UNIVERSITY OF TECHNOLOGY SYDNEY

Comprehensive Framework for Blockchain Technology Adoption in Saudi Public Hospitals

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Thesis submitted in fulfilment of the requirements for the degree of

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under the supervision of Professor Farookh Khadeer Hussain

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Certificate of Original Authorship

I, Adel Abdulrahman Khwaji declare that this thesis, is submitted in fulfilment of the requirements for the award of PhD, in the School of Computer Science/Faculty of Engineering and Information Technology at the University of Technology Sydney. This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

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List of Abbreviations

AGFI	Adjusted Goodness of Fit Index
AMOS	Analysis of Moment Structures
API	Application Programming Interface
AVE	Average Variance Extracted
BI	Behavioral Intention
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
Chisq/df	Chi-square/degree of freedom
CR	Composite Reliability
EHRs	Electronic Health Records
EMRs	Electronic Medical Records
GFI	Goodness-of-Fit Index
HIPAA	the Health Insurance Portability and Accountability Act
HIS	Healthcare Information System
HL7	The Health Level Seven
IFI	Incremental Fit Index
MoH	Ministry of Health
MSV	Maximum Shared Variance
NFI	Normed Fit Index
PBFT	Practical Byzantine Fault Tolerance
PHC	The Primary Health Care
PoET	Proof of Elapsed Time
PoS	Proof of Stake
PoW	Proof of Work
PNFI	Parsimony Normed Fit Index
RMSs	Remote Monitoring Systems
RMSEA	Root Mean Square Error of Approximation
RNI	Relative Noncentrality Index
SEM	Structural Equation Modelling
SLR	Systematic Literature Review
SPSS	Statistical Package for the Social Sciences
SRMR	Standardized Root Mean Residual
TOE	Technological, Organisational and Environmental framework
TLI	Tucker Lewis's Index
VIF	Variance Inflation Factor

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Abstract

Background: Blockchain has great potential and promise in the healthcare sector, even though it has not yet seen widespread adoption. Blockchain is able to address most concerns in healthcare such as security, privacy, interoperability, data sharing and counterfeit medicines. As part of the Saudi Vision 2030, the Ministry of Health established strategic goals aimed at enhancing healthcare services and transforming the healthcare system. The main challenge with blockchain adoption is to ensure that users will accept this new technology.

Aims and Objectives: The aim of this study is to empirically examine the determinants that affect blockchain adoption in public hospitals in Saudi Arabia. It is apparent that there is scant research examining issues related to the adoption of blockchain in developing countries and Saudi Arabia in particular. It is essential to identify and understand the determinants of intentions to use blockchain technology to identify key areas for interventions aimed at enhancing future use. In this thesis, the perspectives of IT employees are taken into consideration. A conceptual framework for the successful adoption of blockchain technology is subsequently proposed based on the technological, organisational and environmental (TOE) framework. This research also investigates IT employees' preferences towards moving healthcare information system (HIS) applications to blockchain technology and proposes a set of guidelines to encourage public hospitals to adopt blockchain technology.

Methods: Quantitative research data were collected via a cross-sectional questionnaire survey from IT employees who work in Saudi hospitals and 363 responses were considered valid. The data were analysed using SPSS and AMOS software. Confirmatory factor analysis was employed to test reliability and validity. Structural equation modelling (SEM) was carried out to test the proposed hypotheses and to identify the determinants that derive the technological, organisational, environmental and human dimensions which influence blockchain adoption in the Saudi hospitals.

Results: A descriptive analysis revealed that about 70 percent of the participants had little knowledge of blockchain technology. 81% of the variance in Behavioral intentions was explained by the adapted research framework ($R^2 = 0.81$). The results of the path analysis showed that all the determinants had a significant influence at the level of 0.05 ($p < 0.05$). Standardised path coefficients showed that government support (beta = 0.28, $p < 0.001$) had the greatest significantly positive effect on IT employees' Behavioral intention to adopt blockchain.

Conclusion: This study provides theoretical empirical evidence based on the TOE framework regarding Saudi healthcare IT employees' attitudes towards blockchain technology. It also presents evidence of the empirical validity of a new extension to the TOE framework by adding two context-specific determinants, namely decision-maker innovativeness and technical competence with their respective measurement scales. The practical implications of the research are offered to governments, hospitals and decision makers so they can achieve a high level of acceptance and usage of blockchain technology

Chapter one:

Introduction

Chapter 1. Introduction

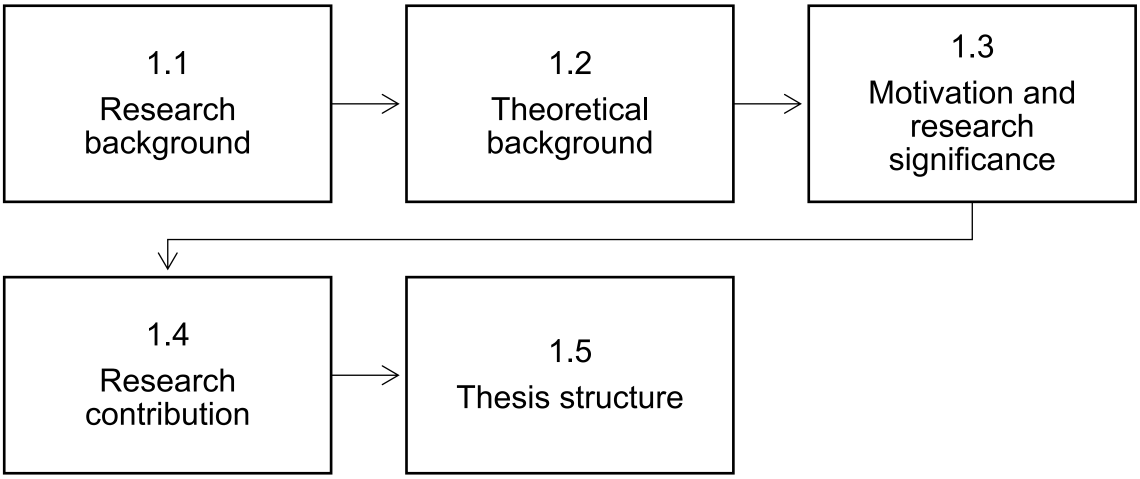


Figure 1 Outline of chapter 1

1.1 Research background

Governments have been successful in evaluating technological trends and participating in strategic planning for future growth throughout the centuries. The Vision 2030 plan, formulated by the Saudi Arabian government for this purpose, oversees the achievements of the country up to the year 2030 (Vision2030, 2018). One of the critical elements of Vision 2030 is innovations in the field of digital healthcare which aim to improve the effectiveness and quality of this sector.

The effectiveness and performance of various organisations' processes have been enhanced through technology, which plays a significant role in obtaining solutions for various problems. An example of a digital innovation is blockchain technology, which has had a significant effect on various industries. It is expected that it will have an influential effect on the services sector, for example, the payment industry (Holotiuk, Pisani, & Moormann, 2017), healthcare industry (Mettler, 2016) and supply chain industry (Korpela, Hallikas, & Dahlberg, 2017).

Blockchain technology can be defined as a time-stamped and immutable group of records of data which is stored on a wide network of participating computers which are not owned by any single central authority (Sharples & Domingue, 2016). There are various advantages of blockchain, for example immutability, decentralisation, anonymity, traceability, transparency and security (Abeyratne & Monfared, 2016). This technology can be used to provide verification without depending on third parties and there is append-only data in blockchain which makes it impossible to modify or delete data (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016).

Healthcare is one industry that can gain significant benefits from blockchain technology. There are several areas of the healthcare system where blockchain technology can be used as it offers accessibility and security. A few of its applications have been used in the medical sector, particularly for the storage and sharing of data pertaining to insurance and medical records (Azaria, Ekblaw, Vieira, & Lippman, 2016). Mobile applications as well as remote monitoring systems (RMSs) also make use of blockchain technology (Chen, Jarrell, Carpenter, Cohen, & Huang, 2019). Furthermore, it helps in solving traceability issues in the drug supply chain (Mettler, 2016) and facilitates interoperability between healthcare organisations (Linn & Koo, 2016).

It appears that blockchain technology has significant potential for various applications; however, the rate at which it has been adopted over the past few years has not been according to expectations. Though there have been extensive studies relating to the adoption of technologies by various organizations, considerably less attention has been given to blockchain as an emerging technology. Nonetheless, it is essential to comprehend blockchain adoption to direct and support its development.

Whenever new technologies are adopted, it is important to determine whether users are willing to accept new systems and whether the new system will integrate with the existing one. To understand whether an organisation will adopt a new technology like blockchain, it is necessary to find the determinants that will affect the adoption process. A variety of theories and models in the information system domain can be used to determine the particular determinants that have a significant or insignificant effect on the use of IT innovations in organisations.

1.2 Theoretical background

The first step to successful adoption of a technology is its acceptance (Davis, Bagozzi, & Warshaw, 1989) and its success relies heavily on potential users (DeLone & McLean, 2002). It is therefore crucial to assess end-user acceptance when implementing a new technology to reduce the risk of failure. There have been several theories and models developed to identify the determinants of technology acceptance.

According to the literature reviews related to technology acceptance, the research in this field is largely based on a positivist paradigm. A positivist researcher uses deductive reasoning to formulate hypotheses based on existing theories, which are tested and confirmed, either completely or partly, causing further development of the theory and providing a better understanding of an individual's behaviour (Saunders, Lewis, Thornhill, & Bristow, 2015). The positivist approach collects and statistically analyses large samples of highly structured quantitative data (Saunders et al., 2015).

The acceptance of e-health technologies has been investigated by a variety of previous studies employing several theories and models such as TAM (Davis, 1989), TRA (Ajzen, 1985), DOI (Rogers, 2003), UTAUT (Venkatesh, Morris, Davis, & Davis, 2003) and TOE (Tornatzky, Fleischer, & Chakrabarti, 1990). The selection of an appropriate model or theory for the present study is based on a systematic literature review that aims to find the most influential determinants and applies these to the most frequently used theory in the context of blockchain adoption. Accordingly, the TOE framework was used to examine the key determinants of blockchain technology acceptance in Saudi public hospitals.

TOE is a framework that analyses how different information systems and information technology services and products are adopted at the organisational level and it examines how technological, organisational, and environmental factors affect the adoption of new IT systems in organisations (Tornatzky et al., 1990). The TOE framework does not take into account how an individual's characteristics influence their adoption of IT innovation (Dwivedi, Wade, & Schneberger, 2011). However, the human factors play an important role in the acceptance of any new IT innovation (Alharbi, Atkins, & Stanier, 2016). Consequently, the proposed framework in the present research augments the human dimension, namely decision-maker innovativeness and technical competence.

1.3 Motivation and research significance

The healthcare industry generates a wide variety of data, for example, laboratory tests, imaging studies like x-rays and MRIs, vital signs, reports, financial documents, etc. The difficulty of accessing healthcare data outside the healthcare facility in which it is stored poses a challenge. It is estimated that one quarter of United States patients report that their records have not been received by another healthcare provider by the time of their appointment (Mehrotra, Forrest, & Lin, 2011; Schoen, Osborn, How, Doty, & Peugh, 2008). Also, there are a number of issues that need to be addressed, including the security of patient records and privacy, interoperability, the exchange of health information, administrative expenses and duplicated effort. Approximately 25% of hospital spending is attributed to administrative costs in the United States, 16% in England, and 20% in the Netherlands (Himmelstein et al., 2014). Approximately 20% of electronic health records (EHRs) are duplicates, leading to confusion (Stewart, Fernandes, Rodriguez-Huertas, & Landzberg, 2010) and it is estimated that approximately 25% of all imaging studies, like MRIs, x-rays, and ultrasounds, are duplicates (Ayabakan, Bardhan, Zheng, & Kirksey, 2017). A duplicate is ordered in the event that the original test results may not be accessible at the time of decision-making about patient care. The elimination of this waste could improve patient satisfaction and reduce healthcare costs. the healthcare industry continues to face a growing problem of medical identity theft, for example, the UCLA Health System reported that 4.5 million patient records had been compromised (Czeschik, 2018). It is believed that these issues can be addressed by blockchain technology.

At present, a lot of attention is being given to the potential to adopt blockchain in the healthcare sector, but the practical applications are currently still emerging. Instead of concentrating on the problems regarding selection and adoption, blockchain technology itself is highlighted. The decision makers need to determine how their organisations are placed in the blockchain technology stages so that the extent of service innovation is enhanced. Decision makers should carefully evaluate the risks pertinent to blockchain adoption and take into account the acceptance of the users. Even the most technically sophisticated and innovative technologies are of no value if the users do not accept them (Mathieson, 1991).

Blockchain adoption in hospitals is still in the stage of rapid development and requires its own theoretical foundation for business value and risk identification (Woodside, Augustine Jr, & Giberson, 2017). The results of this study will play a part in filling the gap in knowledge and addressing the unavailability of a predictive framework to identify the blockchain adoption intent of hospitals. This gives an insight into the work done by others and also involves the integration of theory within the empirical research design thus contributing to the current literature. The study also highlights the role of the TOE framework in making possible the extensive and successful adoption of blockchain technology in Saudi hospitals. In practice, the framework will help IT managers improve the decision framework, including blockchain service, blockchain adoption strategy and implementation priority. This study will help Saudi healthcare to expand and improve e-health services.

1.4 Research contributions

The fundamental contribution made by this study is the design of a framework that functions as a healthcare assessment tool for organisations seeking the adoption of blockchain technology. Hospitals will benefit from this framework while making decisions as it helps in examining the different factors that affect the adoption of blockchain technology. The systematic literature review shows that most of the studies carried out in the past on blockchain technology in developing countries were done in either the South American region or Asian region, while the Middle East and the Arab world have received no attention. Therefore, the first contribution of this research is to identify the determinants that influence blockchain technology adoption in public hospitals in Saudi Arabia. To the best of the researcher’s knowledge, this is **the first study to address**

blockchain adoption in the healthcare context in Arab countries and in particular Saudi Arabia.

With respect to the theoretical contribution, various theoretical models have been examined regarding their suitability to evaluate the factors that affect blockchain technology adoption. When the TOE framework is used as the theoretical model, evidence will be offered in this research regarding of suitability of the TOE framework to the healthcare context. This study will contribute to the existing literature by expanding the factors that have previously been examined with respect to blockchain adoption in healthcare. In addition, it also offers a critical analysis of various aspects of blockchain technology that decision-makers and academics can use to obtain up-to-date information about the framework. Unlike the only study on blockchain adoption in healthcare which is not based on any theoretical model (Wanitcharakkhakul & Rotchanakitumnuai, 2017), to the best of the researcher's knowledge, this is **the first study to investigate the factors influencing the adoption of blockchain technology in healthcare that is based on a theoretical model.**

This study advances the information system literature concerning IT employee's acceptance of health technologies. Although the information system literature offers many research studies which focus on the adoption of technologies, it is necessary to consider specific contexts, as determinants of usage intentions can be influenced by specific factors, such as technology type and the target audience. This study contributes to the information system literature by establishing and validating a healthcare IT employee-based theoretical framework with blockchain technology which is based on the TOE framework for IT adoption. To the best of the researcher's knowledge, this is **the first study to investigate the factors influencing the adoption of blockchain technology in healthcare from IT employees' perspectives.**

This study advances the existing knowledge concerning technology adoption and employs the TOE framework. The present research incorporates human factors into the TOE framework. **This study has demonstrated the validity of a new extension that includes two context-specific determinants, namely decision-maker innovation and technical competence.**

The Saudi government and/or decision makers will benefit from this study by obtaining an improved understanding of the facilitators and inhibitors of blockchain adoption in hospitals. Hospitals will also benefit from this research by acquiring a better comprehension of how the technology can be applied in the context of Saudi Arabia.

1.5 Thesis structure

There are eight chapters in this thesis and this section describes each briefly. This first chapter, **Chapter 1,** describes the background to the research topic blockchain technology adoption in hospitals and provides a theoretical background. It also defines the research significance and outlines the research contributions.

Chapter 2 provides a brief explanation of blockchain technology and its advantages in healthcare along with an overview of the study context, Saudi Arabia. The literature is systematically reviewed to identify the key factors affecting blockchain adoption.

Chapter 3 determines the research problems, research questions, research aim and objectives.

Chapter 4 elaborates on research paradigms, research approaches, research methods, and an overview of the solutions to the research questions. The determinants that affect blockchain technology adoption are identified and incorporated into the proposed framework.

Chapter 5 describes the development of survey questionnaires, determines the target population and sampling method and covers the process of data collection.

Chapter 6 discusses the quantitative results of the questionnaire survey, describes how the researcher dealt with data collection challenges, provides evidence of the reliability and validity of the measurement scales and discusses the SEM multivariate analysis approach used in this study.

Chapter 7 discusses in depth the quantitative results including a discussion of the framework and the determinants and describes the types of HIS applications or services that could be moved to blockchain.

Chapter 8 summarises the main findings, provides theoretical and practical contributions, discusses the limitations, and overviews the potential for future research.

Chapter two:

Literature review

Chapter 2. Literature review

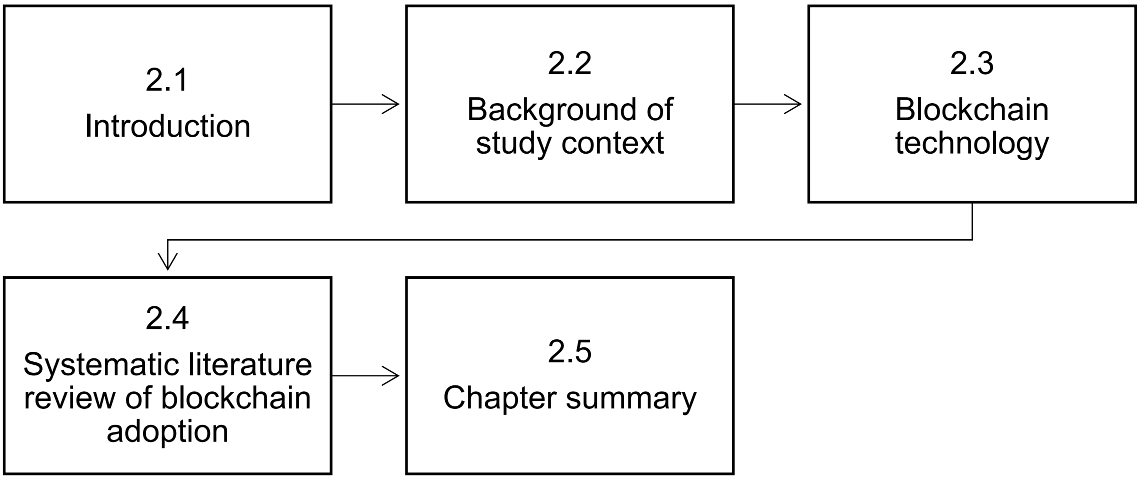


Figure 2 Outline of chapter 2

2.1 Introduction

The importance of this chapter is that it assists to form a solid understanding of the topic, identifies what is already known in the area, and clarifies any gaps in the existing knowledge. This chapter is divided into three main parts. It provides an overview of the study context, Saudi Arabia. It also briefly describes blockchain technology and its advantages in healthcare. Lastly, the literature is reviewed systematically to identify the key determinants that influence the adoption of blockchain technology. This chapter is organised as illustrated in Figure 2.

2.2 Background of study context - Healthcare in Saudi Arabia

The government of Saudi Arabia offers free public health services through the auspices of the Ministry of Health (MOH) (Almalki, FitzGerald, & Clark, 2011), which includes most of the public health care institutes and agencies in the country. A private sector and some non-governmental public facilities are also available.

Saudi Arabia has 478 hospitals and the MOH is the administrator of 57.5 percent of the hospital services in the country (275 hospitals), whereas private sector services (where fees are charged) provide about 33 percent of available care

(158 hospitals) (Exhibition, 2019). Other government agencies cover about 9.5 percent of health care and hospital services (45 hospitals) (Exhibition, 2019). Other government agencies include teaching hospitals, armed and security forces medical services, Aramco hospitals and the Red Crescent. The Primary Health Care (PHC) centres continue to grow. In 2004, 1,848 PHC centres were opened in Saudi Arabia and by 2009, the number had increased by 1,189 to a total of 2,037 PHC centres (Almalki et al., 2011) while in 2019 there were more than 2631 PHC centres (Albejaidi & Nair, 2019).

There continues to be a low adoption rate of health information system (HIS) in Saudi healthcare organisations. A few of the major obstacles for the successful implementation of HIT are insufficient health informatics experts, inadequate experience using computer applications, weak leadership (Alsulame, Khalifa, & Househ, 2015), poor information system infrastructure and technical support (Alkraiji, Jackson, & Murray, 2013), lack of policies and standards (Aldosari, 2017), and lack of an implementation strategy (Khalifa, 2013). Because of this, issues are still experienced in e-health adoption in Saudi Arabia, where 41 of a total of 52 IT projects did not meet their goals (Abouzahra, 2011). Nonetheless, a few success stories do exist, for example, the King Fahad Specialist Hospital, where an EHR system has almost been completely implemented (Khwaji, 2016). Despite facing so many obstacles, Saudi healthcare providers have exhibited a readiness to adopt and enhance e-health services.

One of the ultimate objectives of several governments and organisations across the globe is to deliver healthcare services which excel in terms of quality. In accordance with the Saudi vision 2030, strategic goals were established by the Saudi Ministry of Health to enhance healthcare services across the Kingdom and to transform the healthcare system (Vision2030, 2018). One of these was to utilise information technology and digital transformation to improve the effectiveness and efficiency of the healthcare sector. A list of 70 initiatives for the transformation of the healthcare sector has been established. A few of the initiatives pertaining to the use of information technology are as follows (Vision2030, 2018):

- *E-health:* The aim of the initiative is to enhance the efficiency of the healthcare sector using IT, digital transformation as well as the latest technologies to make it easy to access healthcare.
- *Establish an Electronic Tracking System:* The aim of this initiative is to develop an e-tracking mechanism for pharmaceuticals to allow the tracking of their distribution so that their availability and safety in the market is ensured.
- *National Program for Monitoring Healthcare Quality Indicators:* The purpose of this initiative is to develop an information technology infrastructure that is capable of supporting a data centre through which all indicators in every healthcare facility in Saudi Arabia can be collected, monitored and evaluated.
- *Healthcare Sector Transparency:* The aim of this initiative is to form systems and regulations through which the healthcare sector becomes highly transparent, for instance, in terms of the quality and cost of services.

To make sure that HIT is efficient, certain requirements need to be considered by healthcare providers before making the decision to adopt a new technology. According to Mubaslat (2018), significant requirements need to be met by the healthcare system, including:

- decreasing costs
- preventing fraud
- identity management
- availability of records
- HIPAA compliance
- universal records
- auditability
- support patient involvement

Following the latest advances in information technology, the quality of medical and healthcare services needs to be enhanced. The present healthcare system has several shortcomings that require solutions on the basis of distributed and decentralised approaches. Blockchain technology can play a vital role in meeting these requirements.

2.3 Blockchain technology

Blockchain is simply a time-stamped group of immutable data records that is handled through a group of computers that are not owned by a central authority (Sharples & Domingue, 2016). Cryptographic principles are used to provide security to these blocks of data (i.e. block) and to keep them bound to one another (i.e. chain) (Swan, 2015). A chain of blocks that are secured cryptographically was first proposed by Haber and Stornetta (1990) and the first real application was proposed in Nakamoto's whitepaper (Nakamoto, 2008) as the technology that would give rise to the cryptocurrency Bitcoin. The popularity of Bitcoin has increased over the previous decade, and it continues to be the most significant product that has been created till now over blockchain technology (Hughes, Park, Kietzmann, & Archer-Brown, 2019). A distributed peer-to-peer network can be established using blockchains, which allows non-trusted members to communicate with each other without requiring a trusted third party (Crosby et al., 2016). Blockchain technology comprises a software application, a database, a consensus algorithm, a network of computers, a software environment in which to work, monitoring tools, etc. (Šalehar, 2017).

There are two types of blockchain technologies, namely permissionless and permissioned (Atzori, 2015). Networks that allow any node to function as a verifier of the network without prior authorisation are known as permissionless blockchains (such as Bitcoin, Ethereum) (Wüst & Gervais, 2018). In contrast, permissioned blockchains are those networks that need to obtain authorisation from a centralised entity, which enforces identity management and role-based access control (such as Hyperledger) (Cachin, 2016). Based on whether access control to the network is applicable, blockchain technologies are classified as public or private (Pilkington, 2016). The basis of cryptocurrencies is blockchain; however, this is not its only potential use. It is likely that blockchain will have a significant impact on the economy, influencing the majority of economic sectors and activities (Arias-Oliva, Pelegrín-Borondo, & Matías-Clavero, 2019).

Various important benefits are offered to the users of blockchain as a result of its structural architecture. These include decentralisation, anonymity, transparency, immutability, a consensus mechanism and open source.

Decentralisation This is the fundamental attribute of blockchain which indicates that the blockchain is no longer dependent on a centralised node (Lin & Liao, 2017).

Anonymity The trust problem that is present between each node is resolved by blockchain technologies; hence, it is possible to have anonymous data transfer and data transactions. Only the blockchain address of the person needs to be known (Moser, 2013).

Transparency Every node on the network keeps an identical copy of a blockchain, which permits the real-time inspection and auditing of data sets. This increases the visibility of network operations and activities, decreasing the need for trust (Abeyratne & Monfared, 2016).

Immutability Transactions in a public blockchain cannot be manipulated because many participants store their records (Zheng, Xie, Dai, Chen, & Wang, 2017).

Consensus mechanism This concept is critical as it pertains to the process where an agreement is reached by most/ all of the network validators regarding the state of a ledger (Pilkington, 2016).

Open source The majority of blockchain systems are open to all and it is possible to publicly check records. In addition, blockchain technologies can also be used by individuals to create any applications they require (Niranjanamurthy, Nithya, & Jagannatha, 2018).

Blockchain has been referred to as the next digital revolution because of its various advantages. It is compared with the Internet evolution that commenced in the early part of the 1990s (Kamble, Gunasekaran, & Arha, 2019; Tapscott & Tapscott, 2017). It is claimed that the ‘Internet of Information’ will be changed by blockchain into the ‘Internet of Values’ (Froystad & Holm, 2016). The speed with which transactions are carried out and their cost will decrease due to blockchain

(Peters & Panayi, 2016). After explaining the benefits of blockchain technology in general, in the next section, a short description will be given about this promising technology in the healthcare sector.

2.3.1 Blockchain in healthcare

The healthcare industry has an opportunity to benefit from the adoption of blockchain technology. It is quite likely that blockchain technology will reform the healthcare industry (Mettler, 2016). It is estimated that by the year 2025, savings of almost $100 billion on an annual basis may be brought about by healthcare blockchain in terms of expenses related to operations, IT, support functions and data violation (Donovan, 2019). In a study carried out on patient privacy and data security, it was found that there was at least one security violation in the last two years in 94% of hospitals (Patil & Seshadri, 2014). Blockchain may offer a solution to the most serious security concerns of the healthcare industry.

When blockchain is used, correct and timely information may be acquired by patients, researchers, healthcare providers and others (Bhuiyan et al., 2018). Using blockchain in pharmaceutical industries helps in the fight against counterfeit medicines (Mettler, 2016). It will improve medical record management and insurance claim procedures while increasing the pace of clinical/biomedical research (Kuo, Kim, & Ohno-Machado, 2017). It can bring about more rapid and simpler interoperability between systems and can be scaled efficiently to deal with greater volumes of data and an increased number of blockchain users (Linn & Koo, 2016). Through blockchain, the security of remote patient monitoring systems increases and health-related notifications can be delivered in an automatic manner, while complying to HIPAA (Griggs et al., 2018). Blockchain helps the patients to own and manage their data without having any adverse impact on its safety or restricting health care services from being shared (Yue, Wang, Jin, Li, & Jiang, 2016). It also decreases patient waiting times when using health care systems and also avoids the need for patients to undergo a complete repetitive registration processes (Waxman, Faget, & Daniels, 2019). Manual paperwork and overheads and underlying expenses also decrease by offering transparent and immutable unified health patient records, which can be accessed from all over the world (Rabah, 2017).

Blockchain technology has been implemented in the medical department of Taipei Medical University Hospital to provide better physician referral services to their patients as well as facilitating the assimilation of healthcare networks to allow individuals to approach their personal medical records without any problems (Lo et al., 2019). The example of Estonia shows that blockchain can help in the working of an overall public health infrastructure. Guardtime, an Estonian company, runs a healthcare platform based on blockchain technology (McGhin, Choo, Liu, & He, 2019; Mettler, 2016). The use of Guardtime Blockchain has made it possible for Estonian residents, health insurers and healthcare providers to acquire information on all medical treatments carried out in Estonia (McGhin et al., 2019; Mettler, 2016).

Several blockchain applications are used in the healthcare sector. One of these is MedRec, which is a unique, decentralised system of record management that regulates EMRs using blockchain technology (Azaria et al., 2016). The purpose of MedRec is to keep a record of all the information regarding the patient at a single location, which enables easy access for both patients as well as doctors (Azaria et al., 2016). OmniPHR, a distributed model that integrates PHRs so that healthcare providers and patients can use them, is another example. It also endorses a distributed PHRs, where the health history of patients can be viewed from any device from anywhere in the world (Roehrs, da Costa, & da Rosa Righi, 2017). Table 1 shows the various blockchain applications that are currently being used in healthcare organisations.

Table 1 Healthcare blockchain applications - adapted from (McGhin et al., 2019)

Application	Benefits
Gem Network (Mettler, 2016)	A decentralised network through which health data can be shared, while also providing solutions to legal concerns.
OmniPHR (Roehrs et al., 2017)	Sharing records of patients
MedRec (Azaria et al., 2016)	Sharing data regarding patients' health
PSN (Zhang, Xue, & Huang, 2016)	Sharing health data on IoT devices
Virtual Resources (Samaniego & Deters, 2016)	Storing health data in a model that maintains consistent records; this form of data storage is secure, reliable and scalable.
Context-driven Data Logging (Siddiqi, All, & Sivaraman, 2017)	Health data storage, inserting a degree of confidence in data logging
MedShare (Xia et al., 2017)	Security, sharing and validation of medical information
Trial and Precision Medicine (Shae & Tsai, 2017)	Security of data access and integrity
Healthcare Data Gateways (Yue et al., 2016)	Safety, validation and legal concerns regarding data sharing

Before a new technology is adopted, it is critical to determine if users will accept new systems, applications or services, and if the new system is compatible with the existing one. To understand if an organisation will adopt a new technology like blockchain, the predictors that will have an influence on the adoption process need to be identified. The particular predictors that have a significant or insignificant effect on the use of IT innovations in organisations are determined using various theories and models in the IS domain. Therefore, in the next section, the literature is reviewed systematically to find which theory or model were used the most as well as what predictors had the most significant impact on the adoption of blockchain technology.

2.4 Systematic review of blockchain adoption

The purpose of this section is to examine the existing status of blockchain adoption and to determine the factors that have an impact on its adoption, as well as the shortcomings of the existing studies. The findings identify the most extensively used theory in blockchain adoption research and also identify the most significant variables for blockchain technology acceptance.

2.4.1 Research method

This systematic literature review (SLR) follows the widely accepted guidelines suggested by Kitchenham and Charters (2007) to address the research objectives. The high applicability of this guideline is evident from the Google Scholar's citation count, which shows it was used in more than 6678 studies. This SLR is organised into five stages: the search process, eligibility criteria, study selection, data mining, and data synthesis.

2.4.1.1 Search process

The development of a well-defined search process is dependent on clearly identifying the search sources and search queries (Kitchenham & Charters, 2007). The selection criterion of the search sources is based on the area of review. For the purpose of this study, seven powerful and well-known health informatics and information technology-related databases were chosen to extract the relevant literature (Paperpile, 2019; Wijewickrema, 2021). These databases are:

1. ACM Library (https://dl.acm.org/)
2. IEEEXplore (https://ieeexplore.ieee.org)
3. ProQuest (https://www.proquest.com/)
4. PubMed (https://www.ncbi.nlm.nih.gov/pubmed/)
5. ScienceDirect (https://www.sciencedirect.com/)
6. Scopus (https://www.scopus.com/)
7. WoS (https://www.webofknowledge.com/)

The databases were comprehensively searched using the search queries "blockchain" AND "adopt*" OR "accept*". The initial search revealed 2155 studies which were then filtered against the eligibility criteria as detailed in the following subsections.

