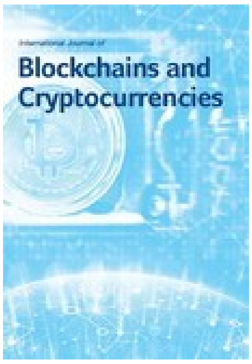

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Crowdsourcing clinical research utilising blockchain-based incentivisation systems

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Abstract: During the ongoing pandemic, the organisation of clinical trials has proven problematic for many researchers. Recruitment challenges aside, the need to maintain participant safety has made it difficult for researchers to enrol a suitable number of participants. As such, many researchers have had to adopt a virtual approach to conducting clinical trials. Virtual clinical trials have the potential to enable mass enrolment of participants in studies, ultimately 'crowdsourcing' clinical data. However, there remains a need to encourage participation in studies and protect data. To overcome this, an incentivisation system which can be trusted by participants and researchers has been discussed in this paper. Titled Cashish, this system is a blockchain-based incentivisation network that encourages participant recruitment by awarding cryptocurrency that can be used in marketplace transactions. Blockchain technology eliminates the need for trust-based systems and allows researchers to be transparent with participants while participants remain anonymous.

Keywords: blockchain; cryptocurrency; cannabis research; virtual clinical trials.

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1 Introduction

Blockchain systems are used to manage cryptocurrency transactions such as Bitcoin as they provide a secure database for online contracts wherein participants can sign off on certain actions with another source (Maslove et al., 2018). Smart contracts are computer protocols running on the blockchain network designed to automatically verify, facilitate, and enforce digital contracts without the use of central authorities. This system has the potential to be utilised beyond direct financial exchanges and would do well serving as an incentivisation system (Maslove et al., 2018; Shrestha and Vassileva, 2018). When applied to clinical trials, this incentivisation system could use blockchain to lower participant recruitment costs, secure data, and increase participant enrolment (Zhang et al., 2020). Similar platforms have been proposed for the incentivisation of research into neural networks and agrobiodiversity, university research and extra-curricular participation, and research publications (Gala et al., 2021; Nikolaidis and Refanidis, 2021; Kochupillai et al., 2021; Wang et al., 2020). However, the system discussed in this paper possesses the ability to exchange the network incentives for different currencies. This paper also aims to establish the use of implementing a blockchain-based data crowdsourcing incentivisation system, such as Cashish.ca, to boost enrolment and protect data transactions in clinical research.

Blockchain technology allows researchers and participants to eliminate the need for a trust-based system when rewarding clinical trial participants. This paper is structured as follows: first, it introduces the relevant platforms and concepts that are discussed throughout such as blockchain, cryptocurrencies, and virtual marketplaces. It then details the systems used in blockchain-based incentivisation for participation in online clinical trials, providing a discussion and comparison of other similarly structured platforms. The research participation incentivisation platform provided in this paper, Cashish, will then be discussed in detail. Additionally, topics such as smart contracts, blockchain frameworks, and the privacy and security of participant data are also explored.

2 Background

An electronic marketplace can be defined as an online platform on which transactions and exchanges for products take place between buyers and sellers (Nardini et al., 2020). A marketplace can also be considered an intermediary between the buyer and seller. While there is not a unified definition for cryptocurrency, most cryptocurrencies can be described as a unit of exchange with more digital options for transactions (Zhang et al., 2020). Cryptocurrencies are typically untied to governments or banks. As they are untied, cryptocurrencies provide value outside of any one nation's sovereignty. Marketplaces are able to use cryptocurrency to exchange funds between individuals or institutions. Cryptocurrency exchanges can assist in incentivising the completion of various research activities within a prospective marketplace (Maslove et al., 2018).

