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Adoption for the implementation of smart card technology in public healthcare

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This study enhances the critical factors for the implementation of smart card technology (SCT) by proposing a conceptual framework based on the healthcare unified theory of acceptance of user technology model (2008), the DeLone and McLean information systems success model and the diffusion of innovation theory (2003) recommending the strategies to be used. The framework was tested using regression analysis on the collected data from 406 self-administered questionnaires from Steve Biko Academic Hospital, Tshwane District Hospital, Kalafong Hospital and Pretoria West Hospital. The structural equation modelling and principal component analysis methods in Statistical Package for Social Sciences were used to analyse the data. The findings of this study show that seven factors – behavioural intention, system use, information quality, service quality, communication, compatibility and trialability – were significantly accepted to ensure the adoption of SCT in public healthcare.

Transdisciplinary contribution: The healthcare sector has not fully addressed the technology use for healthcare professionals. However, the sector exploited much for the patients' needs to improve quality of healthcare. Therefore, this study recommends that this framework will contribute towards the implementation smart card technology within the public healthcare. The study will contribute to the implementation of SCT and ensure the quality of service delivery in public healthcare.

Keywords: smart card technology; implementation; healthcare; adoption; structural equation modelling.

Introduction

Smart card technology (SCT) entails turning a little rectangular piece of card into a smart device. These cards are small enough to fit in your wallet or back pocket, which is the first benefit they provide. Plastic smart cards may become obsolete in the health sector because of the current rise of mobile technology, which threatens to replace credit and debit smart cards in the business sector. As a result, the portable smart cards allow remote patient data collection, education and awareness, remote patient monitoring, disease epidemic outbreak surveillance and compliance with evidence-based therapy and healthcare that are all important in patients' health needs.[1]

The benefits of SCT are experienced in public healthcare as it has the potential to support integrated applications and data in areas such as patient diagnostic and treatment support. Smart devices are eroding the traditional boundaries of patient records and technology allows hospitals to expand their reach and provide on-demand mobile access to medical multimedia data. These devices are superior to smart cards because of their interoperability and mobility. Smart cards require the use of a terminal or computer system to retrieve data. In addition, technology has advanced from the first to the third generation of electronic health systems because of smartphones and tablets. However, to accelerate the adoption of smart personal health devices, 'plug-and-play' data ecosystems were developed.[2] The electronic health card, for example, was adopted in Germany as the foundation of its e-health infrastructure.[3] Some challenges are faced by human users and other systems.[4] However, the lack of data support and confidentiality leads to authenticity control of devices on the network. In Zimbabwe, e-health was implemented to demonstrate the use of technology.[5] However, doctors were required to learn how to use e-health technologies in public hospitals, which require hardware and software that cannot be avoided during treatment.

Generally, technology adoption cannot be separated from implementation science, as the two aspects are closely related. Technology adoption focuses on how end-users adopt technology, while implementation describes the interventions and variables that help promote evidence-based practice.[6] The smart card requires each patient to authenticate themselves to receive better healthcare service.[7] However, because of large populations in hospitals, healthcare professionals were encouraged to continue employing the paper-based method of healthcare delivery, which causes many challenges for the smart identification card.[8]

Research motivation

Public healthcare faces numerous challenges because the use of various information systems (ISs) within public healthcare has become a challenge that affects its efficiency and effectiveness. Various factors need to be considered when implementing such technology systems. In this study, healthcare ISs become more sophisticated; they must be built to support the demands of patients and healthcare professionals.[9]

Also, the quality of services offered by healthcare professionals has an impact on the provision of basic healthcare.[10] As a result, healthcare services continue to be harmed because of a lack of sufficient health skills and drugs, which could lead to a delay in the implementation of SCT.

Some countries have very rudimentary approaches to data storage and retrieval.[11] This is evidenced by the existence of various healthcare facilities that offer these services. Also, while health information technology (HIT) offers numerous benefits, it was found that there are some drawbacks, such as a lack of transparency in the management of prescription errors.[12] Medication documentation errors in patients can be a major source of adverse drug reactions. Compared to traditional paper files, providing great healthcare and access to data through the SCT is essential as it saves time.[13] In most cases, when manual files become misplaced, lost or stolen, it becomes a major problem to replace them. Patients' safety was identified as one of the six fast-track goals for the clinical control of information and quality care of health services by the Department of Health in 2012.[14] In addition, the National Digital Health Strategy for South Africa, 2019–2024, was developed in collaboration with other government departments. It aimed to strengthen digital health governance structures, create robust integrated platforms for the development of ISs and establish the necessary broadband network infrastructure. The objective of this research, as previously stated, was to develop a theoretical framework for the implementation of SCT in South African public healthcare. The study will shed light on further factors that influence healthcare professionals' use of smart cards to improve the delivery of services in the public sector.

