

Opinion Paper

Damien Gruson*, Ronda Greaves, Pradeep Dabla, Sergio Bernardini, Bernard Gouget and Tuğba Kemaloğlu Öz

A new door to a different world: opportunities from the metaverse and the raise of meta-medical laboratories

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Abstract

Objectives: In the digital age, the metaverse has emerged with impressive potential for many segments of society. The metaverse could be presented as a parallel dimension able to enhance the physical world as well as our actions and decisions in it with the objective to use a coalition between the natural and virtual worlds for value creation. Our aim was to elaborate on the impact of the metaverse on laboratory medicine.

***Corresponding author: Pr. Damien Gruson**, Department of Laboratory Medicine, Cliniques Universitaires St-Luc and Université Catholique de Louvain, 10 Avenue Hippocrate, B-1200 Brussels, Belgium; Pôle de recherche en Endocrinologie, Diabète et Nutrition, Institut de Recherche Expérimentale et Clinique, Cliniques Universitaires St-Luc and Université Catholique de Louvain, Brussels, Belgium; and Emerging Technologies Division and MHBLM Committee, International Federation Clinical Chemistry and Laboratory Medicine (IFCC), Milan, Italy, Phone: +32-(0)2-7646747, Fax: +32-(0)2-7646930, E-mail: damien.gruson@uclouvain.be

Ronda Greaves, Murdoch Children's Research Institute, Parkville, VIC, Australia; and Emerging Technologies Division and MHBLM Committee, International Federation Clinical Chemistry and Laboratory Medicine (IFCC), Milan, Italy. <https://orcid.org/0000-0001-7823-8797>

Pradeep Dabla, Department of Biochemistry, G.B. Pant Institute of Postgraduate Medical Education & Research, Associated Maulana Azad Medical College, New Delhi, India; and MHBLM Committee, International Federation Clinical Chemistry and Laboratory Medicine (IFCC), Milan, Italy

Sergio Bernardini, Department of Experimental Medicine, University of Tor Vergata, Rome, Italy; and Emerging Technologies Division and MHBLM Committee, International Federation Clinical Chemistry and Laboratory Medicine (IFCC), Milan, Italy

Bernard Gouget, National Committee for the Selection of Reference Laboratories, Ministry of Health, Paris, France; and MHBLM Committee, International Federation Clinical Chemistry and Laboratory Medicine (IFCC), Milan, Italy. <https://orcid.org/0000-0002-8010-1404>

Tuğba Kemaloğlu Öz, Liv Hospital Ulus, Beşiktaş/Istanbul, Türkiye; and Istinye University, Faculty of Medicine, Istanbul, Türkiye

Methods: Based on the available evidence, literature and reports, we analyzed the different perspectives of the metaverse on laboratory medicine and the needs for an efficient transition.

Results: The convergence and integration of technologies in the metaverse will participate to the reimagination of laboratory medicine services with augmented services, users' experiences, efficiency, and personalized care. The revolution around the metaverse offers different opportunities for laboratory medicine but also open multiple related challenges that are presented in this article.

Conclusions: Scientific societies, multidisciplinary teams and specialists in laboratory medicine must prepare the integration metaverse and meta-medical laboratories, raise the awareness, educate, set guidance to obtain a maximum of value and mitigate potential adverse consequences.

Keywords: artificial intelligence; augmented reality; avatar; digital health; digital twins; metaverse; virtual reality

Introduction

'The future cannot be predicted, but futures can be invented' Dennis Gabor (The Nobel prize winner in Physics 1971 Inventor of Holography). Emerging technologies and Artificial Intelligence (AI) are accelerating the transformation of healthcare and laboratory medicine with potential positive impact on patient care, efficiency of healthcare systems and "augmented" practices of healthcare professionals [1, 2]. The benefits of emerging technologies is translating at different levels such as the improvement of efficiency and productivity (automation of tasks, streamlining of processes...), enhancement of communication and collaboration (real-time connectivity, increased knowledge sharing, collaborative decision making...), better clinical outcomes (increased accuracy of diagnosis, early prevention, remote monitoring...) or increased sustainability (reduction of environmental impact, promotion of sustainable practices...)

[3–5]. Mobile health and digital health devices can also play an important role in monitoring of health conditions at home under doctor supervision connected through automated electrocardiograms devices for the monitoring of heart and blood pressure to evaluate the cardiovascular systems, oxygen saturation, and even blood glucose calculators for diabetic patients, connecting real life with the virtual world [3–5].