2.1 Sensitive research opportunities

Generally, sensitive topics in research can be grouped into three different categories (Powell et al., 2018). These include topics that could be considered sacred, private, or stressful, topics that could cause an individual to become stigmatised, and topics that could expose an individual to a political threat. There are many areas of research that could fit into one or multiple of these categories, making participant recruitment particularly difficult. An area of research that could be considered sensitive is cannabis. While attitudes towards cannabis have grown more positive over time, it is still a restricted substance in many areas and as such, participation in research relating to cannabis could expose individuals to stigma or legal repercussions. Recently, cutting-edge studies have been performed across the world demonstrating the potential of using cannabis products to treat ailments like chemotherapy-related nausea, muscle spasms in patients with nerve injury or degeneration, and multiple psychiatric disorders such as anxiety and sleep disorders (Nutt et al., 2021; Turner and Agrawal, 2020). Given the legalisation of cannabis in several regions, there has been an increase in the amount of clinical trials and studies being initiated to explore the psychological, neurological, and physiological effects of its active substances. Cannabis research must be performed utilising a preclinical and clinical trial framework, but this approach is economically infeasible (Martin et al., 2017). Despite the fact that cannabis is being used for medical therapeutic purposes, the industry does not have the same financial backing as the rest of the traditional pharmaceutical sector, and thus, the rigor of a traditional clinical drug trial is not typically applied.

Key cannabis stakeholders agree that more knowledge is needed regarding the use of cannabis in a therapeutic setting. To fill this gap, an increase in research surrounding cannabis related topics is required (Schlag et al., 2021). Crowdsourcing this data is one option; it allows researchers to gather data rapidly at a very low cost and utilises research subjects that are willing to participate for incentives that are relatively inexpensive compared to the traditional clinical trial costs. To date, there is no scientific crowdsourcing cannabis research data via clinical trials. The method this paper presents ensures that participant data is secure, anonymised, and that research participants can be compensated with a currency that is usable, anonymous, and valuable.

2.2 Incentivisation through cryptocurrency

The term cryptocurrency refers to a decentralised digital currency that can be moved between members on the blockchain network (Dinh et al., 2018). In this type of transaction, the members do not directly transfer assets or data between them. The amount of cryptocurrency held by the members of the network is tracked by the blockchain which will increase or decrease the amount of cryptocurrency held by a network member when it recognises and acknowledges that a transaction has occurred. It is because of this process of tracking transactions that blockchains are often referred to as distributed ledgers.

The monetary value of a cryptocurrency is based on the real life assets it is associated with such as the US dollar. Cryptocurrencies rapidly became popular among tech enthusiasts due to their promise of zero governance, transparency while maintaining anonymity, and complete decentralisation of information (Monrat et al., 2019). As cryptocurrency is a limited resource, its supply becomes depleted as more individuals join the network, causing the value of the smallest unit of a cryptocurrency to keep increasing. This leads to more people joining the network and ultimately increasing the value of the cryptocurrency.

The sensitivity of clinical trial data necessitates a robust security framework. In blockchain systems, asymmetric cryptography is used to protect transactions between members of a network – in this case, researchers and participants. These security features can protect data stored on the blockchain from hackers or other malicious actors. Participants' public keys can be easily shared with other users in marketplaces to facilitate transactions as they are not connected to any of the personal or clinical data collected.

2.3 Smart contracts and applications using blockchain

Blockchain-based applications, which are typically developed for business use, can be built using a collection of smart contracts (Casino et al., 2019). A smart contract represents a contract between two parties in code (Mohanta et al., 2018). This type of contract might outline the transfer of a variety of digital assets such as cryptocurrencies. The introduction of Ethereum served as a significant milestone in the development of blockchain-based applications (Tikhomirov et al., 2018). Solidity is a Turing-complete programming language provided through Ethereum which allows developers to create smart contracts, deploy them on the blockchain, and settle real world transactions using the deployed smart contracts (Almeida et al., 2018; Casino et al., 2019; Macdonald et al., 2017).

