



# An Overview of Existing Publications and Most Relevant Projects/Platforms on the Use of Blockchain in Medicine and Neurology

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**Background:** Blockchain is a new methodology involving a data structure with list of records, called blocks, which are linked using cryptography. The aim of the review is to overview the existing publication, projects, and platforms on the use of blockchain in Medicine and Neurology.

**Methods:** We searched the bibliographic database of MEDLINE and BASE. We also accessed ICObench, Coinmarketcap, and Mobihealthnews databases to explore upcoming, ongoing, and ended projects.

**Results:** In medicine, there are many projects related to health care, disease prevention, and promotion of healthy life style. In neurology, only one project looks promising: Neuro, an ongoing scientific-technical project uniting scientists, engineers, and programmers for development of new architectures and algorithms of neural networks. Bibliographic searches found 117 publications on Medline and 203 publications on BASE referring to the use of blockchain technology in medicine. Most of them are presented as reviews (narrative, systematic, or minireview), opinions and hypotheses, commentaries, or perspectives. As for Neurology, only one publication refers to the use of blockchain, specifically to Parkinson's disease.

**Discussion:** Among the problems related to medicine, there is the lack of information on the patient's clinical history that could allow accurate diagnosis and treatment. The possibility of having a register based on blockchain technology could help doctors in many ways, including patient management, choosing and monitoring treatments, and standardization of clinical trials.

**Conclusion:** The use of the blockchain technology in medicine has been repetitively proposed to solve different problems. In this article, we highlight the possible benefits of this technology, with attention to Neurology. Blockchain use can lead to quantifiable benefits in the treatment of neurodegenerative diseases, especially in clinical trials that can fail because of an incorrect patient recruitment.

**Keywords:** blockchain, decentralized ledger technology, platform, neurology, personalized medicine

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## INTRODUCTION

### Blockchain Technology

Blockchain is a new software methodology in which a data register is structured as a linked sequence of blocks and whose validation is entrusted to a consensus mechanism distributed on all nodes of the network (Siba et al., 2017; Zheng et al., 2017). The first work on a cryptographically secured chain of blocks was described in 1991 by Stuart Haber and W. Scott Stornetta (Haber and Stornetta, 1991). Blockchain received attention in 2008 after a person, or group of people, using the pseudonym “Satoshi Nakamoto” invented the public distributed ledger technology (DLT) of the cryptocurrency Bitcoin<sup>1</sup> (Nakamoto, 2008).

The blockchain technology is based on a network that allows to manage a database in a distributed way (Jiang et al., 2019). From an operational point of view, a blockchain is an alternative to centralized archives (Chen and Zhu, 2017) and it allows all participants in the network to have access to shared and distributed data (Park et al., 2019). All nodes authorized to participate in the process of validation of the transactions are included in the register (Jones et al., 2019). Each block is also an archive of all transactions and of the entire history of each transaction. Furthermore, the block can only be modified with the approval of the network nodes. Thus, the main characteristics of blockchain technology are the immutability of the register, transparency, traceability of transactions, and security based on cryptographic techniques (Yli-Huomo et al., 2016).

### Blockchain Introduction in Medicine

Healthcare sector has accumulated massive amounts of data, but there are still challenges in terms of data distribution, accessibility, comparability, harmonization, and other limiting factors. Many healthcare systems are slow at sharing and processing medical data. Blockchain may provide a decentralized, transparent platform for patients and medical workers to communicate, and exchange case-relevant information, and unify the general healthcare experience (Kuo et al., 2017). Through a coordinated platform, it is much easier to help patients, share expertise from any part of the world, and get consultations with different specialists.

The use of blockchain has already been proposed in various healthcare settings (Kuo et al., 2017; Bell et al., 2018), with potential applications in medical record management, chronic disease prevention (Paglialonga and Keshavjee, 2019), claims processing, health supply chain management, and integration of geospatial data (Kamel Boulos et al., 2018).

The aim of the review is to give an overview the existing publications, projects, and public information on the use of blockchain in the general/broad field of medicine and in the subfield of neurology.