Adoption of smart card technology

Technology adoption cannot be separated from implementation science; as a result, technology adoption focuses on how end-users adopt technology, while implementation describes the interventions and variables that help promote evidence-based practice.[6] The adoption of electronic health records (EHRs) is found to be more complicated and is influenced by a variety of internal factors. As a result, healthcare policymakers and managers can make well-informed decisions about whether or not to embrace and implement systems such as the EHR.[15] The implementation of SCT in healthcare, error, social influence (SI) and disease orientation also has a significant impact on the likelihood of smart card use.[16] The Health Authority of Indonesia uses the Badan Penyelenggara Jaminan Sosial Kesehatan (BPJS Kesehatan) with smart card readers to provide universal healthcare to its population. Health information technology variables such as the expectancy of achievement, the expectancy of exertion, SI and behavioural intention (BI) to use the clinical decision support system were also used. The result of the decision-making trial and evaluation laboratory (DEMATEL) analysis showed that performance expectations and effort expectations have a major impact on attitude; the magnitude of the impact is also higher in attitude than in behaviour.[17] Variables such as information quality in the health sector, on the other hand, remained insufficient, particularly at the periphery levels of districts and health institutions that have the primary operational management duties in Ethiopia.[18] In Dataquest (March 2000), for example, it was predicted that there were 28 million smart card shipments (microprocessors and memory) in the United States of America.[19] In the 1970s, the International Air Transportation Association (IATA) developed the first magnetic stripe cards.[19] The proliferation of e-health can be seen in the dissemination of brochures and flyers that help people meet their basic health needs.[20] The e-health card was launched in Nigeria; the card receives input from an application and provides an output. However, because of large populations in hospitals, healthcare professionals continue to employ the paper-based method of healthcare delivery, which causes many challenges for the smart identification card (ID).[8] In particular, the smart card requires each patient to authenticate themselves to receive better healthcare service.[7]

The adoption of SCT has many benefits which can help the government to establish strategies and policies. The key benefits include policymakers including technology and innovation to public health care. However, the development of technology acceptance model (TAM) theories can be required, similar to the one used for single-platform e-payment technology.[17] Adoption of these models and theories was a motivating decision for the acceptance of technologies in healthcare. The unified theory of acceptance and use of technology was among the theories adopted as part of the E-ZWICH (an electronic payment used in Ghana) experience for Ghana's journey to a cashless economy. Performance efficiency, effort efficiency and social impact influenced people's behavioral intentions to use the cashless system.[21]

Theoretical framework for smart card technology

This study employed three theoretical frameworks: the healthcare unified theory of acceptance of user technology (HUTAUT) model (2018), the DeLone and McLean IS success model (2003) and the diffusion of innovation theory (DoI) (2003) for the adoption of SCT in public healthcare.[22] These theories have been extensively used in the SCT adoption research also, and they have produced significant outcomes.

Healthcare unified theory of acceptance of user technology model

There are various models and theories of technology acceptance, some of which have found applications in healthcare.[23] The HUTAUT model is discussed in this section, and it aims to understand why users accept or reject a technology, as well as how healthcare technology design can improve user adoption. This theory was developed by Maeko and Van Der Haar[24] to influence user awareness and acceptance in healthcare. This theory becomes relevant in the field of ISs because it states that four key constructs, namely performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC) and SI, are direct determinants of usage intention and behaviour.[25]

Delone and McLean information system success model

An assessment of IS success is critical to an organisation's understanding of the value and effectiveness of IS investment and management. This model is widely accepted among IS researchers.[26] It was first presented in 1992 and updated in 2002 and 2003. The most recent iteration of the model consists of six dimensions: IT information quality, system quality, service quality, use, user satisfaction and net benefits. Delone and McLean suggest that system quality, information quality and service quality affect the use and user satisfaction. In turn, both use and user satisfaction are direct antecedents of net benefits, which can be evaluated from individual and organisational impact. The model was modified by Delone and McLean in 2003 to include service efficiency and replace individual effect and organisational benefit with net benefit.[27] Also, the DeLone and McLean model presented various characteristics of IS success, including information, system, service quality, (intend to) use, user satisfaction and net benefit. Therefore, the DeLone and McLean model is effective for efficiency in SCT, which can be easily assessed using more general metrics such as device response time and downtime.

