



The Blockchain Never Sleeps: How Can Blockchain Technology Transform Sleep Medicine?

Seithikurippu R. Pandi-Perumal¹ · Sagar Santaji² · Veena V. Desai² · Thankam Sunil³ · Vijay Kumar Chattu^{4,5}

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Abstract

This paper centers around blockchain-based health services frameworks and presents an extensive review on current work, distinguishing existing and arising difficulties in sleep medicine. We attempt to combine health care, especially sleep medicine, allied with blockchain technology. It addresses the capability of blockchain innovation and how it can potentially be a game-changer in sleep medicine. In the field of sleep health, blockchain technology can improve electronic medical records and health information exchange. Examinations around blockchain are unraveling digital identity, privacy, protection, and security issues in the sleep medical services field. With educated information regarding a patient's history, doctors can settle on brief clinical choices for secure and more effective consideration. Blockchain improves persistent results, improve consistency, lower costs, and empower better utilization of sleep medicine services related information. The framework will guarantee continued assurance and security concerning medical care information necessities in general and sleep medicine in specific.

Keywords Blockchain · Digital health · Privacy · Security · Sleep health records · Sleep medicine

Abbreviations

EHR	Electronic Health Records
EEG	Electroencephalogram (EEG)
REM	Rapid Eye Movement
NREM	Non Rapid Eye Movement
NSCDR	National Center on Sleep Disorder Research
AASM	American Academy of Sleep Medicine
NSF	National Sleep Foundation
NIH	National Institute of Health
RPM	Remote patient monitoring
HPE	Health Professional Education

SOL	Sleep onset latency (SOL)
WASO	Wake after sleep onset
TST	Total sleep time
SE	Sleep efficiency
PSG	Polysomnography
PHI	Personal Health Information
EMR	Electronic medical record
HIE	Health information exchange
P2P	Peer-to-peer
DLT	Distributed ledger technology
POC	Proof on concept

✉ Vijay Kumar Chattu
vijay.chattu@mail.utoronto.ca

- ¹ Somnogen Canada, College Street, Toronto, ON, Canada
- ² Department of Electronics and Communication Engineering, KLS's Gogte Institute of Technology, Udyambag, Belagavi, Karnataka 590008, India
- ³ Department of Public Health, University of Tennessee, Knoxville, TN 37996, USA
- ⁴ Division of Occupational Medicine, Department of Medicine, Temerty Faculty of Medicine, University of Toronto, Toronto, ON M5S 1A8, Canada
- ⁵ Occupational Medicine Clinic, St. Michael's Hospital, Unity Health Toronto, Toronto, ON, Canada

1 Introduction

Over the past few years, the healthcare industry has been adopting technological innovation to enhance the automation of clinical processes and advance research. The healthcare industry works with other sectors such as financial institutions and insurance companies, among others, and there has been a growing demand for interoperability across the involved departments and institutions. Countries such as Taiwan [1], Estonia [2], UK, the USA, and Canada [3] are excellent examples of the application of this revolutionary blockchain technology in their healthcare, public health

infrastructure, and surveillance systems. Especially, sleep healthcare is set to experience development in the future. With today's lifestyle, sleep-related disorders have increased and become a significant concern among many individuals. Although clinical activities and scientific opportunities in this field are expanding, the available research and trained personnel to mitigate the problem are still not sufficient to meet the demand.

Blockchain technology can be incorporated into health care and the sleep health industry to enhance research, patient tracking, and secure data sharing for research [4]. Sleep medication expansion addressing sleep disorders management has limited resource technology to manage sleep medical care considerations such as health care data management, security, and finances. The use of blockchain in sleep medicine presents a considerable weight on the current sleep health care system. Therefore, the current situation necessitates interoperability of maintaining the security of medical records and sleep medicine in health care using blockchain technology, which facilitates medical services data frameworks and encourages health information sharing safely and proficiently. In this context, the current review is aimed to explore the various advantages and challenges of blockchain technology applications in sleep medicine.

1.1 Theoretical Frameworks

1.1.1 Sleep Healthcare Industry

Sleep disorder (or sleep/wake disorder) is a medical condition that involves a problem with the timing, quality, and quantity of sleep, which results in the impairment of daytime functioning in which the sleep patterns of an individual are disrupted and may have mild to severe consequences such as interference with normal physical, emotional, mental, or social function-ability of the individual (Table 1).