To explain the proof of work (PoW) framework which underlies Ethereum's functioning, the general format of a blockchain network must be discussed (Agbo and Mahmoud, 2019). In a blockchain system, users are represented as nodes and each user possesses an identical chronological ledger. This ledger contains cells of data that can be continually expanded (Agbo and Mahmoud, 2019). Each block of data contains data such as transaction information (sender, receptive, transaction amount, etc.) as well as a unique key number (hash) generated from the data. This key is referenced both by the data cell itself as well as the previous and next data block (Agbo and Mahmoud, 2019). As such, any amendments to the ledger of the blockchain must solve the PoW problem and produce a hash which meets specified requirements. If these requirements can be met by a generated number, the block of information is added to the ledger and sent to all the nodes in the network (Agbo and Mahmoud, 2019). The PoW test is difficult to figure out but it is simple to evaluate if it has been solved given the fact that a block's hash is referenced by the cell before and after it. If an error were to occur in the chain, the block referencing would be incorrect (Agbo and Mahmoud, 2019). Generating the number which meets the hash requirements (the nonce) is referred to as mining, and miners are nodes in the blockchain network. Any node in the network can perform transactions or mine, this is referred to as a public blockchain network (Agbo and Mahmoud, 2019).

The Ethereum protocol (also referred to as ERC-20) can be used for custom cryptocurrencies created through Ethereum. Tokens created using this protocol can serve as blockchain-based assets. These tokens can carry value and be transferred between owners (Somin et al., 2018). There are more than 200,000 tokens compliant with ERC-20 standards available on Ethereum's main network, the majority of these being fully compliant with those standards (Chen et al., 2020; Di Angelo and Salzer, 2020). The ERC-20 token allows developers to predict how novel tokens will operate within Ethereum (Fenu et al., 2018; Somin et al., 2018). Additionally, it ensures seamless compatibility between new tokens and other tokens in the Ethereum public network.

The inception of Bitcoin marked the first time a blockchain framework was employed to maintain a digital currency (Nakamoto, 2008). The purpose of Bitcoin was to facilitate transactions and exchanges in a secure network without the need for a central authority. Bitcoin is used to circumvent the negatives associated with centralised currency including, single-point of failure vulnerabilities, processing times introduced by regulations, corruption, mishandling of information and service fees (Nakamoto, 2008). In order to secure the sensitive information handled in transactions it employed a blockchain structure to ensure user security and anonymity. This network also allows users to contribute as both transaction hosts and miners as it uses the same PoW protocol used in Ethereum (Casino et al., 2019).

While Bitcoin and Ethereum are public blockchain systems, Hyperledger presents itself as a common hub for various blockchain platform development-related projects in a federated network (Agbo and Mahmoud, 2019; Dinh et al., 2018). Hyperledger seeks to provide a framework for permission-based cross industry blockchains systems (Casino et al., 2019). Federated blockchain networks help to further secure the data exchanged in cryptocurrency transactions compared to public blockchains (Agbo and Mahmoud, 2019; Casino et al., 2019). Ethereum is also developing a toolset so that permissioned networks can be established. Hyperledger is a collection of standards, tools, and projects that enable the development of private blockchains for businesses (Casino et al., 2019).

Hyperledger also contains fabric, a blockchain framework with modular functionality that companies developing a blockchain business network can utilise. It allows for smart contract generation through common programming languages like Python and Javascript (Casino et al., 2019).

2.4 Using blockchain to protect data in research and healthcare

Blockchain technology has significant potential for use in the storage of healthcare data. A famous problem in the medical field is the fragmented, unstandardised, and inoperable nature of data collection technology employed in the field. Technology spanning decades is employed despite obsolescence. Record keeping is unstandardised, leading to missing and incomplete information as well as difficulty exchanging information between healthcare service providers (Zhang et al., 2018). Information pertaining to different elements of health may be held by different practitioners, and so the full picture of a patient's health is often incomplete. Patient-centred control does not reflect the reality of the current information-holding system, and so practitioners currently maintain control and ownership of the data. With the ever-increasing use of electronic health records (EHRs) to store patient data in online networks, concerns have also arisen about the security of those systems. High-profile data security incidents such as the 2017 WannaCry ransomware attack which affected the National Health Services computer systems in the UK have made clear the need to develop robust systems to protect patient data stored digitally (Dwyer, 2018).

