

Blockchain and Metaverse Definitions, Concepts and Applications in Neuropsychiatry

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Abstract

The following review is an introduction to the terminology and concepts related to blockchain and metaverse platforms including AR, VR, XR-realities, NFTs, operating systems, and security protocols. Methods of overcoming risks, limitations and challenges are explored. Lastly, this review explores current and future applications of blockchain and metaverse platforms in healthcare, including a comprehensive and concise evaluation of various benefits of these advancing systems in the neuropsychiatric setting.

Keywords: Clinical training • Medical research • Neuropsychiatry • Blockchain and metaverse

Introduction

The metaverse (MV) is a virtual and augmented reality environment that digitally enables dynamic user engagement and interaction through digital computational functions. It is the holographic simulation that painted science fiction prophecies of the utopian future; akin to Plato's Allegory of the Cave depiction of cave dwellers entranced by images reflected on the walls, a product of fire and shadows: To them, I said, the truth would be literally nothing but the shadows of the images (Plato, The Republic, and Book VII). Dutch physicist G. 'tHooft proposed the scientifically concrete Holographic Principle of 1993 asserting:

- That all of the information contained in some region of space can be represented as a Hologram—a theory which 'lives' on the boundary of that region;
- That the theory on the boundary of the region of space should contain a maximum of one degree of freedom per Planck area ($L_p=1.6 \times 10^{-33}$ cm; unit of length that can be constructed from the basic quantum mechanics constants) (TSHCTC, 2022). The concept of alternate realities is not novel to mankind.

The MV alternate reality creates a video-game avatar activity, using bio-sensor wearable technology to create feedback responses from the game immersion, evoking physiological responses akin to physical reality. This is where the MV becomes a healthcare tool that can be designed to reach all connected users and stimulate changes. Extended Reality (XR) is a term to encompass all augmentations of Physical Reality (PR) including Virtual Reality (VR) and Augmented Reality (AR). VR explorers wear a headset that displays an integrative, visual world and uses motion tracking sensors for a precise feedback experience. Examples of operational VR include the Oculus Rift and the Playstation VR set. AR superimposes layers of digital images onto the physical world which can be seen through some interface,

such as a smartphone screen or visor. Examples of AR include the Microsoft HoloLens and the Magic Leap 2. Another important term is Mixed Reality (MR) which is the point at which the borders of physical reality and virtual reality merge, through a superimposed virtual interactive experience that is expressed in the coexisting physical reality. There are several existing metaverse platforms with significant user statistics that speak to the market potential. For example, more than 50% of American youth (Gen Z and Alpha) use Roblox at a rate of 50 million users per day; loaded with more than 24 million digital; Meta's Horizons aims to grasp a fair share of that market by offering personalizable avatars, customisable outfits, interactive games and trade in Non-fungible tokens (NFTs)-[NFTs are bits of data on a blockchain database that have trade value]. A BCG report claims that by 2024, AR for medical simulation training will account for 18.9% of the expanded reality market [1].

Blockchain (BC) is an electronic ledger that records asset transactions. The electronic coin should be considered as a chain of digital signatures, where coin ownership is transferred between people through public key user profiles [2] that receive verifiable encryptions (like a luggage lock with a key that can only be used by a verified recipient). Just as fiat currency transactions use accounting books (ledgers) or spreadsheets for recording trades in PR, so does the blockchain database record for VR transactions. In this block cloud, assets are considered tangible (eg. physical property like land, cars, cash) or intangible (eg. patents, copyrights, branding media), and the data involved at every point of a transaction is stored as packets of information that can only be accessed by authorised encryption approved accounts. The global blockchain market is expected to reach USD 39.7 billion in 2025, at a growth rate of 67.3% between 2020 and 2025 [3]. Blockchain is an essential trade tool in the digital metaverse as it functions as the infrastructure for socio-economic growth in these new worlds. For example, the Sandbox platform uses the Ethereum blockchain for the SAND currency which can be used to purchase digital real estate within the metaverse.