2.4.1.2 Eligibility criteria

To ensure the quality and high relevance of the included studies, several criteria are applied before a paper is selected for the SLR. The criteria are based on a set of determinants acting as a standard in the process of inclusion or exclusion of an identified paper. The inclusion and exclusion determinants are presented in Table 2 and Table 3, respectively. After applying both the inclusion and exclusion criteria, 40 studies were included for further analysis.

Table 2: Inclusion criteria

Inclusion Criteria
✓ Peer-reviewed publications, conference papers, books, and dissertations.
✓ Full text.
✓ Papers on the topic of blockchain adoption and/or acceptance

Table 3: Exclusion criteria

Exclusion Criteria
× Non-relevant publications
× Posters, websites, newspapers, blogs and magazine publications
× Papers not in English
× Duplicated papers

2.4.1.3 Study selection process

The search results obtained were imported into the reference management software, Endnote. Then the search results were checked for any duplication of papers and consequently, duplicates were removed from the list. An assessment of the titles and abstracts of each individual paper was conducted. The full text of the remaining papers was obtained and organised in different folders based on the context found. Subsequently, the researcher assessed each of the included papers against the determinants of the inclusion and exclusion criteria detailed in section 2.4.1.2 . Figure 3 illustrates the process of selecting relevant studies.

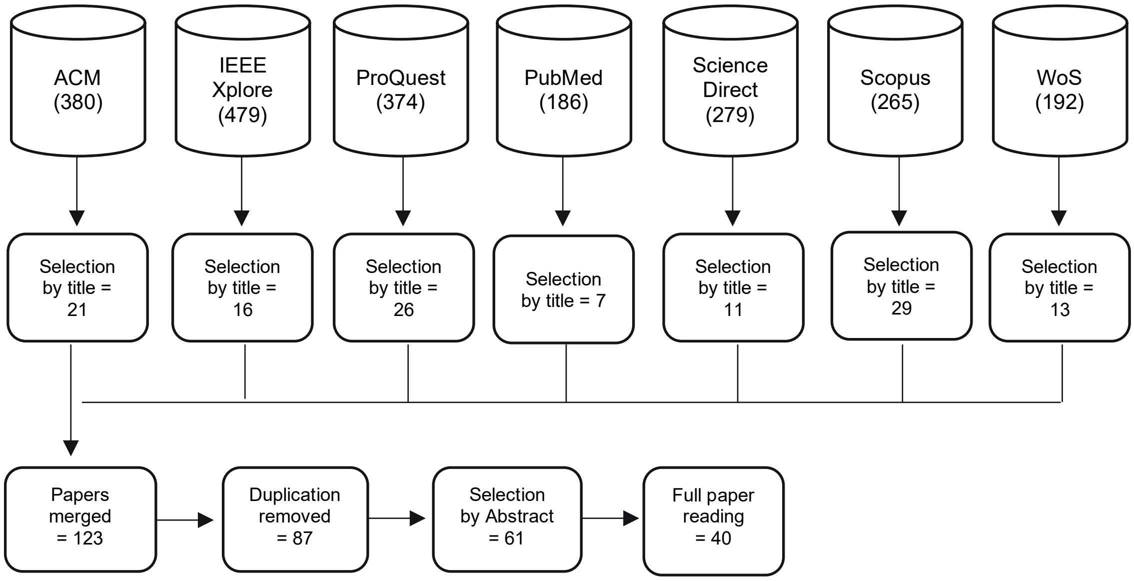


Figure 3 Selection study process

2.4.1.4 Data extraction

In line with the objective of the SLR, the final set of 40 studies was thoroughly analysed to extract the factors related to blockchain adoption. To further ensure the quality of the extracted information and eliminate the occurrence of any bias in the selection process, each of the included 40 studies was assessed using quality assessment criteria consisting of 4 elements, as shown in Table 4. Each of the 40 studies was assigned a score out of 4. A score of 4 indicates high applicability and 1 indicates low applicability.

Table 5 shows the quality criterion score for each study.

Table 4 Quality assessment criteria to evaluate the studies

Quality Assessment Criteria
➢ The study set up an appropriate context for blockchain adoption. ➢ The study was formed on a theoretical basis to address its aims. ➢ The study provides clear findings with justifiable results of factors impacting blockchain adoption. ➢ The study provides future directions.

Table 5: Assessment of the selected papers based on the quality assessment criteria

Study ID	Author	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
1	(Morita et al., 2018)	1	1	0	0	2
2	(Queiroz & Wamba, 2019)	1	1	1	1	4
3	(Dobrovnik et al., 2018)	1	1	0	0	2
4	(Folkinshteyn & Lennon, 2016)	1	1	1	1	4
5	(Schaupp & Festa, 2018)	1	1	1	1	4
6	(Fairooz et al., 2019)	1	1	0	1	3
7	(Lou & Li, 2017)	1	1	0	0	2
8	(Clohessy & Acton, 2019)	1	1	1	1	4
9	(Grover et al., 2019)	1	1	1	1	4
10	(Francisco & Swanson, 2018)	1	1	0	1	3
11	(Kamble et al., 2019)	1	1	1	1	4
12	(Arias-Oliva et al., 2019)	1	1	1	1	4
13	(Lengoatha & F. Seymour, 2020)	1	1	0	0	2
14	(Handoko & Lantu, 2021)	1	1	1	1	4
15	(Kamarulzaman et al., 2021)	1	1	0	1	3
16	(Kumar et al., 2021)	1	1	1	1	4
17	(Molati et al., 2021)	1	1	1	1	4
18	(Drljevic et al., 2022)	1	1	1	1	4
19	(Chengyue et al., 2021)	1	1	1	1	4
20	(Kumar et al., 2021)	1	1	1	1	4
21	(Malik et al., 2021)	1	1	1	1	4
22	(Seshadrinathan & Chandra, 2021)	1	1	1	1	4
23	(Choi et al., 2020)	1	1	1	1	4
24	(Kramer et al., 2021)	1	1	1	1	4
25	(Ullah et al., 2021)	1	1	1	1	4
26	(Nuryyev et al., 2020)	1	1	1	1	4
27	(Wong et al., 2020)	1	1	1	1	4
28	(Park, 2020)	1	1	1	1	4
29	(Orji et al., 2020)	1	1	1	1	4
30	(Hanna et al., 2020)	1	1	1	1	4
31	(Caldarelli et al., 2020)	1	1	1	1	4

32	(Fernando et al., 2021)	1	1	1	1	4
33	(Suwanposri et al., 2021)	1	1	1	1	4
34	(Kalaitzi & Tsolakis, 2022)	1	1	1	1	4
35	(Lin et al., 2021)	1	1	1	1	4
36	(Ganguly, 2022)	1	1	0	1	3
37	(Gökalp et al., 2022)	1	1	1	1	4
38	(Agi & Jha, 2022)	1	1	1	1	4
39	(Nath et al., 2022)	1	1	1	1	4
40	(Wanitcharakkhakul et al., 2017)	1	0	1	1	3

2.4.1.5 Data synthesis

This SLR narratively synthesised the findings of the selected studies. In light of the study objectives, all the data extracted from the 40 selected papers were synthesised and organised in tables. This approach assisted in drawing a clear view of various aspects of the extracted data including contexts, methodological approaches, theories/models, and the factors identified in the related literature, after which they were sequentially classified into two categories. These categories are theory used and frequent determinants as presented in the results section in Table 6, Table 7 and Table 8. Moreover, the determinants affecting blockchain adoption were classified into subgroups, these being technological, organisational, environmental and human. An individual analysis of each category was conducted to define the strength of the identified determinants and the applicability of different theories/models of technology adoption in understanding the acceptance and use of blockchain in different fields. The following are the requirements that the determinant must fulfil for its influence to be concluded: (1) the determinant must be tested using the most commonly used theory or model; (2) the determinant must be investigated in at least five research studies; (3) the majority of studies agree on its influence.

2.4.2 Results

This section provides insights into the 40 selected studies, including publication type, context of investigation, number of annual publications, regional distribution of studies, the theories/models used and finally all the determinants extracted from these studies.

2.4.2.1 Search result

The distribution of the 40 studies is shown in Table 6 based on publication year and type, and the context of the study. All the studies were published between 2016 and 2022, signifying blockchain adoption as an emerging issue which has attracted recent research attention. The 40 papers targeted blockchain adoption in several fields including supply chains, finance, e-government, e-learning, manufacturing and e-health.

Table 6: Classification of the studies

Study ID	Year	Country	Publication Type	Application field
1	2018	Taiwan	Conference	Finance
2	2019	India	Journal	Supply Chain
3	2018	Austria	Journal	Supply chain
4	2016	USA	Journal	Finance
5	2018	USA	Conference	Finance
6	2019	Sri Lanka	Journal	Finance
7	2017	Taiwan	Conference	Finance
8	2019	Ireland	Journal	Blockchain Adoption
9	2019	India	Journal	Finance
10	2018	USA	Journal	Supply Chain
11	2019	India	Journal	Supply Chain
12	2019	Spain	Journal	Finance
13	2020	South Africa	Journal	Academic Library
14	2021	Indonesia	Journal	Finance
15	2021	Malaysia	Conference	E-government
16	2021	India	Conference	E-learning
17	2021	South Africa	Conference	Supply chain
18	2022	Spain	Journal	Blockchain adoption
19	2021	India	Journal	Manufacturing
20	2021	India	Journal	Supply chain
21	2021	Australia	Journal	Blockchain adoption

22	2021	Australia	Journal	Finance
23	2020	Korea	Journal	Supply chain
24	2021	Germany	Journal	Supply chain
25	2021	Malaysia	Journal	E-learning
26	2020	Taiwan	Journal	Finance
27	2020	Malaysia	Journal	Supply chain
28	2020	Korea	Journal	Supply chain
29	2020	Nigeria	Journal	Supply chain
30	2020	Egypt	Journal	Blockchain adoption
31	2020	Italy	Conference	Blockchain adoption
32	2021	Malaysia	Journal	Manufacturing
33	2021	Thailand	Journal	Finance and Supply chain
34	2022	United Kingdom	Journal	Supply chain
35	2021	China	Journal	Supply chain
36	2022	India	Journal	Supply chain
37	2022	UK & Turkey	Journal	Supply chain
38	2022	France	Journal	Supply chain
39	2022	Bangladesh	Journal	Supply chain
40	2017	Thailand	Conference	Healthcare

2.4.2.1.1 Publication year

The distribution of the studies by year with regard to blockchain adoption is shown in Figure 4, which indicates the significant increase in the number of studies on blockchain adoption.

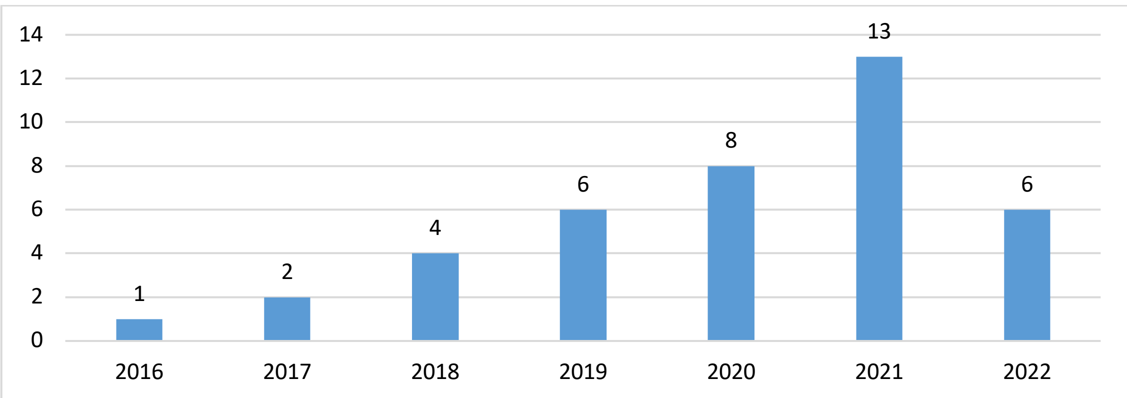


Figure 4 Study distribution by publication year

2.4.2.1.2 Regional Distribution

The majority of the studies (22/40) were conducted in developing countries, as illustrated in Figure 5. The largest number of studies (7/40) were conducted in India, followed by Malaysia (4/40), Taiwan (3/40), and the USA (3/40).

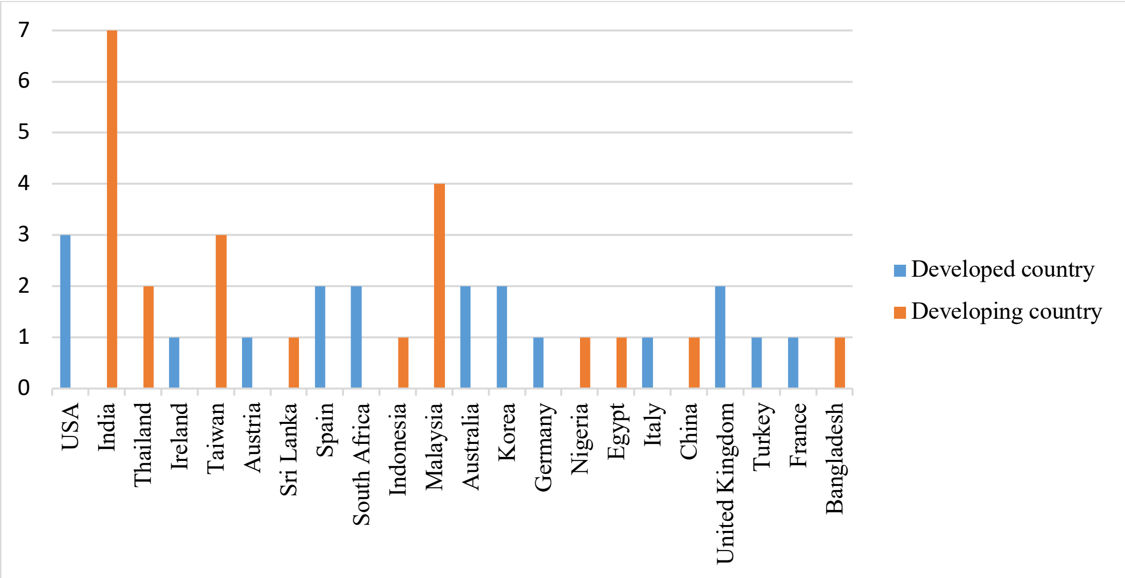


Figure 5 Study distribution by country

2.4.2.2 Application fields of the selected studies

The majority of studies were in the domain of supply chains followed by finance and the minority were in the field of e-government and e-health, as shown in Table 7.

Table 7 Categories of different fields

Application field	Study ID	Total
Supply chain	[2]; [3]; [10]; [11]; [17]; [20]; [23]; [24]; [27]; [28]; [29]; [33]; [34]; [35]; [36]; [37]; [38]; [39]	18
Finance	[1]; [4]; [5]; [6]; [7]; [9]; [12]; [14]; [22]; [26]; [33]	11
Blockchain adoption	[8]; [13]; [18]; [21]; [30]; [31]	6
E-learning	[16]; [25]	2
Manufacturing	[19]; [32]	2
E-government	[15]	1
E-health	[40]	1

2.4.2.3 Theories/models used in the studies

The 40 studies included in this review attempted to investigate the factors which influenced blockchain adoption using a theoretical lens. Of the 40 studies, 32 studies empirically tested the adopted models and clearly reported the significance of the factors while other studies discussed the factors and proposed conceptual models that are yet to be evaluated. In total, the researcher identified ten theories/models used in these studies, namely theory of planned behaviour (TPB), technology readiness index (TRI), technology acceptance model (TAM), TAM2, capability maturity model (CMM), information system successful (ISS), unified theory of acceptance and use of technology (UTAUT), UTAUT 2, diffusion of innovation theory (DOI) and the technology-organisation-environment (TOE) framework. The TOE framework was the most frequently applied theory in the context of blockchain adoption. Table 8 shows the theories/models and their frequency of use.

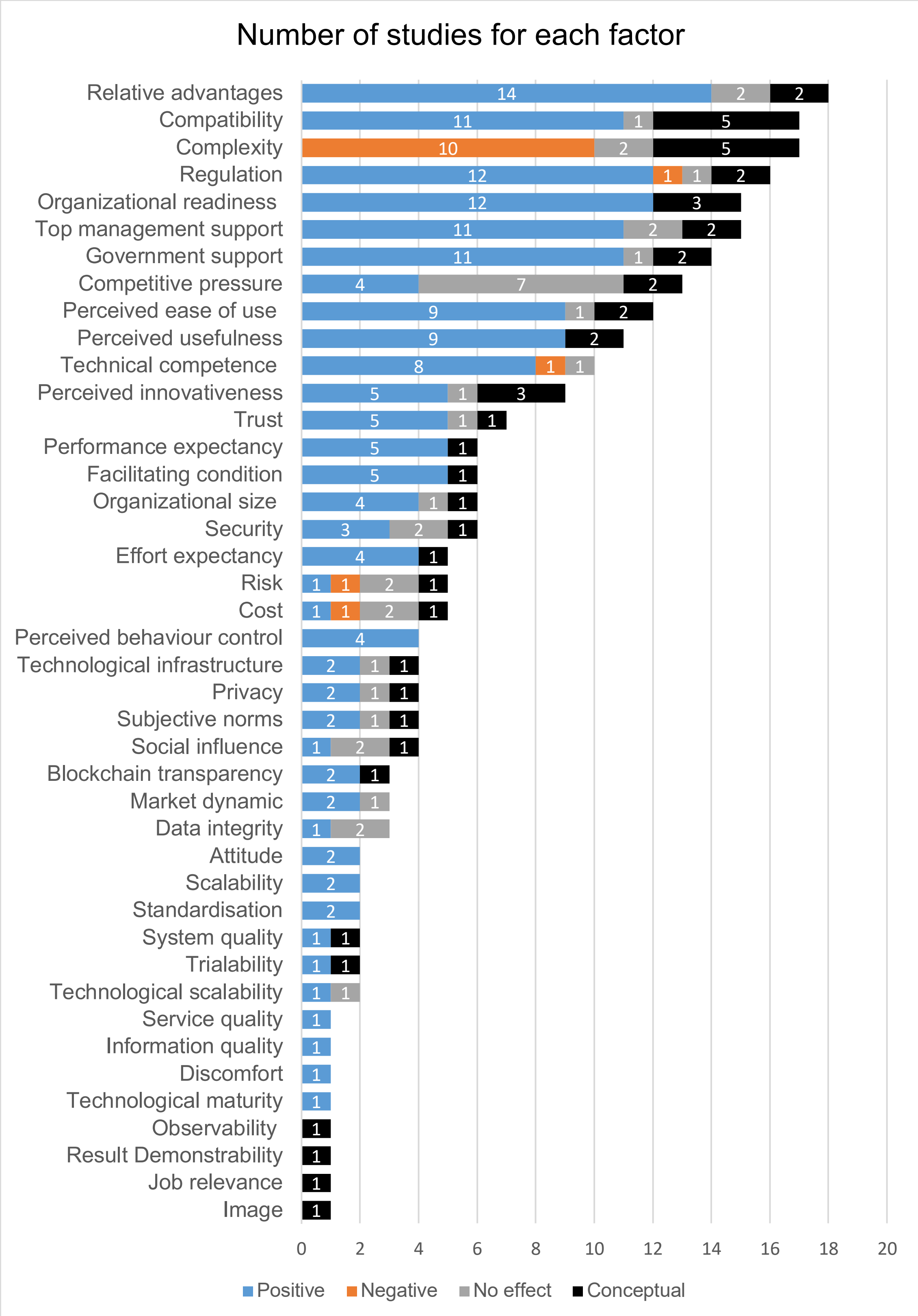
Table 8 Theories of empirical and conceptual studies

Theory	Empirical	Conceptual	No. of theories used
TRB	[5]; [11]; [24]; [35]		4
TRI	[11]		1
TAM	[4]; [9]; [11]; [16]; [18]; [19]; [25]; [26]	[7]	9
TAM2		[1]	1
CMM	[18]		1
ISS	[35]		1
UTAUT	[2]; [12]; [24]; [28]; [31]; [39]	[10]	7
UTAUT 2	[14]		1
DOI	[25]; [38]	[3]; [7]	4
TOE	[6]; [8]; [17]; [20]; [21]; [22]; [23]; [27]; [28]; [29]; [30]; [32]; [33]; [34]; [37]; [39]	[13]; [15]; [36]	19
General concept	[40]		1

2.4.2.4 Factors related to blockchain adoption

Through the data analysis and validation process, a total of 42 factors were identified as being influential to blockchain technology adoption. As shown, the factors were extracted from both empirical and conceptual studies. Table 9 shows the relationship between variables and adoption in which blue indicates a positive relationship, orange indicates a negative relationship, grey no relationship or effect and black indicates it is still conceptual and has not yet been evaluated.

Table 9 Frequency of the factors



2.4.3 Main findings and discussions

The results of the previous section show that from 2016 onwards, the number of studies published on the factors that affect the adoption of blockchain technology has been increasing significantly. These studies were mainly carried out in developing countries, with seven of the total of 40 studies performed in India. It is anticipated that blockchain technology adoption will continue to attract a large amount of research attention because of the rapid developments in this field. This section explains the main findings of the two categories: theory used and frequent determinants.

Based on the evaluation, the 40 studies included in this SLR were divided into two groups, as shown in Table 8, namely empirical studies and conceptual studies. The frameworks and models in the empirical studies are validated and evaluated whereas the models in the conceptual studies have not yet been evaluated and therefore do not influence the research outcomes the researcher is seeking; however, significant contributions are made by the empirical studies. Therefore, this SLR excludes the eight conceptual studies and focuses on the 32 empirical studies.

This SLR gives a narrative synthesis of the findings of the selected studies and classifies them into two categories: theory used and frequent determinants which are discussed in detail in the following subsections.

2.4.3.1 Theory used

With respect to the theories or frameworks implemented in blockchain research, TOE was the most commonly used in the studies on blockchain technology adoption compared to the other theories/models that sought to attain a perspective on the different factors encouraging organisational adoption at the environmental, organisational and technological level (Tornatzky et al., 1990). The TOE framework was used in 17 empirical studies in different contexts including 10 studies on the supply chain (Choi et al., 2020; Gökalp et al., 2022; Kalaitzi & Tsolakis, 2022; Kumar Bhardwaj et al., 2021; Molati et al., 2021; Nath et al., 2022; Orji et al., 2020; Park, 2020; Suwanposri et al., 2021; Wong et al., 2020), three studies on finance (Fairooz & Wickramasinghe, 2019; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021), three studies on blockchain technology adoption (Clohessy & Acton, 2019; Hanna et al., 2020; Malik et al., 2021) and one study on manufacturing (Fernando et al., 2021).

The model used most extensively after TOE was TAM, which puts forward a technique for assessing user acceptance using the intentions, beliefs, thoughts and actual Behavioral adoption (Davis et al., 1989). TAM was applied in eight empirical studies, including three studies on finance (Folkinshteyn & Lennon, 2016; Grover et al., 2019; Nuryyev et al., 2020), two studies on e-learning (Kumar et al., 2021; Ullah et al., 2021) and one study on supply chains (Kamble et al., 2019), blockchain technology adoption (Drljevic et al., 2022) and manufacturing (Chengyue et al., 2021).

UTAUT is used to obtain an improved understanding of the users' main motivations for blockchain adoption. The effectiveness of the model was shown in six studies, most in the fields of supply chain (Kramer et al., 2021; Nath et al., 2022; Park, 2020; Queiroz & Wamba, 2019), one study on finance (Arias-Oliva et al., 2019) and one study on the adoption of blockchain technology (Caldarelli et al., 2020).

TPB was used in three studies on supply chains (Kamble et al., 2019; Kramer et al., 2021; Lin et al., 2021) and finance (Schaupp & Festa, 2018) to identify the factors involved in adopting blockchain and to determine how perceived Behavioral control and subjective norms influence adoption behaviour.

In these studies, DOI was described as the antecedence as the internal and external attributes of individuals for organisational innovativeness in the fields of supply chain (Agi & Jha, 2022) and e-learning (Ullah et al., 2021).

TRI was used in one study on supply chains (Kamble et al., 2019) to determine the widespread technology beliefs of individuals. UTAUT2, ISS and CMM were used in one study on finance (Handoko & Lantu, 2021), supply chains (Lin et al., 2021) and blockchain adoption (Drljevic et al., 2022), respectively.

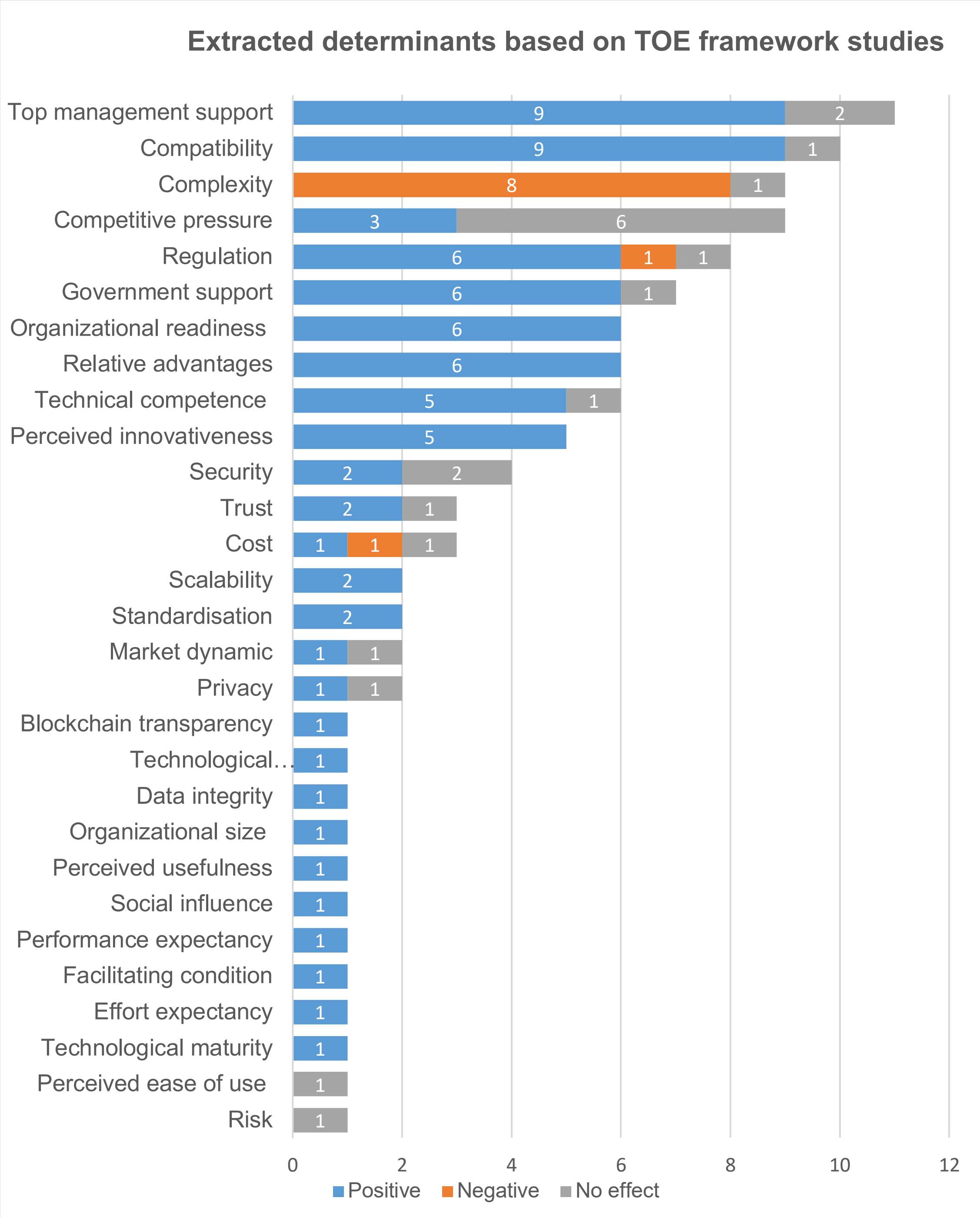
Lastly and surprisingly, only one empirical study was found in the field of e-health and it was not theory-based (Wanitcharakkhakul & Rotchanakitumnuai, 2017).

This review draws the definitive conclusion that TOE is the most employed theory in the previous studies, thus this study will only discuss the 29 factors that have been frequently used in TOE with respect to other theories and models, as detailed in Table 10 in the following subsection.

2.4.3.2 Frequent determinants

To reach a conclusive decision concerning a determinant's influence, it must fulfil the three requirements listed in paragraph 2.4.1.5 which are: (1) the determinant must be tested using the most commonly used theory or model; (2) the determinant must be investigated in at least five research studies; (3) the majority of studies agree on its influence. With respect to the first requirement, the 29 factors were tested based on the most used theory which is the TOE framework, as shown in Table 10.

Table 10 TOE framework determinants



Ten of the 29 determinants were examined in five or more research studies, meeting the second requirement. Most of the studies agreed on nine of the ten determinants, namely relative advantages, complexity, compatibility, top management support, organisational readiness, regulations and laws, government support, decision-maker innovativeness, and technical competence.

More details are provided in the following on how these determinants were used to reach definitive findings on their influences.

The findings of this study show that researchers used different determinants to analyse blockchain technology adoption. Based on the frequency analysis which was performed in the studies examining blockchain adoption, nine determinants were recognised in the study that were grouped into four categories: technological, organisational, environmental and human, as shown in Figure 6.

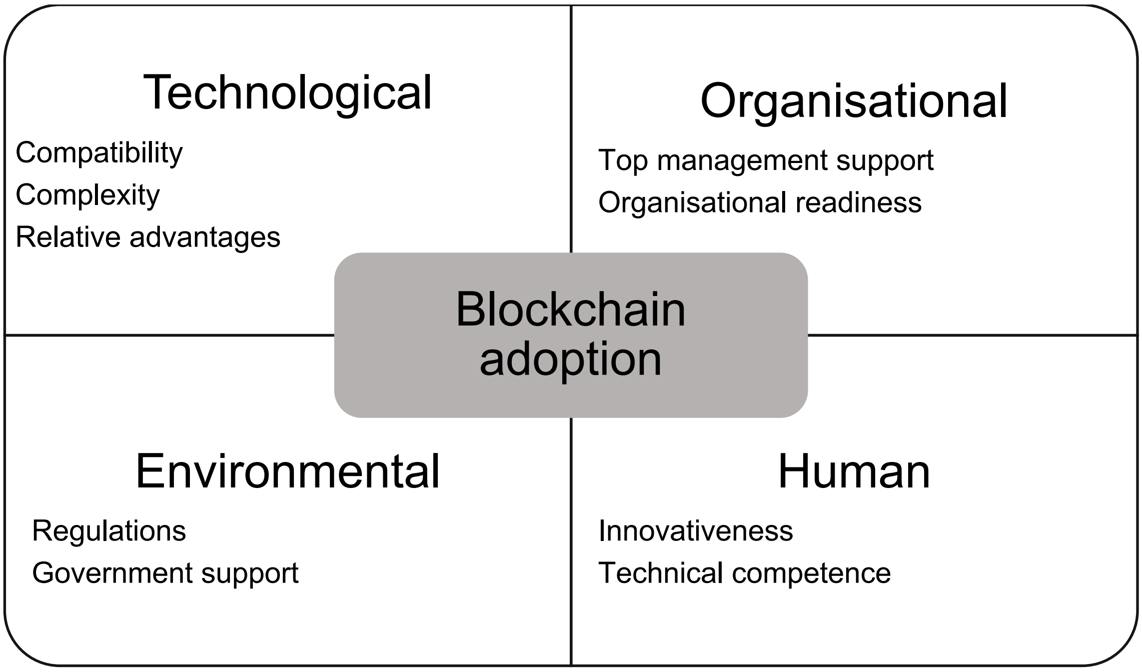


Figure 6 Most frequent and influential determinants

Technological determinants

The most cited factors of this dimension are compatibility, complexity and relative advantage. Compatibility was examined by ten studies and it is evident from nine studies that organisations are willing to adopt blockchain if it is compatible with their existing systems (Choi et al., 2020; Fernando et al., 2021; Hanna et al., 2020; Kalaitzi & Tsolakis, 2022; Kumar Bhardwaj et al., 2021; Malik et al., 2021; Molati et al., 2021; Nath et al., 2022; Orji et al., 2020). Compatibility was only mentioned in one study (Kalaitzi & Tsolakis, 2022) as being a less important determinant affecting intention in the early stages of adoption. It is therefore possible to conclude that compatibility has a positive influence on blockchain adoption. This influence can be explained by the fact that organisations prefer to integrate the new technology with their existing technology so that no changes need to be made to their hardware and software infrastructure and policies, otherwise it will cost effort, time, and money.