Diffusion of innovation theory

Everett Rogers (1962)[28] established the DoI, which is one of the oldest theories in the field of IS. Diffusion of innovation theory has been applied in numerous fields of study like communication, development studies, knowledge management and healthcare. The decision to implement the DoI theory involves a variety of factors, including whether or not to use technology such as SCT.[29] Based on this framework, implementation focuses on methods of variable interventions and promotes variables such as end-user acceptance.[30] Healthcare technology was used to facilitate early discharge, suggesting that healthcare facilities have purchased and implemented evidence-based technology. However, individuals and organisations confirmed that the DoI theory is used in this study to attribute the reported implementation process to health technology.[31]

Conceptual framework and research hypotheses

Healthcare unified theory of acceptance of user technology model constructs

From the proposed conceptual framework illustrated in Figure 1 of this study, five constructs were adopted from HUTAUT. These constructs are EE, PE, SI, FC and BI, and they serve as independent variables.

Effort expectancy

Effort expectation is the extent to which using a system is effortless. The ease of use is key to influencing perceptions of the utility of innovation and is important from both a mandatory and a voluntary point of view. Therefore, the study hypothesises that:

> **H1:** Effort expectancy is expected to have a positive effect on the implementation of SCT in healthcare.

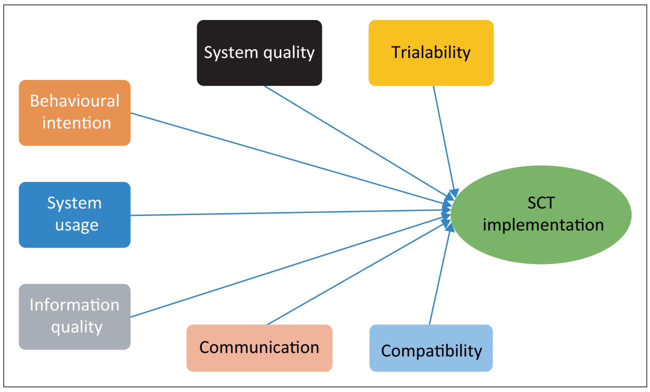
Performance expectancy

Performance expectancy refers to the extent to which an individual believes that the use of technology will benefit healthcare professionals to achieve improvements in job performance. So far, performance expectation has been used to describe the technical context, while subjective standard and funding conditions have been used to define the implementation context.[32] Performance expectancy within information systems is created as a mandatory setting for determining factor for technology deployment. Therefore, the study hypothesises that:

> **H2:** Performance expectancy is expected to have a positive effect on the implementation of SCT in healthcare.

Social influence

In the context of this study, SI is defined as the extent to which a person believes that other important people should use a new system.[33] Social influence was a construct used for social media, with a framework for user awareness and acceptance of the smart card and fingerprint-based access control being developed before implementation was completed. SI is accessed for healthcare professionals on BI as



SCT, smart card technology.

FIGURE 1: Final research model.

a mediating variable for implementation in healthcare. Therefore, social pressure on healthcare professionals impacts intention to use. As a result, the SI construct directly impacts the implementation of SCT for healthcare professionals. This construct tends to make the organisation perceive that it is important to believe in the SCT. Social influence has a significant impact on technology implementation.[34] Therefore, the study hypothesises that:

> **H3:** Social influence is expected to have a positive effect on the implementation of SCT in healthcare.

Facilitating conditions

Facilitating conditions are assessed as the extent to which people can use the new technology without undue restrictions. The impact of these conditions on actual usage was greatest among older workers and those with more experience.[35] The degree to which healthcare professionals contribute makes management to believe and support towards the implementation of technology. Furthermore, people believe that SCT adoption in public health is fully supported. Therefore, the study hypothesises that:

> **H4:** Facilitating conditions are expected to have a positive effect on the behavioural intention to implement SCT in healthcare.

Behavioural intention

In the context of this study, BI relates to a desire or purpose and is a direct determinant of actual usage.[36] The HUTAUT model considers factors that influence BI and technology usage behaviour. Performance expectancy, EE and SI are all affected by the BI to the use of technology, whereas BI and supporting conditions determine the usage of technology. Therefore, the study hypothesises that:

> **H5:** Behavioural intention is expected to have a positive effect implementation of SCT in healthcare.