BC encryption is made of either Keys (codes that safeguard information transfer) or, irreversible data encryption; essentially, encryptions are computer codes that require special calculations to decipher access keys that are protecting blocks of data. The encryption process gives people control over the privacy of their data activities as well as a record of accountability along the course of a transaction. Naturally, corruptibility is a primary BC challenge, i.e. security of personalised data and protection from threats and attacks. Between July 2021 and June 2022, there were a reported 692 large scaled healthcare data breaches [4]. Data that could be shared and put at risk include bio-demographic information, medical progress notes, genomic predictors, radiology and laboratory results, current or likely diagnoses, medication cost expenditure, etc. In the blockchain, data is put into live, shareable data blocks, guarded by access

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chains, making it ideal for longitudinal patient research.

Metaverse Physicians

The metaverse will be a technicoloured landscape produced from the engines of computational power. The Society for Simulation in Healthcare, describes simulation training as “the imitation or representation of one act or system by another” acting as “a bridge between classroom learning and real life clinical experience,” (IDS, 2018). Simulation based training successfully facilitates the transition of theory based medical students into clinically trained junior doctors, through the ability to transfer the algorithms and skills trained in the simulated environment into the clinical environment [5]. Moreover, the predictive power of ML models in combination with reality augmentations opens a gateway to infinite dimensions of existence where healthcare will remain crucial to the survival of the species. Physicians of the future or Medi-verse practitioners will exploit computational tools to automate medical practice.

This process of evolution in the medical metaverse will be developed through several stages [6]. The process is expected to involve: Construction of a holographic map (blueprint) of the hospitals, people, objects and dynamic events occurring within the extended reality; simulation of functional data transfer functions including personalised information, bio-and motion sensor feedback mechanisms to create internal responses to external world stimuli; MR (mixed reality) interception where XR devices allow multi-user interactions with healthcare providers; and ultimately, Hybrid integration of man and machine where brain computer interfaces exponentially augment data transfer and exchange. Throughout these phases, refining ML algorithms, in conjunction with IOT (Internet of Things) applications and evolving hardware will be integral to the expanding experience while BC technologies continue to operate as highly secure accountants.

Benefits of Metaverse and Block chain in Medicine

Lucrative potential applications of the digitally parallel medi-verse world span every facet of healthcare practice in the PW. Given the complex aetiologies involved in common neuropsychiatric disorders, implementing innovative social solutions through technological platforms may offer patients novel methods of approaching therapy, using both blockchain and metaverse technologies. Behavioural neurological pathologies are

often manifested as addictions, mood disorders, neuroses, psychoses, sleep disorders, neurological conditions and degenerative disorders. CBT (Cognitive-behavioural therapy) remains the mainstay treatment approach for neuropsychiatry morbidities, wherein there are dynamic cognitive and behavioural activities aimed at treating maladaptive through processes that lead to negative or low mood states and subsequently negative behaviours that often feedback to worsen the initial symptoms. CBT requires an intimate communication between the mentor (Therapist) and student (patient), to impart methods of thinking to improve emotional and physical ailments through augmented neural synapse/thought patterns, internal and external awareness of self, as well as through thought and behavioural response models to curtail ongoing difficulties.

Secure, private and non-physical realms of interaction may alleviate patient stress and improve discourse during CBT and neuropsychiatric sessions. In the case of cognitive disorders, where patients are victimised with memory impairment, loss of self-monitoring and decision making skills, immersive memory activities in the metaverse may provide ongoing stimulation and mental engagement to alleviate the burden of suffering. Patients suffering from the spectrum of mood and behavioural disorders including depression, apathy and mania may find solace in private, safe virtual spaces where there is no physical risk to parties involved in the therapeutic consultations. Patients suffering from behavioural issues including psychosis as a result of brain trauma via tumours, auto-immune diseases like lupus, traumatic brain injury, epilepsy, post-traumatic stress disorders or even autism would likely benefit from the virtual consultation spaces as difficulties that are traditionally endured by logistics and appointment scheduling can be reduced with blockchain applications. Moreover, patients suffering from sleep disorders could certainly see benefit from virtual monitoring during sleep as well as from secure bio-sensory data collection that can be managed with blockchain applications and then later analysed for research to map variable associations in the aetiology of sleep disorders. Patients who suffer from eating disorders or other conditions that are often considered taboo, including sexomnia, may appreciate non-physical group therapy sessions and consultations as they maintain some anonymity and therefore can share more expressively without fear of judgement or retribution without escape. Patients who are plagued with degenerative disorders suffer from physical and cognitive deficits, making history of symptoms collection flawed by recall error; this too could be alleviated with bio-sensor collections of patient data that can be safely stored in BC solutions, processed by machine learning algorithms and analysed with AI applications to improve the overall clinical experience of neurology patients.