Everyday functions like education, logistics, manufacturing or healthcare could potentially be replicated in the metaverse, connecting physical and digital presence. In the digital age, the metaverse has emerged with impressive potential for many segments of society (entertainment, work, commerce, and the social world) and healthcare [6–8]. The revolution around the metaverse offers different opportunities for laboratory medicine, with the raise of meta-clinical laboratories (MetaLab) but also open multiple related challenges and questions that we would like to emphasize in this short article.

Diving into the metaverse

The term ‘metaverse’ was invented in the 1992 science fiction novel *Snow Crash* and results from the combination of the words “meta” and “universe” [6]. According to the Oxford English Dictionary, a metaverse is “a virtual reality space in which users can interact with an environment generated by computer and with other users” [9]. The metaverse could be described as a parallel experiential dimension able to enhance the physical world as well as our actions and decisions in it, rather than replacing it, with the objective to use a coalition between the natural and virtual worlds for value

creation [6, 8]. Metaverse is therefore a virtual space integrating physical and virtual realities and enabling users and avatars to interact in an environment supported by emerging technologies [6]. The metaverse promises to become a world of its own, an existence somewhere between purely physically and solely digital, it will incorporate several technological elements. Starting from a variety of hardware that includes but is not limited to flat screens, Augmented, Virtual and Mixed Reality devices (AR, VR & MR), smart glasses and mobile devices. The next significant fraction is the vast scope of software that will be essential to the creation of the metaverse and that covers subjects of digital twins, hyper-realistic avatars, data, NFTs, cyber security, 3D modeling, design and many more [10].

We have also to underline that metaverse has different service types: augmented reality (AR), life-logging, mirror worlds and virtual worlds (Figure 1) [8, 11]. AR can be considered as an advanced and versatile version of the external world able to provide value through immersive content combining real world, fantasy, and convenience [11]. Life-logging is more likely a record-keeping tool in which medical professionals can record their work, such as case scenarios, surgeries, treatment regimen, and research projects, in a virtual format and share it with others [11]. Life-logging leverage value through extensive real-world experience and information can be checked at any time and checked by others [11]. The mirror world is a type of augmented reality where real-life situations are simulated in the virtual world to create an experience-based learning environment. Mirror worlds add value through maximized usability by integrating and expanding external information into the virtual space [11]. Lastly, virtual reality (VR) is another type of reality where the environment is built entirely from the real world, and thus the limitation of

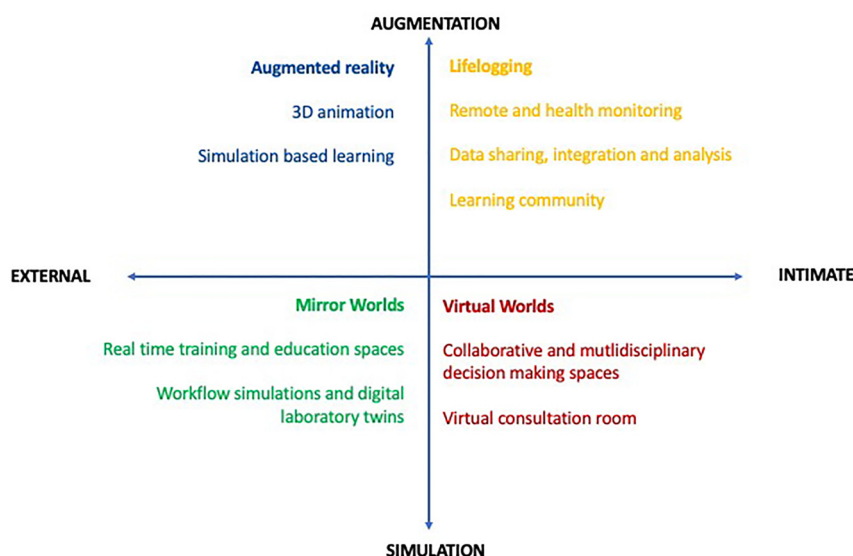


Figure 1: The different service types of the metaverse.