Delone and McLean information system success model

As independent variables in this study for the adoption of SCT technology, three constructs from the Delone and McLean model were adopted: service quality, system quality and information quality.

User attitude

The difference between customer expectations and the achieved reality is referred to as service quality.[37] The ease of designing systems that can be adapted to external conditions is referred to as system quality and relevance. The difference between customer expectations and the reality encountered is believed to contribute to quality.[37] Therefore, the study hypothesises that:

> **H6:** User attitude has a positive effect on the implementation of SCT in healthcare.

User satisfaction

In the context of this study, user satisfaction is referred to as the general use of technology which is reflected in contentment and enjoyment, software and decision satisfaction.[38] As a result, user satisfaction is subjective as it depends on the respondents and the systems they use. Consequently, user satisfaction is defined as the overall rating of the user's experience in using the system and the potential impact of the system. Therefore, the study hypothesises that:

> **H7:** User satisfaction has a positive effect on the implementation of SCT in healthcare.

System use

Any healthcare facility should be able to provide intelligent search capabilities, quick and multi-site access and the capacity to digitally merge data fragments housed in geographically distributed databases by implementing the system.[39] Healthcare organisations must strive to improve the quality of their care. Technology features such as hardware, software and data are used to fulfil user obligations.[40] Smart card technologies entice healthcare professionals to use them for tasks such as recording, patient information, laboratory, radiology (X-ray), neonatal and pharmacy information. Therefore, the study hypothesises that:

> **H8:** System use has a positive influence on SCT implementation.

Information quality

Information quality is a measure of how well the information is presented to a healthcare professional. It also indicates how well the information is formatted and presented. It can be argued that SCT should enable hospitals and clinics to seamlessly integrate business processes. In a proper health information system (HIS) implementation, information quality refers to the integration of several factors such as human, organisational and technical factors.[41] Therefore, the study hypothesises that:

> **H9:** Information quality is expected to have a positive effect on user satisfaction to implement SCT in healthcare.

System quality

System quality designates the component of an IS dimension and thus summarises various measures of the system itself. As a result, system quality is thought to play a role in convenience, technological flexibility, system correctness, response time and usability.[42] The functionality includes the type and level of existing SCT functions, for example, order entry with decision support for reminders and alerts. System quality capacity is commonly viewed as the system's security element, which protects the integrity of the information or data collected and ensures correct authorisation. Therefore, the study hypothesises that:

> **H10:** System quality has a positive effect on the implementation of SCT in healthcare.

Service quality

In the context of this study, service quality is defined as the overall support provided to the service provider, whether the service is provided in-house or by a third party.[43] Smart card technology is used to assess service quality and identify inconsistent and problematic service processes.[44]

For this reason, service quality can be said to have a significant impact on user satisfaction. Therefore, the study hypothesises that:

H11: Service quality is expected to have a positive effect on user satisfaction to implement SCT in healthcare.

Diffusion of innovation theory

The concept of innovation and diffusion is explained by the different independent variables identified in the model. These variables help explain the different stages of innovation and diffusion processes. In this study of implementing SCT technology, three DoI constructs were used: communication, compatibility and trialability.

Communication

According to Roger (2003)[45], DoI defines communication as an innovation that uses specific channels between members of social systems. Communication channels play an important role in technology implementation in this context, and healthcare professionals are engaged in the implementation. Communication is regarded as a scheme used by humans and technology to interact. Therefore, the study hypothesises that:

H12: Communication is expected to have a positive effect on the implementation of SCT in healthcare.

Compatibility

In this study, Rogers (2003)[45] defines, a new system is compatible or incompatible with the beliefs and values of its users. The ability to innovate stems from people adopting technology. Facebook is a social networking platform that allows users to connect with friends, coworkers and strangers online by creating free profiles. It is found that integrating Facebook was simple and inexpensive. All nine public libraries examined, in fact, reported that implementing Facebook was both inexpensive and simple. The data also revealed that there was a window of opportunity that could have greatly facilitated the decision-making process. Therefore, the study hypothesises that:

H13: Compatibility is expected to have a positive effect on the implementation of SCT in healthcare.