## METHODS

### Data Source and Search Strategy

We searched the electronic bibliographic database of MEDLINE (PubMed) and Bielefeld Academic Search Engine (BASE), without language restriction. We also accessed ICObench, Coinmarketcap, and Mobihealthnews databases to explore upcoming, ongoing, and ended projects.

PubMed search strategy was listed as follows, which was adopted for search in the other databases: “blockchain” (or “DLT”) AND “Medicine” OR “brain” or (“neuron”; “cortex,” “cell,” “stem cells,” “mind”) or “Neurology” or (“Neurological diseases”).

## RESULTS

### Bibliographic Database Search

We found 492 publications on blockchain on MEDLINE (31/12/2020); 117 of them specifically refer to medical field of application. All publications found refer to the use of blockchain in different fields of medicine and are presented as reviews (narrative, systematic, or minireview), opinions and hypotheses, commentaries, or perspectives; 35 of them are specific review articles and four of them are systematic reviews. Seven of them propose blockchain-based methods and protocols for data sharing, health management, and clinical trial management. Starting from 2017, the number of publications on the use of blockchain in the medical field is growing exponentially (Figure 1). Despite these increasing numbers, only one publication refers to the use of blockchain in Neurology and specifically to Parkinson’s disease (Zheng et al., 2019). Moreover, the searches with the terms “brain,” “neuron,” “cortex,” “cell,” “stem cells,” “mind,” or “Neurological diseases” retrieved no results.

We found 203 publications with the terms blockchain and Medicine on BASE; 39 of them were review articles (narrative or systematic) introducing the use of blockchain technology in several fields of medicine (including health care management, consent management, cardiovascular medicine, dentistry, oncology, and radiology).

### Blockchain/DLT Project Database Search

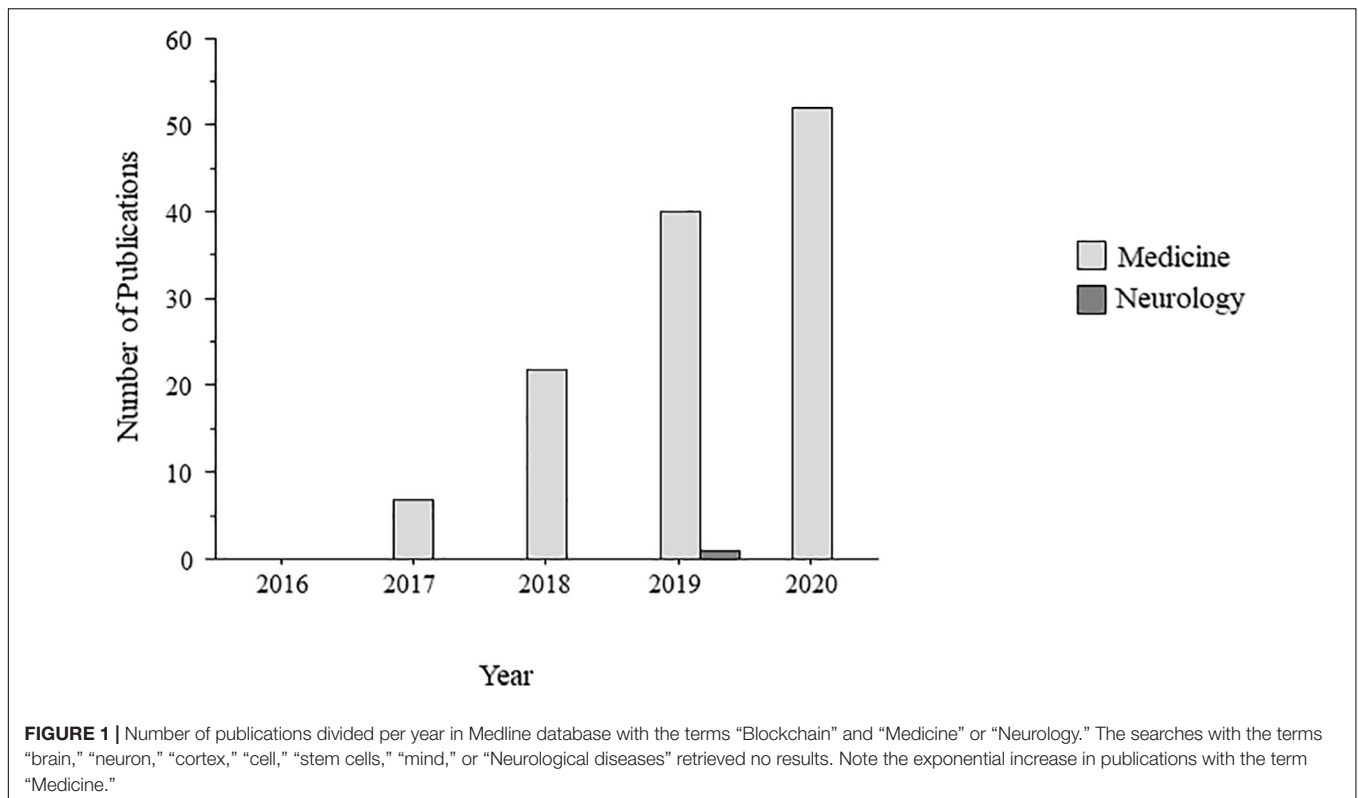
A search within database ICO bench<sup>2</sup> found 273 projects related to health management (containing the search term medicine). Forty-one of them have content related to “medicine”; two of them contain the term “brain”; and one of them contains the terms “Neurology” or “Stem cells” (Table 1).