The maturity of the sleep field led to the development of several organizations and laboratories tasked to enhance the endeavors to promote sleep and sleep-related services, including research related to sleep healthcare. Some of these organizations include the World Sleep Society (WSS), National Sleep Foundation (NSF), National Center on Sleep Disorder Research (NCSDR), American Academy of Sleep Medicine (AASM), and other professional

societies and foundations. In 1970, only a handful of sleep laboratories and organizations were present, but the number increased over time, and in 2001 close to 1300 organizations were reported in the United States. To facilitate the interchange of information, the National Institute of Health (NIH) formed the Trans-NIH Sleep Research Coordinating Committee in 1986 and the National Centre on Sleep Disorders Research (NCSDR) in 1993 to conduct and support biomedical research. The functions of the two organizations were intertwined, and they worked hand in hand to enhance sleep research.

The scientific study of sleep began in 1937 when an electroencephalograph was first used to observe the electrical brain activity during non-rapid eye movement, leading to further advancement in sleep research. Since then, a convergence of research from many fields such as neurology, physiology, neuroscience, among others, has led to a better understanding of sleep as a natural biological activity that affects human functioning. The electroencephalogram (EEG) assessment and polysomnography patterns facilitated testing human sleep, observing anomalies, and explaining connections between sleep and health [6]. Researchers and clinicians had not just recognized and characterized countless sleep issues.

Sleep is a time when several of the body's hormones are released into the bloodstream. These include growth hormone, which is essential for growth and tissue repair, including in adults. As sleep helps to balance our appetite by maintaining optimal hormone ghrelin and leptin levels, examining these biological factors will improvise the system's performance. Today, investigators are examining the cellular and subcellular impacts of disturbed sleep on digestion, hormone imbalances, and other metabolic aspects such as melatonin often referred to as the sleep hormone, which is a central part of the body's sleep/wake cycle [3, 4]. Its production increases with evening darkness, promoting healthy sleep, and helping to orient our circadian rhythm. The main stages of sleep can be grouped into non-rapid eye movement (non-REM or NREM) and rapid eye movement (REM) states, where there is an overall reduction in heart rate and blood pressure during NREM sleep and a more pronounced variation in cardiovascular activity, with overall increases in blood pressure and heart rate during REM sleep [6].

Table 1 Commonly used sleep diagnostic section

Insomnia	Difficulty getting to sleep or staying asleep, with associated daytime consequences
Sleep-related breathing disorders	Obstructive sleep apnea, Central Sleep apnea [6]
Circadian rhythm sleep–wake disorders	Variations from the norm of sleep wake cycles because of misalignment between the biological clock and standard or required sleep wake times [6]
Parasomnias	Abnormal behaviours during sleep such as sleep walking, sleep terrors
Sleep-related movement disorders	Restless legs syndrome (RLS), recurring movement in sleep [4]

When the sleep span dips under seven hours, and particularly when it begins to reduce toward six and half hours or less, various issues become more frequent. Roughly, around 70 million individuals in the US have at least one sleep issue [6], specialists gauge that up to 80% of sleep issues may go undetected or undiscovered [7]. Improving clinical examination in the sleep field will require a helpful, global exertion zeroed in on propelling information about sleep, circadian rhythms, and sleep issues worldwide. The advancement of an International Sleep Research Network, is intended to help sleep researchers and clinicians discover associates with comparable clinical/research interests [8]. Clinical information should be controlled, worked, and permitted by information subjects other than medical clinics. Numerous difficulties are emerging from understanding focused interoperability, such as information guidelines, security, and protection, notwithstanding innovation-related issues, such as versatility and speed, motivating forces, and administration.

1.2 Blockchain Technology

Blockchain technology is a database that is decentralized and managed by various members of the network. The expression “Blockchain” refers to how blockchain stores exchange information in “blocks” that are connected to shape a “chain.” It is widely used in health care systems nowadays due to its interoperability, security, and data management system [9, 10]. Blockchain can use health care data frameworks capacities to improve tolerant consideration; in any case, this has significant administrative, monetary, and operational implications. Private permissioned blockchains are a legitimate choice for the medical services area to deal with delicate patient information. This kind of blockchain organization has gainful consequences on the utilization of blockchain in medical services. Blockchain provides data integration due to which health care data is not easily tampered with. It is essential to provide data security in the health care system; otherwise, it could be mismanaged, leading to cyber-attacks.

