Antecedents of the adoption of blockchain to enhance patients' health information management in South Africa

Authors:
Dineo A. Matlebjane[1]
Patrick Ndayizigamiye[1]

Affiliations:
[1]Department of Applied Information Systems, College of Business and Economics, University of Johannesburg, Johannesburg, South Africa

Corresponding author:
Patrick Ndayizigamiye,
ndayizigamiyep@uj.ac.za

Background: Currently, the South African public healthcare system is hampered by a lack of effective patient data management. This leads to, amongst other challenges, a lack of transparency in the management of patients' health information and unsecure medical records. Blockchain, on the other hand, can make healthcare records more secure, easily auditable, and hence more reliable. These advantages, among others, make Blockchain an appealing technology for managing patients' health information in the South African context.

Objectives: The study investigated the antecedents of the adoption of blockchain technology as a tool to improve the management of patients' health information in the South African public healthcare sector.

Method: The four pillars of a health information system (strong leadership, contingency plan, security and privacy, and IT or vendor support) were adopted as the theoretical grounding for the study. Qualitative data were collected through interviews with IT specialists and healthcare professionals working in the public healthcare sector.

Results: The study identified 11 antecedents that can be related to the four pillars of a health information system. These antecedents must be addressed for blockchain to contribute meaningfully to enhancing patients' health information management in South Africa.

Conclusion: Although blockchain can contribute meaningfully to addressing health information management challenges in South Africa, contextual factors need to be considered for it to fulfil its promises. It is anticipated that the study findings will help stakeholders in the South African public healthcare sector to make informed decisions in their quest to deploy technology innovations like blockchain.

Keywords: patients' health information; blockchain technology; health information systems ecosystem; pillars of health information systems; antecedents; adoption

Introduction

It is vital for the healthcare sector in every country to provide high-quality healthcare and services (Ismail, Abdullah & Shamsuddin 2015). However, healthcare systems in developing countries often face challenges related to providing quality healthcare. Such challenges are further exacerbated by inadequate health records management systems, leading to misdiagnosis, mistreatment and preventable deaths (Mohamadali, Ab Aziz & Zahari 2017). On the other hand, new information technology (IT) solutions show great promise in addressing the shortcomings related to the inadequacies of health information systems (Tanwar, Parekh & Evans 2020). Albeit with limited evidence, blockchain, in particular, has shown great potential in addressing issues of transparency, trust and security within healthcare systems generally and health records management systems more specifically. In South Africa, such evidence remains anecdotal and based on secondary data (see, e.g., Adlam 2020; Ngoepe & Marutha 2021; Ndayizigamiye & Dube 2019). In the same vein, the theorisation of blockchain adoption in patients' health records management in the South African context based on primary data is still lacking. This study thus investigated the potential adoption of blockchain to aid in the management of patients' health information from the South African public healthcare perspective using primary data. In doing so, the factors that need to be considered for the successful adoption of blockchain in managing patients' health records were focused on interviewees' responses.

The study was guided by the research question: what factors may influence the adoption of blockchain in the management of patients' health information in the South African public healthcare sector?

Literature review

Electronic patient health information management and blockchain technology

A digital collection of a patient's medical records and embedded mechanisms for its retrieval is referred to as an electronic health record (EHR) (Devkota & Devkota 2013). Worldwide, there has been an increase in the adoption of EHR systems by healthcare providers; this increase has been sparked by the rise in the adoption of IT in the healthcare sector (Waithera, Muhia & Songole 2017). According to Jawhari et al. (2016), health information systems (including electronic medical record systems) seem to promise an improvement in healthcare delivery. A useful hospital management system should allow a hospital to gather, store, oversee or transfer patient health information between organisations in the healthcare sector (Mohamadali et al. 2017). Health IT can make patient health information readily available to hospital staff (Ismail et al. 2015), and patients would have direct access to their health information (Hoover 2017). In the context of South Africa, Luthuli and Kalusopa (2017) identified that there is evidence of poor management of health records in the South Africa's public healthcare sector that can compromise healthcare service delivery, particularly the accountability and transparency in the healthcare delivery. Technology such as blockchain can help address this by providing a transparent track record of healthcare transactions.