Trialability implementation

In this study, trialability is viewed as the degree to which health professionals provide services to citizens from time to time. In the relationship between innovation acceptance and trialability, health professionals' attitudes can play a mediating role.[46] The implementation of technology in healthcare is for data storage and is a wearable device that keeps all personal data for smart health.[47] Furthermore, the success or failure of the innovation system is determined by factors such as software planning and support, as well as the relationship between innovation and policy implementation and administration. Therefore, the study hypothesises that:

H14: Trialability is expected to have a positive effect on the implementation of SCT in healthcare.

Implementation of smart card technology

In the context of this study, implementation strategies have been varied, and challenges in integrating mobile devices include a lack of administrative support and a lack of time or funding for teacher and student training. Overall, the use of mobile devices appears to bring benefits to nursing students; however, there is limited research.[30] Guidelines for theory selection can encourage implementation scientists to use theories and discourage underuse, use theories sensibly and discourage superficial use, and be aware of the strengths, weaknesses and appropriateness of the theories they select to prevent abuse. Therefore, the study hypothesises that:

H15: Implementation of SCT has a positive influence on healthcare.

Methodology

This study adopted a quantitative approach where self-administered questionnaires were collected from healthcare professionals at Tshwane District Hospital, Steve Biko Academic Hospital, Pretoria West District Hospital and Kalafong Tertiary Hospital in Tshwane. The study design is a cross-sectional, face-to-face-based study distributed at these hospitals. The design of the structured questionnaire was done by professional academics who assisted at Steve Biko Academic Hospital. The questionnaire was distributed in physical form using a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (1), which was used to measure the respondents' views on the adoption of the SCT in public healthcare.

Also, in obtaining sampling elements for this study, a nonprobability sampling technique called purposive sampling was used. As a result, the sample size for this study included four hospitals. For this study, data was collected at four hospitals in Gauteng to ensure reliability. In this study, participants were able to complete the survey and were allowed to be anonymous. The study protocol was approved by the ethical committee at the University of South Africa and the National Health Research Council. The Statistical Package for Social Sciences (SPSS) version 26 and AMOS 26 (both manufactured by IBM Corporation, Armonk, New York, United States) with the structural equation model were also used to evaluate the quantitative data. The Cronbach's alpha value was more than 0.7 after reliability and validity testing, indicating that all the data submitted and analysed were reliable.

Ethical considerations

Ethical approval to conduct the study was obtained from the Health Research Ethics Committee of the University of South Africa (ref. no. 2020/CAES_HREC/081). Further permission was obtained from the National Health Research Data (NHRD) to obtain data from Steve Biko Academic Hospital, Kalafong Tertiary Hospital, Tshwane District Hospital and Pretoria West District Hospital.

Results and findings

Sample and data collection

Data were collected during the coronavirus disease 2019 (COVID-19) pandemic over a period of two months in April

2021. Questionnaires were dropped at the different departments to allow the healthcare professionals opportunity to complete them. Managers were explained to assist the healthcare professionals in completing the questionnaires.

Reliability analysis

In the context of this study, reliability analysis was applied to allow consistency of the measured items by checking each construct. Also, the reliability test was performed on healthcare professionals' responses to the questionnaire to determine whether the data received are reliable or not. This was done using different data themes applied, such as expectancy level, usability, communication and trialability. The cut-off of 0.50 was corrected for the item-total correlation. The degree to which a test consistently measures whatever it measures is referred to as its reliability.[48] Reliability can also be defined as the degree to which a measuring instrument is accurate and stable in measuring what it is supposed to measure.[49] Based on the analyses in this study, each construct and the measurement items were examined as part of the reliability check.

In this study, reliability or accuracy of the questionnaire was tested in SPSS using Cronbach's alpha, also known as the alpha coefficient. Cronbach's alpha is a number ranging from 0 to 1.[48] Acceptable Cronbach's alpha values range from 0.70 to 1.0[47]; a low alpha value could be because of a low number of questions, poor interrelatedness between items or heterogeneous constructs. When the Cronbach's alpha value is greater than 0.7, it indicates that the research instrument or construct is reliable.[48] Table 1 summarises the reliability of the questionnaire survey instrument.