Two types of keys are used in encryption: the public key and the other being the private key [12, 13]. These keys are generated for each user using the encryption function. The expression “hash work” is obtained from the French word “hacher,” which intends to “slash into little pieces,” demonstrating how a hash work is intended to “hack” the information. Hashing is a method to empower security during message transmission when the message is proposed for a specific beneficiary in particular. An equation creates the hash, which assists with ensuring the security of the transmission against altering. This technique validates the data and avoids hacking the patient’s data available in the health domain system [9, 12]. Blockchain innovation can encourage

the change from organization driven interoperability to tolerant focused interoperability. Blockchain innovation permits patients to allocate access rules for their clinical information, for instance, allowing explicit specialists to get to parts of their information for a fixed time frame. With blockchain innovation, patients can associate with different emergency clinics and gather their clinical information naturally.

1.2.1 Decentralization

Decentralization is considered one of the significant features of blockchain technology [8, 9]. It navigates and manages data that provides a streamline of a medical procedure. It ensures data security and allows the patient to fully access his records and share them with health care organizations, pharmacies, doctors, and other stakeholders. It provides unstructured data collection and data security needed for current health care systems [12]. Blockchain technology holds great promise for the future by strengthening the countries’ capacity with simplified early warning surveillance for diseases of epidemic potential by reducing the mortality, morbidity, and economic costs [10, 11]. It offers a possibility for a decentralized answer for computerized information capacity and administration with options for improved security. With sleep medical services turning out to be progressively information-driven, blockchain-driven arrangements that have been demonstrated proficient in other information-driven enterprises have begun discovering applications in the spaces of medical services and biomedical sciences, too [11, 12].

1.2.2 Improved Data Transfer Security

All information stored on the blockchain is time-bound, scrambled, and affixed to the blockchain, making it permanent and sealed. Likewise, the information saved on the blockchain utilizes cryptographic keys to ensure patient data security and included establishments taking into consideration obscurity. To ensure the sleep data security, blockchain would most adequately coordinate as a method of overseeing admittance to access medical data information, even though this could take numerous forms. When a doctor makes a record, it is checked, and its survey authorizations are approved by the patient and put away in a smart contract. A smart contract is a protocol that runs naturally when the essentials are met, and it is a substance separate from the original blockchain innovation. The record can never be altered without the permission of a majority of nodes [12, 13]. When information data is added to the blockchain through verification, the data can not be altered (immutable). In fact, data cannot be forged and guarantees the dependability of information storage. Except for individual private data being scrambled, the

whole information storage framework is transparent and open so that nodes can keep up the system together. Temporary access can be constrained using temporary keys made by users and passed onto those, for example, medical services suppliers and insurance companies, and other stakeholders (Fig. 1). The token is independent of the information, containing just authorization orders, and is approved before the necessary reports are dispatched [14].

1.2.3 Transparency and Trust

Blockchain innovation is interlaced. The fundamental thought behind blockchain is that its exchanges are anonymous and obvious to everybody in sleep medical services and medication research. This encourages acknowledging examination discoveries, medication, and applications by the medical services partners [12]. Blockchain technology provides transparency, autonomy, and the potential to improve healthcare quality as data is shared among all the participants [13]. Blockchain innovation is considered an innovation that enables a profoundly secure and transplant plan for the medical data repository. Sleep data of the patient collected during treatment will have a more diverse opinion about its transparency. It is necessary to check the degree of transparency of the collected data, which may be influenced by many dependencies. Empowering trust has been distinguished as one of the key worries among the specialists. Blockchain assumes an essential function as its logic depends on the exchange of information between non-trusted partners, and the trust can be enabled using a smart contract [14].

1.2.4 Smart Contracts

To ensure secure communication, it is a necessity to establish a protocol. It facilitates an agreement managed by computer code in the blockchain, where it provides the secure transfer of data between two parties. The code has a specific set of rules to be followed in which each party needs to abide by the agreement for any kind of interaction [15]. On the biomedical research front, blockchain with smart contracts carries precision and straightforwardness to a few issues identified with information administration in clinical preliminaries, running from information security and trustworthiness to sharing and recording. Aside from the security challenges, there are issues identified with the costly and restricted versatility of blockchain and the necessary normalization [16, 21].