A search within database Coinmarketcap<sup>3</sup> revealed 12 projects that deal with medical issues or have a name relating to the

<sup>1</sup><http://bitcoin.org/>

<sup>2</sup><https://icobench.com>

<sup>3</sup><https://coinmarketcap.com>



medical field overall or neurology specifically. However, only seven of these projects are related to medicine and two of them contain the term “neuron” (Table 1).

After examination of the identified projects, the most relevant ones in terms of advances in clinical applications are as follows: (1) Medicalchain<sup>4</sup>; (2) TrustedHealth<sup>5</sup>; (3) MediBloc<sup>6</sup>; (4) Oncopower<sup>7</sup>; (5) Neuromation<sup>8</sup>; (6) Medibit<sup>9</sup>; and (7) Curecoin<sup>10</sup>.

## Projects for Disease Prevention and Promotion of Healthy Life Style

Projects based on blockchain technology are related to prevention of diseases and/or incentivize healthy life style (Table 2).

Among them, the most relevant projects related to disease prevention are: (1) Stem cell coin<sup>11</sup>; (2) Virtual Rehab; (3) The eHealth First; (4) Avaqva; and (5) OID.

The most relevant projects related to promotion of healthy lifestyle are: (1) Lympto<sup>12</sup>; (2) Gymrewards<sup>13</sup>; (3) Clinicoin<sup>14</sup>; (4)

MintHealth<sup>15</sup>; (5) Hayver<sup>16</sup>; (6) Sobercoin<sup>17</sup>; (7) Embleema<sup>18</sup>; and (8) HealthWizz<sup>19</sup>.

## DISCUSSION

In this review, we give an overview on the use of blockchain technology in Medicine and Neurology. In our search, we found 117 publications in PubMed database and 41 projects in ICO bench database and 12 projects in Coinmarketcap related to the use of blockchain in medicine. However, not all the projects identified have specific application to the medical field. Thus, we selected the most relevant projects and divided them in different subgroups for the discussion.

### Most Relevant Projects Related to Medicine and Health Care

In this section, we selected the most relevant projects related to medicine and healthcare that can be used by physicians, according to the generalized scheme proposed in Figure 2.