The effect of complexity was examined by nine studies (Choi et al., 2020; Fairooz & Wickramasinghe, 2019; Gökalp et al., 2022; Hanna et al., 2020; Kumar Bhardwaj et al., 2021; Malik et al., 2021; Molati et al., 2021; Orji et al., 2020; Wong et al., 2020). Eight studies were in agreement that blockchain is less likely to be adopted if it is complex. One study only (Orji et al., 2020) found that blockchain adoption is not inhibited by complexity. Therefore, it can be concluded that complexity negatively influences the adoption of blockchain. This can be explained by the fact that if organisations are uncertain about how to use blockchain or are unable to understand its principles, they may experience anxiety about using it, which delays its adoption.

The six studies that examined the influence of the relative advantage of blockchain adoption (Gökalp et al., 2022; Kumar Bhardwaj et al., 2021; Molati et al., 2021; Nath et al., 2022; Seshadrinathan & Chandra, 2021; Wong et al., 2020) reached consensus, finding that the likelihood of an organisation adopting blockchain increases if it perceives that it is useful and practical. Since there were no contrary findings on the influence of relative advantage, it can be concluded that relative advantage and blockchain are positively correlated. The rationale behind this effect can be traced to the fact that blockchain has significant benefits such as visibility and traceability, it improves privacy and security, it has immutable records and a decentralised structure and more.

Organisational determinants

This study found that top management support and organisational readiness are the factors which most affect the adoption of blockchain technology. The influence of top management support on blockchain adoption is examined by eleven studies (Clohessy & Acton, 2019; Fernando et al., 2021; Gökalp et al., 2022; Kumar Bhardwaj et al., 2021; Malik et al., 2021; Molati et al., 2021; Nath et al., 2022; Orji et al., 2020; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021; Wong et al., 2020). Nine studies report that the support of top management facilitates blockchain adoption, while two (Fernando et al., 2021; Wong et al., 2020) reveal that it is insignificant, probably because upper management is not comfortable or knowledgeable about blockchain advantages. Accordingly, this review concluded that top management support positively affects blockchain adoption. This effect may be due to the fact that blockchain requires new regulations which require top management to commit to long-term planning, manage resources effectively, foster a positive workplace culture, support the transformation by conducting workshops and offer assistance in taking steps to overcome resistance to change.

Six studies examined the influence of organisational readiness in relation to blockchain adoption (Clohessy & Acton, 2019; Gökalp et al., 2022; Kalaitzi & Tsolakis, 2022; Molati et al., 2021; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021). These studies discovered that having sufficient organisational resources in hand will facilitate blockchain adoption. Due to the absence of any contrary findings, the current review concludes that organisational readiness influences blockchain adoption positively. An explanation for this influence could be that organisations intend to adopt blockchain if they have adequate resources, financial and technical resources, employees with technical skills and knowledge, and a proper information technology infrastructure.

Environmental determinants

This study found that the two determinants related to blockchain adoption that have the most influence are regulations and laws and government support. The impact of regulations on blockchain adoption was evaluated by 8 studies (Choi et al., 2020; Fairooz & Wickramasinghe, 2019; Gökalp et al., 2022; Kalaitzi & Tsolakis, 2022; Molati et al., 2021; Nath et al., 2022; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021). Six studies found that regulations are an important driver for adopting blockchain while one study (Choi et al., 2020) found that regulations are not yet sufficient for adoption. Regulations were found to negatively affect the adoption of blockchain in one study (Nath et al., 2022) because of the lack of laws and regulations legislated to protect businesses which adopt blockchain technology. Consequently, this review concluded that having regulations positively influences blockchain adoption. This influence may stem from the fact that regulations expedite data integration, address data privacy concerns and define who has right to digital records and who can access them.

The influence of government support on blockchain adoption was investigated by seven studies (Fairooz & Wickramasinghe, 2019; Gökalp et al., 2022; Kumar Bhardwaj et al., 2021; Malik et al., 2021; Molati et al., 2021; Orji et al., 2020; Suwanposri et al., 2021). Six studies indicated that the government plays a significant role in adopting blockchain technology while only one study (Molati et al., 2021) found government support was insignificant because governments were not aware of blockchain technology. It can be concluded that government support increases the probability of adopting blockchain. This effect may be due to the fact that governments are able to provide financial and administrative support, set regulations and rules, provide a proper network infrastructure, initiate research and develop innovations, provide training manpower and more.

Human determinants

The most influential factors found in this study are decision-maker innovativeness and technical competence. The influence of decision-maker innovativeness was asserted by five studies (Clohessy & Acton, 2019; Malik et al., 2021; Nath et al., 2022; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021). All these studies indicated that blockchain is more likely to be adopted if decision-makers are innovative and are prepared to take the risks involved in trying a new technology. As no contrary findings have been found, the conclusive assumption regarding this determinant is that decision-maker innovativeness positively affects blockchain adoption. This may be attributed to the fact that the rate of organisational change is linked to the capabilities of decision makers and the adoption of new technology depends largely on their attitudes toward innovation, hence they will accept or reject a new technology based on their level of innovativeness and their perceptions.

Four studies revealed that if employees of an organisation have technical competence, the organisation is more likely to adopt blockchain (Clohessy & Acton, 2019; Fairooz & Wickramasinghe, 2019; Gökalp et al., 2022; Orji et al., 2020), whereas only one study did not find any relationship between technical competence and blockchain adoption (Fernando et al., 2021). Accordingly, this review concludes that having employees with technical competence positively affects blockchain adoption. This influence may be due to the fact that technically skilled staff play a key role in supporting the planning of the technology infrastructure, ensuring that the available technology is understood at a basic level and providing training, supporting applications to move to blockchain technology and preventing errors that could affect the day-to-day operations of the organisation.

2.5 Chapter summary

This chapter briefly outlined the study context, Saudi Arabia, providing insights into its healthcare systems, hospitals and the Saudi Vision 2030 initiatives for digital transformation and developing e-health. It presented a review of the literature on blockchain technology and its advantages in general and in healthcare in particular. It then reviewed the literature systematically to discuss the determinants which affect blockchain adoption and the intention to use it. TOE was the most commonly used theory of the ten theories that were employed. In this systematic review, 40 studies that examined the influence of 42 determinants on the intention to adopt blockchain technology in different domains were identified. Regardless of this large number of determinants, conclusive decisions were made regarding the influence of nine determinants only. This is because most determinants were not examined based on the most commonly used theory, most studies did not reach consensus on the determinants or they were examined by a very limited number of studies. These determinants will help in developing the framework for blockchain adoption in public hospitals in Saudi Arabia which is discussed in detail in the next chapter.

Chapter three:

Problem definition

Chapter 3. Problem definition

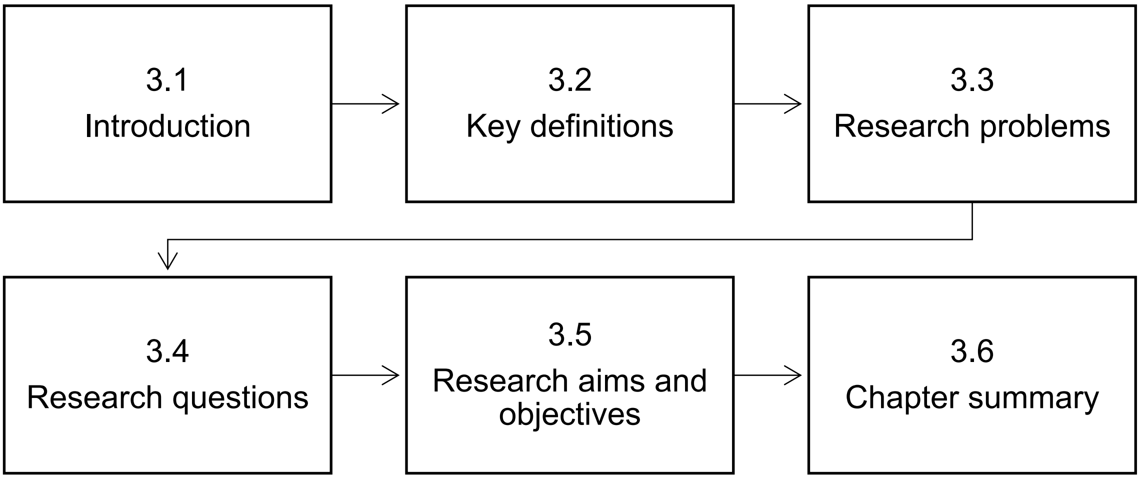


Figure 7 Outline of chapter 3

3.1 Introduction

The purpose of this chapter is to identify the research problems and research questions that are addressed based on the systemic literature review analysed in the previous chapter. These questions assist in formulating the research objectives that are introduced in this chapter. It also defines the key terms used in this research.

3.2 Key definitions

Blockchain is essentially a set of time-stamped records of immutable data handled by computers not owned by any central authority (Sharples & Domingue, 2016). Blockchains can be used to establish a peer-to-peer distributed network, which allows non-trusted members to communicate with each other without the need for a trusted third party (Crosby et al., 2016).

Technology acceptance is the first aim that must be accomplished for a technology to be successfully adopted (Davis et al., 1989). DeLone and McLean (2002) noted that potential users play an integral role in the success of any new technology. Acceptance is the first step that an individual takes when interacting with a technology (Venkatesh et al., 2003). Therefore, a number of theories and models have been proposed to identify the determinants influencing technology acceptance.

Theories and models: Technology adoption studies have attempted to find, predict, and define the factors that affect the behaviour of individuals and organisations in terms of accepting and implementing innovative technologies. Consequently, frameworks and conceptual models have been developed to better understand the relationship that exists between acceptance behaviour determinants, such as the technological, organisational and environmental (TOE) framework (Tornatzky et al., 1990) and UTAUT (Venkatesh et al., 2003) and TAM (Davis, 1985).

Determinants are factors or causes that are responsible for something happening or that cause a decision to be made directly (Atkinson & Allen, 1979). The determinants can be facilitators that positively influence adoption and use, or inhibitors that hinder adoption and use. In this study's context, determinants are the factors that positively or negatively influence the adoption of blockchain technology.

IT employees are skilled employees who perform any function related to information technology (Freeman & Aspray, 1999). In this research, IT employees are those who work in Saudi public or governmental hospitals, either at the managerial, administrative, professional or technician level (e.g., CIOs, CTOs, IT technicians, programmers, etc.).

3.3 Research problems

The adoption of blockchain technology remains relatively low in many countries, notwithstanding its promising advantages (Clohessy & Acton, 2019; Kamble et al., 2019; Queiroz & Wamba, 2019). The slow pace of blockchain adoption may be attributed to several reasons such as low scalability, high energy consumption, lack of standardisation, lack of interoperability and users' limited understanding and acceptance (Glomann, Schmid, & Kitajewa, 2019; Kaur & Gandhi, 2020; Kumar & Mallick, 2018; Sedlmeir, Buhl, Fridgen, & Keller, 2020).

Users' acceptance of a new technology is a major obstacle to its implementation. For example, Kim and Pan (2006) recount the story of a company that had to redevelop its customer relationship management system due to employee resistance. Despite the introduction of Australia's My Health Record program in 2012, the slow uptake of the program and a lack of awareness among Australians hindered its implementation pace (Alsahafi & Gay, 2018; Kasteren, Maeder, Williams, & Damarell, 2017). According to Rizwan (2019), only 25.8% of 116 respondents in Canada accessed the integrated electronic patient records, even though 95% of them perceived the system as useful (Alsahafi & Gay, 2018). Wang, Han, and Beynon-Davies (2018) claimed that supply chain actors are hesitant to change because of their fear of transparency or their previous heavy investment in existing infrastructure, which is why blockchain adoption is slow. Kouhizadeh, Saberi, and Sarkis (2021) found that resistance to change in organisational culture is a major obstacle to blockchain implementation. Therefore, organisations avoid replacing or altering legacy systems which hinders blockchain adoption.

There is an essential need to understand the factors that facilitate or hinder IT employees' intentions toward adopting and using blockchain technology. However, the factors that influence the intention to use blockchain in developing countries and Saudi Arabia in particular are still unclear. A better understanding of these factors will help governments and decision makers modify the design and regulate the use of blockchain in hospitals. This study examines the key factors of IT employees' intention to use blockchain technology in Saudi public hospitals using a TOE framework. Understanding these factors in a better way may help to ensure that blockchain technology, which is still in its initial stages, is implemented in a way that is acceptable to hospitals, so governments and decision makers can better plan for its adoption and promote the meaningful use of the technology (Linn & Koo, 2016). The research problems are outlined briefly in the following points:

- There is scant research on blockchain adoption in general and in healthcare in particular.

- In the context of the present study, there is no existing work on the adoption of blockchain technology in Arab countries, particularly in Saudi Arabia, in any domain including healthcare.
- A review of the relevant literature indicates an absence of theoretical-based studies that act as a framework to explain blockchain adoption in hospitals in developing countries.
- The few studies which investigated blockchain adoption overlook the human factors that might impact blockchain adoption, thus this study incorporates human factors into the TOE framework to gain a better understanding.

3.4 Research questions

The systematic literature review that was conducted as well as the shortcomings that are outlined in Chapter 2 indicated that there are gaps in the literature regarding blockchain adoption in hospitals that need to be addressed. Considering these gaps, the following main research question is identified:

How can blockchain technology be successfully adopted in Saudi public hospitals?

To tackle this main research question more successfully, three sub-questions were also developed:

Research sub-question 1: What are the determinants influencing the adoption of blockchain technology in Saudi public hospitals from the IT employees' perspective?

Research sub-question 2: What are the correlations between the key determinants?

Research sub-question 3: What are IT employees' suggestions and preferences toward moving HIS applications and services to blockchain technology?

3.5 Research aims and objectives

By considering the benefits of blockchain technology in healthcare and the research problems, the overall research aim is *to empirically examine the determinants that might affect blockchain adoption in public hospitals in Saudi Arabia.*

To accomplish the research aim, it is important to review the literature to identify all the possible determinants affecting IT employees' intentions to use blockchain technology. The most appropriate theory or framework is then selected to develop a conceptual framework. Then, the most influential determinants are added to the conceptual framework to make it more relevant to the context of blockchain. An empirical analysis of the adapted framework follows. The final step is to discuss the findings and provide recommendations for governments, decision makers and researchers to promote the future acceptance and use of blockchain. To achieve the research aim, the following objectives are set:

Objective 1: To determine and develop an appropriate framework to study the determinants that have an effect on healthcare IT employees' acceptance of blockchain technology in Saudi public hospitals.

Objective 2: To empirically examine and analyse the relationship between the determinants.

Objective 3: To investigate IT employees' preferences towards moving HIS applications to blockchain technology.

Objective 4: To propose a set of suggestions and guidelines to encourage the potential adoption and use of blockchain technology in Saudi public hospitals.

3.6 Chapter summary

This chapter identified the research problems and research questions that were addressed. As well as defining the key terms used in this research, the research questions were developed which helped to formulate the research objectives. The following chapter explains how the research methodology and approach were implemented to address the research questions with a justification and also a solution overview is provided.

Chapter four:

Methodology and solution overview

Chapter 4. Methodology and solution overview

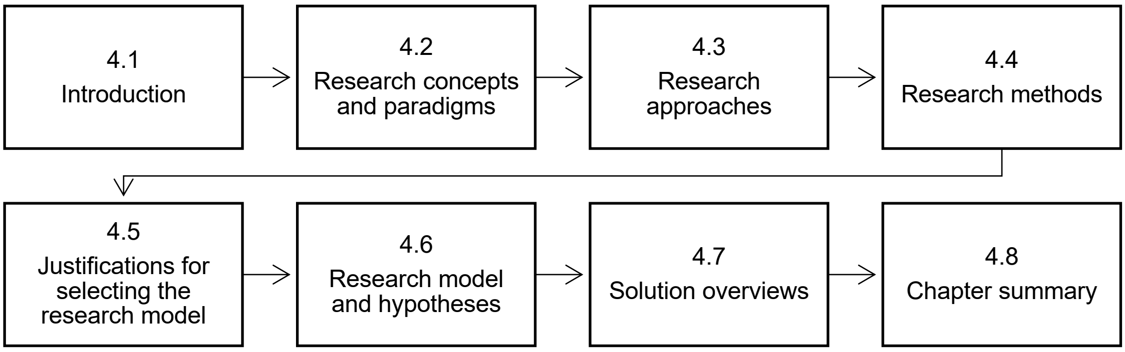


Figure 8 Outline of chapter 4

4.1 Introduction

This chapter is based on the previous three chapters and presents the research paradigms, research approaches and research methods, that can be used to answer the research questions. Subsequently, it gives appropriate scientific justifications for the selection of the methodology and proposes the research hypotheses and model. The factors that affect blockchain technology adoption are identified and incorporated into a proposed framework. This chapter is organised as shown in Figure 8.

4.2 Research concept and paradigms

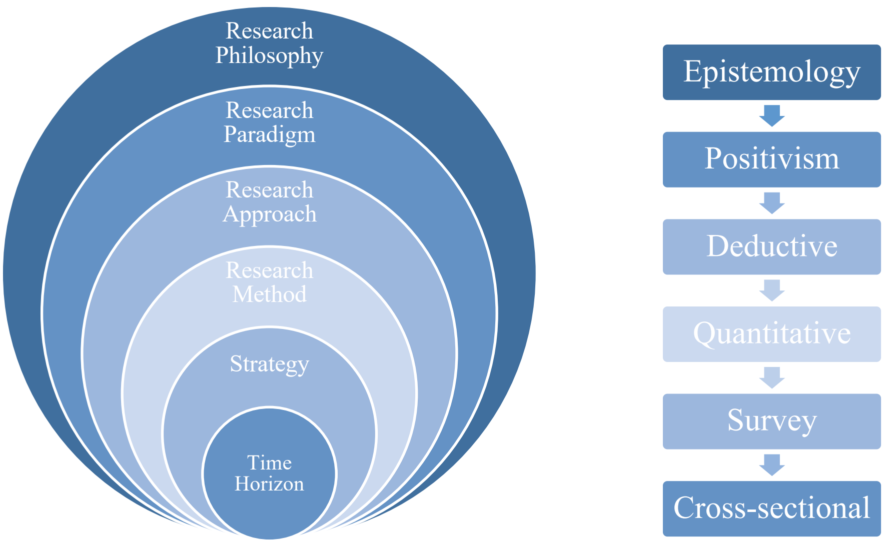


Figure 9 Research process (Saunders, Lewis, & Thornhill, 2007)

The literature presents various research philosophies and paradigms; hence, it is critical to select the most appropriate one for a particular study. A research philosophy has been defined as "*a system of beliefs and assumptions about the development of knowledge*" (Saunders, Lewis, & Thornhill, 2009, p. 124). According to Johnson and Clark (2006), the research strategy we choose should exhibit our awareness of the philosophical commitments we make, as this will have a considerable effect on the way we comprehend the research phenomenon we are examining.

Epistemology refers to a branch of philosophy in which the philosophical concerns inherent in theories of knowledge are taken into account (Pollock & Cruz, 1999). In this study, the literature on blockchain adoption is examined for an epistemological perspective, as it is the most appropriate when various types of research philosophies are being examined. Epistemology plays a crucial role in how researchers are influenced in framing their research to uncover new information. It also provides a predictive framework to enhance knowledge and enable a greater understanding of quantitative research purposes (Saunders et al., 2009).

Five paradigms are used to carry out empirical studies: critical realism, positivism, postmodernism, pragmatism and interpretivism (Saunders, Lewis, Thornhill, & Bristow, 2015). According to the researchers, positivism is the most suitable paradigm to identify a phenomenon and make a prediction that reflects the research paradigm behind the current research (Orlikowski & Baroudi, 1991). Positivist researchers may rely on deductive reasoning and formulate hypotheses using existing theory, which may then be tested and confirmed, either completely or partly, causing further development of the theory (Saunders et al., 2015). Positivism collects and statistically analyses large samples containing highly structured quantitative data (Saunders et al., 2015).

4.3 Research approach

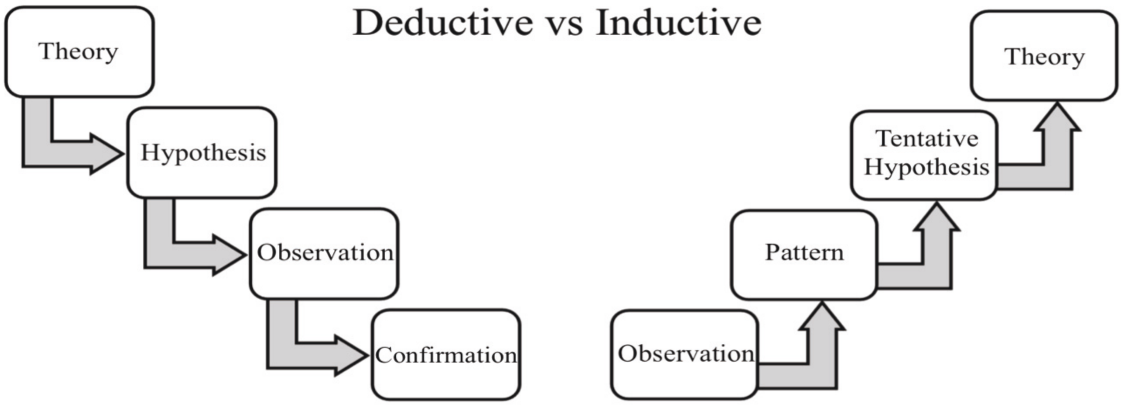


Figure 10 Comparison of deductive and inductive approaches (Trochim & Donnelly, 2001)

There are two types of research approaches: deductive and inductive. As shown in Figure 10, in the deductive approach, the hypotheses are derived based on pre-existing theory and then empirically tested whereas the inductive approach begins with an observation of a phenomenon followed by developing theories and hypotheses based on the findings (Trochim & Donnelly, 2001). This research employs the deductive approach as the most appropriate for the following reasons. It is more consistent with positivism to follow the deductive approach; the ability to explain causal relationships between variables and concepts; the potential to evaluate concepts quantitatively and the feasibility of generalising results (Saunders et al., 2015). Furthermore, due to the study's time constraints, deductive reasoning is a better approach because it is faster to conduct compared with the inductive approach and allows the researcher to plan the study schedule accurately (Creswell & Creswell, 2017).

4.4 Research methods

The next step is to determine the research methodology after the research philosophy and approach have been identified in the previous sections. In the literature, research methods are classified as qualitative or quantitative, the basis of their selection being the nature and objectives of the research (Saunders et al., 2007). The qualitative and quantitative methods differ in the way the data is collected and analysed; put simply, the former uses numbers and the latter uses words. The purpose of the qualitative method is to gain insight into topics that are not fully understood by gaining an understanding of concepts or opinions, while the quantitative approach is to test hypotheses and theories to prove a generalisation of fact about a topic (Creswell & Clark, 2017).

Therefore, the best method for the purpose of this study is the quantitative method for the following reasons. First, when selecting the research methodology, it is essential to consider the study's research philosophy (Bryman, 2016). In the present study, the positivist philosophy was adopted, which is more in line with the quantitative method. Second, methodology selection is influenced by the type of data needed to answer the research questions. Quantitative studies typically deal with structured data, which this study requires, in the form of numbers to prove the adopted theory statistically. Third, a quantitative method is more likely to be effective in generalising the results of this study due to the collection of data from predefined, reliable measures and from a large number of participants (Creswell & Clark, 2017). Table 11 clarifies the features and differences between qualitative and quantitative methods in more detail.

Table 11 Difference between qualitative and quantitative methods

	Quantitative	**Qualitative**
Philosophical position	Tends more to positivism	Tends more to interpretivism
Research aim	Explanation and testing of causal relationships	Exploring phenomena and developing a theory
Research Approach	Tends more to deductive	Tends more to inductive
Type of data	Structured data in form of numbers	Detailed information in words
Data Analysis	Analysed statistically	Analysed through interpretation, summarisation, and categorisation
Data collection	Surveys, experiments	Interviews, focus groups
Sample size	Involves many participants	Involves few participants

Sources: Adapted from (Abd-Alrazaq, 2018; Bernard & Bernard, 2013; Bryman, 2016; Matthews & Ross, 2010; Zikmund, Babin, Carr, & Griffin, 2013)

Hence, in this study, questionnaires will be distributed among the study participants to obtain quantitative data. In this study, different hypotheses will be tested to study how the constructs in the framework are related to each other. Therefore, the primary method used in this research to determine the effects of the constructs will be the quantitative method.

4.5 Justification for selecting the research model

It is essential to comprehend blockchain adoption so that this technology continues to develop. There are several factors in developing countries that can influence the effective adoption of blockchain technology. Determining the theoretical perspective used to formulate the research hypothesis and model is critical. Different theories were taken into account when choosing the most appropriate theory as the basis of this study. This resulted in creating a conceptual framework for the adoption of blockchain technology by hospitals in Saudi Arabia.

Some technology adoption theories are not applicable (e.g. TAM, UTAUT, etc.) as they are concerned with adoption at the individual level while disregarding the organisational level (Venkatesh et al., 2003). This is not appropriate for the blockchain context because it is likely that this technology will affect the organisational level to a significant extent as it helps in the exchange of values between organisations. A suitable model for analysing blockchain technology is a model that tries to examine innovative decision-making at the organisational as well as environmental levels.

The earlier studies on innovative information technology adoption were summarised by Tornatzky et al. (1990), who put forward the TOE framework, which enhances an understanding of the factors that have a considerable influence on the adoption of innovations in IT: the technological dimension, organisational dimension and environmental dimension. Though the TOE framework was generated for other fields, it is often utilised to help understand the adoption of IS in the healthcare domain. For example, Chong and Chan (2012) showed that RFID adoption in the healthcare sector can be understood using the TOE framework. Furthermore, it can be used to understand telecare adoption (Liu, 2011). Ayoobkhan and Asirvatham (2017) carried out a study using the TOE framework to examine the acceptance of cloud computing in healthcare industries in Sri Lanka. Sulaiman and Magaireah (2014) used the TOE framework to explore the factors that influenced the adoption of cloud computing in the EHR system in Jordanian healthcare. The study by (Chang, Hwang, Hung, Lin, & Yen, 2007) showed that the TOE framework is valuable in a hospital setting where it is used to understand e-signature adoption and other studies presented in Table 12.

Table 12 Technology adoption in healthcare

Authors	Area of adoption	Variables
(Ayoobkhan & Asirvatham, 2017)	Cloud Computing	Technological: Relative advantage, compatibility, complexity Organisational: Top management support, technological readiness Environmental: Competitive pressure, trust, trading partner pressure
(Abdekhoda, Dehnad, & Zarei, 2019)	Electronic medical records (EMR)	Technological: Relative advantage, compatibility, complexity Organisational: Organisational competency, management support, training and education. Environmental: Competitive pressure, trading partner support
(Chang et al., 2007)	e-signature	Technological: Security, complexity. Organisational: User involvement, adequate resources, hospital size, internal need. Environmental: Government policy, vendor support.
(Lai, Lin, & Tseng, 2014)	RFID	Technological: Compatibility, complexity, cost, perceived benefits, security and privacy risk Organisational: Top management support, hospital size, financial readiness, technological readiness, users support. Environmental: Government policy, external support, market uncertainty.
(Ahmadi, Nilashi, Shahmoradi, & Ibrahim, 2017)	HIS	Technological: Relative advantage, compatibility, complexity, security concern

		Organisational: IS infrastructure, top management support, hospital size, financial resources Environmental: External pressure, vendor support Human: Employees IS knowledge, perceived technical competence of IS staff.
(Pakarbudi, Mahananto, & Subriadi, 2018)	E-health	Technological: Relative advantage, compatibility, complexity, security, quality of system, quality of information. Organisational: Organisational readiness, top management support, absorptive capacity, hospital size, hospital owner, organisational culture. Environmental: Government, vendor support, hospital location, competitor pressure. Human: Education level, employees IT knowledge, IT staff competencies, behaviour of health professionals.
(Lian, Yen, & Wang, 2014)	Cloud Computing	Technological: Data security, compatibility, complexity, cost Organisational: Top management support, adequate resource, benefits Environmental: Government policy, perceived industry pressure. Human: CIO innovativeness, perceived technical competence.

Very limited research has examined the adoption of blockchain technology as discussed in Chapter 2. The TOE framework was used in most of these studies as the most relevant and widely used theory. Nevertheless, there are other factors apart from technology-related constructs that affect a decision to accept and use technologies and innovations, namely environmental, organisational and human factors. Moreover, this study includes a systematic literature review (SLR) of blockchain adoption in various domains. The findings of the SLR suggest that the most extensively used theory in blockchain adoption research is the TOE framework.

4.5.1 Technology–Organisation–Environment framework (TOE)

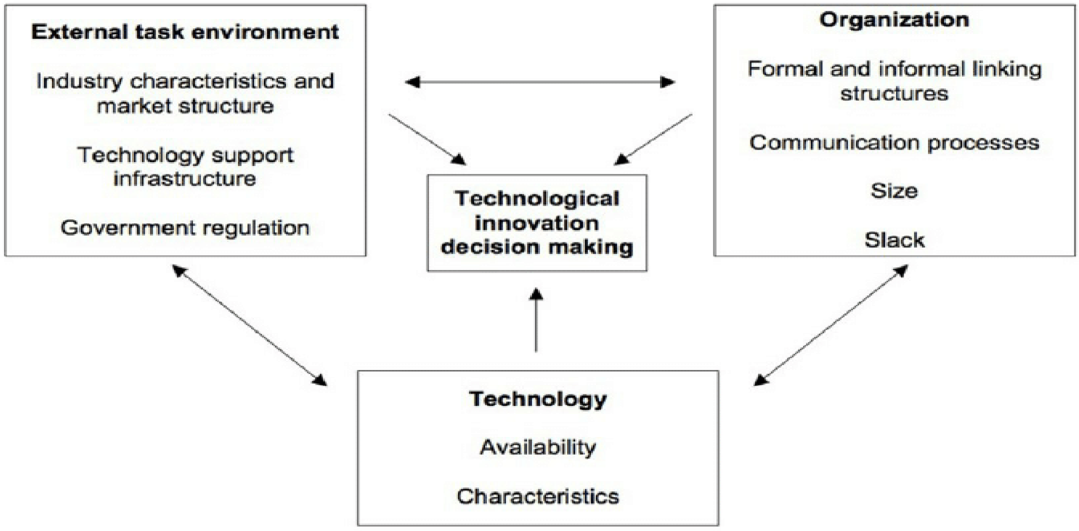


Figure 11 TOE framework (Tornatzky et al., 1990)

Tornatzky et al. (1990) formulated the TOE framework to analyse the organisational level adoption of different information system/information technology services and products. The theoretical foundation of the model is solid and it is suitable for use in IT adoption (Oliveira & Martins, 2011). The TOE framework is a popular theoretical perspective on IT adoption (Zhu, Kraemer, & Dedrick, 2004). Its key objective is to determine the technological, organisational and environmental perspectives that affect the adoption of the latest IT systems in organisations (Tornatzky et al., 1990). Since TOE incorporates technological, organisational, and environmental variables, it has attracted more interest compared to other adoption theories and models when reviewing technology adoption (Gangwar, Date, & Raoot, 2014; Zhu & Kraemer, 2005).