Table 1 indicates that, based on 97 questionnaire items, the research instrument has a Cronbach's alpha coefficient of 0.927. The coefficient value is above the minimum threshold of 0.7; therefore, the research instrument was deemed reliable. To check if the results of the latent variables are valid and reliable, Cronbach's alpha, composite reliability and average variance extracted (AVE) were calculated.[50]

Descriptive statistics of constructs

Using descriptive statistics, the researcher investigated and analysed a summary of information on the distribution and central tendency of continuous variables. The adoption factors for SCT influence usage used descriptive statistics which included the mean, minimum, maximum and skewness values used to analyse. In addition, it comprehends the distribution of the collected data. The mean value represents the midpoint of the available range. Skewness is a measure of asymmetry in a set of statistical data from the normal distribution.[48] Skewness is classified into two types: negative and positive.[48] Table 2 summarises the results of the descriptive statistics extracted from SPSS.

TABLE 1: Reliability analysis.

Cronbach's alpha	Cronbach's alpha based on standardised items	Number of items	Acceptance level
0.929	0.927	97	Good

The results show that all factors except for system quality had a minimum value of 2, which represents 'disagree'. This means that system quality was the only factor with at least one participant who strongly disagreed about its role towards the implementation of SCT in healthcare institutions, and none of the respondents strongly disagreed with the questions asked about the role of the rest of the factors towards the implementation of SCT in healthcare institutions. Regarding the maximum value, all factors had a maximum value of 5, a value that represents 'strongly agree'. This means that all factors had at least one participant who strongly agreed with the role that these factors play towards the implementation of SCT. These minimum and maximum statistics suggest that the majority of the respondents agreed and strongly agreed with the questions asked about the role of each factor towards the implementation of SCT; however, to be more confident with this conclusion, there is a need to interpret the mean and skewness statistics.

Table 2 shows that the mean value for all the factors is 4, a value that represents 'agree'. This suggests that for an average of 4 to be obtained, the majority of the respondents agreed and strongly agreed with the questions asked about the role of each factor towards the implementation of SCT in healthcare institutions. To further cement this conclusion, skewness statistics were analysed, and the results in Table 4 indicate that all factors except for PE and communication have a negative skewness value, which means that the majority of their data points are aligned to the right side of the mean value (the side with 'agree' and 'strongly agree'). This means that for these factors, the majority of the respondents agreed and strongly agreed with the questions asked about the role they play towards the implementation of SCT in healthcare institutions. Communication and service quality have low positive and negative skewness values of 0.001 and -0.003, respectively, which are nearly zero, suggesting that there is a balance between respondents who

TABLE 2: Construct descriptive statistics.

Construct	Minimum	Maximum	Mean	Skewness
Effort expectancy	2	5	4	-0.540
Performance expectancy	2	5	4	0.308
Social influence	2	5	4	-0.282
Facilitating conditions	2	5	4	-0.196
Behavioural intention	2	5	4	-0.222
User attitude	2	5	4	-0.477
Service quality	2	5	4	-0.003
System use	2	5	4	-0.156
Information quality	2	5	4	-0.250
User satisfaction	2	5	4	-0.162
System quality	1	5	4	-0.015
Communication	2	5	4	0.001
Compatibility	2	5	4	-0.113
Trialability	2	5	4	-0.056
SCT implementation	2	5	4	-0.213

SCT, smart card technology.

agreed or strongly agreed and those who disagreed or strongly disagreed. Furthermore, there could be more respondents who were neutral to the questions asked about the role of communication and service quality towards the implementation of SCT. Performance expectancy had a high positive skewness value of 0.308, meaning that most of the respondents disagreed and strongly disagreed with the questions asked about its role in the implementation of SCT in healthcare institutions.

Of all factors with a negative skewness, EE had the highest negative skewness of −0.54, followed by user attitude, SI, information quality, BI and SCT implementation, with skewness values of −0.477, −0.282, −0.250, −0.222 and −0.213, respectively. System quality and trialability have the least negative skewness value of −0.015 and −0.056, respectively. In summary, respondents generally agreed and strongly agreed with the role that the factors investigated by this study play towards the implementation of SCT in healthcare institutions.

Kaiser–Meyer–Olkin and Bartlett's test

The Kaiser–Meyer–Olkin (KMO) and Bartlett's test was the second result of the principal component analysis (PCA) factor analysis. The KMO statistic ranges from 0 to 1. For factor analysis to be effective, the value of KMO should be close to 1 rather than 0. A value close to 1 indicates that correlation patterns are relatively compact, implying that factor analysis should yield distinct and reliable factors. Also, values between 0.5 and 0.7 are considered mediocre, values between 0.7 and 0.8 are considered very good, values between 0.8 and 0.9 are considered very good and values greater than 0.9 are considered superb.[51] The KMO statistical value for the data used in this study was found to be 0.949, as shown in Table 3; this value falls in the superb range, so one can be confident that factor analysis is appropriate for these data.