Features of blockchain technology such as its redundant storage of information and strict data access permissions make it a good candidate to secure data and protect against loss (Farouk et al., 2020). Blockchain technology provides a standardised, time-stamped, immutable, and simultaneously accessible and patient-controlled ledger system (Zhang et al., 2018). One model of a blockchain-based EHR management system uses three different types of smart contracts to handle participant identification, storage and management of participant data, and retrieval of previously stored data (Al Omar et al., 2019; Farouk et al., 2020). This model uses secure network infrastructure requiring authentication at every access point and can be used universally. There are currently many different blockchain-based systems in use for the storage of patient medical data. One of these is the Swiss digital health company HealthBank, which allows patients to control who has access to their health data (Farouk et al., 2020). Another Swiss blockchain-based healthcare system is Medicalchain, which allows for telemedicine sessions through its blockchain architecture. Blockchain technology can also be used in other healthcare related systems such as in the monitoring of drug development, production, and sales, which would benefit from the time-stamped, redundant storage of data (Farouk et al., 2020). Blockchain technology could also function in insurance and claims processing, as well as management and credentialing of employees. The benefits of this system become especially apparent in the case of managing clinical trial data. Here, participants' data can be entered with assurance that the information required is present, untampered, time-stamped, and easily accessible at a later time. Blockchain technology would also assure anonymity and allow data usage only with participant control.

3 Related works

There are several examples of other recently proposed blockchain-based incentivisation frameworks in the fields of research and data management. One such example is a blockchain-based platform which has been proposed to help incentivise the secure collection of agrobiodiversity data for the purposes of research and conservation (Kochupillai et al., 2021). Records of both physical and remote transactions would be tracked on the blockchain and would enable multiple different stakeholders including farmers, researchers, and regulators to communicate. Use of such a platform would allow stakeholders to share information securely, keep track of transactions recorded through the blockchain, and receive incentives for verifying recorded information. This model does not outline the methods by which the blockchain infrastructure would be constructed, or how incentivisation through this system would be organised.

A research publishing platform designed by Wang et al. (2020) dubbed PubChain would seek to use blockchain technology to create an incentivisation system for stakeholders such as reviewers, authors and readers. Their platform would allow for these stakeholders to earn rewards by participating in publishing through this system. The use of blockchain in research publishing would move control of publication from a third party to a decentralised, shared network which can keep an immutable record of actions taken throughout the research process, helping to protect against fraudulent activity. Another type of research incentivisation system proposed by Nikolaidis and Refanidis (2021) would utilise a digital reward system to incentivise researchers to participate in the training of neural networks. The ability to collaborate with other researchers in a secure, reliable, and fraud-resistant manner could help to incentivise teamwork on projects where researchers would otherwise have little reason to give their time and expertise.

The platform most similar to the one proposed in the present paper was designed by Gala et al. (2021). Their platform, designed using VJ chain, a public proof-of-access blockchain, would be used to incentivise student participation in research and other campus activities. Students would be able to register for qualifying activities and earn tokens called VJ Coins which could be spent within the campus ecosystem. This platform is similar to the one proposed presently in that it provides virtual token incentives for the completion of research activities, but it differs in that its tokens cannot be exchanged for others, limiting the utility of the incentive.

The research incentivisation system discussed in the present paper differs from the examples above in that it outlines the use of a token system based in Ethereum protocols, where the other systems list either other native tokens meant to be used within their system or do not list any at all. The use of Ethereum in the design of this incentivisation system allows for tokens earned in the system to be exchanged more seamlessly with other forms or cryptocurrency or even fiat currencies. The other examples discussed above also do not go into detail about how token incentives received in their platforms would be stored by participants.

4 Methods

The design of the Cashish platform, which refers to the complete architecture of the blockchain-based marketplace and the associated reward system, proceeded as follows. A web application that researchers and participants could access to complete research requirements was created using open-source technology applications on the Wordpress and WooCommerce platforms. This was referred to as the Cashish marketplace portal.

Blockchain smart contract functionality was used within the marketplace to encourage research participants' engagement in transactions. Transactions would be conducted between sponsoring brands, strategic partners, or with other research participants. Research participants could register to participate in research through a smart contract transaction. These digitally signed agreements prevented any kind of fraud and eliminated third party payment processing fee(s). The blockchain platform of choice had to support automated transactions based on predetermined conditions or triggered events.

