System: A Scoping Review," *Journal of Functional Morphology and Kinesiology*, vol. 7, no. 3, Art. no. 3, Sep. 2022, doi: 10.3390/jfmk7030063.

[11] J. Lee *et al.*, "Development and Application of a Metaverse-Based Social Skills Training Program for Children With Autism Spectrum Disorder to Improve Social Interaction: Protocol for a Randomized Controlled Trial," *JMIR Research Protocols*, vol. 11, no. 6, p. e35960, Jun. 2022, doi: 10.2196/35960.

[12] D. Yang *et al.*, "Expert consensus on the metaverse in medicine," *Clinical eHealth*, vol. 5, pp. 1–9, Dec. 2022, doi: 10.1016/j.ceh.2022.02.001.

[13] E. Atkinson, "What is the metaverse and why does it matter to healthcare?," *What is the Metaverse and Why Does it Matter to Healthcare?*, 03-Aug-2022. [Online]. Available: https://www.sidekickhealth.com/news/the-metaverse-and-healthcare.

[14] K. Fan and Y. Zhao, "Mobile health technology: a novel tool in chronic disease management," *Intelligent Medicine*, vol. 02, no. 01, pp. 41–47, Feb. 2022, doi: 10.1016/j.imed.2021.06.003.

[15] E. Osei, K. Agyei, B. Tlou, and T. P. Mashamba-Thompson, "Availability and Use of Mobile Health Technology for Disease Diagnosis and Treatment Support by Health Workers in the Ashanti Region of Ghana: A Cross-Sectional Survey," *Diagnostics (Basel)*, vol. 11, no. 7, p. 1233, Jul. 2021, doi: 10.3390/diagnostics11071233.

[16] D. Chen and R. Zhang, "Exploring Research Trends of Emerging Technologies in Health Metaverse: A Bibliometric Analysis." Rochester, NY, Jan. 05, 2022. doi: 10.2139/ssrn.3998068.