In healthcare, the more interesting ICOs launched so far are:

- (1) Medicalchain (see text footnote 4) is a decentralized platform to open and store access to electronic health

<sup>4</sup><https://medicalchain.com>

<sup>5</sup><https://trustedhealth.io>

<sup>6</sup><https://medibloc.org>

<sup>7</sup><https://oncopower.org>

<sup>8</sup><https://neuromation.io>

<sup>9</sup><https://www.medibit.org>

<sup>10</sup>[www.curecoin.net](http://www.curecoin.net)

<sup>11</sup><https://www.stemcell-pj.net/en>

<sup>12</sup><https://lympo.io>

<sup>13</sup><https://gymrewards.io>

<sup>14</sup><https://clinicoin.io>

<sup>15</sup><https://www.minthealth.io>

<sup>16</sup><https://hayver.io>

<sup>17</sup><https://www.sobercoin.net>

<sup>18</sup><https://www.embleema.com>

<sup>19</sup><https://www.healthwizz.com>

**TABLE 1** | List of the projects in ICO bench and Coinmarketcap databases containing the terms “Medicine” or “Brain” or “Neuron” or “Neurology” or “Stem cells.”

Name of the project/platform	Term used for the search					Database source
	Medicine	Brain	Neuron	Neurology	Stem cells	
MediLives	X					ICO bench
Pharmeum	X					ICO bench
eHealth First	X					ICO bench
MediConnect	X					ICO bench
Open Longevity	X					ICO bench
Biohal	X					ICO bench
ClinTex	X					ICO bench
Xeophin	X					ICO bench
Dermavir	X					ICO bench
MedCredits	X					ICO bench
Earthmedz	X					ICO bench
Project Shivom	X					ICO bench
BASIS NEURO	X	X				ICO bench
MediChain	X					ICO bench
Carna Life	X					ICO bench
Trade Pharma Network	X					ICO bench
Vinnd.io	X					ICO bench
Bowhead Health	X					ICO bench
ELCoin	X					ICO bench
FAIMA	X					ICO bench
MedChain	X					ICO bench
MediBloc	X					ICO bench/Coinmarketcap
AI Opinion	X					ICO bench
Bioritmai	X					ICO bench
Doc Coin	X					ICO bench
Docademic	X					ICO bench
iRegMed	X					ICO bench
Lumenus	X					ICO bench
MedAI Network	X					ICO bench
Worldwide Meds	X					ICO bench
HealthCUBE	X					ICO bench
BitMED	X					ICO bench
MDCN	X					ICO bench
MEDICOIN	X					ICO bench
TrustedHealth	X					ICO bench
Yoo-Mi	X	X				ICO bench
TrustedHealth	X					ICO bench
VR MED	X			X		ICO bench
Stem Cell					X	ICO bench/Coinmarketcap
Medicalchain	X					ICO bench/Coinmarketcap
Neuromation	X		X			ICO bench/Coinmarketcap
Medibit	X					Coinmarketcap
Curecoin	X					Coinmarketcap
Neuro	X		X			Coinmarketcap

The searches with the terms “cortex,” “cell,” “mind,” or “Neurological diseases” retrieved no results.

records. This allows for direct communication between patients and doctors to schedule consultations, share opinions, or edit records. The advantage of this platform is immediate access to patient personal data worldwide.

(2) TrustedHealth (see text footnote 5): the main aim of the project is to tackle life-threatening diseases. It offers a

number of medical benefits, including opportunities for patient–physician cooperation to find the best diagnostic methods, improving patient health, and ensuring access to data worldwide.

(3) MediBloc (see text footnote 6) is a Korean health data platform that boasts the highest level of data

**TABLE 2** | List of the projects based on blockchain technology related to prevention of diseases and/or promoting healthy life style.

Name of the project/platform	Disease prevention	Healthy life style	Database source
Virtual Rehab	X		ICObench
eHealth First	X		ICObench
Safeguard	X		ICObench
Discoperi	X		ICObench
Avaqva	X	X	ICObench
FAIMA	X		ICObench
OID - Opioid Token	X		ICObench
Stem cell	X		ICObench
Humanscape		X	ICObench
Armaccoin		X	ICObench
Lymbo		X	ICObench
Lyfe		X	ICObench
IPUX		X	ICObench
Zealeum		X	ICObench
Kynson		X	ICObench
Gym Rewards		X	ICObench
Clinicoin		X	ICObench
Embleema		X	ICObench
Sweatcoin		X	www.mobihealthnews.com
MintHealth		X	www.mobihealthnews.com
Hayver		X	www.mobihealthnews.com
Sobercoin		X	www.mobihealthnews.com
HealthWizz		X	www.mobihealthnews.com

security and integrity. Patients can use their data on the platform as needed. This platform will form the base for medical innovation on database-based disease prediction and research.