Table 1. Health domain benefits from blockchain and metaverse.

Domain improved	Metaverse contributions	Blockchain contributions
Communication	<ul style="list-style-type: none"> -Stigma reduction: Patients may feel less embarrassment about meeting in a secure, private, virtual environment -Telemedicine: Teams of specialised healthcare professionals can engage in virtual, real-time case management whilst sharing and interacting with live digital files -Telemedicine: Remote consultations with concrete biofeedback data and haptic sensory evaluations or examinations 	<ul style="list-style-type: none"> Trust: Patients maintain confidence that personalised medical data is not subject to unauthorised breaches -Reliability: Research is based on uncorrupted data collected and shared only with pre authorised informed consent -Transparency: Patients have a transparent view of all people and events pertaining to a healthcare journey -Accessibility: No geographical limits to accessing or for delivering healthcare services
Compliance	<ul style="list-style-type: none"> -Patient Monitoring: Time and activity in the metaverse can be selectively audited to measure prescribed patient compliance and response to therapy. E.g. Bio sensor or wearables which collect and report on physiological processes such as respiratory monitors, pulse oximeters, thermo-sensors, micro-EEG etc. for real-time physician updates. 	<ul style="list-style-type: none"> -Accuracy: Concrete medical parameters can be used to measure patient status, rather than retrospective patient recall of activities risking recall bias and human error in data transcription.

Economy	<p>-Efficiency: XR will see more efficient and cost-effective healthcare operations through reduced physical patient visits in reduced unnecessary appointments that cause schedule congestion; reduced wait (by proxy, treatment times).</p> <p>-Security: Medical devices could charge patient data, verify procedures anonymously Streamlined financial transactions between patient and product and service providers.</p> <p>-Book-keeping: Hospital financial records are without error using ML data collection from the PW and MV.</p>	<p>-Cost-reduction: A reduction in the healthcare economic burden invested into administrative, human resource and security investments.</p> <p>-Poly-currencies: Financial transactions retain flexibility with NFT and other cryptocurrency methods of payment, secured by validation keys to expedite and secure fiscal processes-COST.</p> <p>-Accountability: Each iterative step in a transaction process is recorded.</p>
Mental Health	<p>-Self-care: Safe well-being spaces for secure and uninterrupted wellness practices, which can be logged with biosensors for feedback analysis.</p> <p>-Autonomy: Support groups with privacy settings, allow patients to enter and exit groups, with anonymity and without consequence or prejudice of race or other discriminators.</p> <p>-Example: Florea's VW offering patient education services for cognitive, social, behavioural, communication abnormalities for persons with Autism Spectrum Disorder (ASD), ADHD, Anxiety, or other neuropsychiatric conditions (Sun et al., 2022)</p>	<p>-Uninterrupted counselling: Users of VR technology will be less distracted or influenced by environmental stimuli during self-care practice times.</p> <p>-Connectivity: Patients can engage with a worldwide audience in real-time, increasing the likelihood of discovering similar cases (much like online forums) knowing that personal health data is protected by their own control.</p> <p>-Justice: Limited mobility patients from injury or disease or geographical locale do not prevent engagement in individual or group consultations.</p>
Personalised Medicine	<p>-Clinical Research: MV tracking can log epigenetic and contributing factors that would otherwise be overlooked-with ML predictive power; this could lead to significantly earlier diagnosis in preventative medicine and corroborate these factors with disease risk and onset to generate detailed personalized medical profiles.</p>	<p>- Confidentiality: Personalised and genomic data is potentially less accessible in a secure blockchain than a compromisable share cloud</p>
Physical Health	<p>-Safety: Physical rehabilitation and exercises can be holographically guided to ensure safe practice techniques, postures and movements (limit risk of injury compared to self-stretch)</p> <p>-Example: Haptic sensors recreate tactile (touch) sensations using multidirectional feedback loops between patient hardware (devices), cloud data and the patient through physical micro-motions including force-back and vibrational sensory experiences.</p>	<p>-Privacy: Patients retain comfort in private environments with attention to performance and progress.</p>
Research and Education	<p>-Accuracy: Collect more concrete data points from sensors, wearables and behaviours in the MV in precision medicine.</p> <p>-Medical training: using 3D visual holographic constructions of anatomic organs reducing the need for cadavers, gross pathology specimens, histology slides, protein and amino acid molecular structure and mapping, chromosomal sequencing for anomaly detection.</p>	<p>-Validation: Reduction of bias in research sampling, data collection and data validation and verification such as in experimental studies and clinical trials.</p> <p>-Development: Drug development processes with iterative recordings of experimental activities would be made more accurate with automated documentations (Haleem et al., 2021).</p> <p>-Tailored education: Customized teaching environments for secure knowledge transfer and exchange.</p>
Time	<p>-Physician education: Physician access to clinical resources to assist in patient progress is instantaneously connected amongst the internet, IOT, predictive ML algorithms and patient results to expedite the diagnostic process or for training and examinations.</p> <p>-Quarantines and Lockdowns: Patient care process will not be interrupted by social distancing mandates during lockdowns.</p> <p>-Patient Journey: Patient experience times including transport, waiting, consultation and post consultation events is reduced with instant virtual appearances and without physical obstacles causing delay.</p>	<p>-Collaboration: Patient information can be instantly shared with other clinicians in pursuit of multi-specialist consensus for course of treatment or in early detection.</p> <p>-Patient Load: Reduced acute and chronic inpatients and outpatients by deferring non-interventional appointments.</p> <p>-Scheduling: Appointment scheduling becomes more efficient with blockchain systems structuring scheduling.</p>