1.3 Implementing Blockchain Technology for Sleep Healthcare

A suitable set up should be provided to secure the information transmission in sleep research. The structure should up-grade data security just as give a way through which patients can be followed and license interoperability among the establishments. Xia et al. proposed a MeD share system that ensures authenticity, accountability, and efficiency to the healthcare data in a blockchain-based framework using the cloud repositories by providing four layers of privacy and security [17]. In another study, High et al. proposed a unique method to access patient information that could not be communicated but can be stored securely on a wearable device using blockchain using an encrypted private key (can

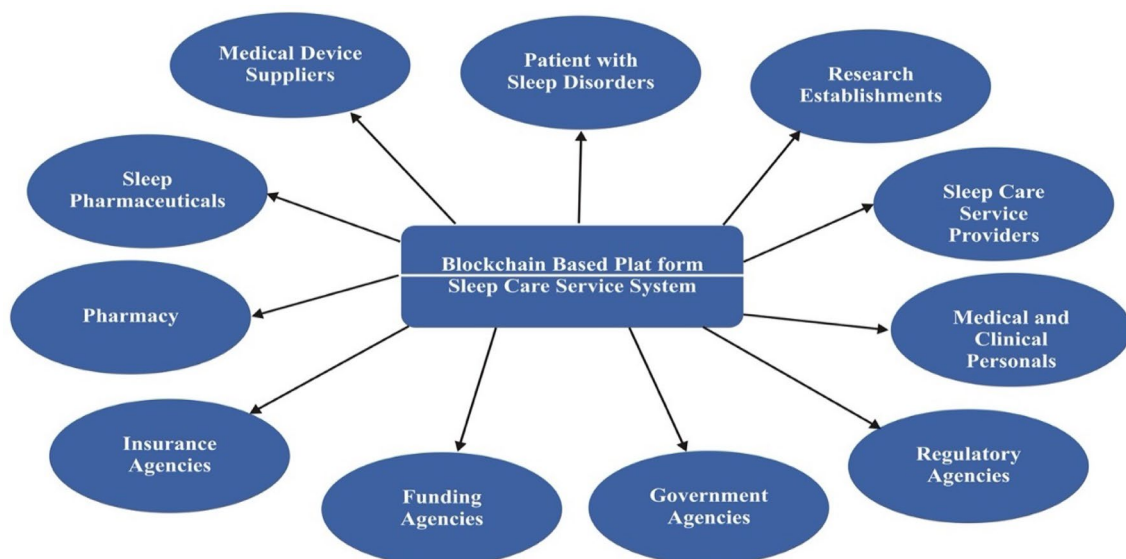


Fig. 1 Blockchain based platform for Sleep Care Services and the various stakeholders

be decrypted only by the biometric signature of the patient) and public key [18].

1.3.1 Blockchain in Remote Patient Monitoring

The remote patient monitoring (RPM) of sleep patients includes the assortment of biomedical information through body sensors, for example, the Internet of things (IoT) gadgets, cell phones [14, 18]. Through these sensors, biomedical information is gathered from patients outside the customary medical services conditions. Determining sleep-related disorders plays a vital role in improvising the overall phenomenon of sleep health care. Furthermore, this data helps research organizations to track the impact of specific drugs and treatment methods utilized. This upgrades the research and permits progress in the best field. The recorded information is then transferred into the blockchain by the sensors, where it is scrambled and annexed to the blockchain for security purposes.

1.3.2 Blockchain in Clinical Sleep Medicine

Blockchain potentially can provide a compelling use case in sleep healthcare and medicine research. Blockchain helps in eliminating any falsified data or the exclusion of undesirable results [19–23]. The transparent and immutable nature of the blockchain allows research institutions to gain access to patient data more efficiently and to get data or results from previous research. Another great potential implementation in sleep healthcare is the Health Professional Education (HPE), which offers competent and valuable education to medical practitioners without third parties [19]. The HPE creates awareness among institutions and patients in the sleep healthcare industry. There is an expanding pattern in conveying blockchain in a wide range of utilizations, including sleep medical care (Table 2).