- (4) Oncopower (see text footnote 7) is a platform developed to solve the daily challenges associated with oncological pathologies. Oncopower uses blockchain technology to create a database of all health-related experiences and help users manage cancer.
- (5) Neuromation (see text footnote 8) is another platform to improve disease detection and diagnosis, including more accurate cancer and injury detection in MRI. Artificial intelligence-based medical imaging solutions also eliminate delays in diagnostic work, enabling faster and more satisfying patient care.
- (6) Medibit (see text footnote 9): MediBit is a globalized healthcare platform for exchanging medical data between insurance companies, veteran hospitals, government agencies, pharmacy networks, general hospitals, fitness centers, research organizations, and blockchain medical platforms.
- (7) Curecoin (see text footnote 10): Curecoin aims to increase the maximum potential of distributed computing networks (DCNs) around the world who are looking for important answers to medical, scientific, and mathematical problems by incentivizing the donation of computational resources, such as central processing and graphics units. The incentive takes place through

the creation of a unique blockchain that rewards this research.

## Projects Related to Disease Prevention and Promotion of Healthy Life Style

In addition to these platforms, there are many other projects based on blockchain technology that are related to prevention of diseases and/or incentive healthy life style (Table 2). There have been introduced several cryptocurrencies with the attempt to promote physical activity, specific workout, healthy behavior, and sobriety. Most of the currencies can be cashed-in for goods like workout gear, discounted services including coaching. Other companies are also using the digital currency as an incentive for patients to release personal data.

This is a short list of most interesting projects and cryptocurrencies launched so far.