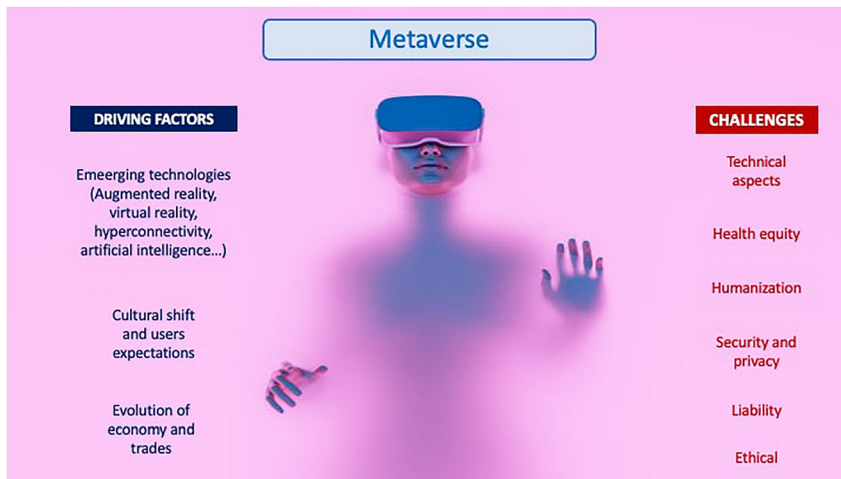


Figure 2: The driving factors and challenges around the metaverse (background image from https://www.istockphoto.com/fr/photo/personnage-avec-lunettes-vr-immers%C3%A9es-dans-un-liquide-diffus%C3%A9-tro%C3%A9clair%C3%A9-gm1388545145446153881?irgwc=1&cid=IS&utm_medium=affiliate&utm_source=Eezy%2C+LLC&click-id=04uW6oRm7xyNTgqSFxTpAx-aAUkAwqDWG23r9100&utm_term=www.vec-teezy.com&utm_campaign=SRP&utm_content=1141987&irpid=38919).

virtual reality is that person's imagination. VR value is to provide a new virtual space that does not exist and where various individuals can perform activities [11].

The driving forces

Different factors are pillars of the metaverse and stimulate its development (Figure 2) [12]:

- *Technological:* Progresses and development of the 5G and 6G communication network and infrastructures, the Web 3.0 and the high-speed transfer of high volumes of data. Blockchain technology and artificial intelligence are also at the heart of the metaverse and its ecosystem as well as wearables and sensors. The metaverse appearing as a new convergence of these emerging technologies. One thing is for sure, that we cannot expect a sudden switch from flat screen devices to purely immersive technology.
- *Cultural:* The spread of the digital culture and digital services is one of a key element. The rise of cybernetics, which has led to the miniaturization of high-speed networking devices and the widespread of both mobile device and wearable technology, allowed technology to move closer to one's body, making users more prepared for the coming of headword immersive devices. The evolution of social relationships across digital media has also to be pointed out. The desire of alternatives to broke reality and face-to-face contact are becoming the new normal and the metaverse appears as a way for imagining and creating a better or different world.
- *Demographic pressure:* Patients' rising expectations for customization delivery are also reshaping the Healthcare market.

- *Economical:* The metaverse is expected to disrupt healthcare and open new channels of treatment while lowering costs. New business opportunities are emerging in the metaverse with new faces for interactive e-commerce, visits, demonstrations, and experiences. The metaverse also provide the ability to travel and trade freely between new goods, products, and services [13]. Blockchain offers the ability to secure payments and exchanges.

The opportunities of the metaverse in laboratory medicine

The metaverse is largely discuss in different fields of healthcare such as oncology, cardiology, mental health, or imaging [8, 14–19]. Several applications of the metaverse such as educational and teaching, surgical simulations, conferences and meetings, awareness programs, research programs, visualization of complex anatomy have been developed or are under research. Though not limited but bibliometric analysis of virtual reality and augmented reality emphasize that the metaverse applications can be suitable for various diagnostic and surgical procedures. The latest applications has shown satisfying results in rehabilitation on pain, stroke, anxiety, depression, fear, cancer, and neurodegenerative disorders. Further, researchers can use this metaverse tool to make the research studies faster and with larger sample size and even extending to global levels.

Several perspectives and scenarios could be associated to development of Meta-Medical laboratories such as:

- Smart manufacturing, in-silico modeling, pre-evaluation and simulation of assays and devices performances.