Deloitte (2018) defines blockchain as a group of records (called blocks) that use cryptography to be linked together in a way that will not allow modifications. De Martino et al. (2019) further define blockchain as a data structure that makes it possible to create a distributed, tamper-proof, peer-to-peer ledger system that contains time-stamped, immutable and cryptographically connected data blocks. They further state that once data are written on a blockchain ledger, it becomes read-only for all users. Dattani (2019) expands on the description of blockchain technology stating that blockchain is a decentralised ledger that makes use of algorithms and impenetrable encryption for recording digital data or transactions. He further notes that the recording of data is done in an anonymous, secure and transparent way (Dattani 2019). As aforementioned, blockchain uses peer-to-peer (P2P) networks, which can be distributed publicly or privately to all users; this allows for data storage to be reliable and verifiable (Gaggioli 2018).

Factors that may influence the adoption of blockchain in the management of patients' health information

A survey by Deloitte (2018) indicated that while blockchain applications are growing at a rapid speed, the understanding of the technology and the potential it has is still far from being widespread. De Martino et al. (2019) mentioned that the adoption of blockchain in the healthcare sector is still emerging, and that the widespread adoption of the technology faces many challenges.

Katurura and Cilliers (2018) conducted a systematic literature review on the implementation of EHRs to identify the barriers to implementing such records in the South African public healthcare sector. They found three main categories of barriers to the implementation of EHRs, namely technical, environmental and social. These comprise the lack of supporting infrastructure (technical barriers), the lack of an implementation and management framework for EHRs (environmental barriers) and the lack of user training and commitment (social barriers). To overcome these barriers, the authors recommended investing in supporting infrastructure, encouraging participation from all stakeholders and having legislation and frameworks for implementing EHRs. Katurura and Cilliers (2018) concluded that there is a need to successfully implement EHRs to better manage patients' health information. The barriers, therefore, must be addressed before blockchain is implemented for the management of patients' health information.

Pillars of a health information system

Mohamadali et al. (2017) identified challenges to using health information systems and proposed a conceptual framework to address them. They found that from all the challenges identified, four vital factors influence users to adopt a health information system. These factors (or pillars) are strong leadership, proper planning, security and privacy and IT or vendor support:

- Strong leadership:
  - The commitment and support of (top) management is an essential factor in initiating and adopting IT processes. Continued support from leadership is essential for the long-term survival and sustained successful implementation of a health information system.
  - Several studies have shown that health information systems are difficult to implement when there are organisational barriers, such as top management's lack of support because of their lack of understanding of the system's benefits (Anwar & Shamim 2011; Lluch 2011) and their lack of technical and business knowledge (Anwar & Shamim 2011; Maas & Eriksson 2006; Lluch 2011).
  - An organisation requires significant capital expenditure to implement health information systems. Managerial support is thus necessary to authorise such expenditure (Chae et al. 2011).
  - Bisrat et al. (2021) stated that a strong leadership team is required to successfully implement EHRs.

It is therefore imperative a blockchain system that seeks to enhance patients' health information management is championed by strong leadership:

- Proper planning:
  - Inadequate planning could cost money and potentially lead to avoidable deaths. For example, hospital database servers have to run 24 h a day because hospitals always have a continuous flow of inbound and outbound patients. In this case, it is crucial to ensure that the servers or systems operate at their optimal capacities.
  - Cost, opposition and a lack of common standards, policy backing and knowledge have all been listed as barriers to electronic medical records system adoption (Gesulgaa et al. 2017; Mohamadali & Zahari 2017; Uwambaye et al. 2017).
  - There is also a need for a well-thought-out contingency plan as a failed ICT infrastructure may cause the loss of medical records (Khan et al. 2012).

Like any health information system, any blockchain solution geared towards enhancing patients' health information management must be carefully planned. The aforementioned pointers can assist in the planning phase of the solution:

- Security and privacy:
  - There must be standardised security and policy to ensure that a health information system is usable for the long run without being compromised. Any possible scenario that could lead to unauthorised access, manipulation and health information abuse must be addressed.
  - It has been found that privacy issues often pose a barrier to the adoption of EHRs (Gesulgaa et al. 2017; Mohamadali & Zahari 2017; Uwambaye et al. 2017). It is thus important to ensure that the adopted health information system safeguards the security and privacy of patients' health information.
  - It is important for relevant organisations to standardise health information system security and policy adherence (Mohamadali et al. 2017).