After the generation of a smart contract upon registration for a research activity, the participant would have to complete that activity within a specified timeframe. Following completion, their rewards were made available in a virtual wallet. A blockchain enabled mobile wallet was created for research participants to collect their virtual points. This Metamask wallet held the incentives research participants received in a proprietary points system called Cashish. Cashish points were awarded based on the type of research tasks completed, with examples including surveys, clinical trials, sharing stories, or product feedback. The points awarded were deposited in the wallet and could be redeemed within the marketplace for 2× the value. Alternatively, the value could be transferred to other cryptocurrencies such as Ethereum using online exchanges. Cashish points were implemented using the ERC-20 protocol. This protocol is necessary for smart contracts created on the Ethereum blockchain using token implementation and outlines rules which all tokens based in the Ethereum platform must follow. The standards set by the ERC-20 outlined how tokens can be transferred, the approval process for transactions, and the process for users to access token-related data.

5 Results

5.1 Comparing blockchain platforms for clinical trial use

As there are multiple platforms and technologies available for developing blockchain systems, choosing the most suitable platform for clinical trial data is essential to developing a functioning system. Three frameworks were compared for potential use; Ethereum, Bitcoin, and Hyperledger. These platforms all offer a substantial set of functionalities that could assist in developing and maintaining a crowdsourcing incentivisation network such as Cashish.

Hyperledger Fabric is the most diverse and comprehensive blockchain platform for use in a healthcare setting. This platform is designed to address issues which frequently arise when designing and managing blockchain systems for industry level networks. Its private, permission-based toolset provides security while the flexibility in its programming compatibility allows for a wide range of varied functionalities. It also has in-depth controls for data anonymity and granular access. Despite these advantages, they also mean that a lot of effort is required to develop solutions that are natively available in other platforms (Dinh et al., 2018). For example, Hyperledger required a custom wallet application to be built and shipped to support the blockchain. In contrast, Ethereum had many popular, publicly available wallets which could support custom cryptocurrency like the one required for this incentivisation system. Hyperledger fabric does not have a cryptocurrency or other token built into their system. This makes it difficult to use Hyperledger to develop and manage an incentivisation system for data crowdsourcing. Ultimately, this resulted in the choice to neglect it for use in Cashish.

Ethereum and Bitcoin are public blockchain platforms that pose a higher risk in their usage (Agbo and Mahmoud, 2019). Public networks where permissions are not controlled are prone to breaches and that presents a problem when handling sensitive clinical data. However, while Bitcoin and Ethereum are platforms that do not allow for the creation of private channels, they can participate in confidential transactions (Agbo and Mahmoud, 2019). By offloading data to networks outside the blockchain, the blockchain network can be used to hold only the keys for the data. As such, participants can only access the keys on their ledgers while the confidential data can only be accessed through approved parties such as researchers (Agbo and Mahmoud, 2019). As this approach creates a vulnerability for data breach in the off-blockchain network, this method could lead to ransomware, thus negating the benefits of using a blockchain in the first place. The main factor giving Ethereum an advantage over Bitcoin within the clinical trial incentivisation network is the fact that Bitcoin does not allow for smart contracts to be used (Agbo and Mahmoud, 2019). As such, it cannot be used to securely handle the data in clinical trials or any other healthcare/personal data related materials. Thus, Ethereum was the blockchain platform of choice for Cashish.