Internal and external technologies are described from the technological perspective, and these are pertinent to the organisation, including existing systems and emerging ones and by considering the different impacts on the organisation (Aljowaidi, 2015; Chau & Tam, 1997). The organisation's internal processes, knowledge, expertise, and infrastructure are part of the organisational perspective (Oliveira & Martins, 2011; Tornatzky et al., 1990). The factors that affect the routine business functions of the organisation are included in the environmental perspective, for example, regulation, government interaction and competitive pressure (Oliveira & Martins, 2011; Tornatzky et al., 1990).

There is high flexibility in the TOE framework, which is used to examine the possible or actual effect of different types of innovation on organisations (Pudjianto & Zo, 2009; Tornatzky et al., 1990). Because of this flexibility, it can be applied to several adoption research contexts, industries or organisations, thus ensuring that it remains prevalent. The TOE framework is appropriate as it offers an extensive understanding of the three key contexts regarding blockchain adoption. Due to the flexibility of the framework, it emphasises many factors that may affect blockchain adoption. The contexts analysed in this study include technology, organisation and environment (Tornatzky et al., 1990).

As asserted by Pudjianto and Zo (2009), due to the flexibility of the TOE framework, it can accommodate additional factors as well as classifications to facilitate the identification of the factors responsible for enhancing or impeding the adoption of technology. This suggests that further themes, as well as sub-themes, may be incorporated depending on the aim of the study. The effect of an individual's characteristics on the adoption of IT innovation is not considered by the TOE framework (Dwivedi et al., 2011). However, human factors play a significant role in adopting any novel IT innovation (Alharbi et al., 2016). Furthermore, when deciding to adopt cloud computing in a healthcare setting, careful consideration should be given to the human factors (Paré & Trudel, 2007). Consequently, the human dimension will be included in the proposed conceptual framework.

4.6 Research model and hypotheses

To develop a model that is consistent with the aim of this research, those factors that have been identified as being the most influential in the previous studies are extracted and classified into the four contexts based on the TOE framework, technological, organisational, environmental and human. The TOE framework will be used in this study by applying it to the context of Saudi Arabia to comprehend blockchain technology adoption in hospitals. In the following sections, every context of the TOE framework is explained, and the conceptual framework is also proposed.

4.6.1 Technological context

The features of the technology are explained by the technological dimension, comprising the functionalities, equipment, expenses and techniques for technology adoption (Oliveira & Martins, 2011; Tornatzky et al., 1990). Because blockchain has only recently been introduced, the factors that impact its adoption have not been well identified so far. Hence, it is essential to assess a variety of factors. With respect to the technology context, various perceived technological factors are considered pertinent to the adoption decision (Rogers, 1995). Various perceived technological factors have either a positive or a negative impact within the TOE framework, namely complexity, relative advantage and compatibility.

4.6.1.1 Complexity

Complexity is the extent of the apparent intricacy and difficulty associated with the comprehension and utilisation of a certain innovation or technology (Tornatzky et al., 1990). It is imperative that new technologies are user-friendly to increase the adoption rate. On the other hand, adoption is less likely when it is believed the innovation is difficult to use (Sahin, 2006).

Because of the perceived levels of complexity and the inadequate business use cases, many larger companies and SMEs have rejected the use of blockchain (Clohessy & Acton, 2019). This suggests that complexity functions as a barrier to the adoption of blockchain. There is a negative relationship between an innovation’s perceived complexity and its adoption (Abbas, Shahid Nawaz, Ahmad, & Ashraf, 2017; Holak & Lehmann, 1990). In the blockchain context, Clohessy, Acton, and Rogers (2019) stated there is a negative link between complexity (e.g. smart contract, validation algorithms, etc.) and the adoption decision.

In the healthcare context, one of the most significant factors to influence public cloud adoption by U.S. hospitals was complexity (Lee, 2015). In the hospital industry in Taiwan, it was the fifth most important factor to influence the adoption of the cloud computing (Lian et al., 2014). Nilashi, Ahmadi, Ahani, Ibrahim, and Almaee (2015) identified that the most critical factor affecting the adoption of health information systems (HIS) in Malaysian public hospitals was complexity. It was also found to have a significant but negative impact on EMR adoption in healthcare (Abdekhoda et al., 2019). Thus, the proposed hypothesis is:

H1: Complexity has a negative influence on blockchain adoption in hospitals.

4.6.1.2 Relative advantage

Relative advantage is defined as “*the degree to which an innovation is perceived as being better than its precursor* (Moore & Benbasat, 1991, p. 195). In this study context, relative advantage refers to the degree to which blockchain technology is believed to be better in comparison with its predecessor for healthcare organisations. The higher the perceived advantage of blockchain technology (such as security, fast transactions, immutability, etc.) to an organisation, the greater the possibility of the organisation adopting the innovation (Clohessy et al., 2019). To ensure that adoption is successful, key stakeholders should acknowledge the relative advantage of the technology. If the stakeholders perceive a clear benefit regarding the use of the innovation, innovation adoption is most likely to be successful (Faber, 2014; Rogers, 1995).

Various studies have been carried out in the area of healthcare that demonstrate the significance of perceived relative advantage in expediting adoption. It is considered a critical factor in adopting blockchain technology for electronic medical record systems (Wanitcharakkhakul & Rotchanakitumnuai, 2017). The most significant factor impacting the adoption of cloud computing in Saudi university hospitals is relative advantage (Almubarak, 2017b). It is also the most critical factor impacting public cloud adoption by hospitals in the U.S. (Lee, 2015). Thus, the proposed hypothesis is:

H2: Relative advantage has a positive influence on blockchain adoption in hospitals.

4.6.1.3 Compatibility

Compatibility is defined as *"the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters"* (Rogers, 1995). The adoption decision of an organisation is affected by compatibility. The lack of compatibility between new technologies and the prevailing principles and practices being followed in the workplace will affect adoption (Kwon & Zmud, 1987). It was asserted by Tornatzky et al. (1990) that the perceived high compatibility of the innovation with the existing technologies of an organisation may have a positive effect on the adoption process. The weak integration of novel systems with existing technologies may cause a significant problem (Akbulut, 2003). In the healthcare context, innovation should be consistent with the current perceived needs and requirements (Zhang, White, Schmidt, Lenz, & Rosenbloom, 2018). A significant factor pertaining to the adoption of health data standards in hospitals in Saudi Arabia is compatibility (Alharbi et al., 2016; Alkraiji et al., 2013) and this had a positive impact on adoption. Thus, the proposed hypothesis is:

H3: Compatibility has a positive influence on blockchain adoption in hospitals.

4.6.2 Organisational context

Descriptive measures regarding the organisation, for example, management structure, scope and size, fall under the organisational context (Oliveira & Martins, 2011; Tornatzky et al., 1990). Organisations personally and independently regulate their internal factors, known as organisational factors. These factors significantly affect the decision-making process (Oliveira, Thomas, & Espadanal, 2014). Extensive studies have been carried out on organisational factors to determine their motivating or restricting impact on the adoption of IT (Clohessy & Acton, 2019; Grandon & Pearson, 2004). It is expected in this study that top management support, hospital size and hospital readiness will be critical factors in the adoption of blockchain by Saudi hospitals.

4.6.2.1 Top management support

Top management support is described as the views of the management regarding technological initiatives, their involvement in those initiatives, and the degree to which technological growth is encouraged by top management (Kulkarni, Robles-Flores, & Popovič, 2017). Top management plays a significant role in the adoption of the innovative supply chain management of small- and medium-sized enterprises using blockchain technology (Nayak & Dhaigude, 2019).

Top management support is vital to the adoption of blockchain because, as there may be a need to introduce new regulatory requirements (Castaldo & Cinque, 2018), there could be extensive complexity (Dos Santos, 2017), new resources may need to be obtained and integrated with existing resources (Li et al., 2018), all business-to-consumer and business-to-business transactions may need to be restructured (Nicoletti, Nicoletti, & Weis, 2017), there may be a need to exchange information, and new skills and proficiencies may need to be acquired (Funk, Riddell, Ankel, & Cabrera, 2018). Clohessy et al. (2019) conducted a study that showed that organisations which adopted blockchain had a high degree of support from management. In addition, the study found that in those organisations that adopted this technology, the support for blockchain by top management developed slowly and was affected by employees who could demonstrate the practical value of using blockchain by generating blockchain prototypes that sustainable business models reinforced.

In Taiwanese hospitals, the support of managers was an important variable that affected cloud computing adoption (Lian et al., 2014). The diffusion of RFID technology in Malaysian healthcare organisations was examined by Chong and Chan (2012), and it was shown that RFID adoption was positively affected by top management support. Thus, the proposed hypothesis is:

H4: Top management support has a positive influence on blockchain adoption in hospitals.

4.6.2.2 Hospital readiness

Having particular organisational resources in hand to adopt blockchain technology is referred to as organisational readiness (Iacovou, Benbasat, & Dexter, 1995). When an organisation shows greater willingness to adopt a new technology, it is more likely that management and staff will support this change and will display a cooperative and supportive attitude (Wang, Wang, & Yang, 2010). Existing theoretical studies indicate that blockchain adoption is affected significantly by organisational readiness (Swan, 2015). When innovation is incorporated in an organisation that exhibits greater readiness in terms of organisational resources, there is a higher chance of it being successful (Rogers, 1995).

In a study carried out by (Clohessy & Acton, 2019), it was shown that if IT infrastructure is easily accessible and there are adequate economic and human resources, then these conditions have a positive impact on the company's intention to adopt blockchain technology. It has been shown that RFID adoption in the healthcare sector is greatly affected by hospital readiness (Cao, Jones, & Sheng, 2014). Thus, the proposed hypothesis is:

H5: Hospital readiness has a positive influence on blockchain adoption in hospitals.

4.6.3 Environmental context

The distinctive features of the external world where the organisation performs its business is known as the environmental context (Alharbi et al., 2016; Tornatzky et al., 1990). Organisational environment can support or restrict an organisation in adopting innovation (Rogers, 2003). External factors such as government or competitors will impact the use of blockchain technology in the field of healthcare. There are two factors in this research framework related to blockchain adoption, regulations and laws and government support.

4.6.3.1 Regulations and laws

The adoption of new technologies can be influenced by the prevailing laws and regulations (Liang, Qi, Wei, & Chen, 2017). To supervise and regulate organisations for compliance, new rules and policies may need to be devised (Crosby et al., 2016). A ban has been imposed on cryptocurrencies in some countries such as Russia, China and Vietnam (Bajpai, 2019). In this situation, the speed with which blockchain technology may develop is affected by countries' or organisations' laws and regulations. Technologies like blockchain should be regulated by governments, which should simultaneously cooperate with organisations and the community (Tapscott & Tapscott, 2016). Within the healthcare context, it has been shown that adhering to regulations and policies is vital for the adoption of RFID patient tracking (Cao et al., 2014). Chang et al. (2007) indicated that government policy positively affects hospitals seeking to adopt new technology. Healthcare providers' decisions to adopt new technologies can be influenced by laws and policies (Yusof, Kuljis, Papazafeiropoulou, & Stergioulas, 2008). Thus, the proposed hypothesis is:

H6: Regulations and laws have a positive influence on blockchain adoption in hospitals.

4.6.3.2 Government support

Organisations' willingness to adopt new technologies is affected by government support. A government can support innovation in several ways, including strengthening digital infrastructure, supporting technology incubators, and funding organisation research and development (Garcia & Mohnen, 2010). A blockchain roadmap was released by the government of Australia to promote blockchain adoption in the country, showing it had a positive influence (Malik, Chadhar, Chetty, & Vatanasakdakul, 2020). In Saudi Arabia, the government may support Saudi healthcare organisations and hospitals, as it is seeking to generate a digital transformation in the country in accordance with the 2030 vision (Khan, 2016). According to Koster and Borgman (2020), organisations adoption of blockchain technology is accelerated through government support. Moreover, it was shown by Sadoughi, Ali, and Erfannia (2020) that government support has a positive relationship with the adoption of cloud technology by hospitals. Thus, the proposed hypothesis is:

H7: Government support has a positive influence on blockchain adoption in hospitals.

4.6.4 Human context

The human dimension refers to the attributes of the personnel within the organisation which may influence their willingness to adopt blockchain technology (Wisdom, Chor, Hoagwood, & Horwitz, 2014). Prior to the introduction of any information technology project, consideration should be given to the human dimension. The human dimension impacts the implementation of an innovative technology (Yusof et al., 2008). As stated by Ahmadi, Ibrahim, and Nilashi (2015), the factors involved in the human context should be considered when any technology is to be implemented in the hospital industry. Therefore, the human component is evaluated in this study in terms of the innovativeness and technical expertise of the decision-maker so that the blockchain adoption decision in Saudi hospitals can be understood.

4.6.4.1 Decision-maker innovativeness

The readiness of senior executives (such as the CEO, CIO, owner) to introduce innovation by testing innovative technologies to develop new products, services or technology is referred to as the innovativeness of the decision-maker (Alam, Masum, Beh, & Hong, 2016). This factor plays a vital role in the adoption of new technology in any hospital (Hung, Hung, Tsai, & Jiang, 2010).

The rate at which hospitals adopt new information technologies is typically slow because of the attributes of the decision-maker, for example, experience, innovativeness and risk affinity (Haddad, Gregory, & Wickramasinghe, 2014). The personal qualities of the decision-maker should be considered by hospitals. This may be attributed to the fact that the change-implementing capabilities and expertise of the managers directly affect the rate of change brought about in an organisation (Almubarak, 2017a). A significant barrier to adopting innovation by organisations is the decision-maker’s resistance to change (Antlová, 2009).

Blockchain technology is one of the latest IT innovations. Hence, decision-makers play an essential role in the adoption decision process (Lian et al., 2014). Therefore, it is critical to know if decision-makers can easily accept and comply with information technology changes, which indicates that they will have a positive impact on new IT technology adoption (blockchain technology) (Lian et al., 2014; Thong & Yap, 1995). In the study carried out by Hung Hung et al. (2010), the innovation of senior executives was also found to have a positive relationship with CRM adoption in hospitals in Taiwan. Thus, the proposed hypothesis is:

H8: Decision-maker innovativeness has a positive influence on blockchain adoption in hospitals.

4.6.4.2 Technical competence

The ability of an IS employee is known as perceived technical competence (Lian et al., 2014; Nilashi et al., 2015). The competence of a hospital's IS staff should be meticulously examined before making a decision to adopt blockchain technology. The technological abilities and/or skills of the IS staff will affect a hospital when innovative information technology is being adopted (Lin & Chen, 2012). As stated by (Lian et al., 2014), if IS staff have adequate knowledge and sufficient competency to implement innovative IT technology, hospitals will show greater confidence throughout the adoption process. If the IS staff have ample knowledge and the skills required to adopt blockchain technology, then the hospital will exhibit greater confidence in the adoption process. Generally, a lack of technical knowledge is perceived as an obstacle for e-health development (Boonstra & Broekhuis, 2010).

The Health Level Seven (HL7) integrated technology was examined by Lin, Lin, Roan, and Yeh (2012), showing that a hospital has a greater likelihood of adopting HL7 if they have IS staff with the required competency. It was found that experience in using IT innovation was a significant factor in adopting new technology in Saudi Arabia (Sait, Al-Tawil, & Hussain, 2004). It was also shown that an efficient IT ability was a critical and positive factor for cloud computing adoption in healthcare (Alharbi et al., 2016; Hsu, 2013). Thus, the proposed hypothesis is:

H9: Technical competence has a positive influence on blockchain adoption in hospitals.

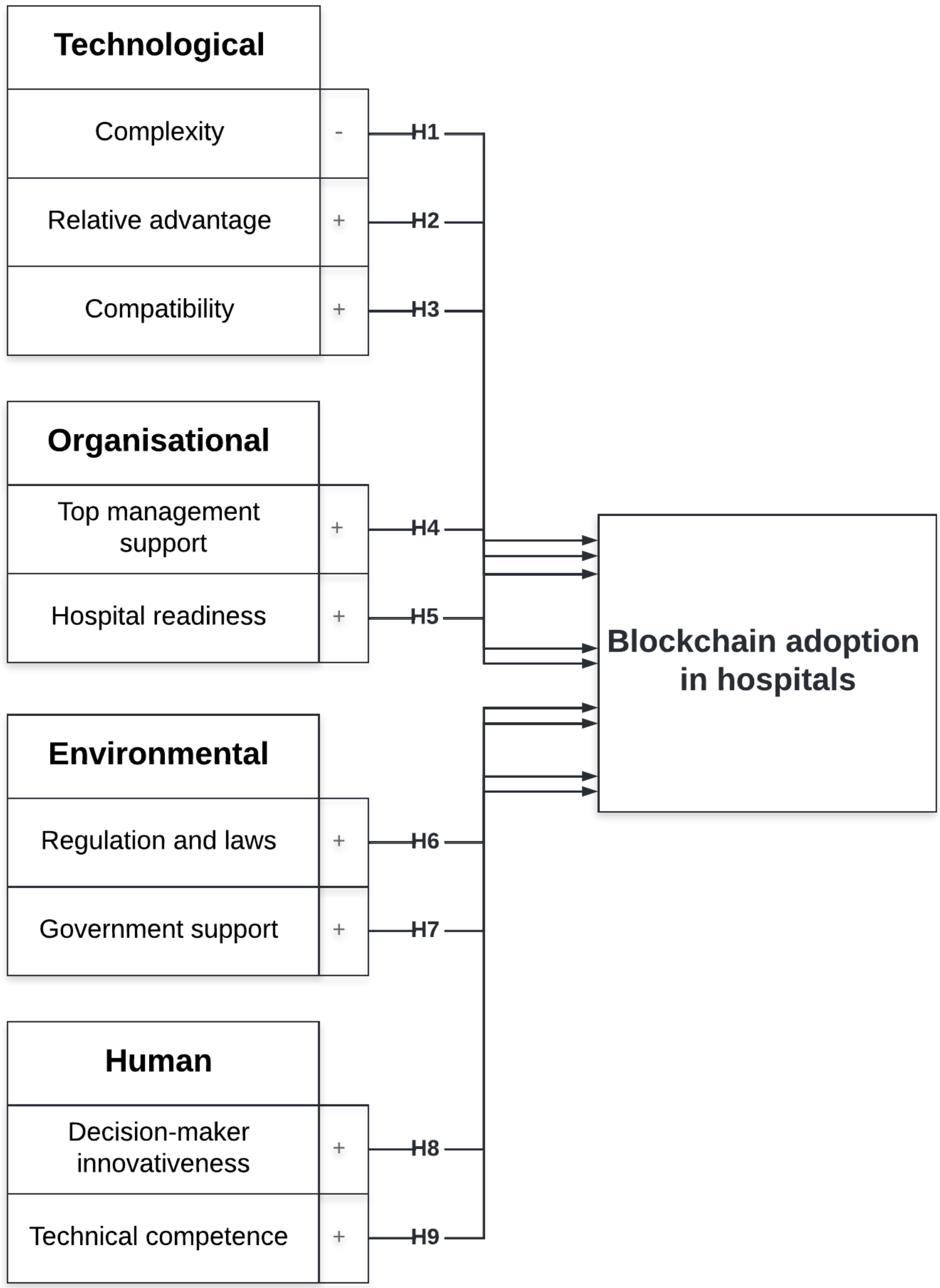


Figure 12 Proposed framework for blockchain adoption in hospitals in Saudi Arabia

4.7 Solution overviews

This section overviews the solutions to find the determinants that affect IT employees' intention to use blockchain technology and their attitude to move some current HIS applications to blockchain.

4.7.1 Overview of the solution for research sub-question 1

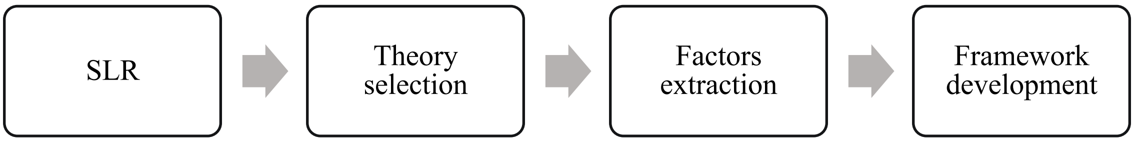


Figure 13 The process of RQ1 solution overview

Research sub-question one is "*What are the determinants influencing the adoption of blockchain technology in Saudi public hospitals from the IT employees' perspective?*" To answer this question, the researcher conducted the following steps. First, the literature on the factors that have an impact on blockchain technology adoption was systematically reviewed with the objective of finding the theory/framework that was used most often as well as the factors that affect blockchain adoption. In systematic literature reviews, all relevant studies related to a research question or phenomenon of interest are identified, evaluated and interpreted (Kitchenham, 2004). Using a systematic review, the researcher can better understand the factors affecting the adoption of blockchain technology in hospitals. Systematic reviews and meta-analyses are considered the most substantial evidence and are placed at the top of the evidence hierarchy (Abd-Alrazaq, 2018; Glasziou, Irwig, Bain, & Colditz, 2001).

The systematic review adheres to the guidelines provided by Kitchenham (2004) to address the various research objectives. The literature was retrieved from seven electronic scientific databases, ACM library, IEEEXplore, ProQuest, PubMed, ScienceDirect, Scopus and WoS, using the search queries "blockchain" OR "block chain" AND "adopt*" OR "accept*". Several criteria were considered to ensure that the included studies are high-quality and relevant. The criteria are based on a set of factors that are considered when determining the inclusion or exclusion of a paper. In the selection process, sequential steps were followed including selection by title, removing duplicated papers, selection by reading the abstract and finally, selection by reading the full papers. The assessment criteria included four elements to further ensure the quality of the extracted studies. Based on the results of the systematic review, the conceptual model was developed by adding the most influential factors found to the most appropriate model was selected. Second, an online questionnaire was developed targeting IT employees who work in Saudi public hospitals to empirically test the proposed framework. Third, the quantitative data collected were analysed using the Statistical Package for the Social Sciences (SPSS) and its supplementary program AMOS. Finally, path analysis was performed to identify the key determinants that affect the behaviour of IT employees and to test the hypotheses. The p-values of each path coefficient in the research model were calculated to determine whether the hypothesis is supported or not.

4.7.2 Overview of the solution for research sub-question 2

To answer research question two, the proposed model should be empirically examined, following several steps. First, the data were collected through survey questionnaire as discussed in detail inChapter 5 (data collection chapter). SPSS was used to screen and clean the data of any missing values, unengaged responses and outliers and was checked for normality and multicollinearity. Second, following the preparation of the data, it is essential that univariate frequency distribution is used to outline and summarise the characteristics of the respondents (Anderson, Sweeney, Williams, Camm, & Cochran, 2016). The respondents' characteristics are categorical variables thus they are summarised and presented in a table using percentages and numbers. Third, before evaluating the research model, both the reliability and the validity of its components should be measured. Reliability refers to the degree of internal consistency between the items (Golafshani, 2003). Internal consistency shows the extent of the relations between the collection of items and how they relate to each other as a group (Price, Jhangiani, & Chiang, 2015). Cronbach's alpha is a commonly used method to determine the interrelationship between the various items of a construct. According to Hair, Black, Babin, Anderson, and Tatham (2006), a construct reliability value of over or equal to 0.70 suggests that the construct's items are reliable. Another important step in calculating reliability is inter-item correlation, which provides an indication of the strength and relationship between two indicators. A low correlation value indicates poor reliability, the minimum acceptable value being 0.30 (Hair et al., 2006). More detail is provided in Chapter 6 (Data analysis and results chapter).

Table 13 The acceptable levels of reliability

Reliability measures	Acceptable levels
Cronbach's alpha	≥ 0.70
Inter-item correlation	≥ 0.30

Validity refers to the degree to which a set of indicators mirrors theoretical variables (Golafshani, 2003). To measure scale validity, including convergent and discernment validity, confirmatory factor analysis (CFA) is an ideal method for this study. CFA is a type of structural equation modelling (SEM) and is a factor analysis method. In CFA, a theory-based model is assessed by how well it fits the collected data (Suhr, 2006). Convergent validity takes two measures that supposedly measure the same construct and shows that they are related. Convergent validity can be measured statistically using composite reliability (CR), average variance extracted (AVE) and factor loading (Hair, Black, Babin, & Anderson, 2013). Discriminant validity indicates that two measures which are not supposed to be related are, in fact, unrelated. Testing discriminant validity in CFA can be done by checking whether each construct has a square root of AVE larger than its correlation with another construct, and also the AVE value should be larger than the maximum shared variance (MSV) value to prove discriminant validity (Henseler, Ringle, & Sarstedt, 2015). The acceptable levels of both convergent and discriminant validity measures are shown in Table 14.

Table 14 The acceptable levels of validity

Validity measures	Acceptable levels
Composite reliability (CR)	≥ 0.70
Average variance extracted (AVE)	≥ 0.50
Factor loading	≥ 0.70
Discriminant validity	square root of AVE > MSV

Fourth, to examine the correlations between the proposed TOE framework and to test the hypothesis for the determinants in the proposed framework, SEM is employed. SEM is one of the statistical techniques used to test hypotheses by estimating the path coefficients of the fundamental relationships between indicators and latent constructs (Hoyle, 1995). There are two types of SEM. The first is the measurement model, which includes the correlations between the measured variables and the latent variables, and the second is the structural model which includes the correlations between the latent variables (McGannon, 2007). Before the structural model is tested, the measurement model should be tested on its own to make sure that there is a fit between the model and the sample data.

The measurement model is evaluated by determining its goodness of fit and the quality of the instruments used in the proposed model. This is done by drawing the research model on AMOS software which provides various goodness of fit indices to determine whether the theory-based model fits the collected data model. Table 15 shows the goodness of fit indices that are used to assess the research model as suggested by Hair et al. (2013). As the measurement model's primary objective is to identify the correlations between the observed variables and latent constructs, the structural model's priority is to identify the causal relationships associated with the constructs that are hypothesised in the model. However, the structural model was assessed based on the assessment criteria outlined in Table 15, followed by performing path analysis to identify the main predictors of IT employees' behavioral intentions.

Table 15 Goodness of fit indices and their requirements

Category	Index	Requirement	References
Absolute fit	RMSEA	< 0.08	(Browne & Cudeck, 1992)
	GFI	> 0.90	(Byrne, Shavelson, & Muthén, 1989)
Incremental fit	TLI	> 0.90	(Hair, Black, Babin, Anderson, & Tatham, 1998)
	CFI	> 0.09	(Bentler, 1992)
	IFI	> 0.90	(Byrne et al., 1989)
Parsimony fit	Chisq/df	< 5	(Marsh & Hocevar, 1985)

4.7.3 Overview of the solution for research sub-question 3

Research question three is "*What are IT employees' suggestions and preferences toward moving HIS applications and services to blockchain technology?".* To answer this, questionnaires were used to determine the perceptions of IT employees on moving some HIS applications to blockchain technology. Respondents expressed their opinions by choosing from a multiple selection list. Elangovan et al. (2022) conducted a systematic review on the use of blockchain technology in healthcare and revealed that most of the research focused on electronic health records (EHRs), data sharing, health insurance, pharmaceutical supply chains, clinical trials, remote patient monitoring and medical device management. Thus, the list included all these HIS applications. The data collected to answer this question were analysed using descriptive statistics and multiple response options in SPSS, presenting them as percentages in a clustered bar chart.

4.8 Chapter summary

This chapter discussed the various research methodologies and approaches used to conduct this empirical study. It also highlighted the importance of TOE as an appropriate theoretical framework for the current study. Nine determinants were extracted and the process of developing the conceptual framework and hypotheses were discussed and justified. Finally, the solutions to the research questions were described. The following chapter discusses the data collection procedure.

Chapter five:

Data collection

Chapter 5. Data collection

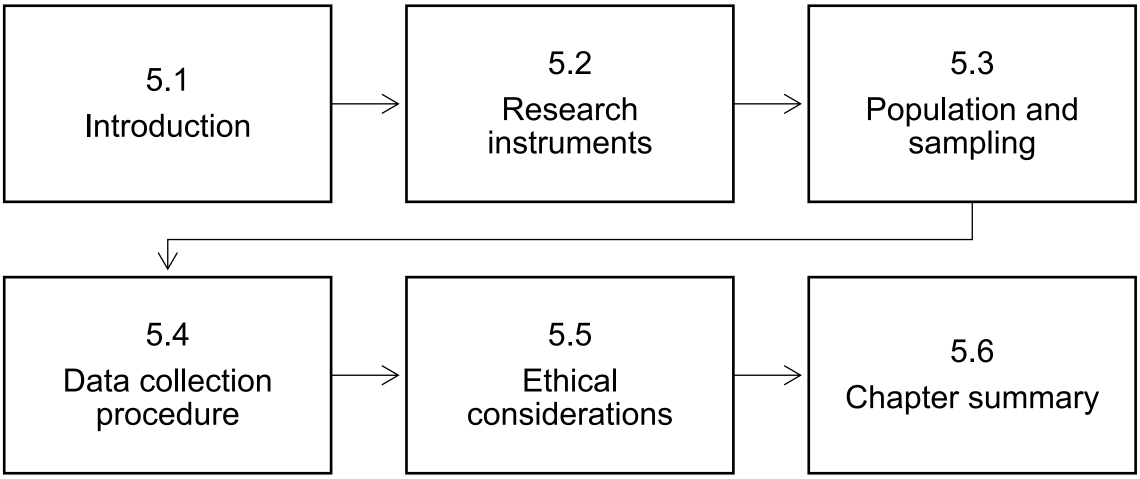


Figure 14 Outline of chapter 5

5.1 Introduction

This chapter describes the development of the survey questionnaires that were used to determine the factors that affect blockchain technology acceptance in Saudi hospitals using the TOE framework. A justification for the survey instrument is presented in this chapter and details are provided on how the instrument was developed, including item creation, pre-testing and pilot testing. The target population and sampling methods are also determined and explained in this chapter. The process of data collection is covered in detail in this chapter. The chapter concludes with the ethical issues considered during the research. This chapter is organised as shown in Figure 14.

5.2 Research instruments

Research instruments are the measurement tools used to collect data on a subject of interest. Various instruments can be employed, including surveys, interviews, observations, experiments, or even checklists (Birmingham & Wilkinson, 2003). However, survey studies are most commonly conducted using interviews and questionnaires. Interviews are one of the data collection methods that the researcher uses to engage in interactive discussion with participants to collect information or opinions, whether face-to-face or remotely, such as virtual meetings (Gillham, 2001). The questionnaire, in contrast, is a type of data collection tool consisting of a series of questions or items that aim to collect information about a group of people's experiences, perspectives or attitudes (Gillham, 2008).

The questionnaire instrument is considered more appropriate than interviews for this research for the following reasons. Firstly, there are around 3111 IT personnel working in Saudi hospitals (MinistryofHealth, 2020), and this research gathers information from a minimum of 320 participants. Therefore, an online questionnaire will be more effective, increase the response rate, and save the cost and time associated with collecting data from a large group of people across a vast geographic region (Gillham, 2008). Secondly, unlike interviews, the participants can answer the questionnaire at a time and place which is convenient for them and they can choose to complete it in one session or in multiple sessions (Gillham, 2008). Thirdly, questionnaires can also help reduce the bias that arises from interactions between the interviewer and the participants. If the researcher is present when the respondents answer the questionnaire, this might indirectly affect the answers (Salazar, 1990). Fourthly, several studies have used questionnaires to examine the factors which impact blockchain adoption (Choi et al., 2020; Hoxha & Sadiku, 2019; Ku-Mahamud, Omar, Bakar, & Muraina, 2019; Kumar Bhardwaj et al., 2021; Orji et al., 2020; Wanitcharakkhakul & Rotchanakitumnuai, 2017; Wong et al., 2020). Lastly and most importantly, data were collected between August 2020 and May 2021 in Saudi Arabia. At that time in Saudi Arabia, to control the spread of the COVID-19, there were curfews, travel restrictions and distancing guidelines that had to be followed (Khan et al., 2021). Face-to-face interviews were therefore impossible, and it was difficult to conduct virtual meetings (e.g., Zoom, Microsoft Team) with the target population. The researcher was not able to reach many of the participants due to the workload of hospital employees during the COVID-19 pandemic, including IT personnel.