Blockchain is also decentralized, because the framework's design does not allow confirmation and capacity of exchange information by a specialist. Since information is recorded in the general population record and all of the nodes in the blockchain network have record reinforcements. They can get to this information whenever and anywhere, such a framework guarantees information straightforwardness and serves to manufacture trust among appropriated nodes in sleep medicine [20]. It likewise encourages information review and responsibility by having the ability to follow alter safe, authentic records. Blockchain is also utilized in maintaining Electronic Health Records (EHRs). Profoundly sleep clinical data put away in EHRs improves clinical dynamics, particularly in crises. Blockchain gives the essential security and places the patient in charge of her/his information [15, 18]. Information sharing is a unique cycle (Tables 3, 4).

Figure 2 depicts a typical blockchain application in sleep medicine.

To guarantee adaptability and take out many-to-one traffic streams in sleep healthcare, we need a decentralized framework [22]. A distributed network [23–25] comprises explicit nodes, and they need to demonstrate that they are confirmed with a legitimate authentication. To expand network versatility and evade network delay, we bunch the nodes as numerous groups. Each node has one cluster head that deals with the public keys of the node. Any node joined with any group can change the group whenever there should be deferral occurrence. Additionally, the node appended to a bunch can change the group head.

In sleep stage data monitoring, our model depends on the organization's dispersed nature and other extra security properties. Sleep data can be communicated openly in the blockchain network and contain additional data about both the sender and beneficiary. Hyperledger includes a security foundation for validation and approval; it's a permissioned blockchain utilizing a certification authority, a substance that can produce authentications for key sets for marking and encryption for the companion nodes. Sleep clinical records utilized the hyperledger texture blockchain stage, where they were sending clinical information to the hyper record blockchain network [22]. With the differing scope of information from organizations and patients put away on the Blockchain, this gives an interesting chance to tackle the intensity of other developing advancements like Machine Learning (ML) and Artificial Intelligence (A.I). These two advances upgrade the exchange of learning methods to understand the prescient examination of sleep issue related information and advance the exploration in the territory of medication and treatment accuracy.

According to Liang et al., mobile and wearable technology plays a crucial role in enhancing the quality of healthcare services provided; there is a secure way to share the healthcare data. The authors proposed a user-centric system to implement healthcare data's security and privacy using blockchain technology [23]. The same system could be extended to wearable devices in sleep medicine that gives comprehensive information on the overnight polysomnographic data, which includes sleep onset latency (SOL), wake after sleep onset (WASO), total sleep time (TST), sleep efficiency (S.E.), and other sleep, heart, and respiratory data that can be uploaded on the cloud, where the user can access anytime (Fig. 3).

All medical data in various forms would be stored on the blockchain in a data repository [24, 25]. These repositories are profoundly versatile and can hold a wide range of information. Sleep checking is portrayed as getting subjective sleep measurements by observing an individual's sleep during the night. These serve two capacities. One is to detail a target perspective on the nature of an individual's sleep,