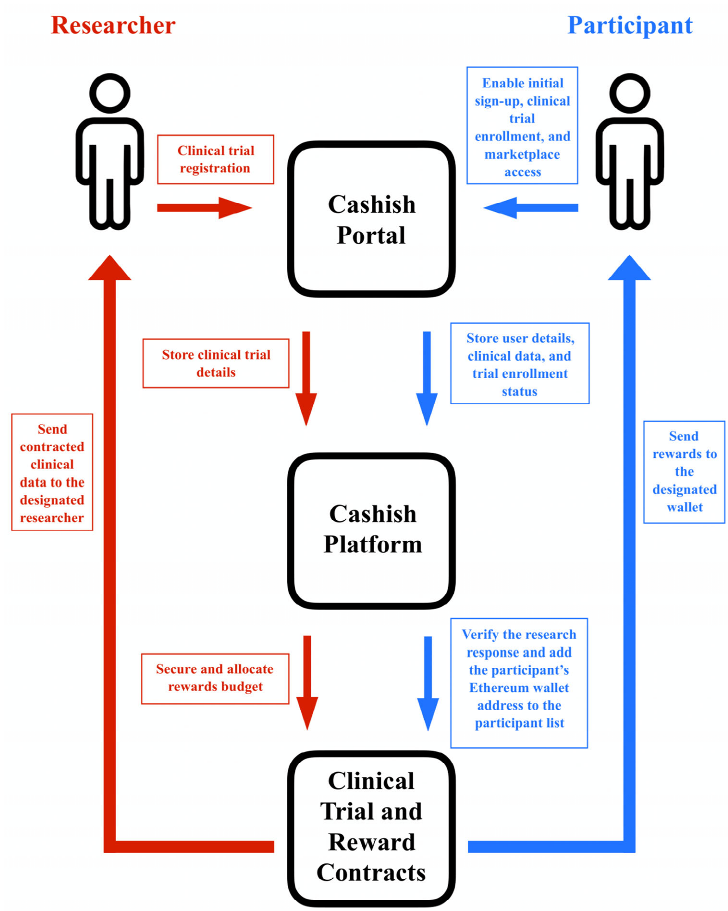
5.2 Crowdsourcing data through incentives

The Cashish platform flow was initiated when requests were posted on the Cashish portal for research participants to sign up for research tasks in exchange for Cashish points. In total, 86 participants responded to the posting to sign up for a cannabis survey. From the 86 that completed the survey, 60 opted for inclusion into a prize draw. Of the 36 prize winners only 26 signed up for the Cashish platform to participate in the incentives program. Those participants gave their public Ethereum address (i.e., their account number) so that their rewards could be sent. This was achieved by linking a Metamask wallet to the Cashish portal, a native function of Metamask wallets.

5.3 Utilising smart contracts for an online marketplace

Given that the smart contracts used in the study were created within the public Ethereum network, they were generated using solidity; in the case of Cashish points, this was done using an ERC-20 contract. The wallet address of this contract was used for the allocation of Cashish points depending on study enrolment. To register new clinical trials, a smart contract was used when researchers created a research project. The institution managing the research then acquired Cashish points to fit the research budget outlined by the project from the Cashish platform holder. Purchases were made using sovereign currency such as USD or CAD, or by spending Ethereum. A smart contract was used to ensure that the trial requirements were fulfilled by the participant. This served to automatically transfer Cashish points from the researcher’s account to the participant’s wallet upon the required tasks being completed. As purchasing goods from the Cashish platform marketplace involved exchanging Cashish points, smart contracts were written to enable this type of transaction. Figure 1 depicts a flowchart of what incentive network access looks like through the lens of both participants and researchers. It illustrates the flow of smart contracts and illustrates the business goals for the Cashish platform.

Figure 1 A flowchart illustrating how researchers and participants utilise Cashish, and in general, any incentivisation system which implements smart contracts similarly (see online version for colours)



One of the findings that threatened the viability of this project was the excessive fees charged to conduct a transaction. Gas fee in cryptocurrency refers to the computational power required to execute a transaction. The fees charged to execute the smart contract were more than the value of the incentives in some cases when a user had few cashish points.

6 Discussion

6.1 The public image of cryptocurrency

One of the key considerations of this pilot study was what participants could do with the Cashish cryptocurrency they redeemed. Despite Bitcoin's rise to prominence, the use of cryptocurrency has generally been limited to technology investors and cryptocurrency advocates (Basu et al., 2018). As most participants would likely be unfamiliar with cryptocurrency transactions, a marketplace with goods and services was implemented to allow them to redeem their tokens within the platform.

Multiple studies have employed surveys to investigate the American public's attitude towards cryptocurrency. These often focus on Bitcoin as it is the most exchanged cryptocurrency (Jha, 2018). As surveys indicate that most Americans have never heard of Bitcoin, it can be assumed that the average person is generally unaware of cryptocurrency (Joo et al., 2019). When people are familiar with cryptocurrency, often it is because they have heard concerns about its security, volatility, potential for tax evasion, and settlement risk (Feder et al., 2017).