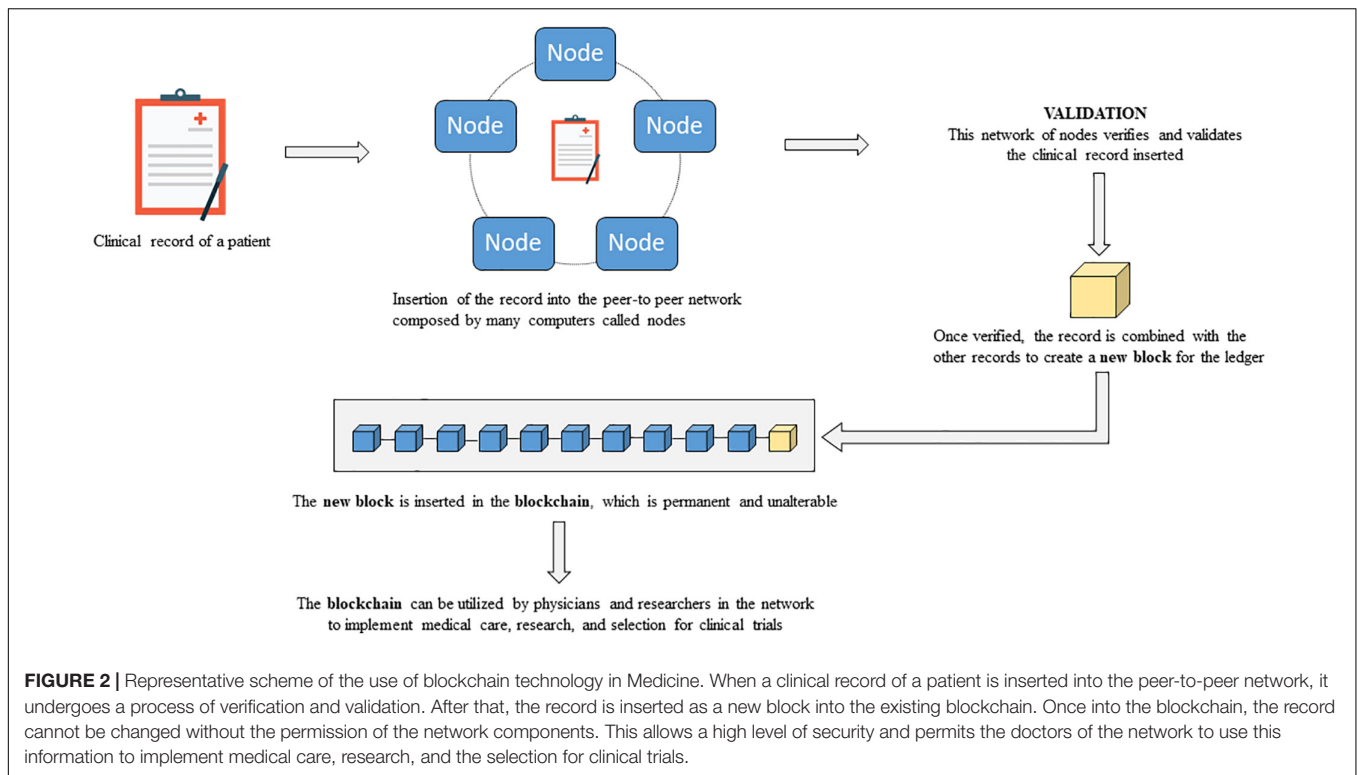
### Disease Prevention

- (1) Stem cell coin (see text footnote 11) is a cryptocurrency created in Japan with the aim of supporting the use of stem cells in the elderly, in aging and regenerative medicine. The intention is to use it for the construction of clinics and the development of technology and clinical administration.
- (2) Virtual Rehab: Virtual Rehab leverages advances in virtual reality, artificial intelligence, and blockchain technologies for the psychological rehabilitation of vulnerable populations (pain management, prevention of substance use disorders, improvement of autistic individuals, communication skills, and rehabilitation of repeat offenders).
- (3) eHealth First is an IT platform based on blockchain technology to support decision making in the field of health management, longevity, diagnostics, prevention, and treatment of common diseases for non-specialist users, medical specialists, researchers, and businesses. EHealth First uses machine learning, natural language analysis, neural networks, clinical epidemiology, evidence-based medicine, and telemedicine.
- (4) Avaqva: Avaqva is produced by special technology with the use of natural ingredients to produce functional waters with unique health benefits to maintain a healthy lifestyle and prevent disease. Currently, the Avaqva product line consists of four drinking waters that offer truly effective solutions for the prevention of diabetes, obesity, diseases of the cardiovascular system and the gastrointestinal tract, as well as for the improvement of the body's immune status.
- (5) OID—Opioid Token is a currency that will be used to treat patients with opioid/drug addiction problems and to help build the necessary infrastructure and support staff.

### Promoting Healthy Lifestyle

- (1) Lymbo (see text footnote 12) is a fitness-focused platform that rewards users for their healthy behaviors through a cryptocurrency called LYM token. Users can use the token to purchase goods and services from the platform.
- (2) Gymrewards (see text footnote 12) is an app that rewards people for training. Gymrewards uses wearable devices to





track heart rate and estimated calories burned to “mine” the GYM currency.

- (3) ClinicoIn (see text footnote 14) allows users to collect tokens as an incentive for their own business and health reward system and for participating in research studies. Participants can exchange their ClinicoIn tokens for items in the platform’s wellness market. The app also allows users to set goals and track their fitness.
- (4) MintHealth (see text footnote 15) is a platform for using the blockchain to allow patients to access their medical records. It allows patients to use digital currency called “vidamints” within the MintHealth ecosystem. Tokens are provided to patients who engage in healthy behaviors.
- (5) Hayver (see text footnote 16) helps users cope with addiction. This service uses a combination of daily check-ins and randomized urine tests, as well as an accountability network, which includes friends and family. All users, including people in the accountability network, are eligible for coins.
- (6) Sobercoin (see text footnote 17) was developed to help people undergoing physical recovery. People can get sobercoin coins by joining, inviting friends, and using the sobercoin app, which supports recovery. Coins can be exchanged for online recovery coaching, sobercoin advertising, or training to become a coach.
- (7) Embleema (see text footnote 18) compensates patients with cryptocurrency for sharing medical data. Embleema tokens allow users to access the platform’s PatientTruth, which allows users to share their data with their vendors and researchers.