The questionnaire was created to gather information from IT personnel about the factors affecting the adoption of blockchain technology. This information will help answer the study questions and find the determinants to develop the TOE framework for adopting blockchain in Saudi hospitals. However, obtaining reliable results from a questionnaire relies on the development and design of the questions and their quality. To gather reliable data, the questions must be worded appropriately and must be understandable for the participants and the study context (Bhattacherjee, 2012). To ensure accurate results are obtained, the participants must be given an understandable questionnaire. Thus, the steps included in the process of the questionnaire data collection are as follows: developing the questionnaire including item creation, scales, and item testing; translation procedure; and designing the questionnaire. The following subsections provide more detail on each of these steps.

5.2.1 Questionnaire development

The questionnaire development procedure created by Moore and Benbasat (1991) which was used in this study, has three stages: stage one: item creation, stage two: scale development and stage three: instrument testing, which is explained in detail in the following subsections.

5.2.1.1 Stage one: Item creation

In this stage, the literature is reviewed to find well-validated items which can then be modified and used to measure the constructs. Blockchain adoption factors and other factors in the literature on information technology/information system adoption in healthcare are integrated into this study. During the literature review, the researcher extracted all the relevant items related to the constructs of interest. As a result, 32 measures were developed, as shown in Table 16. The measures were slightly modified and paraphrased to fit the blockchain context. The Likert scale was employed to measure the constructs of the proposed framework of the current study. The Likert scale is the most commonly used scale for gathering information on the participants' ideas, attitudes and perceptions (Davis, 1989; Wilson & MacLean, 2011). Therefore, all factors in the framework are measured using a five-point Likert scale, where the scale varies from 1= strongly disagree to 5= strongly agree.

Table 16 Measurement items

Constructs		Items	Sources
CPX	CPX1	The use of blockchain is seen as complex for hospital operations	(Choi et al., 2020; Grover, 1993; Moore & Benbasat, 1991)
	CPX2	It would be very difficult to resolve transactional errors when using blockchain	
	CPX3	The skills required to adopt blockchain could be complicated for the hospital's employees	
RA	RA1	The use of blockchain will allow hospital operations to be managed effectively	(Lustenberger et al., 2021; Grover, 1993; Moore & Benbasat, 1991)
	RA2	The use of blockchain will allow tasks to be performed faster	
	RA3	The use of blockchain will improve the productivity of the hospital	
	RA4	The use of blockchain will be beneficial for patients	
COM	COM1	Using blockchain services will be fully compatible with current operational practices	(Lustenberger et al., 2021; Rogers, 2003; Ramamurthy et al., 1999; Moore & Benbasat, 1991)
	COM2	Using blockchain will be compatible with the hospital's existing hardware	
	COM3	Using blockchain will be compatible with the hospital's IT infrastructure	
	COM4	Using blockchain will be compatible with the hospital's goals and values	
TMS	TMS1	The hospital's management is willing to take risks involved in blockchain adoption	(Wang et al., 2010; Soliman & Janz, 2004; Grover, 1993)
	TMS2	In our hospital, top management will support the adoption of blockchain	
	TMS3	Top management will be aware of blockchain benefits	
HR	HR1	Network infrastructure in the hospital would be available for adopting blockchain	(Lokuge et al., 2019; Im et al., 2013; Byrd & Turner, 2001)
	HR2	IT human resources in the hospital would be available for adopting blockchain	
	HR3	Financial resources in the hospital would be available for adopting blockchain	
RL	RL1	Regulations and laws could be sufficient to deal with blockchain issues	(Gui et al., 2020; Oliveira et al., 2014; Zhu & Kraemer, 2005)
	RL2	Regulations and laws would be adequate for protecting the use of blockchain	
	RL3	Regulations and laws would facilitate the use of blockchain	
GS	GS1	There would be available financial support from the government to encourage the adoption of blockchain	(Kumar Bhardwaj et al., 2021; Malik et al., 2021; Iacovou et al., 1995)
	GS2	There would be supportive policies from the government regarding the adoption of blockchain	
	GS3	There would be training and educational support from the government to boost the adoption of blockchain	
DMI	DMI1	Decision makers in the hospital will seek to take advantage of new technologies	(Lian et al., 2014; Agarwal & Prasad, 1998)
	DMI2	Decision makers in the hospital will be keen to experiment with emerging technologies	
	DMI3	Decision-makers will be confident to try out new technologies	
TC	TC1	It would be easy to learn about blockchain	(Lian et al., 2014; Kuan & Chau, 2001)
	TC2	It would be easy to have the ability to support blockchain adoption	
	TC3	It would be easy to have the expertise to support blockchain adoption	
BI	BI1	The hospital intends to adopt blockchain	(Venkatesh et al., 2003; Davis, 1989)
	BI2	The hospital is likely to adopt blockchain in the next 12 months	
	BI3	The hospital is likely to take steps to adopt blockchain in the future	

5.2.1.2 Stage two: Scale development

In this stage, the researcher should ensure the clarity and validity of the questionnaire items to avoid misinterpretation. This is the procedure for ascertaining that the items in the questionnaire are straightforward and accurately reflect their constructs (Hair et al., 2006). This can be accomplished by carefully extracting the correct items measuring the construct of interest from previous studies, and pre-testing the questionnaire by sending a draft to experts for critical evaluation (Bernard & Bernard, 2013). The researcher sent a draft of the questionnaire to seven experts with experience in technology adoption and health informatics. The experts raised the following issues: some questions needed to be rephrased, negative statements needed to be avoided, a rating index should be used and ambiguous items needed to be clarified. The researcher modified the items in accordance with the experts' comments.

5.2.1.3 Stage three: Instrument testing

In the last stage, the questionnaire was pilot tested before being distributed to the participants. According to Gillham (2008), pilot testing is commonly conducted with participants who have similar characteristics to the sampling frame. However, the purpose of this pilot study was to test the feasibility, validity and practicality of the questionnaire by conducting it with a variety of participants. Hertzog (2008) considered 25 as the lowest threshold for the pilot test sample size. Hence, the questionnaire was sent to two small groups totalling 32 participants; the target population (IT employees) who will assess the validity and clarity of the questions and PhD students who will be asked to check any issues related to the time needed to complete the questionnaire and how easy the survey tool is to use. Subsequently, no issues were raised by the participants and there were no problems concerning reliability. The questionnaire was then ready to distribute to IT employees in Saudi hospitals. Appendix B provides the full version of the questionnaire.

5.2.2 Translation procedure

It was necessary to translate the original questionnaire into Arabic since Arabic is the national language of Saudi Arabia and the original questionnaire was in English. A back translation method was used to ensure the language was understandable and clear for all the participants. Back translation involves reverting a translated document to its source language (Brislin & Freimanis, 2001), and the following steps are undertaken in the translation process. The researcher translated the original English questionnaire into Arabic. Then, the Arabic translation with the English version was sent to an English teacher who teaches in a high school in Saudi Arabia. The researcher received feedback from the teacher, including translation quality issues which were modified accordingly. The Arabic version was then sent to another English teacher in a different high school to translate it into English. Consequently, the two versions were nearly similar, confirming the effectiveness of the translation process.

5.2.3 Questionnaire design

Various suggestions and existing questionnaires in the literature were used as a guideline for designing this questionnaire (Ackerman, Cranor, & Reagle, 1999; Gillham, 2008; Holden & Karsh, 2010; Jensen, Potts, & Jensen, 2005; Mekawie, 2013; Venkatesh et al., 2003). The questionnaire consisted of the five following parts:

Part 1: consists of a cover letter that includes a consent or approval document and information regarding the research, information on the researcher conducting the study, the researcher's supervisors and their contact information. The cover letter also states that the UTS Research Ethics and Integrity Policy has been followed in all stages of the research.

Part 2: asks for the participant's demographic information, for example, nationality, gender, age, educational level, the participant's responsibility in the hospital and the location of the hospital. The participant's identity will be anonymous.

Part 3: concentrates on the participant's computer skills level and knowledge of blockchain technology. It also asks the participants about their experience using blockchain services or applications.

Part 4: A short description of blockchain technology is provided in case IT employees have limited knowledge on blockchain to ensure participants understand the technology before answering the questions. The various dimensions that may impact blockchain adoption in Saudi hospitals are also examined. It comprises items on the proposed framework constructs to determine how they influence participants' Behavioral intention regarding blockchain technology adoption.

Part 5: asks the participants to suggest possible IT services and applications that could be moved to blockchain technology. Also, the participants are asked to provide additional suggestions to an open-ended question regarding how the research can be enhanced.

5.3 Population and sampling

After designing the questionnaire, the next step is to determine the target population and identify the sampling process. A population is a group or set of cases with specific characteristics which are investigated by the researcher (Banerjee & Chaudhury, 2010). In this research, the population includes all the IT employees (e.g., CIOs, CTOs, IT technicians, programmers, etc.) who work in Saudi public or governmental hospitals, whether at the managerial level or technicians. This population is targeted because they play a crucial role in decision-making at the strategic and operational levels. They are familiar and knowledgeable about the technology and these employees would be the ones to introduce the frontline adoption of new technology.

As defined by Thompson (2012), a sample is a representative group of cases taken from a population for research purposes. A sample can be formed using two sampling techniques: probability and non-probability. Probability sampling ensures that all subjects are eligible to be selected for a representative sample. In contrast, non-probability sampling is when no one knows which individual will be selected from the population to form a sample (Thompson, 2012). Employing the probability sampling technique requires determining the sampling frame. The sampling frame consists of a list of all items of the target population from which the sample is drawn (Zikmund et al., 2013). Due to the unavailability of the list, which means the sampling frame is not identified, this study employed a non-probability sampling technique.

Snowball sampling is one of the non-probability sampling techniques where the researcher requests assistance from the participants to find other potential participants (Biernacki & Waldorf, 1981). Snowballing is the most appropriate sampling technique for the current research for the following reasons. First, several existing studies employed snowball sampling in the Saudi context (Aldraehim, Edwards, Watson, & Chan, 2013; Alharbi, 2017; Alkraiji et al., 2013). Second, the population in this study is difficult to reach due to COVID-19 restrictions. Faugier and Sargeant (1997) stated that snowball sampling is a feasible method used for hard-to-reach populations. Third, it allows the researcher to identify participants who match the required characteristics and who are representative of the population as those recruited tend to refer others with similar characteristics to their own, meaning if the initial group are IT employees who work in Saudi hospitals, they will likely refer people with the same characteristics, leading to the exact target population. To avoid bias, the researcher asked the participants if they were IT employees working in Saudi hospitals. If the participants answered ‘no’, an ending message appeared, and the participants were not able to fill out the questionnaire.

Before determining the sample size, the researchers need to consider what method of data analysis will be employed. Structural equation modelling (SEM) is a multivariate statistical method used to test hypotheses and analyse the research model. It is widely acknowledged that the rule of the thumb for the sample size for studies in which data analysis is carried out through SEM is that it should be a minimum of ten times the number of indicators (Hair et al., 2013; Nunnally & Bernstein, 1967). There are 32 indicators measuring the nine latent constructs in the proposed framework; therefore, 320 was considered the minimum sample size needed to gain a complete understanding of the research topic.

5.4 Data collection procedure

The researcher distributed the questionnaire to his contacts working in Saudi hospitals as an invitational link to the online questionnaire. The invitation letter was written in Arabic and English, and a short overview of the research purpose and its importance was also provided. Those contacted were asked to participate in the survey and invite other relevant people to participate. The researcher used his contacts on social networking websites (such as WhatsApp, Twitter, LinkedIn) to increase the response rate by inviting the targeted participants to complete the questionnaire. A study found that 89.8% of Saudis use WhatsApp as a social networking tool followed by Twitter, and this increases to 96.7% among healthcare employees (Alhaddad, 2018; Dhuha, Boumarahb, Masoudib, & Boubshaita, 2021). The researcher asked social media influencers who work in IT department in Saudi hospitals if it would be possible to post the survey link on their social media profiles. The influencers offered assistance with data collection and agreed to distribute the survey.

The data collection took place between August 2020 and May 2021 in Saudi Arabia. A cross-sectional design was used to collect the quantitative data. A cross-sectional design enables data to be collected at one single time point, contrary to a longitudinal design in which data is collected from the same sample repeatedly over a more extended and separated times (Hua & David, 2008). Data were collected through an online questionnaire. As 98% of the Saudi population have access to the Internet (WorldBank, 2020), the use of an online questionnaire is justified. The online questionnaire was designed and developed using an online tool called Qualtrics, the full version of which was provided by the University of Technology Sydney.

5.5 Ethical considerations

Before the commencement of the data collection (Buchanan & Hvizdak, 2009), ethical approval must be obtained. The researcher submitted the relevant ethics form to the Human Research Ethics Committee at the University of Technology, Sydney and approval was obtained in August 2020 (NO. ETH20-5126) as shown in Appendix A. The researcher informed the participants that during all the stages of the research, the code of ethics of UTS would be adhered to. Written information regarding the aims and objectives of the study were given to all the participants. It was mentioned in the consent form that participation in this study is voluntary, and that participation can be withdrawn at any time. The data collection process took place in a highly confidential manner, and the participants' identities were kept anonymous. The data are only utilised for this research and the findings are limited to academic publications only. Participants were provided with the contact information of both the researcher and supervisor if they wanted to ask for further details.

5.6 Chapter summary

This chapter has described how to develop a questionnaire for quantitative data collection and how to collect data from identifying the necessary information to pilot testing. The previous studies on technology adoption, specifically in healthcare, assisted the questionnaire's development and helped the extraction of 32 items based on the TOE framework. A snowball sampling technique was chosen because it was most applicable to the characteristics of the population. By the end of the sampling process, it was determined that a minimum of 320 IT employees would be the sample size. The distribution procedure through social media and the data collection process based on a cross-sectional design were explained and ethical guidelines were followed. In total, 449 responses were obtained and an analysis of the responses is presented in the next chapter.

Chapter sex:

Data analysis and results

Chapter 6. Data analysis and results

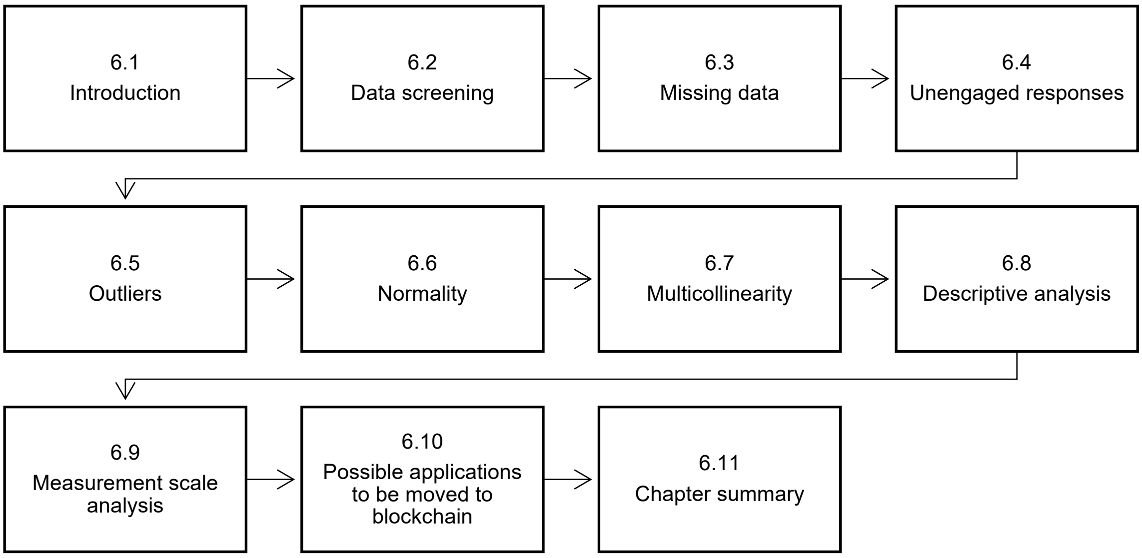


Figure 15 Outline of chapter 6

6.1. Introduction

This chapter describes the findings of the quantitative data conducted through the questionnaire survey. It explains how the researcher dealt with the variety of challenges that may arise throughout the data collection process, such as missing data, unengaged responses, and outliers. It also presents a general summary of the participants' backgrounds and characteristics. It discusses the measurement scales that were utilised in this study and provides evidence of the reliability and validity of each scale. It overviews the SEM multivariate analysis approach which was used in this study to evaluate the research measurement and structural model. Finally, it provides a detailed description of the outcomes of the study's investigation of the respondents' views regarding which application or services they suggest be moved to blockchain technology. This chapter is organised as shown in Figure 15.

6.2. Data screening

It is important to thoroughly screen and clean the collected data to ensure its accuracy before undertaking structural equation modelling (SEM) analysis. This step can help meet statistical assumptions and reduce the impact of errors during data collection (DeSimone, Harms, & DeSimone, 2015). 449 responses were obtained and to ensure that the data represented the views of the IT employees who work in Saudi hospitals, the participants were asked to identify their job roles. Following Hair et al. (2006), the data were screened for missing values, checked for errors, unengaged responses and outliers, and examined to ensure the data were normally distributed. These assumptions are tested and detailed in the following sections.

6.3. Missing data

Missing data is data which is not stored for a particular variable. It can affect the validity of findings and cause biased results (Allison, 2001). Missing demographic data does not significantly impact the statistical analysis, but an imputation technique for missing data related to the research model constructs should be performed. Musil et al. (2002) compared five techniques and concluded that list-wise deletion is a conservative and safe technique for dealing with missing data. List-wise deletion is when all responses with missing data are deleted, leaving only answers with complete records (Musil, Warner, Yobas, & Jones, 2002). After applying list-wise deletion, 38 responses were removed entirely, leaving 411 responses for further analysis.

6.4. Unengaged responses

Unengaged responses occur when the respondents answer with the same value for every or most of the questions. A visual inspection was performed to detect this, and a standard deviation was calculated for each response. A previous study suggested that if the standard deviation value of the response was less than 0.5, it should be considered an unengaged response (Charalampi, Michalopoulou, & Richardson, 2019). Thus, 41 responses were detected with less than 0.5

standard deviation. Consequently, they were deleted, and the remaining 370 cases were used for analysis.

6.5. Outliers

The low occurrence of outliers in this survey data is mainly due to multiple-choice questions instead of text input. The use of a Likert scale eliminated the risk of inaccuracy by reducing the number of respondent errors. Although there is a low likelihood of an outlier occurring in this survey data, this is still a possibility if the data point values are highly different from the others. Outliers are extreme values that deviate from a variable's overall trend (Hair et al., 2013). There are two types of outliers: univariate outliers and multivariate outliers.

6.5.1. Univariate outliers

A univariate outlier is a data point that contains an extreme value on one variable (Ben-Gal, 2005). It is detected by converting variables to z-scores, and it is done by creating mean composites for each construct then standardising the composite. If any of the standardised values/z-scores are above or below 3.29, it is considered an outlier (Tabachnick, Fidell, & Ullman, 2007).

Table 17 Z-score variables

Z-score	N	Minimum	Maximum
ZCPX	370	-1.85967-	3.36382
ZRA	370	-3.55470-	1.42475
ZCOM	370	-3.45710-	1.61612
ZTMS	370	-3.19902-	1.08331
ZHR	370	-2.53772-	1.76744
ZRL	370	-2.64374-	1.79448
ZGS	370	-3.45400-	1.27607
ZDMI	370	-3.43767-	1.39525
ZTC	370	-3.30368-	1.09805
ZBI	370	-3.41168-	1.43324

Accordingly, as presented in Table 17, some cases meet the criteria outlined above, and six samples were detected and removed. A total of 364 responses are left for the following step.

6.5.2. Multivariate outliers

A multivariate outlier is a data point that has an unusual score on two or more variables (Ben-Gal, 2005). Cook's distance was employed to estimate the influential outliers in the research data. As a rule of thumb, if the difference between Cook's distance and the mean is more than three times, it is considered to be an outlier (Hair et al., 1998). After applying Cook's distance, one element was abnormal, as shown in Figure 16, so it was deleted, and 363 samples remain for the research data analysis.

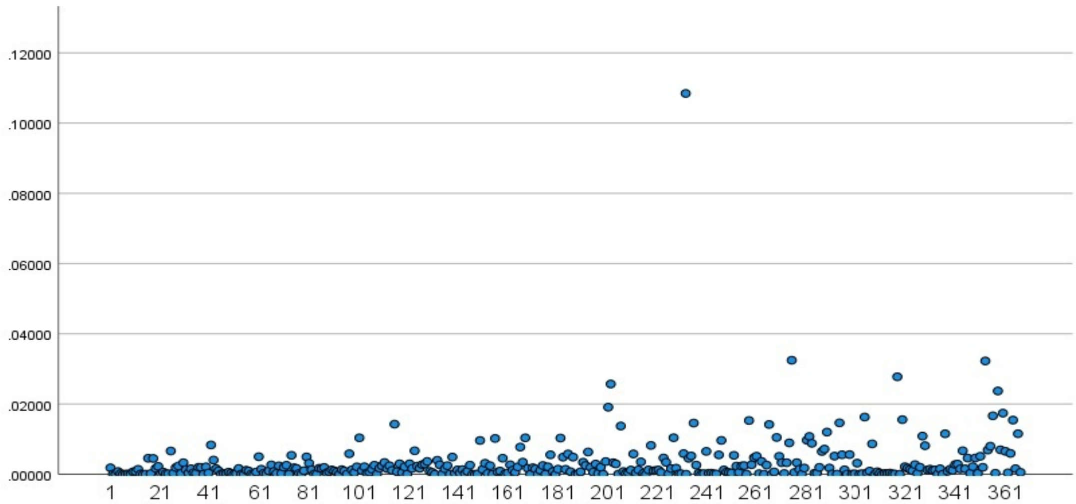


Figure 16 Cook's distance scatter plot

6.6. Normality

Normality is the "*degree to which the distribution of the sample data corresponds to a normal distribution*" (Hair et al., 2013, p. 34). It is essential to check normality before conducting SEM because it is one of the critical assumptions pertaining to data distribution (Tabachnick et al., 2007). It can be examined by looking for the skewness and kurtosis values. Kurtosis is a measure of the distribution's flatness or peakedness, and skewness is a measure of the symmetry of the distribution (Hair et al., 2013). If the value is zero, the distribution is close to normal. As shown in Table 18, in this research, the skewness and kurtosis values were within the ranges (±2.58) suggested by Hair et al. (1998) as generally used critical values for testing normality.

Table 18 Normal distribution detection for the research model construct (N=363)

Construct	N	Skewness	Kurtosis
Complexity (CPX)	363	0.611	1.307
Relative Advantage (RA)	363	-0.838-	0.285
Compatibility (COM)	363	-0.643-	-0.013-
Top Management Support (TMS)	363	-0.980-	0.914
Hospital Readiness (HR)	363	-0.374-	0.299
Regulation and Laws (RL)	363	-0.187-	-0.004-
Government Support (GS)	363	-1.297-	1.346
Decision-Maker Innovativeness (DMI)	363	-1.159-	1.16
Technical Competence (TC)	363	-1.077-	1.245
Behavioral Intention (BI)	363	-0.298-	-0.691-

6.7. Multicollinearity

Multicollinearity can be observed in cases where independent variables are highly correlated (Hair et al., 2013). Independent variables should have a strong relationship with the dependent variable but not with each other. High multicollinearity can cause a decrease in the statistical significance of a given coefficient. This can be checked by estimating the value of the variance inflation factor (VIF) and tolerance for the observed variable. Tolerance is defined as "*the amount of variability of the selected independent variable not explained by the other independent variables*" (Hair et al., 2013, p. 197). VIF is the inverse of tolerance value (1 ÷ tolerance) and is used to calculate the impact of an independent variable on the standard error of a regression coefficient (Pallant, 2010). Data will be free of multicollinearity issues if tolerance value is more than 0.1 and VIF less than 10 (Hair et al., 2013). Accordingly, as shown in Table 19, all values are more significant than 0.1 in the tolerance column, and no value exceeds 10 in VIF. Therefore, there is no multicollinearity problem between the independent variables in the data.

Table 19 Multicollinearity assessment

	Multicollinearity*	
	Tolerance	VIF
Complexity (CPX)	0.647	1.545
Relative Advantage (RA)	0.708	1.412
Compatibility (COM)	0.780	1.282
Top Management Support (TMS)	0.636	1.573
Hospital Readiness (HR)	0.735	1.360
Regulation and Laws (RL)	0.939	1.065
Government Support (GS)	0.759	1.317
Decision-Maker Innovativeness (DMI)	0.745	1.342
Technical Competence (TC)	0.804	1.243
Behavioral Intention (BI)	0.647	1.545
*Dependent Variable: BI		

6.8. Descriptive analysis

As an initial stage in a statistical study, descriptive statistics are commonly generated and used to define the essential characteristics of data in research (Liu, Parelius, & Singh, 1999). 449 respondents participated in the survey, and after the data screening process was completed, 363 responses were considered valid. The demographic characteristics of the respondents revealed that they are mainly IT employees work in Saudi hospitals. The findings of the demographic analysis are presented in this section. Table 20 presents the demographic information on the IT employees and includes information on their nationality, gender and age, level of education, region and hospital type and their job. It also provides information on the level of their computer skills, blockchain knowledge, and experience using blockchain services or applications.

Table 20 Demographic summary of respondents

	Participants		IT employees in Saudi Arabia*	
	No.	%	No.	%
Gender				
Male	253	69.7%	3111	67.4%
Female	110	30.3%	1506	32.6%
Age				
18-24	82	22.6%		
25-34	170	46.8%		
35-44	69	19%		
45-54	32	8.8%		
55+	10	2.8%		
Educational level				
High school	7	1.9%		
Diploma	18	5%		
Bachelor	276	76%		
Postgraduate	62	17.1%		
Job role				
Managerial level	51	14%		
Administrative level	27	7.4%		
Professional level	198	54.5%		
Technician level	87	24%		
Region				
Central	137	37.7%		
Western	82	22.6%		
Eastern	51	14%		
Southern	69	19%		
Northern	24	6.6%		
Hospital type				
Public	215	59.2%		
Governmental	148	40.8%		
Computer skills				
Very poor	-	-		
Poor	-	-		
Moderate	3	0.8%		
Good	48	13.2%		
Very good	312	86%		
Blockchain knowledge				

Very poor	91	25.1%	
Poor	163	44.9%	
Moderate	88	24.2%	
Good	16	4.4%	
Very good	5	1.4%	
Blockchain use			
Yes	46	12.7%	
No	317	87.3%	
Blockchain experience			
Less than 1 year	36	78.3%	
1 – 3 years	10	21.7%	

* (MinistryofHealth, 2020)

6.8.1. Gender and age

As illustrated in Table 20, of the 363 respondents, 253 IT employees were male (69.7%), and 110 were female (30.3%). It can be seen from the age distribution that more than half of the participants (69.4%) were between 18 and 34, followed by 69 respondents (19%) aged between 35 and 44. 32 respondents (8.8%) were aged between 45 and 54 and the remaining 10 (2.8%) were more than 55 years old.

6.8.2. Educational level

The respondents were asked to identify their highest educational level. Table 20 shows that about three-quarters of the respondents had a bachelor's degree (76%), while 17.1% had a postgraduate degree. Only 5% of the respondents indicated that they had a diploma, and a small percentage had a high school diploma (1.9%).

6.8.3. Job role

Table 20 shows that over half (54.5%) of the respondents were at the professional level and a quarter (24%) were at the technician level. The remaining participants were either at the management level (14%) or at the administrative level (7.4%).

6.8.4. Region and hospital type

Saudi Arabia has five provinces: Central, Western, Eastern, Sothern and Northern. As presented in Table 20, the geographical distribution of the participants indicates that the majority are from the Central (37.7%) and Western (22.6%) provinces, 19% are from the Southern province and 14% are from the Eastern province. The remaining 6.6% participants are located in the Northern province. The hospital type characteristic of the respondents indicates where they work, with the majority indicating they work for the Ministry of Health in Saudi Arabia (59.2%). The others are from government hospitals (40.8%) such as King Faisal Specialist Hospital & Research Centre and national guard hospitals.

6.8.5. Computer skills

The majority (86%) of the respondents stated that they had excellent computer skills while 13.2% reported that they had good skills. Only a small percentage (0.8%) reported they had moderate computer skills. None of the respondents had poor computer skills.

6.8.6. Blockchain knowledge and experience

About 44.9% and 25.1% of respondents indicated that their overall knowledge of blockchain technology is poor and very poor, respectively. 24.2% stated that they have moderate blockchain knowledge. A further 4.4% stated that their knowledge is good, and only 1.4% indicated that they had excellent blockchain knowledge. Of the 363 participants, only 46 had experience using blockchain. However, the results indicate that almost 78.3% of those 46 respondents had less than one year of experience, while 21.7% had 1 to 3 years of experience using any blockchain services or applications.

6.9. Measurement scale analysis

This section analyses the various measurement scales employed to identify the influence of the nine constructs that were adopted in the current study. Before evaluating the research model, its reliability and validity should be measured. Reliability determines the degree of internal consistency among each construct's items, while validity refers to the degree to which a set of items represents and mirrors a theoretical latent construct (Golafshani, 2003). The findings of the reliability and validity tests are outlined in the following subsections.

6.9.1. Reliability

In this research, nine independent scales and one dependent scale were used to examine the proposed TOE framework constructs. The independent scales are complexity (CPX); relative advantage (RA); compatibility (COM); top management support (TMS); hospital readiness (HR); regulations and laws (RL); government support (GS); decision-maker innovativeness (DMI); and technical competence (TC), while the dependent scale is Behavioral intention (BI) to use blockchain technology in Saudi public hospitals. To indicate that the scales effectively reflect the meaning of the model constructs, scale reliability was undertaken, and it is assessed by analysing the internal consistency and inter-total correlation as explained in the following subsection.

6.9.1.1. Internal consistency

The internal consistency reliability metric assesses how similar results are produced by different test items examining the same construct (Henson, 2001). One of the most commonly used reliability estimates to calculate the interrelationship of the items is Cronbach’s alpha (Brown, 2002). Cronbach alpha values vary between zero and one, where a low value demonstrates a poor construct (Litwin & Fink, 2003). “High correlations between alternative measures or large Cronbach’s alphas are usually signs that the measures are reliable” (Straub (1989, p. 151). There are four reliability degree scales: excellent, high, moderate and low, with values of 0.90,0.70 to 0.90, 0.50 to 0.70 and equal to or less than 0.50, respectively. Hair et al. (2006) stated that construct reliability values of more than or equal to 0.70 suggest good reliability. Using SPSS, the researcher undertook an internal consistency reliability analysis for each set of constructs individually to determine the extent to which the research instruments are consistent. Table 21 shows the Cronbach’s alpha for each construct, all of which had a reliability coefficient varying between 0.75 and 0.90. The reliability coefficients met the threshold outlined by Hair et al. (2006) ; hence it can be concluded that the measurement scales showed high internal consistency and the study instruments are highly reliable.