Table 2 Effective utilization of block chain in sleep medicine

The potential use of blockchain in sleep healthcare	Blockchain applications for medical services information make utilities for patients, specialists, and medical services organizations in the bearings of patient record access and control
Blockchain and digital sleep health monitoring system	We can utilize smart agreements in sleep medication to make portrayals of existing clinical records that are put away on the network inside individual hubs [18]
Blockchain and mobile sleep health	In the Mobile sleep health framework, patients got meetings through a talk program each day. The program included a completely robotized cell phone application. Patients needed to include their m-Health information twice/threefold every day, toward the beginning of the day, evening, and at night [21]
Blockchain and development and utilization of mobile technology to record sleep/wake pattern (or rest/activity pattern)	With Mobile technology like fitness wearables, a person's sleep pattern is tracked daily, and scheduling timely exports of such data allows a better understanding of how patients implement lifestyle changes for a sleep-related disease like sleep apnea insomnia
Blockchain and medical information management	Electronic medical record available in today's era does not provide an effective relationship between patients and provide limited information. Blockchain plays an important role in overcoming the limitation by establishing a strong connection between health care organizations, laboratories, pharmacies, and patients for better health care delivery [22]
Blockchain and data security in sleep healthcare	Blockchain provides a solution for data security in sleep health care with the help of decentralizing storing mechanisms, encryption, and smart techniques
Blockchain and care of patients with sleep disorders	Blockchain can collect comprehensive sleep data over a lifetime that is required to understand the sleep disorders of the patients that will help doctors, physicians to understand treatment plans for an individual based on his genetics, lifestyle, and environment
Blockchain in medical records management in sleep medicine	The cloud-based medical record is associated with viewing permissions and data retrieval instructions, thus using the Blockchain to record patient's sleep data and the medications given via smart contracts. Once a doctor creates a record, it is verified, and its viewing permissions are authorized by the patient and stored in a smart contract [14]
Blockchain-Authenticated Sharing of Genomic and Clinical Outcomes Data of Patients With sleep disorders	Sleep is hereditarily controlled. Although ecological elements can affect the span of sleep, the hereditary guideline is borne out by the heritability of sleep attributes. The blockchain-validated framework guarantees secure sharing of patient's genomic information got from standard genomic testing, and electronic health records
Blockchain in telemedicine services in sleep medicine	Pharmacists can get direct prescriptions of a patient for therapy on sleep diseases from the doctor and then the drug cart is delivered along with the computerized prescription to the nurse who administers the therapy of the patient
Blockchain-based personal health information (PHI)	PHI consists of medical history, health conditions, health insurance information that is collected by health care officials to provide proper care [22]. Healthcare organization needs to ensure that all security and privacy of collected information is maintained using blockchain-based information systems ensures the medical record of the patients is accessed and shared to different health care organizations without any interventions
A Decentralized Peer-to-Peer Remote Health Monitoring System	Remote health monitoring (RHM) empowers specialists to screen patient's physiological conditions from their homes and liberates sweeping medical care offices [27]. Wearable Sensors and information created by them to encourage RHM have been the subject of innovative work
Blockchain and the design of a secure protocol for cloud-assisted Electronic Health Record (EHR) System	As patient medical services records have been created from conventional paper the executives to an electronic record the board, they can be securely put away and approved uniquely by real clinical focuses

Table 2 (continued)

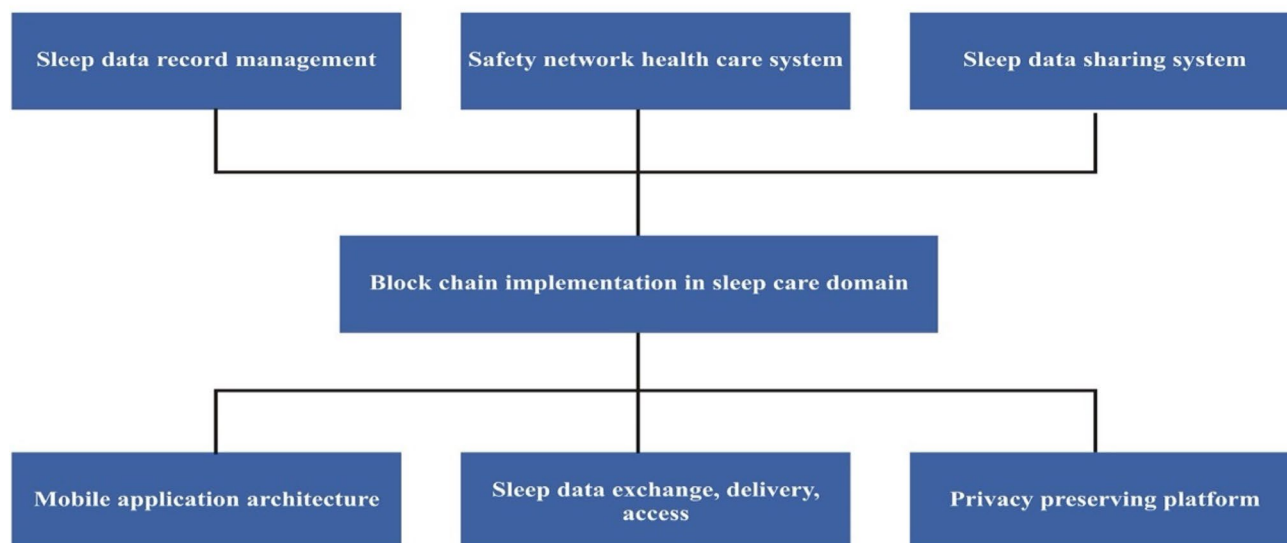
Blockchain in sleep pharmaceuticals	Pharmacists can get direct prescriptions of a patient for therapy on sleep diseases from a doctor and then the drug cart is delivered along with the computerized prescription to the nurse who administers the therapy of the patient [1, 5]
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Table 3 Challenges in sleep medical care