Blockchain is inherently secure due to strong encryption algorithms embedded in a blockchain ledger. This means that once transactions are appended to the ledger, they are secure. However, it is possible that transaction data can be tampered with before it is appended on the ledger. Hence, it is important to ensure that all aspects of data/information security are addressed to ensure that data/information appended on the ledger is authentic. Moreover, in the South African context, it is important to ensure that the implementation of blockchain complies with South Africa's Protection of Personal Information Act (POPIA):

- Information technology support:
  - The IT department or vendor responsible for the health information system is an important factor in maintaining the system and ensuring that it is always in good condition.
  - The lack of IT vendor support and maintenance often becomes a barrier to adopting EHRs (Gesulgaa et al. 2017; Mohamadali & Zahari 2017; Uwambaye et al. 2017). Bisrat et al. (2021) found that unfriendly user interfaces, inadequate IT support and other hardware or software concerns are roadblocks to implementing electronic medical records. Training on the use of electronic medical records systems and follow-ups were identified as critical aspects of electronic medical record implementation, and they must be considered before any large-scale electronic medical record implementation (Muinga et al. 2018; Pantaleoni et al. 2015). This shows how vital IT or vendor support would be in adopting blockchain to manage patients' health information.

The above four factors emanated from the challenges that are experienced in health information systems and were validated in the Malaysian study noted earlier (Ismail et al. 2015). This study adopted these factors (or pillars) as the guiding framework for theorising the antecedents of blockchain adoption in patients' health records management in the South African context.

Research design and method

The study adopted a deductive research approach coupled with the qualitative research method. Four IT and four healthcare professionals were purposively sampled and interviewed. The participants were selected based on their knowledge of blockchain and/or the South African public healthcare sector. Data were collected in the Gauteng Province of South Africa through online video meetings (Google Meet) and telephone calls. The data collection was guided by a semi-structured interview, and the questions asked were formulated based on the current literature, the research question guiding the study and the four pillars of a health information system. The interviews were recorded and transcribed with the aid of Otter.ai software. The findings were analysed using a combination of content and thematic analysis. The researchers took steps to guarantee that the study's findings were dependable (reliability) and valid as recommended by Golafshani (2003) and McMillan and Schumacher (2006). As aforementioned, respondents were chosen from IT and healthcare professionals who were knowledgeable about blockchain. This helped to ensure the dependability of the results. To ensure the validity of the results, all interviews were recorded from the beginning to the end. In the analysis phase, participants' own words were used to support the discussion of the findings.

Results and discussion

The demographics of the study participants included the industry in which they worked and their job roles. The participants are referred to by their participant codes (see Table 1) to ensure their anonymity.

The thematic analysis of the interviews revealed 11 factors related to the four pillars of a health information system that need to be considered before the adoption of blockchain to manage patient health information becomes a reality in South Africa. These factors are discussed in the following sections under each pillar of a health information system.

Strong leadership

Health institutions' leadership

Participant 7 explained that the Department of Health would significantly influence the adoption of blockchain to enhance patient health information management. The participant stated:

> 'When it comes to the health system, number one, there is a political influence which has nothing to do with field-specific knowledge; you would find that in most cases. Meaning that whatever needs to be procured has been politically influenced. The Department of Health has a big influence on the adoption of blockchain. Usually, people start there when they want to propose a healthcare solution, by presenting to the Department of Health.' (P7, Quality assurance coordinator)

Mohamadali et al. (2017) stated that leadership support is essential for the long-term survival and successful implementation of a health information system. The lack of support from top management due to their lack of business and technical knowledge hinders the adoption of health information systems (Anwar & Shamim 2011; Lluch 2011). To adopt a health information system, organisations need considerable capital investment, and this will only be attained through management support (Chae et al. 2011). Health institutions' leaders will thus play an important role in adopting blockchain because, without their consent, the required resources to successfully adopt the technology to manage patients' health information will not be allocated.

TABLE 1: Description of the study participants.