Table 21 Reliability results

Construct	Items	Cronbach's Alpha	Comments
Complexity (CPX)	3	0.77	High reliability
Relative Advantage (RA)	4	0.75	High reliability
Compatibility (COM)	4	0.88	High reliability
Top Management Support (TMS)	3	0.83	High reliability
Hospital Readiness (HR)	3	0.81	High reliability
Regulation and Laws (RL)	3	0.79	High reliability
Government Support (GS)	3	0.76	High reliability
Decision-Maker Innovativeness (DMI)	3	0.82	High reliability
Technical Competence (TC)	3	0.77	High reliability
Behavioral Intention (BI)	3	0.90	Excellent reliability

6.9.1.2. Inter-item correlations

Inter-item correlation is another essential step in scale analysis that identifies the extent to which the scores for one item are related to all the other items in a given scale (Cohen, Swerdlik, & Phillips, 1996) and it also identifies the strength and relationship between the two indicators where a low correlation value indicates poor reliability and vice versa. According to Hair et al. (2006), the minimum acceptable value is 0.30 for inter-item correlation. A value less than 0.30 shows that the observed variables are measuring different constructs. The correlation matrix for each construct is computed by checking the 'inter-item' option in SPSS while conducting the scale reliability analysis. This procedure and the results are detailed in the following 10 subsections.

6.9.1.2.1. Analysis of complexity

Complexity is the extent of the apparent intricacy and difficulty associated with the comprehension and utilisation of a certain innovation (Tornatzky et al., 1990). In this study, complexity is hypothesised as a negative influence on technology adoption and to measure the perceived level of blockchain complexity on the adoption, three items were adopted from the previous literature (Choi et al., 2020; Teo, Wei, & Benbasat, 2003). Table 22 shows the correlation values of the three items which were higher than 0.30 and ranged between 0.498 and 0.508. Thus, this indicated that their relationship is reliable.

Table 22 Inter-item correlation matrix for complexity construct

Complexity (CPX)		CPX1	CPX2	CPX3
Inter-item correlation	**CPX1**	1.000	.503	.498
	CPX2	.503	1.000	.508
	CPX3	.498	.508	1.000

6.9.1.2.2. Analysis of relative advantage

Relative advantage is defined as "*the degree to which an innovation is perceived as being better than its precursor*" (Moore & Benbasat, 1991, p. 195). Relative advantage is hypothesised to positively impact the adoption of blockchain and is measured using four adopted items from previous research (Teo et al., 2003). These items measure the degree to which blockchain technology is believed to be better in comparison to its predecessor for hospitals. Table 23 shows that the values are greater than 0.30, ranging between 0.498 and 0.508 which suggests the inter-item correlation has a high reliability.

Table 23 Inter-item correlation matrix for relative advantage construct

Relative Advantage (RA)		RA1	RA2	RA3	RA4
Inter-item correlation	**RA1**	1.000	.643	.633	.656
	RA2	.643	1.000	.647	.641
	RA3	.633	.647	1.000	.602
	RA4	.656	.641	.602	1.000

6.9.1.2.3. Analysis of compatibility

Compatibility is defined as *"the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters"* (Rogers, 1995, p. 224). It also has a positive effect on blockchain adoption, and four indicators are used to measure whether blockchain is consistent with hospitals' existing perceived needs and requirements. The indicators are adapted from studies done by Alam et al. (2016). As illustrated in Table 24, the results of the test reveal that four items' values ranged from 0.602 to 0.656 which is greater than 0.30, indicating they have a strong reliable relationship.

Table 24 Inter-item correlation matrix for compatibility construct

Compatibility (COM)		COM1	COM2	COM3	COM4
Inter-item correlation	**COM1**	1.000	.522	.584	.596
	COM2	.522	1.000	.516	.554
	COM3	.584	.516	1.000	.506
	COM4	.596	.554	.506	1.000

6.9.1.2.4. Analysis of top management support

Top management support is described as the views of management regarding technological initiatives, their involvement in those initiatives, as well as the degree to which technological growth is encouraged by top management (Kulkarni et al., 2017). To measure the positive impact of a high degree of support from management to adopt blockchain, three items were adapted from (Li, 2008; Teo et al., 2003) and reliability was tested using the correlation matrix. Table 25 shows that the correlation coefficients ranged between 0.555 and 0.632 which means the values are greater than 0.30, hence the instruments are consistent and reliable.

Table 25 Inter-item correlation matrix for top management support construct

Top Management Support (TMS)		TMS1	TMS2	TMS3
Inter-item correlation	**TMS1**	1.000	.555	.623
	TMS2	.555	1.000	.579
	TMS3	.623	.579	1.000

6.9.1.2.5. Analysis of hospital readiness

Having particular organisational resources in hand to adopt blockchain technology is referred to as organisational readiness (Iacovou et al., 1995). The hospital readiness construct has a positive influence on blockchain adoption and it is measured by three validated instruments adapted from (Grandon & Pearson,

2004) to determine whether the hospital has sufficient IT infrastructure and adequate economic and human resources to adopt blockchain. These instruments can be tested by computing the correlation matrix. The results of the test are summarised in Table 26, showing that the three items are highly reliable, as indicated by values greater than 0.30 and ranging from 0.534 to 0.561.

Table 26 Inter-item correlation matrix for hospital readiness construct

Hospital Readiness (HR)		HR1	HR2	HR3
Inter-item correlation	**HR1**	1.000	.534	.581
	HR2	.534	1.000	.561
	HR3	.581	.561	1.000

6.9.1.2.6. Analysis of regulations and laws

This factor refers to the framework of laws and regulations, as well as the policies that are in place to oversee and encourage the implementation of new technology by the government or organisations (Scupola, 2009; Seshadrinathan & Chandra, 2021). Three observed variables adapted from (Choi et al., 2020; Gui, Fernando, Shaharudin, Mokhtar, & Karmawan, 2020) were used to measure whether blockchain adoption is affected by the country's or hospital's laws and regulations. The values of the correlation matrix of these observed variables are above 0.30 so a high reliability exists between the instruments. The correlation matrix values range between 0.483 to 0.536 as shown in Table 27.

Table 27 Inter-item correlation matrix for regulations and laws construct

Regulation and Laws (RL)		RL1	RL2	RL3
Inter-item correlation	**RL1**	1.000	.483	.533
	RL2	.483	1.000	.536
	RL3	.533	.536	1.000

6.9.1.2.7. Analysis of government support

A government's support is manifested in policies, programs, or incentives designed to encourage the adoption of new technology. Three observed items adapted from (Choi et al., 2020; Malik et al., 2021) were used to measure if the Saudi government is willing to adopt blockchain as it is seeking to generate a digital transformation in the country (Khan, 2016). Table 28 shows that the correlation coefficients of these indicators are above 0.30, ranging from 0.599 to 0.624, therefore there is high consistency and reliability between these items.

Table 28 Inter-item correlation matrix for government support construct

Government Support (GS)		GS1	GS2	GS3
Inter-item correlation	**GS1**	1.000	.624	.599
	GS2	.624	1.000	.599
	GS3	.599	.599	1.000

6.9.1.2.8. Analysis of decision-maker innovativeness

The readiness of senior executives (such as the CEO, CIO, business owner) to introduce innovation by testing innovative technologies to develop new products, services or technology is referred to as the innovativeness of the decision-maker (Alam et al., 2016). This variable has a positive impact on blockchain adoption. To measure if decision-makers accept and comply with changes to blockchain technology easily, three observed items were adapted from the previous literature (Alam et al., 2016). As shown in the correlation matrix in Table 29, there is a consistent and reliable relationship between the observed items as the values are higher than 0.30, ranging between 0.515 to 0.540.

Table 29 Inter-item correlation matrix for decision-maker innovativeness construct

Decision-Maker Innovativeness (DMI)		DMI1	DMI2	DMI3
Inter-item correlation	**DMI1**	1.000	.540	.519
	DMI2	.540	1.000	.515
	DMI3	.519	.515	1.000

6.9.1.2.9. Analysis of technical competence

The ability of an IS employee is known as perceived technical competence (Lian et al., 2014). Three items adopted from (Kuan & Chau, 2001) were modified and used to measure whether IS staff have the sufficient knowledge and skills required to adopt blockchain technology. As shown in Table 30, the values range between 0.516 to 0.536 which indicates there is high consistency between the indicators.

Table 30 Inter-item correlation matrix for technical competence construct

Technical Competence (TC)		TC1	TC2	TC3
Inter-item correlation	TC1	1.000	.522	.516
	TC2	.522	1.000	.536
	TC3	.516	.536	1.000

6.9.1.2.10. Analysis of Behavioral intention

A behaviour intention is defined as the likelihood of an individual engaging in a particular behaviour (Venkatesh et al., 2003). Indicators from (Venkatesh et al., 2003) were used to measure IT employees' willingness and determination to adopt blockchain. As shown in the correlation matrix in Table 31, the values are above 0.30, ranging between 0.683 and 0.779 which indicates a high level of the consistency and reliability between the items.

Table 31 Inter-item correlation matrix for behavioral intention construct

Behavioral Intention (BI)		BI1	BI2	BI3
Inter-item correlation	BI1	1.000	.762	.779
	BI2	.762	1.000	.683
	BI3	.779	.683	1.000

6.9.2. Validity

Validity refers to the degree to which a latent construct is mirrored by a set of observed items or unidimensional measures (Golafshani, 2003). Anderson, Gerbing, and Hunter (1987, p. 435) stated that a unidimensional measure is *"the existence of one latent trait or construct underlying a set of measures"* (Farooq, 2016). Golafshani (2003) argues that the assessment of scale validity is essential as it helps in the identification and elimination of unnecessary variables, which enhances the validity and unidimensionality of a construct. There are two types of construct validity, convergent validity and discriminant validity (Osberg, 1987). Convergent validity refers to the correlation between two indicators measuring the same latent variable that should be related whereas discriminant validity shows the unrelatedness between two indicators that are not supposed to be related. To test validity and determine the goodness of fit for the proposed framework, confirmatory factor analysis (CFA) is used (Hair et al., 2013).

6.9.2.1. CFA

CFA is utilised in this study to determine construct validity. CFA is a factor analysis method that measures how well a theory-based model fits the collected data (Suhr, 2006). CFA is a type of structural equation modelling (SEM) to examine whether the construct's indicators are reliable with its underlying latent construct (Brown & Moore, 2012). In other words, latent variables (factors) are identified by examining how they are related to observed variables (items). Before building the structural model, CFA must be carried out by assessing the convergent and discriminant validity of the measurement model as recommended by Hair et al. (2013). The following subsections describe the assessment of construct validity.

6.9.2.1.1. Convergent validity

Convergent validity indicates a strong relationship between several observed variables underlying the same latent variable (Brown and Moore, 2012). The factor loading level, composite reliability (CR), and average variance extracted (AVE) are used to assess whether there is convergent validity (Hair et al., 2013). Factor loading is a measure of how well the observed variables relate to latent constructs and is expected to be at least equal to or greater than 0.70, as recommended by Hair et al. (2013). All observed variables in the research model had a high loading, greater than 0.70, on their related constructs, as shown in Table 36.

CR measures the internal consistency between observed items and a cut-off level of greater than 0.70 indicates high consistency (Henson, 2001). AVE is a measure of convergence between a group of indicators that reflect a latent variable and, as recommended by Hair et al. (2013), AVE values of 0.50 or higher indicate adequate convergent validity. The results in Table 32 show that the AVE and composite reliability values of the model constructs range from 0.50 to 0.75 and 0.75 to 0.90, respectively. Therefore, the factor loadings, CR, and AVE values show that the research model constructs have sufficient convergent validity.

Table 32 Convergent validity results

Construct	Composite Reliability	Average Variance Extracted
Complexity (CPX)	0.77	0.53
Relative Advantage (RA)	0.75	0.50
Compatibility (COM)	0.88	0.64
Top Management Support (TMS)	0.83	0.55
Hospital Readiness (HR)	0.81	0.59
Regulation and Laws (RL)	0.79	0.56
Government Support (GS)	0.76	0.52
Decision-Maker Innovativeness (DMI)	0.82	0.61
Technical Competence (TC)	0.77	0.53
Behavioral Intention (BI)	0.90	0.75

6.9.2.1.2. Discriminant validity.

Discriminant validity gauges the degree to which indicators of specific latent variables correlate with each other and is distinct from other indicators in the research model (Osberg, 1987). In CFA, a test of discriminant validity can be conducted by checking when each construct's square root of AVE is larger than its correlation with another (John & Benet-Martínez, 2014). Further, it is suggested that maximum shared variance (MSV) be incorporated in testing discriminant validity and the AVE value should be larger than the MSV value to prove discriminant validity (Henseler et al., 2015). Table 33 shows that the AVE square roots (presented diagonally in bold) are larger than both the inter-construct correlations and the MSV values, which means that all ten constructs' scales of the proposed model achieve discriminant validity.

Table 33 Discriminant validity results

	MSV	CPX	RA	COM	TMS	HR	RL	GS	DMI	TC	BI
CPX	0.491	**0.709**									
RA	0.299	-0.374	**0.799**								
COM	0.377	-0.614	0.304	**0.740**							
TMS	0.475	-0.588	0.390	0.611	**0.766**						
HR	0.289	-0.461	0.355	0.365	0.412	**0.747**					
RL	0.358	-0.477	0.446	0.418	0.419	0.437	**0.720**				
GS	0.407	-0.420	0.325	0.323	0.425	0.319	0.387	**0.779**			
DMI	0.162	-0.232	0.371	0.104	0.217	0.202	0.297	0.283	**0.725**		
TC	0.086	-0.256	0.041	0.107	0.136	0.057	0.099	0.034	0.001	**0.724**	
BI	0.491	-0.701	0.547	0.595	0.689	0.538	0.598	0.638	0.402	0.293	**0.863**

Note: MSV= Maximum shared variance, CPX=Complexity, RA=Relative advantage, COM=Compatibility, TMS=Top management support, HR=Hospital readiness, RL=regulation and laws, GS=Government support, DMI=Decision-maker Innovativeness, TC=Technical competence, BI=Behavioral intention.

6.9.3. Structural equation modelling (SEM)

SEM is defined as a family of statistical techniques for analysing and examining the correlation between measured variables and latent variables (Hair et al., 2006). SEM is used to test hypotheses by estimating the path coefficients of the fundamental relationships between indicators and latent construct (Hoyle, 1995). The use of SEM is essential for research in behavioral sciences, especially in information system/information technology research (Hoyle (1995). According to Kline (2010), a measurement model is a part of the model that outlines the relationship between a latent construct and its indicators while a structural model determines all the hypothetical latent constructs used in path analysis. SEM is a multivariate statistical method that is employed in analysing a measurement model and structural model and, in this study, SEM was conducted in two stages. The first stage entailed an estimation of the relationship between observed items and latent constructs in the measurement model while the second stage entailed testing the correlation between the constructs (Hair et al., 2013). Both stages involved the use of Analysis of Moment Structures (AMOS) version 28. AMOS is IBM software designed for the use of SEM path analysis and CFA.

6.9.3.1. Measurement model

To conduct SEM, the first stage is to evaluate the measurement model which includes an inspection of the goodness of fit and the quality of the instruments in the proposed model. The research model needs to be drawn on AMOS software and it provide various goodness of fit indices to determine the fit between the theory-based model and the model of the collected data. It is important to note that there is no general agreement between methodologists nor is there a general rule of thumb as to the best kind of fit indices to examine the model fit, as there are more than 20 different tests (Sun, 2005). The model of fit indices fall into three categories: *absolute fit indices* (Chi-square (Chisq), goodness-of-fit index (GFI), the root mean square error of approximation (RMSEA), standardised root mean residual (SRMR)); *incremental fit indices* (normed fit index (NFI), tucker Lewis index (TLI), comparative fit index (CFI), incremental fit index (IFI), relative noncentrality index (RNI)); and *parsimony fit indices* (Chi-square/degree of freedom (Chisq/df), adjusted goodness of fit index (AGFI), parsimony normed fit index (PNFI)) and as suggested by Hair et al. (2013), the fit of a model should be checked by at least one fit index from each category. This study utilised the most common and frequently reported indices in the previous literature, as shown in Table 34

Table 34 Goodness of fit indices and their requirements

Category	Index	Requirement	References
Absolute fit	RMSEA	< 0.08	(Browne & Cudeck, 1992)
	GFI	> 0.90	(Byrne et al., 1989)
Incremental fit	TLI	> 0.90	(Hair et al., 1998)
	CFI	> 0.09	(Bentler, 1992)
	IFI	> 0.90	(Byrne et al., 1989)
Parsimony fit	Chisq/df	< 5	(Marsh & Hocevar, 1985)

AMOS software was used to draw and test the measurement model (Figure 17) and all indicators loaded adequately on their latent variable, with values ranging from 0.70 to 0.94. The relationship between each pair of latent variables was less than 0.69, as suggested by Hair et al. (2006). Table 35 presents the results of the fit indices which show a good degree of fit (x^2/df=1.2, GFI=0.93, TLI=0.98, CFI=0.99, IFI=0.99, RMSEA=0.02).

Table 35 The results of goodness of fit indices

Fit index	Recommended Value	Research Model	Comments
x^2/df	<5.0	1.2	The required level is achieved
GFI	>0.90	0.93	The required level is achieved
CFI	>0.90	0.99	The required level is achieved
IFI	>0.90	0.99	The required level is achieved
TLI	>0.90	0.98	The required level is achieved
RMSEA	<0.08	0.02	The required level is achieved

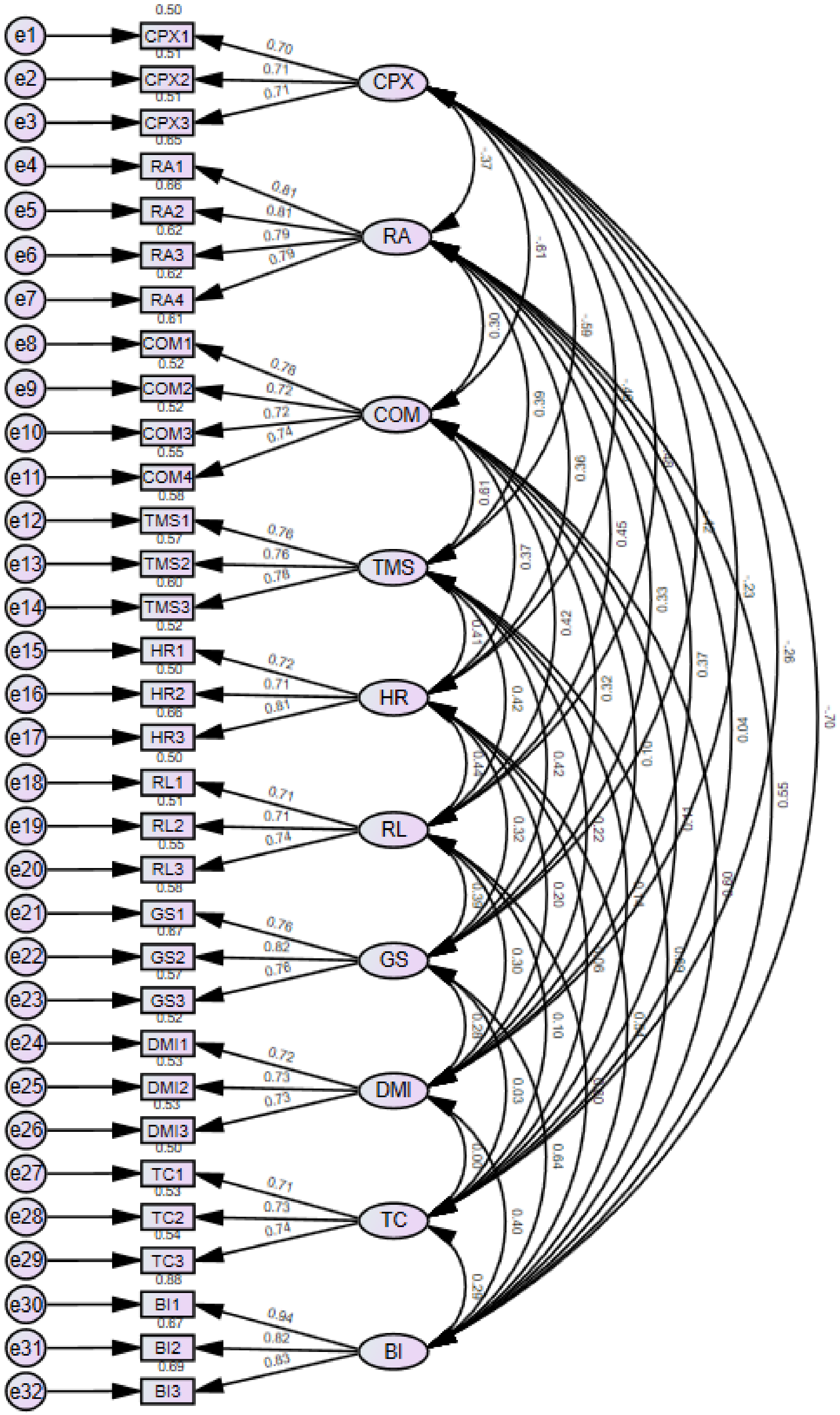


Figure 17 Measurement model with standardised estimates

Table 36 presents the measurement model results showing that the measurement model meets all the requirements and shows significant validity.

Table 36 CFA results

Construct	Factor loading	Composite Reliability	Average Variance Extracted
Complexity (CPX)		0.77	0.53
CPX1	.70		
CPX2	.71		
CPX3	.71		
Relative Advantage (RA)		0.75	0.50
RA1	.81		
RA2	.81		
RA3	.79		
RA4	.79		
Compatibility (COM)		0.88	0.64
COM1	.78		
COM2	.72		
COM3	.72		
COM4	.74		
Top Management Support (TMS)		0.83	0.55
TMS1	.77		
TMS2	.76		
TMS3	.78		
Hospital Readiness (HR)		0.81	0.59
HR1	.72		
HR2	.71		
HR3	.81		
Regulation and Laws (RL)		0.79	0.56
RL1	.71		
RL2	.71		
RL3	.74		
Government Support (GS)		0.76	0.52
GS1	.76		
GS2	.82		
GS3	.76		
Decision-Maker Innovativeness (DMI)		0.82	0.61

DMI1	.72		
DMI2	.73		
DMI3	.73		
Technical Competence (TC)		0.77	0.53
TC1	.71		
TC2	.73		
TC3	.74		
Behavioral Intention (BI)		0.90	0.75
BI1	.94		
BI2	.82		
BI3	.83		

6.9.3.2. Structural model

After the successful evaluation of the measurement model in the previous stage, the next stage assesses the structural model to test the research hypotheses. While the key focus of the measurement model is to determine the correlations between the observed variables and the latent constructs, the key focus of the structural model is to establish the causal relationships concerning the constructs as hypothesised in the research model. In relation to goodness of fit and based on the assessment criteria outlined in Table 34, the structural model shows a good degree of model fit with values of (x^2/df=1.25, GFI=0.93, TLI=0.97, CFI=0.99, IFI=0.99, RMSEA=0.02).

To determine the main predictors of IT employee s' behavioral intention, a path analysis was performed. A p-value was computed for each path coefficient indicating a key hypothesis in the research model. The current study adopted a 5% (0.05) significance level, meaning that for a hypothesis to be supported, the standardised path coefficient must have a p-value less than 0.05 (Byrne, 2001). The results reveal that all the hypothesised paths are statistically significant at a 5% significance level, as shown in Table 37.

Table 37 Structural relationship results

Hypothesis	Structural path	Proposed effect	SRW	t-value	p-value	Result
H1	CPX → BI	-	-0.16	-2.467	.014	Supported
H2	RA → BI	+	0.14	3.216	.001	Supported
H3	COM → BI	+	0.12	2.220	.026	Supported
H4	TMS → BI	+	0.21	3.713	***	Supported
H5	HR → BI	+	0.12	2.605	.009	Supported
H6	RL → BI	+	0.11	2.327	.020	Supported
H7	GS → BI	+	0.28	6.339	***	Supported
H8	DMI → BI	+	0.12	2.935	.003	Supported
H9	TC → BI	+	0.18	4.557	***	Supported

Note: SRW= Standardised regression weight, CPX=Complexity, RA=Relative advantage, COM=Compatibility, TMS=Top management support, HR=Hospital readiness, RL=regulation and laws, GS=Government support, DMI=Decision-maker Innovativeness, TC=Technical competence, BI=Behavioral intention. *** = $p < 0.001$

The results of the path analysis reveal that H7 government support is supported and has the greatest significant positive impact on behavioral intention to adopt blockchain technology (p < 0.001). H9 technical competence is supported and has the second highest positive effect on behavioral intention (p < 0.001). The results also show that H4 top management support is the third most significant positive influence on IT employee s' behavioral intention to adopt blockchain technology in Saudi hospitals (p < 0.001). Additionally, the results reveal a significant positive influence of relative advantage on behavioral intention (p = 0.001), supporting H2. Decision-maker innovativeness had a strong positive influence on behavioral intention (p = 0.003), supporting H8. Hospital readiness had a significant positive effect on behavioral intention (p = 0.009), supporting H5. Complexity had a significant negative effect on IT employees' behavioral intention to use blockchain technology in Saudi hospitals (p = 0.014), supporting H1. Regulation and laws had a significant positive impact on behavioral intention (p = 0.020), supporting H6. Finally, compatibility had the least significant positive effect on behavioral intention (p = 0.026), supporting H3. Overall, the results show that all the hypothesised relationships were supported by the research data, hence we conclude that the proposed model is empirically supported. The final structural model is illustrated in Figure 18 with an R-squared value = 0.81 which demonstrates that the variance explained by behavioral intention is 81%.

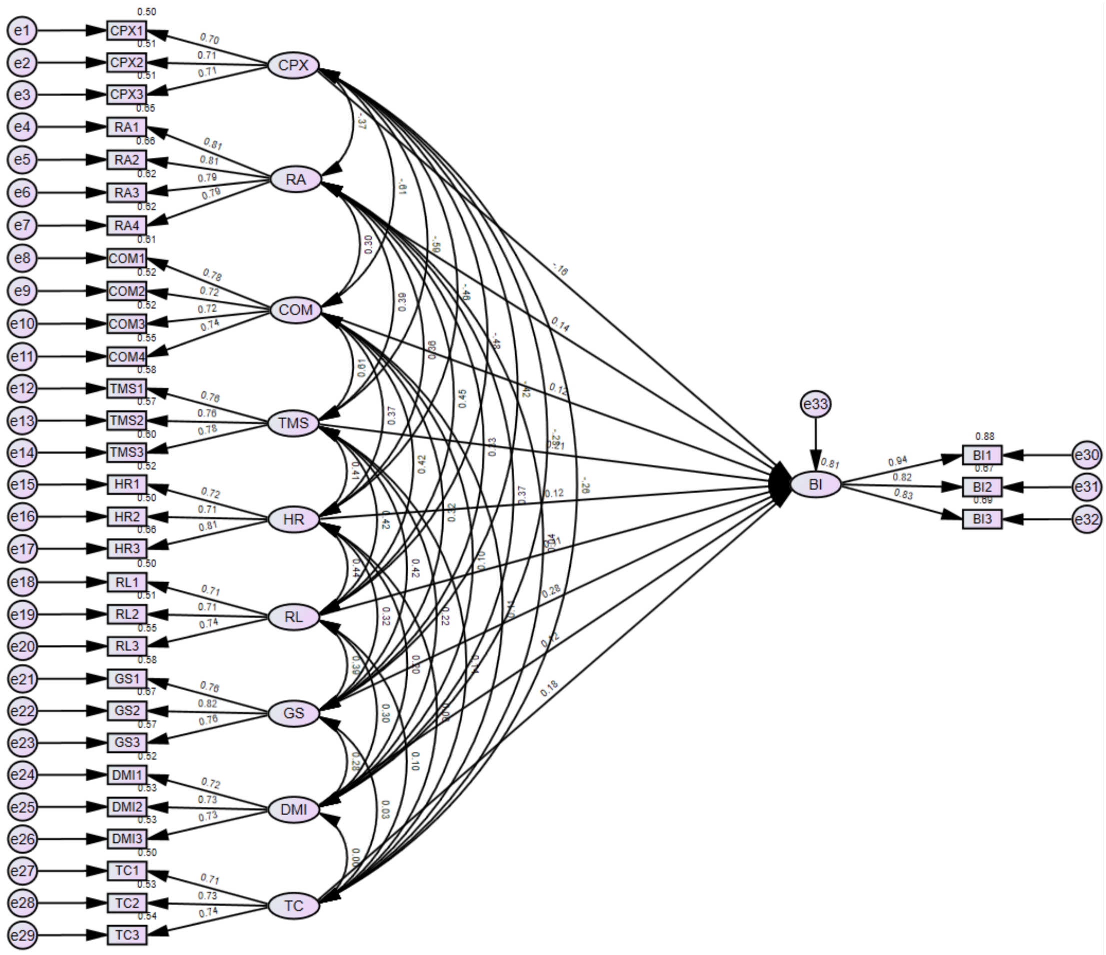


Figure 18 Structural model

6.10. Possible applications or services to be moved to blockchain

The participants were asked to suggest from their point of view which HIS applications or services could be moved to blockchain technology. It was most strongly advised that electronic health records (EHRs) (34.3%) should be transferred to blockchain technology, followed by data sharing (25.5%), pharmaceutical supply chains (12%), health insurance (9.2%) and clinical trials (7.8%). The respondents also considered remote patient monitoring (5.5%) and medical device management (5.3%) be moved to blockchain. Staff credential verification was among other applications mentioned by 0.4% of the participants.

Figure 19 depicts the participants' perceptions of the types of HIS services and systems that Saudi hospitals may be able to shift to blockchain in the future.

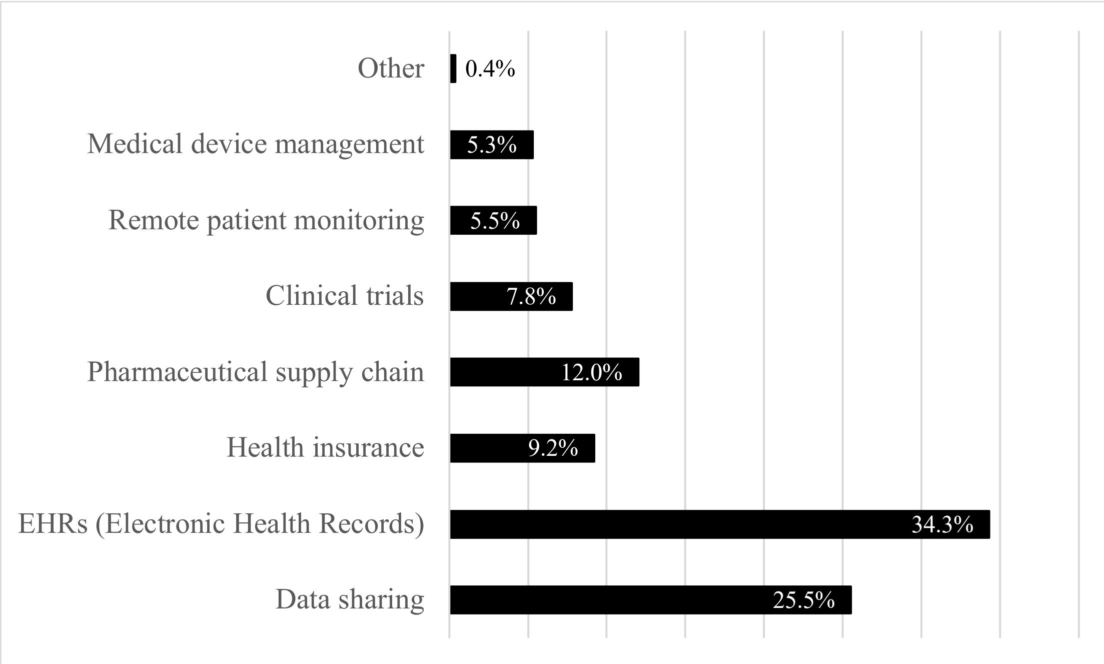


Figure 19 HIS applications or services to move to blockchain

6.11. Chapter summary

This chapter provided the results of the quantitative data gathered from the questionnaire survey and gave an in-depth analysis of the measurement scale. The analysis eliminated several samples through the process of finding missing data and unengaged responses and removing the outliers. It also provided the demographic data of the respondents, IT employees who work in Saudi public hospitals. In the analysis, SPSS software was used to evaluate the model's construct reliability. The CFA approach was used with the AMOS 28 software to determine and corroborate the convergent and discriminant validity. Therefore, the reliability and validity of the measurement model were determined to be satisfactory. The results revealed that all the hypotheses were supported and statistically significant and of all the hypotheses, government support was shown to have the most positive influence on behavioral intention to use blockchain technology with p-value < 0.001. This chapter defined the key findings (factors influencing blockchain adoption) that will be discussed in further detail in the next chapter to achieve the main research objective (determining the impact of the technological, organisational, environmental, and human factors on blockchain adoption in Saudi hospitals.