- (8) HealthWizz (see text footnote 19) allows users to sell access to their medical records to researchers and pharmaceutical companies in exchange for coins. The HealthWizz app has the ability to aggregate data from multiple different sources including electronic health records, laboratory results, and genetic data.

## Blockchain Use in Medicine

At present, in the health care system, there is the great issue of the multitude of sources (Frenk, 2010). For example, there is no single national register of pharmacological therapeutic prescriptions, but a multitude of sources, often fragmented, that must be coordinated. In this scenario, it has been proposed that a secure, decentralized, and “immutable” record management system can provide faster access to the data needed at that moment (Dubovitskaya et al., 2020).

Managing patients’ medical data through a shared system would allow physicians to share information about patients in a secure, efficient, and fast way. Patients can share their records with healthcare providers, eliminating repeated tests and providing high-quality data for disease prediction and optimized medication. Blockchain technology can maximize patient satisfaction by offering personalized care based on their complete indexed history of medical records (Figure 2).

The potential of blockchain in medicine has been highlighted in some recent articles. In a systematic review by Dubovitskaya et al. (2020), the importance of starting to use blockchain technology in the oncological field is emphasized, specifying how the prototypes present for general healthcare can also be applied in oncology. In case of chronic diseases such as cancer,

this is particularly important, due to the multiple-medication intake, diagnosis, and treatment conducted at multiple hospitals. Moreover, employing blockchain technology can enable fast and secure data access for medical practitioners and researchers, leading to improved cancer treatment with significantly increased efficiency and reduced cost.

Blockchain technology can also be applied for pain management, as evidenced by Chang et al. (2020), or to manage opioid addictions (Raghavendra, 2019). These articles highlight the advantage of managing medical information in a faster and secure way. Regarding opioid abuse addictions, blockchain technology could help reduce opioid abuse. Currently, there are health systems that use big data analytics to predict opioid risks/overdoses. Big data analytics using blockchain-based technology could make these predictions faster and more accurate. For example, if all epidemiological data relating to opioid abuse and/or deaths were put on a blockchain, the data would become stronger and immediately available. These data could be consulted, e.g., by the competent authorities in order to gain a better understanding of the epidemic course and the development of appropriate solutions (Raghavendra, 2019).

Another interesting application of the blockchain concerns food safety control, a problem that is gaining increasing attention in recent years with the economic development (Xu et al., 2020). Also in this case, it is highlighted how the use of blockchain technology can help manage the management of food safety control more efficiently (Xu et al., 2020).

In another recent article, the potential of blockchain in various fields of medicine is highlighted, such as electronic health records, health insurance, biomedical research, drug supply and procurement processes, and medical education (Radanović and Likić, 2018). Despite this, the authors highlight the current problems related to the use of this technology. Among these, it is worth to mention the lack of public or expert knowledge, scalability, security of data sharing, and user adoption.

Overall, we can assume that the use of the blockchain in medicine shows evident advantages. Many healthcare systems are rather slow in sharing and processing medical data. Blockchain provides a decentralized, transparent platform for patients and medical workers to communicate, exchange case-relevant information, and unify the general healthcare experience. Therefore, the use of blockchain would help medicine and healthcare to improve the service provided to patients. Furthermore, the use of the blockchain can help to speed up and standardize clinical trials, thanks to the possibility of connecting multiple data sources and collecting information in a shorter time and in a transparent way.

## Blockchain Use in Neurology

In the unique publication present in PubMed (Zheng et al., 2019), the authors introduce the use of blockchain technology to share anonymous patient related tremor data helping to consolidate the research. In this way, the authors claim that researchers can share and access to wider essential tremor related information, helping to understand individual evolution in both short and long terms.

As for projects and/or platforms, we only found one pertinent project called “Neuro,” which is an ongoing scientific-technical

project uniting scientists, engineers, and programmers for the development of new architectures and algorithms of neural networks<sup>20</sup>. The neural networks may be used to calculate molecular interactions in protein environments. This system will help to look for new types of drugs for cancer, Alzheimer’s disease, and other serious problems of modern medicine.