Participant code	Industry	Job role
P1	IT	Lead solutions engineer
P2	Health and IT	Medical doctor and chief executive officer
P3	IT	Chief technology officer
P4	Health	IT support
P5	Health	Medical doctor
P6	Health	Medical doctor
P7	Health	Quality assurance coordinator
P8	IT	IT implementation consultant

IT, information technology.

National policy and funding

Participant 1 explained that the focus should be on ensuring that there is a national policy for the adoption of blockchain in the management of patients' health information – 'You've got to get governance. You've got to align it with a national strategy. You've got to have a policy, and only then can you talk about technology' (P1, Lead solutions engineer). Jalghoum et al. (2019) indicated a need to have policies and regulations to support the development of e-health initiatives and secure the required funding. Participant 4 also explained that 'blockchain can be an expensive solution to adopt so that too may be a factor' (P4, IT support). This emphasises the need to secure adequate funding for blockchain implementation in healthcare management.

Malakoane et al. (2020) found that to enhance the performance of public healthcare, it is essential to allocate adequate resources. Katuwal et al. (2018) further stated that there must be a robust assessment of the overall cost factors related to blockchain-based healthcare services within a healthcare organisation's operational and business model. Chen et al. (2019) found that the implementation costs of a blockchain system are a concern because as a user requests a transaction, they need to pay for the computation. The authors further explained that the vast number of transactions that require processing in a hospital setting would lead to a sizable cost of a blockchain solution. In a similar vein, Luthuli and Kalusopa (2017) found that interventions for transforming public healthcare services by the South African Department of Health are often constrained by the lack of human and financial resources.

Alignment of blockchain with national policy and national strategy

Participant 1 opined that more significant issues currently exist within the healthcare sector that are at the top of the list of priorities in the sector, and, therefore, it may not be the right time to advocate for the adoption of blockchain:

> 'I think there's a lack of priority for blockchain. So, we've got so many other things that we must fix, you know, people don't have access to clean water. People don't have access to HIV and TB drugs. There are clinics; they don't have enough staff, their clinics don't have electricity, toilets, you know, we can carry on. Where in that priority list is blockchain? I don't think it comes close to the top. So, if it doesn't align with a national policy, and a national strategy, they're never going to get to it.' (P1, Lead solutions engineer)

Protection of privacy and security

Right to delete own information on a blockchain

Participants were asked if privacy and security would have an impact on the adoption of blockchain. In response, Participant 3 stated that:

> 'It definitely does. Because there are things like the right to have your information deleted, which is impossible for information stored on the blockchain, you can't delete it. So, it's a little bit conflicting.' (P3, Chief technology officer)

Mayer, Da Costa and Righi (2019) found that the immutability characteristic of blockchain may end up directly conflicting with privacy rights. Tanwar et al. (2020), Chen et al. (2019) and Agbo and Mahmoud (2020) explained that when using a blockchain, once the transaction has been committed, it cannot be reversed or changed. This characteristic is a key barrier to blockchain adoption because it conflicts with a patient's right to have their health information deleted from the health system.

However, notwithstanding this constraint, Prokofieva and Miah (2019) found that the implementation of blockchain solutions in healthcare systems will improve the interconnectivity of health information systems while maintaining the security of the systems cost-effectively. Capece and Lorenzi (2020) stated that immutability and transparency are guaranteed in a blockchain-based EHRs system. These are important aspects for secure management and storage of health data. Capece and Lorenzi (2020) further explained that the implementation of blockchain in public healthcare institutions could strengthen the integrity and citizens' trust in the public healthcare sector. Chen et al. (2019) also found that the security of a patients' health information management system can be maximised when blockchain is used in the management of patients' health information. Similarly, Benchoufi and Ravaud (2017) stated that blockchain reduces the possibility of errors and loss of information, thus increasing the security of the patients' health information management system.