<p>Visualisation</p>	<p>-Machine Learning Object Recognition: Analysis and manipulation of media files across multiple MV platforms via superimposed holographic layers onto physical reality to expedite diagnosis and improve prognosis.</p> <p>-Epidemiological Mapping: Geographical mapping of outbreak patterns.</p>	<p>-Reduced human diagnostic error: Object recognition algorithms empower collaborative teams in secure discussion environments (especially for histopathology and radiology media) in anomaly detection.</p>
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Table 1 delineates some notable domain applications that will see health benefits by using BC and MV platforms in medicine.

The incorporation of Blockchain, Internet of Things, Machine Learning and Metaverse technologies in the healthcare landscape births a new clinical practice of Dimensional Medicine. Examples of existing BC-HC applications in the MV include the Akiri network that configures data and secures verification of patient information exchange; and Guardtime that works on refining cybersecurity within healthcare systems [7]. Immersive Touch surgical simulation technology enhances medical education and training using XR technology. Currently, BC is making medical headlines for security of health data and the specific benefits to the patients suffering from neuropsychiatric disorders is large.

Challenges and Risk Mitigation

The modus operandi of the metaverse has one challenge: Balancing social legislature in multiple platforms that are secured by private or decentralized control.

Firstly, communication between blockchain storage systems and across metaverse platforms in the form of intra-system dialogue is one method of reducing multi-metaverse communication redundancies. One such solution made by Linus Foundation is ‘Hyperledger’ which is an open-source BC that allows multiple contributors to share and use codes that are inter-system operable. For MV healthcare ventures, this would enable international collaborations to advance clinical practice and research endeavors.

Mitigating security risks for patient confidentiality and privacy rights is the skeletal component of BC systems, and security protocols should be subject to ongoing evaluations and quality control tests during its evolution. Currently most BC security systems employ the SHA-256 (Secure Hash Algorithm 256-bit) which generates irreversible unique 256-bit (32-byte) unique signatures (hexadecimal hash strings); built on Merkle-Damgard construction with unidirectional compression function from block ciphers that will need standards and policies implemented by legislature bodies.