Technical	Blockchain executions are pseudonymous, specifically, personality is regularly clouded behind a public key, it cannot guarantee conditional security for every open key thus the estimation of exchanges is freely obvious Blockchain-based answers for work viably, partners' medical services suppliers, patient, and protection must be happy to collaborate and set norms about what information is put away on or off the blockchain, what size and configuration is offered [12, 25, 38]
Organizational	organization of co-activity of numerous nodes must be found to give the processing power important to create blocks after an exchange is delivered. In this manner, it needs financial, operational for participation. Integration with many medical care strategy producers ought to be officially cooperation and make administrative system concerning patient's protection [18, 27]
Behavioural	Blockchain is still in the progress stage thus it goes up against social difficulties social move, social acknowledgment thus it should be users training [39]

Table 4 Key domain effect on sleep health

Patient monitoring	Non-intrusive technique for patient monitoring is easy and more appropriate for patient recovery [40]
Sleep technicians	Accessing newly available sleep data and monitoring helps in making the clinical decision [41]
Pharma	Monitoring the effect of the drug [42]
Insurance	Necessary to maintain a healthy lifestyle and monitor the effect of other intrusions [43]
Others	Various sleep health care application and stakeholders [44, 45]

**Fig. 2** Block chain in sleep medicine

while the other job is to decide the sleep patterns. Respiratory rate and body developments are viewed as the most itemized estimations for sleep checking during the sleep dozing session.

Ordinarily, inspecting an individual's sleep health requires an overnight evaluation with the help of polysomnography (PSG). Polysomnography (or sleep study) has been considered a gold standard diagnostic tool for the

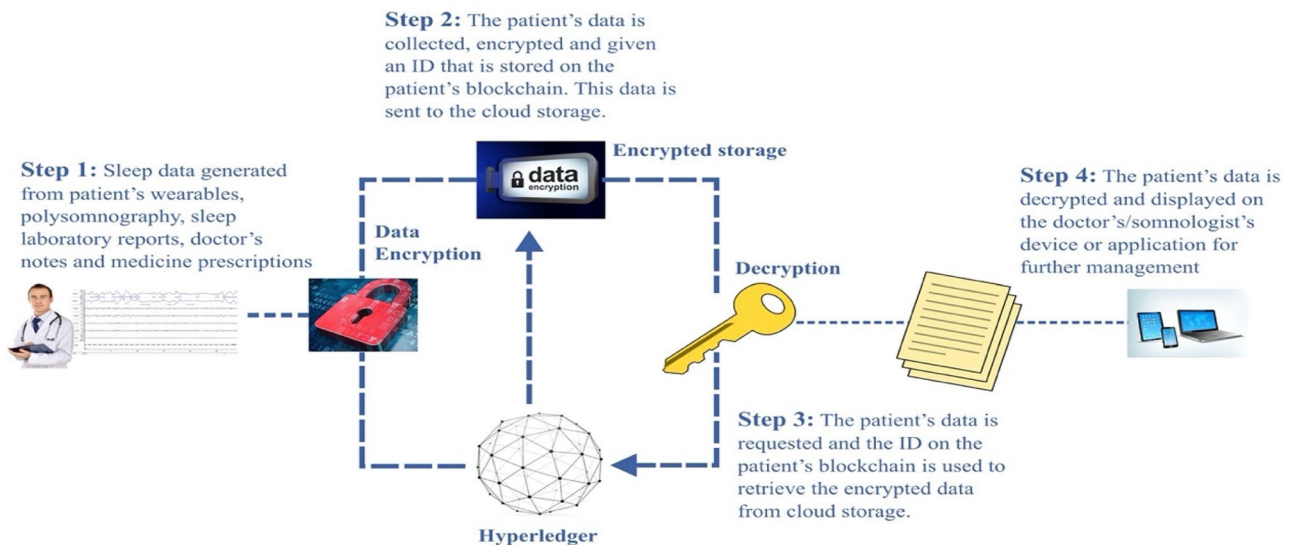


Fig. 3 Step-by-step processing of information through electronic devices using block chain technology in sleep medicine

comprehensive evaluation of various breathing disorders. The PSG is a comprehensive monitoring procedure that requires multiple sleep-related physiological parameters [6]. This includes the brain wave activity (EEG; electroencephalography), eye movement (EOG; electrooculogram), muscle activity (EMG; electromyogram), heart rate and rhythm (EKG; electrocardiogram), airflow and respiratory effort (both thoracic and abdomen), blood oxygen saturation level (SpO₂), limb movements, and other optional measurements such as the body position during sleep.