Chapter seven:

Discussion

Chapter 7. Discussion

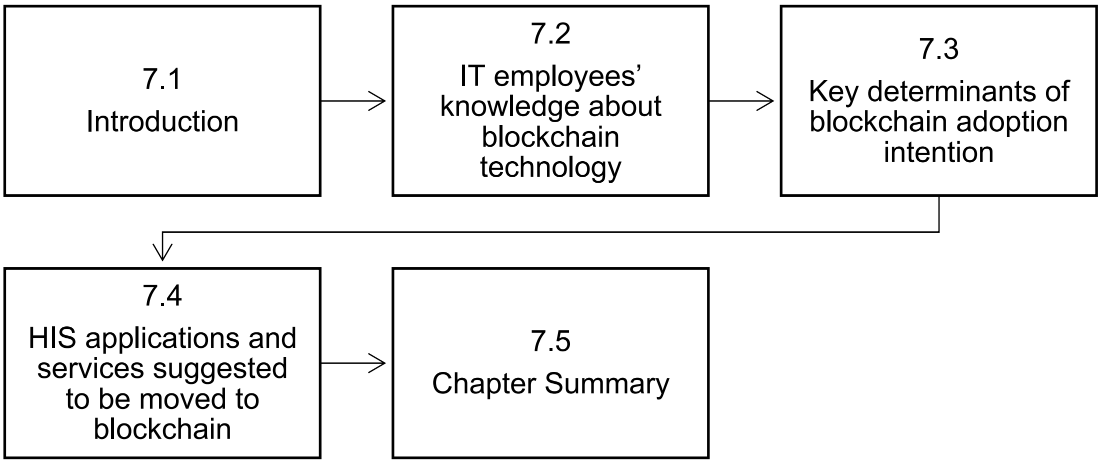


Figure 20 Outline of chapter 7

7.1 Introduction

This chapter discusses in detail the quantitative results of this research, which were outlined in the previous chapter. The discussion begins with an overview of participants' knowledge of blockchain technology. This is followed by a discussion of the framework and a detailed discussion of the identified determinants. The next section discusses the kinds of Health Information System (HIS) applications or services that are suggested to be moved to blockchain technology. It concludes with a summary of the main points covered in this chapter. This chapter is organised as shown in Figure 20.

7.2 IT employees' knowledge of blockchain technology

The questionnaire asked participants to rate their knowledge of blockchain technology. As a result of the descriptive analysis, it was determined that about 70 percent of the participants had little knowledge about blockchain technology. This indicates that there is a lack of knowledge of blockchain among IT employees in Saudi public hospitals. One reason for this may be that blockchain technology is relatively new (Tapscott & Tapscott, 2017). This is supported by the participants' comments in the last part of the questionnaire, which revealed that

19% of respondents had never heard of blockchain but had been informed about it from the link provided with the questionnaire explaining the technology. For example, of the comments received, one participant's response was, "I am wondering why the Ministry of Health does not put adequate effort into educating and training the staff about this technology". Another participant stated, "It is imperative that the staff become aware of what blockchain technology is and the benefits it brings". Furthermore, another participant wrote "I have only just found out about blockchain technology and it should be made more widely known in healthcare organisations".

The lack of knowledge of blockchain is preventing small and medium-sized businesses from adopting the technology in Italy (Bracci, Tallaki, Ievoli, & Diplotti, 2021). In a study of German consumers, Knauer and Mann (2019) have revealed that a lack of knowledge might be one of the barriers to blockchain adoption. IT employees should have a thorough understanding of how blockchains work and how they are built. They should be familiar with distributed ledgers, hash functions, cryptography, smart contracts and other related concepts. Accordingly, the Ministry of Health in Saudi Arabia should take advantage of the best practices that have previously been implemented in developed countries and apply these to avoid such obstacles by educating staff about blockchain. These practices could include providing staff with paid online or face-to-face courses to gain a better understanding of the technology; encouraging them to read important white papers or scientific publications; providing them with information explaining a topic related to blockchain; providing them with reading materials such as books in the hospital's library; and organising blockchain meetups, events or seminars. In doing so, the likelihood of blockchain technology being adopted meaningfully would increase.

7.3 Key determinants of blockchain adoption intention

The objective of this research is to make IT employees' Behavioral intentions towards using blockchain technology more understandable and explainable by identifying the key factors driving their attitudes toward blockchain technology. To do so, the research uses an adaptation of the TOE framework (Tornatzky et al., 1990) for the context of hospital IT employees. The TOE framework has been modified and extended with context-related human factors, namely decision-maker innovativeness, and technical competence.

Regarding the appropriateness of the adapted research framework to explain the pre-usage Behavioral intentions of IT employees, the model explains 81% (R^2 = 0.81) of the variance. It is noteworthy that the explanatory power of the framework presented in this research is high and superior in comparison to other adoption frameworks proposed in previous empirical studies in the blockchain context by Wong et al. (2020) (R^2 = 0.48), Hanna et al. (2020) (R^2 = 0.523), Kalaitzi and Tsolakis (2022) (R^2 = 0.63), Fernando et al. (2021) (R^2 = 0.661), Nath et al. (2022) (R^2 = 0.775) and Choi et al. (2020) (R^2 = 0.792).

The findings demonstrate that the adapted TOE framework is a good predictor of hospital IT employees' intention to use blockchain technology and clearly the model has a significant goodness-of-fit. The research framework adapted and evaluated in this study is shown in Figure 21 which confirming the nine proposed hypotheses.

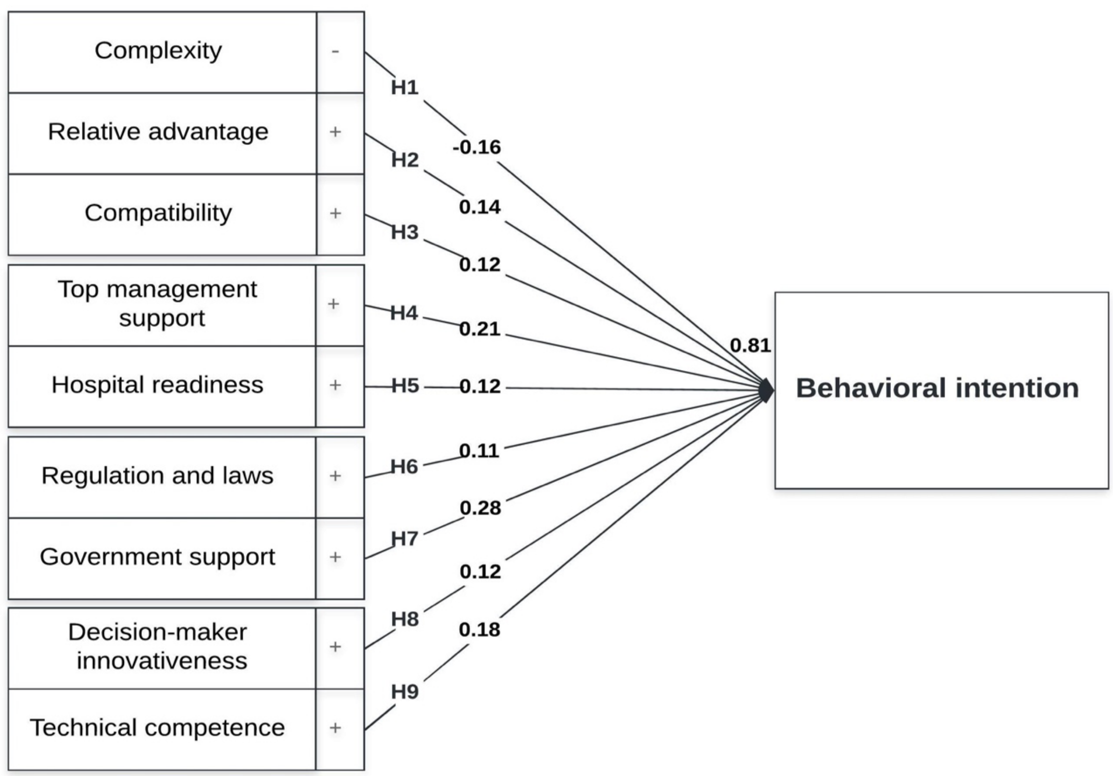


Figure 21 Research framework representing the confirmed hypotheses

This study's hypotheses and findings are discussed in the following subsections regarding the role of the key determinants in understanding the Behavioral intentions of IT employees to adopt blockchain technology.

7.3.1 Complexity

In this study, the degree of complexity is determined by how difficult it appears to comprehend and employ blockchain technology. Complexity was hypothesised as follows:

> *H1: Complexity has a negative influence on blockchain adoption in hospitals.*

Based on the quantitative analysis of the data, the following conclusion was drawn that complexity was supported in this study's model and it had a significant negative effect on participants' Behavioral intention to adopt blockchain technology (beta=-0.16, p=0.014). This result is in line with prior studies where organisations were significantly disadvantaged by the complexity of technology when it comes to adopting blockchain (Choi et al., 2020; Fairooz & Wickramasinghe, 2019; Gökalp et al., 2022; Hanna et al., 2020; Kumar Bhardwaj et al., 2021; Malik et al., 2021; Molati et al., 2021). This could indicate that participants are initially apprehensive and anxious regarding the complexity of using blockchain or the technical skills required for working with it. One argument explaining this is that participants lack the awareness and education coupled with an insufficient understanding of blockchain. This argument is supported by previous studies which revealed that knowledge of an innovation reduces the perception of its complexity and vice versa (Swan, 2015; Vasseur & Kemp, 2015).

As a result of the participants' perceptions that blockchain is a difficult technology to use or understand, they feel hesitant to adopt it, thereby contributing to its low adoption rate. To address this, healthcare organisations or hospitals need to have a solid understanding of how to configure, design, and implement blockchain in order to utilise it effectively. The availability of IT expertise within hospital and training facilities for its employees will reduce the perceived complexity of the technology.

7.3.2 Relative advantage

Relative advantage refers to the degree to which blockchain technology is regarded as being more beneficial to hospitals than its predecessor and it was hypothesised as follows:

> *H2: Relative advantage has a positive influence on blockchain adoption in hospitals.*

The quantitative analysis of the data led to the following conclusion that the relative advantage determinant has a strong effect on blockchain adoption with a high significantly positive influence (beta=0.14, p=0.001). This is consistent with the findings of previous studies that identified relative advantage as a significant indicator in blockchain adoption (Gökalp et al., 2022; Kumar Bhardwaj et al., 2021; Molati et al., 2021; Nath et al., 2022; Seshadrinathan & Chandra, 2021; Wong et al., 2020).

Based on the results of this study, hospitals must be assured that the expected benefits of blockchain are realistic in order to consider its adoption. Increased awareness of blockchain's benefits leads to a greater acceptance of the technology and greater implementation success. These benefits include the encryption and distribution of patient records which improve data integrity and security, enhanced automation through smart contracts by which certain actions can be automated to reduce transaction costs and avoid human errors, the elimination of intermediary, universal immutable health records, the traceability of drugs, transparency and interoperability (Clohessy & Acton, 2019; Kamble et al., 2019; Peters & Panayi, 2016; Zheng et al., 2017). The adoption of blockchain by hospitals increases when relative advantages are recognised. This recognition can be achieved by education and training and increasing the awareness of blockchain benefits among employees.

7.3.3 Compatibility

Compatibility was defined as a measure of how well blockchain is perceived as being compatible with existing technology, values and needs of the hospital. Compatibility was hypothesised as follows:

> *H3: Compatibility has a positive influence on blockchain adoption in hospitals.*

Based on the quantitative analysis of the data, it has been determined that compatibility had a significant but a low effect on blockchain adoption (beta=0.12, p=0.026). This is consistent with the findings of the existing literature (Choi et al., 2020; Fernando et al., 2021; Hanna et al., 2020; Kumar Bhardwaj et al., 2021; Malik et al., 2021; Molati et al., 2021; Nath et al., 2022; Orji et al., 2020) which also found that blockchain adoption is positively correlated with compatibility, however one study showed no significant effect of compatibility in the early stages of adoption (Kalaitzi & Tsolakis, 2022). This indicates that Saudi hospitals are more interested in adopting blockchain as it is perceived as being compatible with their hardware and software infrastructure, policies, potential needs and their work environment, without the need to make major modifications to adapt it.

Hospitals' internal systems are complex, sensitive, and contain a huge amount of data. It is more likely that blockchain would be adopted by hospitals if it matched the existing IT infrastructure. The integration of blockchain into existing systems reduces time and cost, allowing hospitals to take advantage of this emerging technology. To make a decision regarding blockchain adoption, hospitals should carefully evaluate and understand whether it is compatible with their objectives and needs.

7.3.4 Top management support

Top management support refers to how management views technological initiatives, how they engage in these initiatives, and how much they encourage technological growth. It was hypothesised as follows:

> *H4: Top management support has a positive influence on blockchain adoption in hospitals.*

As a result of the quantitative analysis of the data, it is determined that top management support had a great significant positive effect on blockchain adoption (beta=0.21, p<0.001). There is a similarity between this result and that demonstrated in the previous literature (Clohessy & Acton, 2019; Gökalp et al., 2022; Kumar Bhardwaj et al., 2021; Malik et al., 2021; Molati et al., 2021; Nath et al., 2022; Orji et al., 2020; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021) except for two studies which found there was no significant relationship between upper management and blockchain adoption, perhaps due to of the lack of awareness or knowledge of blockchain by upper management (Fernando et al., 2021; Wong et al., 2020).

In the context of Saudi Arabia, senior management support is essential for blockchain adoption. This is explained by the fact that managers are responsible for making decisions that affect the workflow of the hospital, such as adopting new technologies and allocating resources to them. A manager’s lack of knowledge hinders the adoption of technologies (Rejeb, Rejeb, Keogh, & Zailani, 2022), however, upper management should have an adequate and sufficient knowledge of blockchain technology and open channels of communication with the government to explore any opportunities. Support may be provided in the form of education or financial or by receiving updates regarding regulations and policies.

Employee resistance is one of the biggest challenges facing upper management. If management detects employee resistance, they should investigate the reasons for this resistance (Choi et al., 2020). Communication is one of the most effective methods for ensuring that employees are on board with technological change. By involving employees, a brainstorming session within the hospital can allow employees to create new technological innovations by working together, making them feel like they are a part of something meaningful. In addition to providing the necessary resources and training classes to assist employees to use blockchain technology, it is important to encourage a "try and fail" environment (Islam, 2015). Finally, yet importantly, it is necessary for managers to recruit new talent and upskill their employees.

7.3.5 Hospital readiness

Organisational readiness is described as the ability of a hospital to adopt blockchain technology and the availability of human, financial and technological resources. This determinant was hypothesised as follows:

H5: Hospital readiness has a positive influence on blockchain adoption in hospitals.

The data obtained from the quantitative analysis revealed that hospital readiness has a positive influence on the adoption of blockchain in Saudi public hospitals (beta=0.12, p=0.009). There is consistency between the results of this study and the findings reported in previous studies (Clohessy & Acton, 2019; Gökalp et al., 2022; Kalaitzi & Tsolakis, 2022; Molati et al., 2021; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021). This indicates that there is a high probability that hospitals that have a high readiness level in regard to blockchain technology will be more able to adopt it. Any decision regarding blockchain adoption made without the readiness of the hospital would be disadvantageous to the hospital (Malik et al., 2021). Hence, it may be a more reasonable explanation to speculate that hospitals have an intention to adopt blockchain technology if they have adequate resources, both financial as well as technical, employees with technical skills and knowledge, and a proper IT infrastructure to support blockchain technology adoption.

However, the key to the successful future deployment of healthcare blockchain technology is an understanding of how it works and what technological requirements are necessary. Accordingly, there are several technical specifications should be taken into consideration or should be available to ensure hospital readiness. Examples of these considerations are the type of processing power, storage capacity for the nodes (computers or servers), memory (RAM/SRAM) as well as the types of environmental conditions, such as shock and vibration, temperature fluctuations, and humidity (Byers, 2017).

7.3.6 Regulations and laws

To promote the adoption of new technologies, regulations and laws are instrumental in implementing policies and laws that encourage the adoption of blockchain governing the ownership and responsibilities of data. This determinant was hypothesised as follows:

H6: Regulations and laws have a positive influence on blockchain adoption in hospitals.

The quantitative analysis of the data found that regulations and laws positively and significantly influence blockchain adoption but have a low effect (beta=0.11, p=0.020). Similarity exists between this result and the results reported in the previous literature (Fairooz & Wickramasinghe, 2019; Gökalp et al., 2022; Kalaitzi & Tsolakis, 2022; Molati et al., 2021; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021) but it contradicted the findings of Choi et al. (2020) and Nath et al. (2022) which found regulations had no influence and a negative influence on blockchain adoption, respectively. An explanation for the low effect could be because blockchain technology is still in its infancy, and regulations surrounding it are still developing. As this technology is still new, restrictive regulations or laws could constrain or hinder the use of blockchain during the early stage of its development. This is in accordance with an earlier study suggesting scholars gain a better understanding of blockchain technology and experiment with it regardless of the established regulations (Chalmers, Matthews, & Hyslop, 2021).

The regulators in Saudi Arabia have much more flexibility in understanding and interacting with new technologies (Alzahrani, Daim, & Choo, 2022). Therefore, it would be beneficial for hospitals and healthcare organisations to interact with regulatory authorities and propose new regulations and laws as a means of facilitating the adoption of blockchain that may enhance the quality of healthcare. To ensure compliance and adherence to privacy regulations, hospitals should engage technological and legal teams to guide the implementation works and to ensure there is a comprehensive understanding of blockchain technology and healthcare regulations such as the Health Insurance Portability and Accountability Act (HIPAA), data sharing, technological laws, protected health information and the Health Information Technology for Economic and Clinical Health Act (Kiel, Ciamacco, & Steines, 2016).

Existing regulations and laws do not address concepts and issues such as smart contracts, consensus mechanisms, what data should be stored on and off-chain, data ownership, access control and cryptographic signatures that are a part of blockchain technology (Kumar Bhardwaj et al., 2021), therefore, it is important for hospitals to have a blockchain governance strategy to ensure their blockchain use complies with legal regulations and ethical obligations (Liu, Lu, Zhu, Paik, & Staples, 2021).

7.3.7 Government support

Government can support innovation and the adoption of blockchain in several ways, including strengthening the digital infrastructure, providing funds for research and development, offering incentives and introducing initiatives. This was hypothesised as follows:

> *H7: Government support has a positive influence on blockchain adoption in hospitals.*

The quantitative analysis of the data showed that government support influences blockchain adoption positively and significantly, having the greatest effect of all other factors (beta=0.28, $p<0.001$), indicating that support from the government fosters hospital confidence in blockchain technology and increases their trust. This study confirms the findings of several studies where a significant relationship was found between government support and Behavioral intention, acceptance and adoption (Fairooz & Wickramasinghe, 2019; Gökalp et al., 2022; Kumar Bhardwaj et al., 2021; Malik et al., 2021; Orji et al., 2020; Suwanposri et al., 2021). In contrast, a previous study revealed inconsistency regarding the effect of government support on the adoption of blockchain technology and it was found to be insignificant (Molati et al., 2021).

Over recent years, the Saudi Arabian government has provided unlimited support to ensure their Vision 2030 is a success, especially in relation to digital transformation in the healthcare sector. The government needs to provide a range of initiatives to accelerate the adoption rate of blockchain technology (Abdul Hameed, 2012). Some of the Vision 2030 initiatives are to create a unified national database for real-time reporting; include advanced technology solutions for digital transformation and develop an e-tracking mechanism for pharmaceuticals (Vision2030, 2018). These initiatives are in line with the advantages of blockchain technology.

Accordingly, hospitals and healthcare organisations should cooperate with the government and obtain benefits from this support and the initiatives provided. Moreover, hospitals and healthcare organisations should communicate with the government regarding developing adequate policies, regulations and data standardisation to prevent the misuse of blockchain as the government plays a crucial role in these issues. Blockchain adoption is expected to be facilitated by the government by removing barriers, providing a proper network infrastructure, providing administrative support, providing training and manpower, providing subsidies for hospitals and making information and opportunities more accessible.

7.3.8 Decision-maker innovativeness

Decision-maker innovativeness refers to the willingness of senior executives to introduce blockchain to create new products or services. This was hypothesised as follows:

> *H8: Decision-maker innovativeness has a positive influence on blockchain adoption in hospitals.*

Based on the quantitative analysis of the data, it was concluded that decision-maker innovativeness has a positive influence on the adoption of blockchain and the influence is highly significant (beta = 0.12, p=0.003). There is consistency between this empirical finding and previous research (Clohessy & Acton, 2019; Malik et al., 2021; Nath et al., 2022; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021) which indicated that it is more likely that blockchain technology will be adopted if decision makers are innovative and willing to take risks. Only those decision makers who are more innovative will be willing to take the risk of introducing blockchain into hospitals, whereas less innovative decision makers will find other solutions that are less revolutionary and therefore carry a lower risk. Therefore, decision makers in healthcare organisations and hospitals should experiment with blockchain technology as taking risks is an essential characteristic of successful technological innovators (Thong & Yap, 1995).

IT knowledge reduces adoption uncertainty and a basic understanding of blockchain and its features is necessary for decision makers (Ozdemir, Ar, & Erol, 2020). Thus, decision makers should approach the adoption of blockchain in an optimistic manner and be aware of its advantages and benefits, which will promote a positive attitude toward its adoption. Government agencies should concentrate their efforts on increasing blockchain literacy, which can be accomplished through subsidies for blockchain seminars and training programs specifically designed for decision makers in the healthcare sector. The responsibility of decision makers lies also in providing and maintaining long-term resources, collaborating with government authorities and obtaining the appropriate expertise in the development and maintenance of blockchain technology.

7.3.9 Technical competence

Technical competence refers to an understanding of the specific technical principles and information necessary for the adoption of blockchain technology and was hypothesised as follows:

> *H9: Technical competence has a positive influence on blockchain adoption in hospitals.*

The quantitative analysis of the data led to the following conclusion that there is a similarity between this study's finding and the previous studies where having employees with technical competence positively affects blockchain adoption (Clohessy & Acton, 2019; Fairooz & Wickramasinghe, 2019; Gökalp et al., 2022; Orji et al., 2020) whereas only one study did not find any effect (Fernando et al., 2021). The relationship was significant with a high effect (beta=0.18, $p<0.001$). This indicates that hospitals with existing technical capabilities may be more likely to adopt and implement blockchain technologies. In the absence of internal IT expertise, hospitals perceived themselves to be unable to adopt blockchain technology (Dehghani, Kennedy, Mashatan, Rese, & Karavidas, 2022). A hospital will certainly have a greater sense of confidence throughout the adoption process if its IT staff is knowledgeable and has the necessary skills or experience to implement blockchain. To adopt complex innovations, extensive IT competence and a knowledge of innovation are required (Abdul Hameed, 2012). Hospitals should enhance its firm-level learning to ensure that employees are up-skilled with the latest technical competency to take advantage of emerging technologies such as blockchain.

IT employees should have a basic understanding of blockchain development concepts such as distributed systems, consensus mechanisms, cryptography, peer-to-peer networks, smart contracts and distributed ledgers, etc. (Sarmah, 2018). Hospitals should provide extensive training and education to IT employees, not only in blockchain understanding and concepts but also in the ability to utilise at least one high-level programming language for blockchain development such as Python, JavaScript, Solidity or C++ etc.

7.4 Health information system applications and services suggested to be moved to blockchain

A health information system (HIS) is a system that collects, stores, reports, manages, and transfers healthcare data to help improve the quality and efficiency of health services through a better management system at all levels (Haux, 2006). It includes electronic health records (EHRs), data sharing, pharmaceutical supply chains, health insurance, clinical trials, remote patient monitoring and medical device management, etc. The participants were asked to provide suggestions, based on their own point of view, as to which HIS applications or services they believed should be moved to blockchain technology.

Based on the results, it is evident that participants strongly recommended that EHRs and data sharing should be moved to the blockchain technology followed by pharmaceutical supply chains, and health insurance and clinical trials. There are possibly several reasons for this. First, privacy and data breaches are always a concern when EHRs are beyond the patients' control, despite hospitals claiming HIPAA compliance (Keshta & Odeh, 2021). Second, sometimes patients are unable to access their records when moving from one healthcare provider to another (Kierkegaard, 2012). Third, blockchain provides immutable, distributed, transparent, decentralised records with the features of interoperability and integrity (Mayer, da Costa, & Righi, 2020). Consequently, the participants believed that blockchain technology would be a suitable solution to improve healthcare services and hospitals should make EHRs and data sharing their first priority in the adoption stages.

Moreover, healthcare organisations and hospitals should take steps to incorporate blockchain technology into the pharmaceutical supply chain to trace pharmaceutical origins, the transportation of drugs, and the procurement of raw materials so counterfeit medication can be prevented, costs can be reduced and safety can be improved by eliminating intermediaries involved in the process (Mettler, 2016). Another consideration for hospitals or healthcare organisations is the power of smart contracts. In clinical trial sequences, smart contracts enable transparency, traceability, and control, making it easier to track closely how events occur (Benchoufi & Ravaud, 2017). This indicates that it is possible for hospitals to chain together the steps of a clinical trial in a preceding order, ensuring transparency and inhibiting the beautification of data. By using smart contracts, a more advanced analytics system can be used by insurance providers to optimise health outcomes and costs (Abujamra & Randall, 2019). Therefore, insurance companies and hospitals should share digital contracts on a blockchain rather than each having their own.

7.5 Chapter summary

This discussion chapter began by assessing the participants' knowledge of blockchain technology and indicating that IT employees in Saudi public hospitals lack knowledge in this area. The research model used in this study and the key determinants of the Behavioral intentions of IT employees were then discussed. Based on the findings of this study, the adopted research model was deemed effective in explaining IT employees' Behavioral intentions, with an explanatory power of 81% (R2 = 0.81). The key determinants of IT employees’ Behavioral intentions toward using blockchain technology were complexity, relative advantages, compatibility, top management support, hospital readiness, regulations and laws, government support, decision maker innovativeness and technical competence, all of which were significant and supported. Finally, the chapter identified the HIS applications and services that IT employees suggested should be moved to blockchain technology. The conclusions of the thesis are presented in the next chapter, followed by a discussion of the thesis contributions, implications, limitations and recommendations for future research.

Chapter eight:

Conclusions

Chapter 8. Conclusions

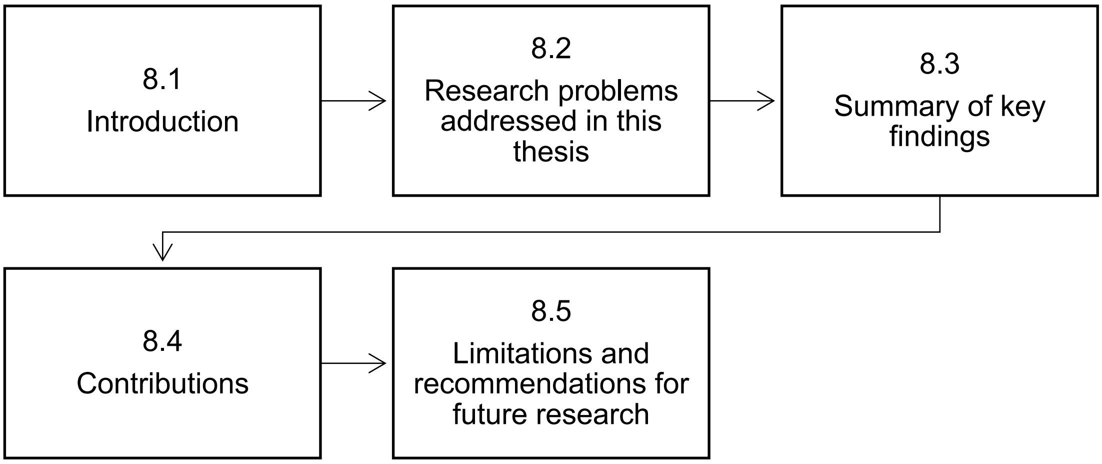


Figure 22 Outline of chapter 8

8.1 Introduction

The purpose of this chapter is to present the research conclusions. It provides a summary of the research problems addressed in this thesis and provides an overview of the key findings of the research in relation to the research questions. This chapter discusses the theoretical and practical contributions. Finally, the research limitations are outlined, along with some suggestions for future research.

8.2 Research problems addressed in this thesis

Though blockchain technology offers a number of advantages, its adoption is still relatively low in many countries. Users' limited understanding and acceptance may explain the slow pace of blockchain adoption. It is crucial to understand the factors that facilitate or hinder IT employees' intentions to adopt and use blockchain technology. In developing countries and in Saudi Arabia in particular, it is unclear which factors influence the intention to use blockchain. The purpose of this study is to examine the key factors affecting IT employees' intentions to use blockchain technology in Saudi public hospitals using the TOE framework. It may be useful to understand these factors to ensure that blockchain technology, which is still in its infancy, is implemented in a manner that is acceptable to hospitals, so that governments and decision makers can better plan, design and regulate its adoption to promote the meaningful use of the technology. In this thesis, the following research issues are identified and addressed:

- There is scant research on blockchain adoption in general and in healthcare in particular.
- In the context of the present study, there is no existing work on the adoption of blockchain technology in Arab countries, particularly in Saudi Arabia, in any domain including healthcare.
- A review of the relevant literature indicates an absence of theoretical-based studies that act as a framework to explain blockchain adoption in hospitals in developing countries.
- The few studies which have investigated blockchain adoption overlook the human factors that might impact blockchain adoption, thus this study incorporates human factors into the TOE framework to gain a better understanding.

8.3 Summary of key findings

This study posed one main research question that aimed at identifying how to successfully adopt blockchain technology in Saudi public hospitals, and therefore three sub-questions were formulated to answer the question. The main research question is:

How can blockchain technology be successfully adopted in Saudi public hospitals?

The three following sub-questions were developed to answer this question.

8.3.1 Research sub-question 1

What are the determinants influencing the adoption of blockchain technology in Saudi public hospitals from the IT employees' perspective?

The following steps were taken to answer this question. Firstly, the literature on the factors that affect blockchain adoption were systematically reviewed with the objective of identifying the most frequently used theory or framework as well as the most influential factors. 40 studies were thoroughly analysed and a conceptual model was developed by adding the most influential factors to the most appropriate model based on the results of the systematic review. Second, the proposed framework was empirically tested through the development of an online questionnaire targeting IT employees working in Saudi public hospitals. 449 responses were obtained and 363 responses were considered valid for the analysis. Third, the researcher used the Statistical Package for the Social Sciences (SPSS) and its supplementary program AMOS to analyse the quantitative data collected. Lastly, a path analysis was performed to identify the factors that influence the behaviour of IT employees and to test the hypotheses.

Based on the path analysis results, it was found that all the proposed determinants, namely complexity, compatibility, relative advantage, top management support, hospital readiness, regulation and law, government support, decision-maker innovativeness and technical competence, were significant at the level of 0.05 ($p < 0.05$). Adopting blockchain effectively requires an understanding to configure, design and implement it, and the availability of IT expertise within hospitals and training facilities for employees will reduce the perceived complexity. Hospitals adopt blockchain when relative advantages are recognised, and this recognition can be achieved through education, training, and increasing employee awareness. Also, hospitals must carefully evaluate and understand whether blockchain is compatible with their objectives and needs. Managers must recruit new talent and upskill their employees and encourage a "try and fail" environment to avoid employee resistance to the use of blockchain. Hospitals must also ensure they have the technological capacity to implement blockchain, for example processing power, storage capacity for the nodes (computers or servers) and memory (RAM/SRAM). The government plays a crucial role in ensuring hospitals and healthcare organisations have adequate policies, regulations, and data standardisation. The government should remove barriers and provide infrastructure, administrative support, training and manpower. A decision maker has also a responsibility to provide and maintain long-term resources, collaborate with government authorities, and attain the necessary expertise in blockchain development.