Addressing potential harm incurred in decentralized blockchain and in the metaverse is another challenging aspect of the new world. Cyberbullying, mental exhaustion, circadian-rhythm sleep disorders, social isolation, mass hysteria and an infinite multitude of other risks to user well-being should be researched concretely as new worlds carry new risks to survival. Bullying in the cyber space could take on the form of hurtful, abusive or threatening communications, identity theft and data hacking which can be used to target bully (UNICEF, 2022); the list of bullying tactics will evolve with evolving interactive platforms whereby PW bullying include ‘face to face’ and/or group intimidation abuses will need mitigation from platform parameter developers, possibly by logging activity within the MV in BC packets which can act as accountability ledgers. This is a recommendation for future research and an invitation for multi-disciplinary discussion on solutions for this guaranteed risk.

Circadian rhythm disorders are interruptions to circadian rhythms (typically, abnormal suprachiasmatic nuclei physiology) that manifest as sleep wake disorders causing unintentional and disruptive changes to sleep and sleep wake schedules. Delayed sleep phase disorder is 16% more prevalent in youth than adults, is associated with late sleep timings, sleep disorder sequelae; and is related to sunlight exposure worsened by extended screen time (AASM, 2008) which is imminent in the VR landscape. Adolescents

reporting at least one nocturnal awakening from mobile phone use are more likely to develop restless sleep (OR 5.66, 95% CI: 2.24-14.26), difficulty initiating sleep (3.51, 1.05-11.74) than non-interrupted counterparts. Likewise, young peoples’ screen time was associated with insomnia, exhaustibility, lack of energy and diminished focus [8]. The mechanisms of action involve blue light overexposure suppressing melatonin, a circadian hormone; and non-compliance to sleep schedules which cause disharmony to sleep hygiene effecting the risk of circadian rhythm disorders. Another way to mitigate this is to educate MV users on appropriate behaviours and constituents of a trespass.

Social risks carry potential detriment in the way of loneliness as well as limited physical social interaction which could create a ripple wave of mental health sequelae. Social media anxiety, relationship abuse, peer-pressure and all other perversions to the physical world society will be virtually alive in the MV. BC applied here could limit the likelihood of transgressions by security reporting of language used or types of social interactions that are documented in a cloud ledger. Adolescent development is largely influenced by public self-image and fear of peer rejection [9]. Moreover, the scope of belief systems that permeate the virtual world will play a role in determining how traditional aggression in the PW will translate into the VW and future hybrid realities. Cyber-aggressive acts, not including bullying will require a flexible definition of criteria that can grow as life matrices evolve. Therefore there is an essential need for legislature and systems of population control to some extent.

BC is rapidly shunning traditional ‘technology based’ selection methodologies (that focus on data structures, programming methodologies, functionality, portability, secure development, parallel programming, high performance computing, etc) as well as ‘domain specific’ solutions pertaining to functional requirements [10]. Selecting a suitable BC platform for a healthcare solutions involves identifying medically environmentally suitable platforms; then selecting from a list using something like SMART (Simple Multi Attribute Rating Technique) criteria [11-16] to complement existing healthcare stakeholder key performance indicator expectations; followed by clinical and algorithmic evaluations in the pre and post implementation phases to mitigate risks; and lastly, by process protocol validation through established mathematical quality control and operations quality assurance methods.

Discussion

Blockchain is used in medicine to preserve the integrity of all aspects of patient data. The chain of security provided by BC systems is ideal for the metaverse planes where emerging hardware and software technologies will conspire to generate a perfect opportunity to seal communication gaps and remove current physical world deficits in healthcare service delivery.

Conclusion

Blockchain, metaverse and AI solutions have created a new realm of possibilities, wherein patients suffering from neuropsychiatric conditions and from the gaps in the medical management systems, can benefit from the offerings and potentially improve condition prevalence rates. Truly splendid is the advent of man-generated dimensions of existence that create concrete and measurable personalised data which can be applied to innumerable personalised and preventative medicine solutions.

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Consent to Participate

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I consent to have this published.

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