Despite several advantages, conventional PSG is an inherently intensive, costly, and tedious procedure. In this way, the medical care network is asking for novel non-meddling approaches that can improve the nature of medical services for the patient while continuing the administration's expense [24]. Actigraphy is a non-invasive method for inferring human rest/activity patterns based on movement data gathered using wrist actigraphs. Actigraphy is used as an alternative in collecting large-scale data in epidemiological investigations [26, 27]. Nevertheless, this device is not as elaborate as the PSG. Nonetheless, its data, which depends on the patients' movement, is basic for medical care experts to decipher and dissect the clients' sleep characteristics [25–28].

All data put away in the data repository would be encrypted and digitally signed to guarantee the protection and genuineness of the data. This way, several sleep parameters, for instance, the term of a sleep period, the number of arousals, a span of upset sleep periods, and the time needed to nod off.

Each time sleep data is collected and saved; the health record is enrolled in the blockchain alongside the client's

one of a kind identifier. The sleep patient is advised that health information was added to his blockchain. Utilizing a hashing procedure and propose a recent encryption calculation to encode the exchanges containing individual and touchy information about patients. This calculation's advantage is its capacity to cover an enormous number of exceptionally recognized clinical items and its extremely low time unpredictability [29–32]. In a similar style, a patient would have the option to include sleep-data with advanced signs and encryption from versatile applications and wearable sensors. The user would have full admittance to his information and power over how his information would be shared. The user would appoint access authorizations and assign who can question and compose information to his blockchain. A portable dashboard application would permit the user to see who has the authorization to get to his blockchain [33–35]. A similar dashboard would permit the user to give and renounce access authorizations to any person who has a novel identifier. Yoon highlighted that Blockchain technology allows patients to assign access rules for their medical data [36, 37, 38], e. g. permitting specific researchers to access parts of their data for a fixed period. With this technology, the patients can connect to other hospitals and collect their medical data automatically [37]. Therefore, the same can apply in sleep medicine for patients and treating specialists in sleep clinics and making it easier for patients to collect their sleep data from other sleep clinics/ hospitals.

1.4 Challenges

Blockchain innovation is a rising innovation carrying with it a lot of preferences and openings. Notwithstanding, this

innovation accompanies several difficulties that ought to be tended to, with the executives' significant information. Though there are security issues [26,28] with the cloud [17,37], the blockchain can address the health data's security aspects. Therefore, health data (or sleep data) sharing and storing with the blockchain-based cloud can address several issues concerning medical data management [38]. The health care area is vast and spreads its wings into many different divisions. In this way, it has a lot of information that must be handled daily and annexed into the Blockchain. With time, research inside the medical care industry is set to increment the information, representing a test of dealing with the capacity limit of the medical services blockchain [39]. Sleep medical care [44] conveyance comprises a wide range of information sources, and the medication supply chain is large part regarding both amount and cost and in this way defenseless against deceitful assaults. Besides, including the functionalities, such as private keys and smart contracts, the framework could give authenticity, dependability, validness, and verification of responsibility for drug sources. Current executions of blockchain innovation in sleep medical services are either the prototyping stage or the improvement stage. Hence, it needs more exploration, trial executions, and speculations for assessing its impact on administrations and results.

2 Conclusions

Blockchain has evolved from the time it was introduced through Bitcoin. Currently, it is implemented into general-purpose technological solutions with use cases in many industries. Sleep Healthcare and medicine are also relatively new medical specialties that require technological innovativeness to enhance research and interoperability. As seen above, blockchain can take sleep healthcare to the next level by providing a platform that allows data sharing for research and remote patient tracking. With the fast headway and deployment of the blockchain in the medical services area, these advancements are firmly identified with individuals. Thus, protection and security are significant concerns in sleep medicine. However, more research still needs to be conducted to better understand and characterize the utility of blockchain technology in Sleep Healthcare.

3 Materials Availability

Not applicable.

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Other remaining authors declare that they have no proprietary, financial, professional, nor any other personal interest of any nature or kind in any product or services and/or company that could be construed or considered to be a potential conflict of interest that might have influenced the views expressed in this manuscript.

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