Despite this paucity of data, there are issues in Neurology that could be addressed with blockchain technology. In particular, neurodegenerative disorders such as Alzheimer’s and Parkinson diseases could benefit from this technology. In fact, besides the difficulty of diagnosis, there is the lack of information on the patient’s clinical history that could allow a more accurate definition of the state of illness and treatment (Morris, 1993). It is believed that many clinical trials have failed because of the lack of proper information necessary for patient recruitment (Fogel, 2018). These types of errors have undermined the outcome of the trial and may have impacted the development of new drugs (Heneghan et al., 2017). This problem is especially felt in the field of cognitive disorders (Mangialasche et al., 2010). There are various forms of dementia, which are in turn characterized by various states of illness (Karantzoulis and Galvin, 2011). The possibility of having a register, like the one provided by the blockchain, could help the pharmaceutical companies to recruit patients and help doctors in choosing the most appropriate treatment (Angeletti et al., 2017). In this regard, protocols for the use of the blockchain to conduct clinical trials and manage their data have already been proposed (Nugent et al., 2016; Benchoufi and Ravaut, 2017; Maslove et al., 2018; Wong et al., 2019). These authors claim that the use of blockchain technology can improve clinical trial data management, boost trust in clinical research and the ease at which regulators can oversee trials.

There are other areas related to neurology where the use of the blockchain can have promising applications. In a recent article, it is highlighted how the use of blockchain can be useful in the field of medical imaging, with particular reference to the possibility of image sharing, including direct patient ownership of images, tracking of implanted medical devices, research, teleradiology, and artificial intelligence (McBee and Wilcox, 2020). In the neurological field, this application could be of considerable importance, especially for diseases characterized by neurodegenerative processes that need to be monitored over time.

In addition, it has been proposed the use of blockchain for tele-healthcare service, a topic of relevance during the pandemic situation caused by COVID-19 (Celesti et al., 2020). Blockchain may be used to support a system based on tele-medical laboratory service where clinical exams are performed on patients directly in a hospital by technicians through Internet of Things (IoT) medical devices and results are automatically sent via the hospital Cloud to doctors of federated hospitals for validation and/or consultation.

Monitoring the course of a disease with blockchain could be important in case of progressive neurodegenerative disorders

<sup>20</sup><https://neurocoin.org/>

such as Alzheimer's disease and multiple sclerosis. The topic of monitoring diseases has been discussed for example in the context of diabetes mellitus (Fernández-Caramés et al., 2019), where the authors highlight the vantage of a system with IoT capabilities to allow for monitoring patients remotely and warning them about potentially dangerous situations.

Dosage of medication could also benefit from the use of blockchain technology. It has been proposed the use of cryptopharmaceuticals where pharmaceutical products are connected in a patient-specific blockchain of individual dosage units (Nørfeldt et al., 2019). The advantages are the possibility to visualize the dosage unit for each patient included in the blockchain and incorporate this information into a system that provide means to avoid counterfeit products and to enable innovative logistic solutions. The adoption of this system could be very useful in the neurological field, to solve issues related to an incorrect and/or ineffective dosage, a common problem in the treatment of neurodegenerative diseases.

## CONCLUSION

Blockchain technology is one of the most promising innovations to improve our health. Nevertheless, the use of this technology in medical field does not yet have a consolidated application in real life and the technology itself is still far from the achievable efficiency level. In the neurological field, its application is practically absent nowadays. However, the use of the blockchain in neurology can lead to quantifiable benefits in the treatment of neurological disorders, especially in monitoring patient health and clinical history, treatments, disease course monitoring, and recruitment in clinical trials. Despite these advantages, we must first solve the problems related to a practical application of the blockchain in the medical field, such as security issues and lack

of public or specialized knowledge capable of guaranteeing the optimal functioning of blockchain protocols.

## AUTHOR CONTRIBUTIONS

FA and JH drafted the manuscript. MV, KK, and JH performed critical editing. MV, KK, and BZ participated in constructive outline, discussions, and editing. All authors read and approved the final manuscript.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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