Factor analysis

Factor analysis is a method of modelling the covariation among a set of observed variables as a function of one or more latent constructs.[52] Factor analysis is used for determining the nature of the latent constructs that underpin the variables of interest.[52] This method seeks to identify underlying variables, or factors, that explain the pattern of correlations within a set of observed variables or construct items. One common goal of factor analysis is to produce a small number of factors that can be used to replace a much larger number of variables.[53] Factor analysis is a data reduction technique that attempts to identify a small number of factors that explain most of the variance observed in a much larger number of manifest variables.[54] This means that at the end of factor analysis, the researcher will be left with variables that explain most of the variance, while those that explain the least variance are discarded.

The study extracted factors using the PCA method. The goal of PCA is to find a sequence of orthogonal factors that represent the directions of the greatest variance.[55] Principal component analysis was used because it can form uncorrelated linear combinations of the observed variables. It is also used to obtain the initial factor solution and can be used when a correlation matrix is singular. As a factor rotation method, a direct oblimin method was used because the literature suggested some theoretical grounds that imply that the factors in this study are related or correlated during theory development. The study chose to display the coefficients in order of size and to suppress coefficients with absolute values less than 0.4. In this study, the following outputs were extracted and explained: correlation matrix, KMO and Bartlett's test, factor extraction and rotated pattern matrix.

Exploratory factor analysis (EFA) was conducted using maximum likelihood with promax rotation to determine if the items loaded well onto the variables and correlated adequately. Maximum likelihood estimation was chosen to determine the unique variance among items and the correlation between factors. According to Pallant,[48] maximum likelihood also provides a goodness-of-fit test for the factor solution. Promax was chosen because of the large data set (n = 406) because promax can account for the correlated factors. The 14-factor pattern matrix (Table 4) shows the outcome of the factor analysis. Before the factor analysis, Bartlett's test of sphericity and KMO measure of sampling adequacy were assessed. The results revealed a KMO of 0.949 and Bartlett's test is significant at $\alpha = 0.000$ with a Chi-square value of 20225.791, indicating the suitability of conducting exploratory factor analysis (Kaiser, 1974).[56] Items that did not show high loadings were removed (effort expectancy [EE4], information quality [IQ6], system quality [SYQ4 and SYQ5]).

Hypotheses testing

Seven of the 13 hypotheses (Table 5) were supported by the model, as shown in Figure 1 and Table 4. The first hypothesis (H1) was not supported. This suggests that EE does not have a significant impact on the implementation of SCT ($\beta = -0.575$, $p = 0.862$, $R^2 = 0.75$). The second hypothesis (H2) was dropped because of low reliability. The third and fourth hypotheses (SI and FC effect on implementation of SCT) were not supported ($\beta = -0.054$, $p = 0.882$, $R^2 = 0.75$ and $\beta = -208$, $p = 0.840$, $R^2 = 0.75$, respectively).

Hypothesis five, which states that BI has a significant impact on implementation of SCT, was supported ($\beta = -0.209$, $p < 0.001$, $R^2 = 0.75$), suggesting an inverse relationship between the two variables. Hypotheses six and seven (user attitude and user satisfaction effect on implementation of SCT) were not supported ($\beta = 0.480$, $p = 0.741$, $R^2 = 0.75$ and

TABLE 3: Kaiser–Meyer–Olkin and Bartlett's test.

Test	Variable	Value
Kaiser–Meyer–Olkin Measure of Sampling Adequacy.	-	0.949
Bartlett's Test of Sphericity	Approx. Chi-Square	20225.791
	df	1485
	Sig.	0.000

df, degree of freedom; Sig., significance.

TABLE 4: The 14 factor pattern matrix.