6.2 Interoperability of blockchain systems

Any discussion regarding the use of blockchain technology must take into account the issue of interoperability. Interoperability refers to the ability of blockchain systems to properly access, read, and verify transactions that have spanned multiple different blockchain systems (Hardjono et al., 2019). More simply put, it is their ability to interface in a secure and coherent manner.

In the context of clinical research data and healthcare in a broader sense, interoperability refers to the ability of systems, typically those handling individual data, to communicate and exchange data (Gordon and Catalini, 2018). Interoperability of these systems has many benefits including streamlining appointment scheduling to reduce duplicate bookings, improving access to patient or participant data, and lightening administrative load. While its benefits are clear, there are many challenges to wide-scale interoperability in clinical research and the healthcare system. Cooperating systems would need to organise agreements and processes for sharing data and matching participants. Multiple technical hurdles such as user authentication, activity monitoring, and operation errors would also have to be solved.

Blockchain has the ability to simplify much of this process. Using a shared blockchain platform, access rights to patient/participant data can be managed by the owner themselves by outlining permissions for sharing (Gordon and Catalini, 2018). When an individual is in control of managing their data permissions, they could link data that might be spread across various blockchains and make it available for any care providers or researchers to access. Systems designed in this way would mean that patients, care providers, and researchers would only have to interface with one type of platform. Despite these advantages, blockchain does have several notable limitations. One of the most significant of these is data storage – current blockchain systems do not currently have the capacity to handle the amount of clinical data that would be required for them to function at any significant scale (Gordon and Catalini, 2018). Other limitations include issues of privacy, as patients' authentication information would need to be protected very strongly, as well as those of patient engagement, as patients would need to be involved in controlling permissions for use of their data.

7 Future research

Future research into the subject of this paper should look at the overall feasibility of such a system in the real world. To ensure that such a system would be useful in generating participants for studies, it is important to understand whether using a token-based incentivisation system such as Cashish points is received well in comparison to normal methods. Follow-up research to determine the level of participant engagement using the prototype compared to traditional studies is also required. Another important area of research is to explore the usability and ease of use of such a system.

Regarding the use of blockchain-based systems in general, future research could continue to examine how blockchain can be deployed in sectors other than finance and healthcare. Blockchain has been used for a wide variety of functionalities, such as for domain name server (DNS) control, the storage of secure documents on cloud-based online platforms, and in the music industry to allocate royalties (Nofer et al., 2017). Blockchain technology has also been proposed in areas such as employee recruitment (Rathor and Agrawal, 2020). The ability to securely and immutably store information on the blockchain would allow for hiring committees to verify criminal or academic records through a blockchain-integrated system.

Another area in need of further research and development is that of blockchain interoperability, described above. This is a complex and long-standing issue that affects all types of blockchain systems. Currently, essential processes for platforms like Cashish such as the transferring of tokens can typically only be done on one blockchain, limiting the ability for different blockchain systems to interface (Schulte et al., 2019). The diversity of blockchain platforms creates another problem for interoperability. As different platforms have different functionalities, any solution would have to use functions common to all major platforms.

8 Conclusions

Blockchain-based systems, specifically those implementing smart contracts, can be used in creating research incentivisation systems that both participants and researchers can trust to fulfil study enrolment requirements and protect clinical data. This paper discussed the benefits of blockchain systems in the context of a prototype incentivisation system titled Cashish. Cashish served the purpose of modelling the crowdsourcing of data for use in VCTs organised by researchers. This incentivisation system utilised a cryptocurrency exchange to encourage participant enrolment. While platforms similar to Cashish have been proposed for the incentivisation of specialised research, these varied in the completeness of their blockchain platform framework. The Cashish platform is distinct from others in that its incentivisation currency, Cashish points, can be exchanged for other types of currency. By navigating the research portal, participants can securely approve the use of their data in various studies to earn incentives in the online marketplace and contribute novel data.

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