- Dynamic 3D visits of virtual clinical laboratories and digital modeling of laboratory spaces, environments and workflows.
- Use of augmented and virtual reality to assist with laboratory testing and analysis.
- Virtual comparative of laboratory services to analyze and improve users' experience.
- Remote services with the integration of point of care testing, mobile health technologies and sensors for early detection of diseases and real time monitoring of patients.
- Virtual services and care pathways to support prevention and diagnostic with the inclusion of telemedicine and teleservices.
- Tailoring clinical laboratory services to patients and creation of real virtual care pathways reinvented in the metaverse.
- Reduction of physical and paper-based patients' records and personalized health data monitoring by raw data sharing and integrating clinical, imaging and laboratory data.
- Designing and simulating sustainable facilities and processes to reduce the environmental footprint of laboratory services and for a better compliance to legal requirements.
- Recruitment and training (including training on blood collection or pre-analytical steps).
- Remote work and collaboration.
- Use of VR and AR to face the shortage of healthcare resources and facilitate collaborative multidisciplinary care.
- Consultation, education and information to patients and caregivers in virtual facilities within the metaverse, from anywhere in the world and with great potential for rare diseases.
- Phantoms, digital laboratory twins and patients' avatars to integrate multiple data from omics technologies and develop augmented predictive model and personalized care services.
- Assist with data analysis, improving the speed and accuracy of laboratory tests.
- Integration and manipulation of different medical data for improvement of diagnosis and treatment options.
- Discussion of complex cases through AR and benefits from peer support.
- Use of VR and lecturing in 3D at congresses and educational sessions.
- Virtual training and education to offer a more immersive and interactive way for laboratorians to train and educate themselves.
- Enhance the development of sustainable practices.

Open challenges in the metaverse

The metaverse is a revolution for healthcare and for laboratory medicine. However, several challenges need to be addressed before a broader use of the metaverse and regulation and legal frameworks will have to be adjusted [10, 20, 21]. Technical aspects remain of course to overcome, and the growing lack of essential components needs to be considered. Health equity and fairness will be other important aspects to allow access to technology and avoid digital divide. A careful attention will have to be paid to users/human's emotions, cognition, and behavior within virtual environments to avoid dehumanization and breakdown of social relations the protection and recognition of human characteristics, rights and moral values in such disruptive ecosystems will be of major importance with the definition of ethical guidance. Another very important aspect for the progression of the metaverse is the interoperability of the electronic medical records (EMR) and laboratory informatic systems as well as the exchange of structured data is still needed the use of standards such FHIR, which is a widely adopted standard for exchanging healthcare information, can help ensure that different systems can communicate. Application Programming Interfaces (APIs) allow also software systems to communicate with each other in a standardized way. Centralized database and health data space. Improving the interoperability between healthcare software still requires a collaborative effort between different stakeholders in the healthcare industry and clinical laboratories including EMR and software vendors, healthcare providers, and government agencies. The security and privacy of data and model are critical features as well as the liability to cover adverse effects resulting from the metaverse. Education and training of users, policymakers to the benefits and risks will be another issue where scientific societies and the clinical laboratory community will play a fundamental role.

Overall, the metaverse has the potential to change the way laboratorians work and interact with colleagues and patients, offering more opportunities for remote work and collaboration, virtual training and education, and the use of augmented and virtual reality. However, the full extent of these changes and their implications on the laboratorians' role is yet to be seen, as the metaverse is still in its infancy. Specialists in laboratory need to embrace this revolution and be actively engaged for this transition and for providing the validation and warrantee of this novel ecosystem but also for the continuous monitoring of the quality and safety. The clinical laboratory community should also carefully define the new digital and data competences for the best use of the metaverse, meaning that it

will not imply the death of laboratory medicine but its augmentation.

Conclusions

The metaverse will be an exciting new chapter in not just the history of the internet, but in the development of medical care globally, providing countless new opportunities. This is a new world that is advancing daily, and our knowledge grows with the innovations who are building the new metaverses. Laboratory medicine and *in vitro* diagnostics will benefit a lot from the metaverse creating a sustainable and affordable paradigm. The convergence and integration of technologies in the metaverse will participate to the reimagination of laboratory medicine services with augmented services, users' experiences, efficiency, and personalized care. Scientific societies, multidisciplinary teams and specialists in laboratory medicine must prepare the transition, raise the awareness, educate, set guidance to obtain a maximum of value and mitigate potential adverse consequences. Thus, the metaverse can be considered a tool to improve the quality of the health care system in terms of improving diagnostics interventions and patient treatment.

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