8.3.2 Research sub-question 2

What are the correlations between the key determinants?

The structural equation model (SEM) was used to analyse the correlations between the proposed TOE framework and to test the hypothesis for the variables within the proposed framework through a measurement model and structural model. A measurement model was evaluated by looking at its goodness of fit and instrument quality. The model was drawn on AMOS software, which provides a variety of goodness of fit indices that indicate whether the theory-based model matches the data collected. The relationship between each pair of latent variables was less than 0.69. Consequently, the results of the fit indices show a good degree of fit (x^2/df=1.2, GFI=0.93, TLI=0.98, CFI=0.99, IFI=0.99, RMSEA=0.02). Also, the structural model was assessed and showed a good degree of model fit with values of (x^2/df=1.25, GFI=0.93, TLI=0.97, CFI=0.99, IFI=0.99, RMSEA=0.02).

The results demonstrated that government support had the greatest significant positive effect on behavioural intention to adopt blockchain technology in Saudi public hospitals (beta = 0.28, $p < 0.001$) followed by top management support (beta = 0.21, $p < 0.001$) and technical competence (beta = 0.18, $p < 0.001$). Relative advantage was also a significant positive influence and was fourth (beta = 0.14, $p = 0.001$) followed by decision-maker innovativeness (beta = 0.12, $p < 0.05$) and hospital readiness (beta = 0.12, $p < 0.05$). Complexity had a significant negative effect and was seventh (beta = -0.16, $p < 0.05$) followed by regulation and laws (beta = 0.11, $p < 0.05$). Finally, compatibility had the lowest effect (beta = 0.12, $p < 0.05$).

Table 38 Summary of hypotheses assessment results

Hypothesis	SRW	P-value	Result
H1 CPX has a negative influence on blockchain adoption in hospitals	-0.16	.014	Supported
H2 RA has a positive influence on blockchain adoption in hospitals	0.14	.001	Supported
H3 COM has a positive influence on blockchain adoption in hospitals	0.12	.026	Supported
H4 TMS has a positive influence on blockchain adoption in hospitals	0.21	***	Supported
H5 HR has a positive influence on blockchain adoption in hospitals	0.12	.009	Supported
H6 RL has a positive influence on blockchain adoption in hospitals	0.11	.020	Supported
H7 GS has a positive influence on blockchain adoption in hospitals	0.28	***	Supported
H8 DMI has a positive influence on blockchain adoption in hospitals	0.12	.003	Supported
H9 TC has a positive influence on blockchain adoption in hospitals	0.18	***	Supported

Note: SRW= Standardised regression weight, CPX=Complexity, RA=Relative advantage, COM=Compatibility, TMS=Top management support, HR=Hospital readiness, RL=regulation and laws, GS=Government support, DMI=Decision-maker Innovativeness, TC=Technical competence, *** = $p < 0.001$

8.3.3 Research sub-question 3

What are IT employees' suggestions and preferences toward moving HIS applications and services to blockchain technology?

Based on IT employees' perspectives, participants were asked to suggest which HIS applications or services might be moved to blockchain technology. There was a strong recommendation that electronic health records (EHR) (34.3%) should be transferred to blockchain technology, followed by data sharing (25.5%), pharmaceutical supply chains (12%), health insurance (9.2%), and clinical trials (7.8%). Furthermore, the respondents also considered the use of blockchain for remote patient monitoring (5.5%) and medical device management (5.3%). In light of these findings, participants felt that blockchain technology will improve healthcare services and that hospitals should set EHRs and data sharing as their top priorities when adopting blockchain.

8.4 Contributions

The use of blockchain has great potential for transforming the healthcare sector. A key component of the success of blockchain technology is the readiness and motivation of users to accept this change. A better understanding of the various factors influencing IT employees' behaviour is critical to avoid failures that might prevent them from utilising blockchain optimally. The purpose of this study is to gain a deeper understanding of the key determinants of IT employees' behavioural intentions. This study contributes to our understanding of blockchain adoption and implementation processes in hospitals. Essentially, this research contributes to both the theoretical and practical understanding of the adoption and implementation of blockchain technology in hospitals.

8.4.1 Contributions to theory

- A comprehensive and systematic review of the existing literature on blockchain adoption is provided in this thesis. Seven electronic scientific databases were searched, namely the ACM library, IEEEXplore, ProQuest, PubMed, ScienceDirect, Scopus, and Web of Science. The studies were evaluated according to several criteria to ensure that they were of high quality and relevant to the topic. To further ensure that the extracted studies were of high quality, four elements were included in the assessment criteria. The evaluation process led to the selection of 40 relevant papers which were then critically reviewed and analysed. The outcome of the review determined that the existing literature did not provide a framework for identifying the factors that influence the adoption of blockchain technology in healthcare. To the best of the researcher’s knowledge, this study is the first to investigate blockchain adoption from a comprehensive perspective by considering the essential determinants influencing the adoption of blockchain technology and evaluating their weights in a healthcare setting.
- The main contribution of this study is to adapt and validate the TOE framework in the context of the acceptance of blockchain technology in hospitals. This research provides evidence regarding the suitability of the TOE framework when used as a theoretical model in the healthcare context. A number of determinants within the TOE contexts were found to influence blockchain adoption in hospitals, which supports the findings of several previous studies in different contexts. This study confirms the

explanatory power of the TOE framework and its relevance to understanding organisational innovation adoption.

- The outcome of the systematic review also showed that the vast majority of blockchain technology studies in developing countries were conducted in South America and Asia, and to date, no attention has been paid to the Middle East and the Arab world. This research contributes to the existing literature by empirically investigating the adoption of blockchain in a different country context. This is the first study to address blockchain adoption in the healthcare context in Arab countries and in particular Saudi Arabia.

- This study makes a contribution to the literature on IT employees' acceptance of health technologies. Specifically, it contributes to the information system literature by establishing and validating a healthcare IT employee-based theoretical framework with blockchain technology, based on the TOE framework for IT adoption. To the best of the researcher's knowledge, this is the first study to examine the determinants influencing the adoption of blockchain technology in the healthcare sector from the perspective of IT employees.

- This study advances the existing knowledge on technology adoption by extending the TOE framework and validating the extension empirically. The majority of previous studies ignore the effect of human factors in the context of blockchain adoption. This current study presents strong evidence to support the validity of the new extension, which includes two context-specific determinants, namely decision-maker innovation and technical competence.

- In this study's survey, a number of approved questions were adapted from prior research. The questions were slightly modified to the subject of blockchain technology. The present research contributes to the body of knowledge by delivering a well-validated questionnaire for future research pertaining to blockchain technology adoption.

8.4.2 Contributions to practice

It is essential to understand IT employees' perceptions to design and implement effective interventions to encourage positive usage intentions regarding blockchain technology. This research provides hospitals and the Saudi government with practical implications to ensure the high adoption of blockchain by describing IT employees' usage intentions toward the technology. Hospital providers and decision makers who are involved in the implementation of blockchain in healthcare will be able to access the Saudi Digital Library where this thesis will be uploaded and available.

The research quantitative findings show that government support is the most influential factor on behavioural intention to adopt blockchain followed by technical competence and top management support. Providing resources and efforts to enhance the healthcare sector is a priority of the Saudi government represented by Ministry of Health. Healthcare provider decision makers and the IT team need to seriously consider adopting blockchain to move forward more rapidly technologically and economically than traditional technologies are currently able to do. This can be achieved by the following:

- This research determined that about 70 percent of the participants had little knowledge about blockchain technology. This indicates that there is a lack of knowledge of blockchain among IT employees in Saudi public hospitals. It is therefore essential that the Saudi Ministry of Health conducts awareness-raising activities to educate employees about the benefits of blockchain technology. For ensure these awareness campaigns are effective, the Ministry of Health should utilise communication channels such as television, social media, and e-mail to reach all employees and IT employees in particular. Internal awareness campaigns can be organised within the hospital by distributing printed and digital materials.

- The study found that the level of technical competence of the target population had a significant influence on IT employees' usage intentions towards blockchain technology. This indicates that hospitals with existing technical capabilities may be more likely to adopt and implement blockchain technology. The lack of internal IT expertise caused hospitals to perceive themselves as being unable to adopt blockchain. Providing comprehensive and extensive training programs for IT employees is likely to increase the technical competence to successfully implement blockchain technology in Saudi hospitals. It is necessary for hospitals to have the knowledge and tools required to understand and build their own blockchain. The training materials should include an introduction to blockchain technology which provides a broad overview of the fundamental concepts, such as decentralised consensus, smart contracts, immutable distributed ledgers and mining. It also should include types of blockchain consensus algorithms such as Proof of Work (PoW), Proof of Stake (PoS), Proof of Elapsed Time (PoET) and Practical Byzantine Fault Tolerance (PBFT) (Baliga, 2017). IT employees should learn how to use various tools for blockchain development that can facilitate the development process such as Mist, Geth, Hyperledger Caliper, Remix, Metamask, Solidity Compiler and Blockchain Testnet (Aarti, 2022). There are several platforms for developing blockchain applications which be beneficial to learn about such as Ethereum, Hyperledger Fabric, EOS and Hyperledger Sawtooth (Suvitha & Subha, 2021). Technical employees and particularly developers should have knowledge of at least one high-level programming language applicable to blockchain development, such as Python, JavaScript, Solidity, C and C++. After training, an ROI model can be created for training evaluation (Phillips, 1998).

- The study's findings also revealed the positive effect of decision makers and top managers on blockchain adoption. It is imperative that decision makers and managers have a comprehensive understanding of blockchain technology to develop strategies and plan effectively for the introduction of blockchain technology and to make use of it. Hospitals should develop a blockchain strategy that integrates the current hospital strategy based on their resources. The strategy may include identifying a priority area for blockchain implementation which, in this case, would be EHRs, data sharing, pharmaceutical supply chains, health insurance, clinical trials, remote patient monitoring and medical device management. These priorities are supported by the findings of this study where the participants were asked to suggest, from their point of view, which HIS applications or services could be moved to blockchain. Furthermore, blockchain is a technology that needs collaboration at all levels of the healthcare organisation including all stakeholders. It is therefore important to identify and engage all stakeholder involved in the healthcare domain such as patients, IT professionals, medical professionals, the Ministry of Health and health insurance companies. A key element of the strategic plan should also include blockchain governance, which is not simply about who controls the blockchain, but also relates to establishing mechanisms for resolving issues as they arise (Maggiolino & Zoboli, 2021). Governing blockchain involves how technical decisions are made and how the database features are modified, what data should be stored on- and off-chain and whether permissionless or permissioned blockchain will be developed. In addition, it is recommended that hospitals hire external qualified consultants with experience in blockchain to provide strategic advice based on research and inventive evaluation on implementing it effectively to decrease the possibility of failure and reduce costs.

- Before planning for blockchain implementation, certain technical specifications should be taken into consideration or should be available to ensure hospital readiness. Based on the study's findings, hospital readiness positively influences blockchain adoption in Saudi public hospitals. It appears that hospitals with a high readiness level for blockchain technology are more likely to adopt it. The basic requirements that should be available are high performance computers and a stable internet connection. Other considerations should be taken into account such as the type of processing power, storage capacity for the nodes (computers or servers), memory (RAM/SRAM) as well as the environmental conditions, such as shock and vibration, temperature fluctuations, and humidity (Byers, 2017). The higher the complexity of the system, the more specifications and requirements are needed. The first consideration in planning what type of blockchain (public, private, consortium) to implement is to select the most suitable consensus protocol (e.g. PoW, PoS, PoET, PBFT) and to choose the most suitable platform (Ethereum, Hyperledger Fabric, EOS and Hyperledger Sawtooth). An application programming interface (API) needs to be considered and the user interface needs to be designed using a programming language (e.g. Python, JavaScript, Solidity, C and C++). There is no restriction on the language used for the front-end of the application, but smart contracts must be used in the backend. Examining current healthcare blockchain projects will assist with the development process. For example, Medicalchain is a platform for the fast and secure exchange and utilisation of medical information on blockchain and access to medical records is controlled by permissions (Medicalchain, 2018). Two blockchains are used by Medicalchain, one built on Hyperledger Fabric and the other based on Ethereum. GitHub provides access to the Medicalchain repository, which contains both smart contracts and APIs. There are also other healthcare applications and platforms built on blockchain such as MedRec for medical data management (Azaria et al., 2016), Akiri and Patientory for data sharing (Akiri, 2018; McFarlane, Beer, Brown, & Prendergast, 2017), MediLedger for the medical supply chain (Chronicled, 2022), FarmaTrust for pharmaceutical traceability (FarmaTrust, 2017) and Bloqcube for clinical trials (Bloqcube, 2017). It is important to note that there are many reputable companies that provide blockchain consulting services and solutions such as Amazon, IBM, HPE and Accenture. These companies could also help with the timeline and cost as these two factors are critical for developing a successful blockchain strategy and plan.

- Once the necessary groundwork has been laid, pilot projects should be introduced in non-critical or sensitive applications that will not interfere with hospital operations. Examples of this are staff credential verification and medication tracking. A credential data solution on blockchain is already being used in pilot projects by companies such as ProCredEx (ProCredEx, 2022). Also, in this testing stage, it should be ensured that the blockchain solution integrates seamlessly with legacy systems as this is one of the key aspects of the blockchain implementation strategy. The current study found that compatibility has a significant effect on blockchain adoption. Finally, it is worth noting that the implementation of blockchain is a long-term transformation process which may take several years to complete. It will be necessary to conduct further research to develop effective implementation strategies that can be used to encourage the use of blockchain in hospitals.

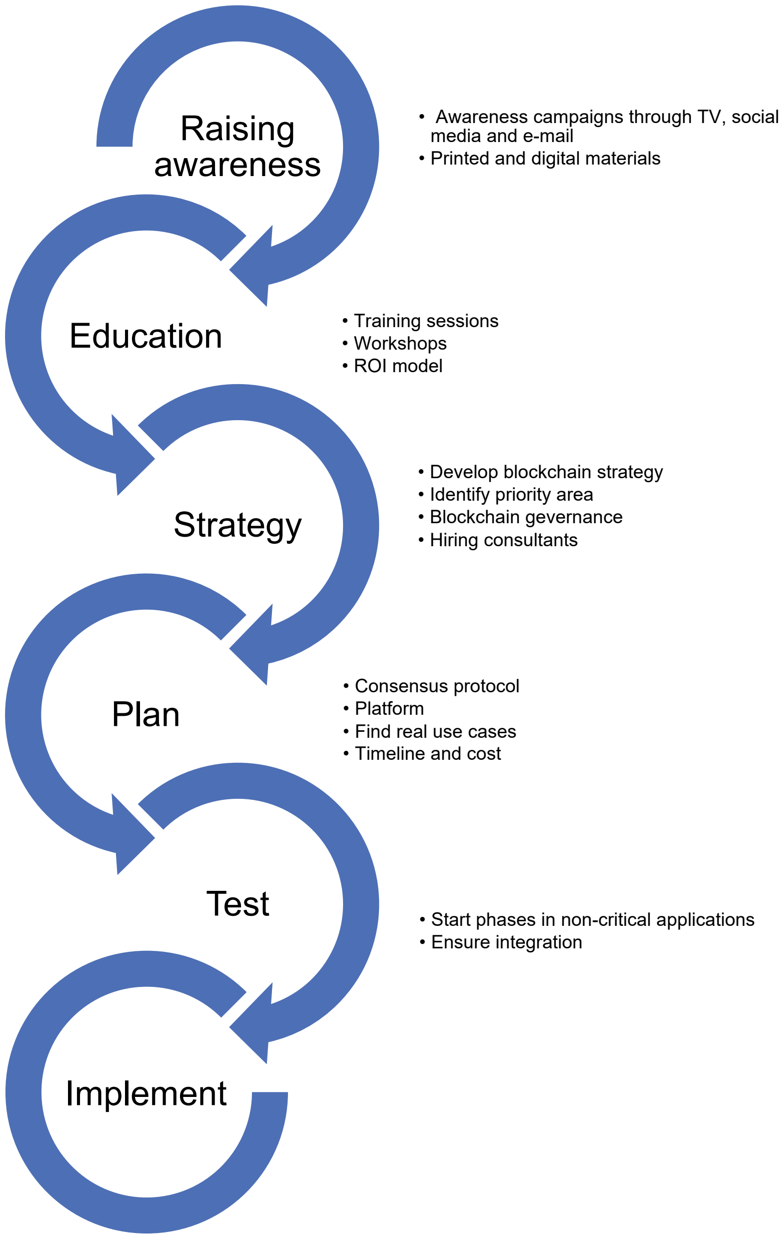


Figure 23 Roadmap for blockchain adoption in hospitals

8.5 Limitations and recommendations for future research

There is no doubt that this empirical research has made significant contributions, but it has certain limitations that need to be considered in future research:

- The current study aimed to explain and understand IT employees' behavioural intentions towards the use of blockchain technology in hospitals; therefore, the findings were not intended to represent or evaluate actual or ongoing usage of blockchain technology. It is recommended that the use of blockchain technology should be assessed through further studies. These studies should be conducted longitudinally to examine how the effects of the proposed determinants change over a period of time. Whenever researchers examine the continuing use of blockchain technology, they should take into account factors such as habit and experience which are related to continuing use.

- When quantitative and qualitative methods are combined, the researcher is able to obtain a more extensive understanding and substantiation, while also countering the shortcomings that are experienced when each approach is used on its own (Carvalho & White, 1997). The researcher initially intended to conduct a focus group interview with IT employees at Saudi hospitals for the purpose of qualitative data collection, but this method was significantly inhibited by the ongoing COVID-19 situation during the time of data collection. Therefore, future research may consider the applicability of mixed methods research. Mixed methods research gives rise to the possibility of triangulation, which is a key characteristic of this approach. Through triangulation, one is able to more precisely determine the features of a phenomenon by examining it from distinct vantage points by employing varied techniques and methods (Dootson, 1995).

- Snowballing was the most appropriate sampling technique because the population was difficult to reach due to COVID-19 restrictions. So, there could be a sampling bias in this study due to the use of a non-probability sampling method to recruit participants. Therefore, the generalisability of the findings cannot be guaranteed. It is worth considering in future research a probability sampling method such as simple random sampling as it results in an unbiased representation of target population.

- This research investigated the acceptance of blockchain in hospitals from technological, organisational, environmental and human perspectives and there is a possibility of improving the proposed framework by extending new dimensions on the subject of blockchain adoption. Reviewing the determinants recognised in the literature would allow researchers to find and examine new dimensions that have not been explored in this study, such as financial and social dimensions. Further research are recommended to investigate the applicability of the extended framework in different contexts.

- This study was limited to the adoption of blockchain among IT employees who work in Saudi public hospitals for the reasons discussed in Chapter 2. This brings a limitation to this study and it is important to investigate factors related to the adoption of blockchain technology among different groups such as doctors, nurses, and patients. Taking into account different perspectives will generate new predictors regarding blockchain adoption in healthcare settings. By doing so, it will be possible to improve the generalisation of this study and identify more determinants influencing blockchain adoption.

- This research covers public and government hospitals and does not take into account private hospitals. Saudi Arabia has 478 hospitals and the MOH and government hospitals administer 67 percent of the hospital services in the country (320 hospitals), whereas private sector services (where fees are charged) provide about 33 percent of available care (158 hospitals) (Exhibition, 2019). Further research to investigate the private sector will be beneficial. It would also be helpful if more research and a comparison were undertaken between the two sectors to provide more insight into the adoption of blockchain in healthcare.

- An additional limitation of this thesis is the lack of in-depth focus on the integration of blockchain technology with existing healthcare solutions in Saudi Arabia. While the study provides valuable insights into the determinants influencing blockchain adoption in hospitals, it does not investigate extensively into the specific challenges and opportunities presented by the integration of blockchain within the Saudi healthcare context. Therefore, future research should prioritise exploring the difficulties and implications of integrating blockchain technology with existing health solutions in Saudi Arabia.

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Appendix A: Ethical approval

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

CRICOS Provider Code 00099F

Neg Risk approval - ETH20-5126

Dear Applicant

Re: ETH20-5126 - "Comprehensive Framework for Blockchain Technology Adoption in Saudi Hospitals"

You have declared your research as Negligible Risk and that it **DOES NOT** involve any of the following:

- Establishment of a register or databank for possible use in future research projects
- Collection, transfer and/or banking of human biospecimens(1)
- Any significant alteration to routine care or health service provided to participants
- Interventions and therapies, including clinical and non-clinical trials, and innovations
- Targeted recruitment or analysis of data from any of the participant groups listed in Chapter 4 of the National Statement (or where any of these participants are likely to be significantly over-represented in the group being studied) including:
  - Women who are pregnant and the human fetus
  - Children and young people (under 18 years)
  - People in dependent or unequal relationships
  - People highly dependent on medical care who may be unable to give consent
  - People with a cognitive impairment, an intellectual disability, or a mental illness
  - People who may be involved in illegal activities (including those affected)
  - Aboriginal and Torres Strait Islander Peoples
- Collection, use or disclosure of personal information (except where expert opinion is being canvased with full disclosure, consent and identification for use in the public domain)
- Collection, use or disclosure of health information(2)
- Collection, use or disclosure of sensitive information(3)
- Covert observation, active concealment, or planned deception of participants
- Activity that potentially infringes the privacy or professional reputation of participants, providers or organisations (except where expert opinion is being canvased with full disclosure, consent and identification for use in the public domain)
- Potential for participants to experience harm (e.g. physical, psychological, social, economic and/or legal)
- Direct contact with UTS staff/students, patients, consumers or members of the public (except where expert opinion is being canvased with full disclosure, consent and identification for use in the public domain)
- Participants who have a pre-existing relationship with the researcher (except where expert opinion is being canvased with full disclosure, consent and identification for use in the public domain)
- People unable to give free informed consent due to difficulties in understanding the Information Sheet or Consent Form
- People in other countries

The UTS HRECs consider the following to be of negligible risk:
(1) use of commercial cell lines and/or supply of blood or blood products from Australian Red Cross Lifeblood
(2) consensus methods (i.e. Delphi)
(3) use of existing collections of data or records that contain only non-identifiable data about human beings (i.e. no codes)

I declare that I believe this research to be of negligible risk in accordance with the National Statement on Ethical Conduct in Human Research (Chapter 2.1)

I will notify the UTS Human Research Ethics Committees of any variation to this research that may alter the level of risk associated with it. This research will be undertaken in compliance with the

the UTS Research Ethics and Integrity Policy or any replacement or amendment thereof.

This research will be undertaken in compliance with the Australian Code for the Responsible Conduct of Research and National Statement on Ethical Conduct in Human Research.

Please keep a copy of your ethics application form and approval letter on file to show you have considered the risks associated with your research. You should consider this your official letter of approval.

If you have any queries about this approval, please do not hesitate to contact your local research office or Research.Ethics@uts.edu.au.

Kind regards,
UTS HREC Ethics Secretariat

C/- Research Office
University of Technology Sydney
Research.Ethics@uts.edu.au |
Website PO Box 123 Broadway
NSW 2007

Ref: Ethics 2 -Neg Risk approved (c)

Appendix B: The questionnaire

Comprehensive Framework for Blockchain Technology Adoption in Saudi Public Hospitals

INFORMATION SHEET AND CONSENT FORM FOR ONLINE SURVEYS
Comprehensive Framework for Blockchain Technology Adoption in Saudi Public Hospitals

Dear Participant,
My name is Adel Abdulrahman Khwaji and I am a Ph.D. student at the University of Technology Sydney (UTS). My supervisor is Dr. Farookh Hussain.
This research seeks to identify factors that influence the future acceptance or adoption of blockchain technology in Saudi public hospitals. The Saudi government is seeking to generate a digital transformation in the country in accordance with the 2030 vision. The government and/or decision-makers will benefit from this study by getting an informed understanding of the advantages and challenges of blockchain adoption in healthcare. Healthcare organisations will also benefit from this research by acquiring a better understanding of potential challenges that might hinder the adoption of blockchain in the context of Saudis' hospitals.

Please only complete this survey if you are an IT professional who works or worked in a Saudi hospital. Participation in this study is voluntary. It is completely up to you whether or not you decide to take part. If you decide to participate, I will invite you to complete an online questionnaire, it should take no longer than 10-15 minutes of your time. You can change your mind at any time and stop completing the surveys without consequences.
The process of data collection will take place in a highly confidential manner and the participants' identity will be kept anonymous. The data will only be utilized for the purpose of this research and findings will be limited to academic publications only

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact us on
Adel Khwaji
Adel.khwaji@student.uts.edu.au
+61416[redacted]
+96659[redacted]
Or
Farookh Hussain
Farookh.Hussain@uts.edu.au

If you would like to talk to someone who is not connected with the research, you may contact the Research Ethics Officer on 02 9514 9772 or Research.ethics@uts.edu.au and quote this number [ETH20-5126]

Part 1
Demographic information

Please respond by selecting the appropriate box to the following items:

Q1 Nationality

- Saudi
- Non-Saudi

Q2 Gender

- Male
- Female

Q3 Age

- 18 to 24
- 25 to 34
- 35 to 44
- 45 to 54
- 55+

Q4 Education level

- High school or lower
- Diploma
- Bachelor
- Post-graduate degree

Q5 Are you an IT employee/ do you work in IT department?

- Yes
- No

Display This Question:

If are you an IT employee/ do you work in IT department? = Yes

Q6 What is your role level?

- Managerial level (e.g. CIO, Manager, Consultant, etc)
- Professional level (e.g. Programer, Analyst, Engineer, etc)
- Technical level (e.g. IT support, Network technician, etc)
- Administrative level (e.g. Network administrator, IT coordinator, etc)

Q7 In which region do you work?

- Central region
- Western region
- Eastern region
- Southern region
- Northern region

Q8 The hospital you work at:

- Public (MoH)
- Governmental
- Private

End of Block: Demographic information

Start of Block: Experience and knowledge about blockchain technology

Part 2
Experience and knowledge about blockchain technology Please respond by selecting the appropriate box to the following items:

Q9 How would you rate your computer skills?

- Very poor
- Poor
- Moderate
- Good
- Very good

Q10 How would you rate your current knowledge about blockchain technology?

- Very poor
- Poor
- Moderate
- Good
- Very good

Q11 Have you been ever worked on any of blockchain applications/services?

- Yes please specify ________________________________
- No

Skip To: End of Block If Have you been ever worked on any of blockchain applications/services? = No

Q12 If yes, how long have you been working on it?

- Less than 1 year
- 1-3 years
- More than 3 years

End of Block: Experience and knowledge about blockchain technology

Start of Block: Blockchain explanation

A brief explanation about blockchain technology

Blockchain is a time-stamped group of immutable data records that is handled through a group of computers that are not owned by a central authority (Sharples & Domingue, 2016). Cryptographic principles are used to provide security to these blocks of data (i.e. block) and to keep them bound to one another (i.e. chain) In healthcare, blockchain can bring about more rapid and simpler interoperability between systems and can be scaled efficiently to deal with greater volumes of data and an increased number of blockchain users (Linn & Koo, 2016). It can help fight counterfeit medicines (Mettler, 2016), it can improve medical record management and insurance claim procedures and increase the pace of clinical/biomedical research (Kuo, Kim, & Ohno-Machado, 2017).

The security of remote patient monitoring systems may increase and health-related notifications can be delivered in an automatic manner while complying with relevant health legislation (Griggs et al., 2018). Blockchain makes it possible for patients to own and manage their data without any adverse impact on safety or restricting health care services from being shared (Yue, Wang, Jin, Li, & Jiang, 2016). Blockchain offers transparent and immutable unified health patient records, which can be accessed from all over the world (Rabah, 2017). For more explanation, please visit this link https://youtu.be/md0K6nGewTU
Please do not hesitate to contact me at adel.khwaji@student.uts.edu.au, if you require additional clarifications or have questions

Start of Block: TOE

Part 3

TOE model questions

Please select the choice that indicates your level of agreement/ disagreement with the following statements

		Statement	Strongly disagree	Disagree	Neither	Agree	Strongly agree
	Technological						
	Complexity (CPX)						
13	CPX1	The use of blockchain is seen as complex for hospital operations.	1	2	3	4	5
14	CPX2	It would be very difficult to resolve transactional errors when using blockchain.	1	2	3	4	5
15	CPX3	The skills required to adopt blockchain could be complicated for the hospital's employees.	1	2	3	4	5
	Relative advantage (RA)						
16	RA1	Blockchain will allow hospital operations to be managed effectively.	1	2	3	4	5
17	RA2	The use of blockchain will allow tasks to be performed faster.	1	2	3	4	5
18	RA3	The use of blockchain will improve the productivity of the hospital.	1	2	3	4	5
19	RA4	The use of blockchain will be beneficial for patients.	1	2	3	4	5
	Compatibility (COM)						
20	COM1	Using blockchain services will be fully compatible with current operational practices.	1	2	3	4	5
21	COM2	Using blockchain will be compatible with the hospital's existing hardware.	1	2	3	4	5
22	COM3	Using blockchain will be compatible with the hospital's IT infrastructure.	1	2	3	4	5
23	COM4	Blockchain will be compatible with the hospital's goals and values.	1	2	3	4	5
	Organisational						
	Top management support (TP)						

24	TMS1	The hospital's management is willing to take risks involved in blockchain adoption.	1	2	3	4	5
25	TMS2	In our hospital, top management will support the adoption of blockchain.	1	2	3	4	5
26	TMS3	Top management would be aware of blockchain benefits.	1	2	3	4	5
	Hospital Readiness (HR)						
27	HR1	Network infrastructure in the hospital would be available for adopting blockchain.	1	2	3	4	5
28	HR2	IT human resources in the hospital would be available for adopting blockchain.	1	2	3	4	5
29	HR3	Financial resources in the hospital would be available for adopting blockchain.	1	2	3	4	5
	Environmental						
	Regulations and laws (RL)						
30	RL1	Regulations and laws could be sufficient to deal with blockchain issues.	1	2	3	4	5
31	RL2	Regulations and laws would be adequate for protecting the use of blockchain.	1	2	3	4	5
32	RL3	Regulations and laws will facilitate the use of blockchain.	1	2	3	4	5
	Government support (GS)						
33	GS1	There will be an available financial support from the government to encourage the adoption of blockchain.	1	2	3	4	5
34	GS2	There would be supportive policies from the government regarding the adoption of blockchain.	1	2	3	4	5
35	GS3	There will be training and educational support from the government to boost the adoption of blockchain.	1	2	3	4	5
	Human						
	Decision-maker innovativeness (DI)						
36	DMI1	Decision makers in the hospital would seek to take advantage of new technologies	1	2	3	4	5
37	DMI2	Decision makers in the hospital will be keen to experiment with emerging information technologies	1	2	3	4	5

38	DMI3	Decision-makers will be confident to try out new information technology	1	2	3	4	5
	Technical competence (TC)						
39	TC1	It would be easy to learn about blockchain.	1	2	3	4	5
40	TC2	It would be easy to have the ability to support blockchain adoption	1	2	3	4	5
41	TC3	It would be easy to have the expertise to support blockchain adoption	1	2	3	4	5
	Behavioral intention (BI)						
42	BI1	The hospital intends to adopt blockchain.	1	2	3	4	5
43	BI2	The hospital is likely to adopt blockchain in the next 12 months.	1	2	3	4	5
44	BI3	The hospital is likely to take steps to adopt blockchain in the future.	1	2	3	4	5

End of Block: TOE model questions

Start of Block: Blockchain applications

Q45 Which of the following should be considered to be moved to blockchain technology in the hospital?

- EHR (Electronic Health Records)
- Data sharing
- Clinical trials
- Pharmaceutical supply chain
- Health insurance
- Remote patient monitoring
- Medical device management
- Other, (Please specify)

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End of Block: Blockchain applications

Start of Block: Block 4

Q46 Do you have any comments you would like to add?

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End of Block: Block 4