Information technology or vendor support

The role of information technology vendors

Some participants indicated that IT vendors would have the role of developing and hosting the blockchain solution. Participant 1 explained:

'I think, certainly, there would be a role for IT vendors, but they might not be commercial vendors. It might be like the CSIR [*Council for Scientific and Industrial Research*] that develops a public blockchain; for public health, it wouldn't be a private venture company or Discovery that would be an IT vendor … They would develop the system and probably host the system as well. So, it would be mandated – the Department of Health would go to the CSIR and say, 'We want you to develop a blockchain for us with the public healthcare sector, and the CSIR would build it, they would hand it over to our IT infrastructure, national IT infrastructure, like the SITA [*State Information Technology Agency*] hopefully.' (P1, Lead solutions engineer)

Participant 2 detailed, 'They [IT vendors] are the ones that engage with buyers, which will be hospital managers, for example' (P2, Medical doctor and chief executive officer). Participant 4 stated:

'The role of IT vendors is to develop the blockchain patient information management system and advocate for it as to why this solution would be better than their current paper-based system.' (P4, IT support)

It has been found that the lack of IT vendor support and maintenance for a specific IT solution is frequently cited as an obstacle to EHRs adoption (Gesulgaa et al. 2017; Mohamadali & Zahari 2017; Uwambaye et al. 2017). Bisrat et al. (2021) indicated that unfriendly user interfaces, insufficient IT support and other hardware or software concerns impede the adoption of electronic medical records. Some participants (P1, P2 and P4) explained that IT vendors would ensure that the blockchain-based patient health information management system is usable and adheres to all its expected requirements. The literature suggests that the lack of support and systems maintenance from IT vendors leads to the failure to adopt EHRs (Gesulgaa et al. 2017; Uwambaye et al. 2017). This means that it is important for the IT vendors to ensure that the system users receive all the support they need for the successful adoption of blockchain in the management of patients' health information. Information technology vendors also have to ensure that they build a high-quality system to make certain that users can use the system daily without experiencing any difficulties.

Provision of information technology support

Participant 3 believed that providing IT support can encourage the adoption of blockchain but that it first needed buy-in:

'Yes, it should [*IT support should encourage the adoption of blockchain*], but you need buy-in in the first place into the technology. So once that buy-in is the thing, it's really just up to you to do it the nice user-friendly and efficient way as possible.' (P3, Chief technology officer)

Participant 4 considered it necessary for users to know that IT support would be provided – 'It would be absolutely vital to know that people who have to use that system are going to receive the support that they need' (P4, IT support). Participant 5 explained that:

'[*E*]nsuring that as the system is being proposed, the public healthcare sector would be assured that all the necessary training to use the system will be given and since blockchain would be a very new technology in the healthcare system it would be a good way to advocate for the technology.' (P5, Medical doctor)

Electronic medical record training and follow-up training are important components of electronic medical record implementation that must be considered before any large-scale implementation takes place (Muinga et al. 2018; Pantaleoni et al. 2015). Katuwal et al. (2018) also found that training healthcare IT personnel is an important aspect of adopting blockchain technology.

Proper planning

Improving the existing patients' health information management systems

Some participants expressed that before blockchain can be adopted, some improvements should be made to the current patients' health information management systems. Participants explained that an electronic patient health information management system must be introduced before adopting blockchain. Participant 4 stated that:

'[F]irstly, an electronic information management system because currently the patient information is stored in a physical format so once there's a patient information management system that is electronic then it will be easier to adopt blockchain.' (P4, IT support)

Participant 5 also explained that:

'[H]aving an electronic health records systems would be a good place to start because if you are already using technology then it will be easier to gradually change and adopt a blockchain system. Currently, the majority of the public healthcare institutions are not using an electronic patient information management system, so it would be a very big change having to move to an electronic system.' (P5, Medical doctor)

Participant 6 also expressed that 'a proper and secure computer or app system to manage patients' information [*is needed*] before introducing a new technology' (P6, Medical doctor). Given these responses, it is evident that it is necessary to successfully implement EHRs to better manage patients' health information (Katurura & Cilliers 2018) prior to adopting blockchain.

Participant 8 emphasised the importance of ensuring that the existing systems have accurate and consistent information:

'Existing legacy systems need to have 100% accurate data and efficient data capturing processes. For instance, the way health information is recorded (the format, the location, the times) needs to be consistent in all healthcare practices. Without consistency, there could be data incongruence and reduced data security.' (P8, IT implementation consultant)

Katuwal et al. (2018) indicated that a blockchain system must integrate well with current systems. Therefore, as mentioned by Malakoane et al. (2020), it is vital to identify the deficiencies within a public healthcare system as a whole to identify the required changes to enhance the system's performance. Before blockchain can be introduced to manage patients' health information in the South African public healthcare sector, the current patient information management system must be improved.

Implementing national standards for patients' health information management

Some participants stated that before blockchain can be adopted, it is necessary to adopt and implement standards for managing patients' health information. Participant 1 said that 'the national adoption of standards on how data are stored, and data are exchanged needs to happen before blockchain can be adopted' (P1, Lead solutions engineer). Similarly, participant 5 also stated that 'creating national standards for the way patients' information is managed because currently there aren't any national standards set for the way patients health information is managed' (P5, Medical doctor). Participant 2 raised the issue of policy vis-à-vis standards arguing that:

'[T]he lobbying for policy to ensure that standardisation happens is critical. Make sure that the standards are set so as not to compromise patient confidentiality. So, it starts with the politician, and then it's the training at management level and the clinical level.' (P2, Medical doctor and chief executive officer)

Participant 7 also pointed to the importance of standardising the management of patients' health information before introducing new technology:

'You would find that we all have our different systems that cannot work together. So, it is important to standardise all the systems so they can work together because this is one of the major challenges that we experience.' (P7, Quality assurance coordinator)

Standardising the development of e-health can have great value to those responsible for e-health initiatives (Jalghoum et al. 2019). According to Luthuli and Kalusopa (2017), it is important to implement a health records management framework to ensure good recordkeeping. The framework will help establish the needed technology and infrastructure to support its implementation. According to many electronic health professionals, the deployment of blockchain in the healthcare sector is being held back by regulatory and general data protection regulation issues (HIMSS 2019). Luthuli and Kalusopa (2017) emphasise that the governance of records management requires a legal and regulatory framework (Luthuli & Kalusopa 2017).

Fears surrounding the adoption of blockchain

Some participants believed that the fear surrounding the adoption of blockchain will prevent the technology from being adopted in the management of patients' health information. Participant 6 believed that the 'fear of system crashes' may prevent the adoption of blockchain, while other participants (P2 and P5) believed that the fear of the unknown may be a barrier to the adoption of the technology. Participant 5 explained: 'The fear of the unknown would be the biggest barrier because most of the time people are afraid of change or new things' (P5, Medical doctor). Similarly, Participant 2 said:

'… [F]ear of the unknown and people thinking that I don't know this, I'm comfortable with what I've always used. But on another level, it's just, I don't like computers, I'm still happy with what I've been using. There is no genuine reason why it cannot be adopted, but, it's like whenever there is a change management approach that needs to happen, it is always the same case.' (P2, Medical doctor and chief executive officer)

Educating people about blockchain technology

Some participants believed that there is still a lot of misunderstanding and misconceptions surrounding blockchain technology that will impede its potential adoption in the management of patients' health information. Participant 1 explained that:

'I think there's a lack of understanding at a national level and provincial level of the value of it [*blockchain*], and I think that's understandable. I think there are probably companies who are approaching the problem of health, with ulterior motives. It's just calling to get blockchain for personal gain, and I think that creates a lot of scepticism around these kinds of solutions, which makes it harder for those trying to push an ethical solution.' (P1, Lead solutions engineer)

Similarly, Participant 4 explained that:

'The people who would be responsible for the approval of the technology not understanding the solution being proposed which I think would be one of the biggest factors, that is, people not knowing and understanding blockchain.' (P4, IT support)

Participant 2 believed that people often identify blockchain with crypto, and that is something they do not want to get into – 'Just the general public education to deal with the issue that I'm talking about where people see blockchain equal crypto equal 'I'm staying away from [*it*]' (P2, Medical doctor and chief executive officer). Participant 5 also identified the same possible barrier to the adoption of blockchain:

'There's this thing in South Africa that when people hear the word blockchain, then they associate it with crypto and scams which may also pose as a barrier because the minute people think that something is a scam, they immediately become disinterested.' (P5, Medical doctor)

In support of the two participants, Bennett, Rieger and Lee (2020) point out that there is often a misunderstanding that blockchain is synonymous with cryptocurrency, which impacts its adoption.

Participant 3 raised the issue of 'unrealistic expectations' (P3, Chief technology officer), preventing the adoption of blockchain technology. Participant 4 opined: 'The lack of tech-savvy personnel in the public healthcare sector' who are well informed about the use of technology may be a barrier to the adoption of blockchain in the management of patients' health information (P4, IT support).

Prokofieva and Miah (2019) found that the healthcare sector is mostly traditional and resistant to innovations while HIMSS (2019) pointed to the lack of knowledge and skill concerning the application of blockchain in the healthcare sector. Agbo et al. (2020) found that because blockchain is still a relatively new technology, there is much speculation, inaccurate information and uncertainty about its potential use in the healthcare sector.

Some participants expressed that for people to accept the use of blockchain in managing patients' health information, they must be taught about the technology. Participant 1 believed that writing research papers is one way to advocate for the adoption of the technology – 'I think possibly papers like you're writing. That will, I think, maybe slowly bring some sanity to how blockchain could be implemented where these papers are possibly peer-reviewed' (P1, Lead solutions engineer). Participant 5 noted the importance of 'educating people about blockchain and making them feel comfortable with the technology' (P5, Medical doctor). Participant 3 felt that it is necessary to teach people about some aspects of the technology – 'better education [*needed*] about the encryption, data and the security' (P3, Chief technology officer). Participant 6 believed that talking about the possible benefits of blockchain would be a good way to advocate for the technology while teaching people about the technology – 'By mentioning the benefits of such a system – its easy access, good quality care of patients, no long queues' (P6, Medical doctor). Participant 8 also believed that explaining some of the benefits of the technology would be a good way to advocate for blockchain – 'It is cost-effective and reduces the chances of hacking or ransomware' (P8, IT implementation consultant). It is evident that talking about the benefits of blockchain not only advocates for the technology but also teaches people about it.

Blockchain pilot project

Participant 3 believed that having a blockchain pilot project and showing what it can do would be an excellent way to advocate for the adoption of the technology – '… get adoption that obviously works on this much smaller scale networks and get something good. Doesn't have to be in the healthcare sector but demonstrate an application that really works' (P3, Chief technology officer). Doing so would be one of the ways to spark interest in the adoption of blockchain.

Limitations

The study could have had more participants, but unfortunately because of the limited number and unavailability of professionals who know about both blockchain and the management of patients' health information, only eight participants were identified. Furthermore, some of the healthcare sector participants only had limited knowledge of blockchain. This, together with the small number of participants, may well have impacted the richness of the results obtained. However, notwithstanding these limitations, the study contributes to the body of knowledge by providing a theoretical foundation for understanding factors that should be considered before adopting blockchain for managing patients' health information in the context of the South African healthcare sector.

Recommendations

Based on the study's findings, it is recommended that a national set of standards and procedures be established to manage patients' health information. This will ensure that the public healthcare sector in South Africa has a standardised format for patients' health information. It is also recommended that all patient health information management systems should be converted into electronic systems before adopting blockchain. Finally, all stakeholders in the management of patient healthcare information should be involved in adopting blockchain to ensure that everyone understands what the technology is about, how it works and how it will help.

Conclusion

This study focused on identifying the antecedents for adopting blockchain in the management of patients' health information in the South African public healthcare sector. The four pillars of health information systems provided the theoretical grounding for the study. Eight semi-structured

interviews were conducted with professionals from the IT and healthcare sectors. Questions asked were formulated in light of the research question, the literature and the four pillars outlined earlier. Findings revealed several antecedents that need to be considered for adopting blockchain, and these were all related to at least one of the four pillars of a health information system. Most of the antecedents have possible solutions that can be implemented to ensure that they do not become barriers to adopting blockchain in the management of patients' health information. All the necessary resources (human, financial and infrastructural) need to be put in place before blockchain can be adopted. The current patients' health information management system in the South African public healthcare sector has to be improved to ensure that blockchain can integrate well with it, and this improvement includes converting, where necessary, patient health information into electronic format. Moreover, all the necessary policies, procedures and standards for managing patients' health information have to be put in place and standardised before blockchain technology can be adopted. However, as some participants pointed out, there are currently more critical issues that the public healthcare sector has to address before the adoption of blockchain can be prioritised. Thus, it seems that for blockchain to be adopted for the management of patients' health information, the elements within the priority list as articulated in the South African eHealth Strategy first need to be addressed.

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Competing interests

Authors' contributions

Ethical considerations

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Data availability

Disclaimer

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