Constructs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
EE5	0.854	-	-	-	-	-	-	-	-	-	-	-	-	-
EE2	0.805	-	-	-	-	-	-	-	-	-	-	-	-	-
EE4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SI5	-	0.415	-	-	-	-	-	-	-	-	-	-	-	-
SI3	-	0.836	-	-	-	-	-	-	-	-	-	-	-	-
SI1	-	0.785	-	-	-	-	-	-	-	-	-	-	-	-
FC6	-	-	0.814	-	-	-	-	-	-	-	-	-	-	-
FC5	-	-	0.336	-	-	-	-	-	-	-	-	-	-	-
FC3	-	-	0.858	-	-	-	-	-	-	-	-	-	-	-
FC2	-	-	0.804	-	-	-	-	-	-	-	-	-	-	-
FC1	-	-	0.647	-	-	-	-	-	-	-	-	-	-	-
BI5	-	-	-	0.537	-	-	-	-	-	-	-	-	-	-
BI3	-	-	-	0.838	-	-	-	-	-	-	-	-	-	-
BI2	-	-	-	0.717	-	-	-	-	-	-	-	-	-	-
BI1	-	-	-	0.796	-	-	-	-	-	-	-	-	-	-
UA5	-	-	-	-	0.812	-	-	-	-	-	-	-	-	-
UA4	-	-	-	-	0.509	-	-	-	-	-	-	-	-	-
UA3	-	-	-	-	0.639	-	-	-	-	-	-	-	-	-
UA1	-	-	-	-	0.773	-	-	-	-	-	-	-	-	-
SQ6	-	-	-	-	-	0.771	-	-	-	-	-	-	-	-
SQ4	-	-	-	-	-	0.451	-	-	-	-	-	-	-	-
SQ3	-	-	-	-	-	0.743	-	-	-	-	-	-	-	-
SQ2	-	-	-	-	-	0.701	-	-	-	-	-	-	-	-
SU1	-	-	-	-	-	-	0.792	-	-	-	-	-	-	-
SU4	-	-	-	-	-	-	0.708	-	-	-	-	-	-	-
SU5	-	-	-	-	-	-	0.557	-	-	-	-	-	-	-
IQ1	-	-	-	-	-	-	-	0.610	-	-	-	-	-	-
IQ3	-	-	-	-	-	-	-	0.772	-	-	-	-	-	-
IQ5	-	-	-	-	-	-	-	0.709	-	-	-	-	-	-
US2	-	-	-	-	-	-	-	-	0.685	-	-	-	-	-
US4	-	-	-	-	-	-	-	-	0.584	-	-	-	-	-
US6	-	-	-	-	-	-	-	-	0.790	-	-	-	-	-
IQ6	-	-	-	0.562	-	-	-	-	0.508	-	-	-	-	-
SYQ2	-	-	-	-	-	-	-	-	-	0.294	-	-	-	-
SYQ3	-	-	-	-	-	-	-	-	-	0.344	-	-	-	-
SYQ6	-	-	-	-	-	-	-	-	-	0.376	-	-	-	-
SYQ4	-	-	-	-	-	0.320	-	-	-	0.371	-	-	-	-
SYQ5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C1	-	-	-	-	-	-	-	-	-	-	0.761	-	-	-
C2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C3	-	-	-	-	-	-	-	-	-	-	0.434	-	-	-
C5	-	-	-	-	-	-	-	-	-	-	0.634	-	-	-
C6	-	-	-	-	-	-	-	-	-	-	0.824	-	-	-
CP1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CP2	-	-	-	-	-	-	-	-	-	-	-	0.551	-	-
CP4	-	-	-	-	-	-	-	-	-	-	-	0.714	-	-
CP6	-	-	-	-	-	-	-	-	-	-	-	0.872	-	-
TR1	-	-	-	-	-	-	-	-	-	-	-	-	0.610	-
TR2	-	-	-	-	-	-	-	-	-	-	-	-	0.768	-
TR3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TR4	-	-	-	-	-	-	-	-	-	-	-	-	0.684	-
TR5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TR6	-	-	-	-	-	-	-	-	-	-	-	-	0.701	-
IM1	-	-	-	-	-	-	-	-	-	-	-	-	-	0.840
IM2	-	-	-	-	-	-	-	-	-	-	-	-	-	0.380
IM3	-	-	-	-	-	-	-	-	-	-	-	-	-	0.330
IM5	-	-	-	-	-	-	-	-	-	-	-	-	-	0.801
IM6	-	-	-	-	-	-	-	-	-	-	-	-	-	0.651

EE,effort expectancy; SI,social influence; FC,facilitating conditions; BI,behavioural intention; UA,user attitude; SQ,system quality; SU,system use; IQ, information quality; US,user satisfaction; SYQ,system quality; C, communication; CP, compatibility; TR, trialability; IM, information matrix.

β = −0.317, p = 937, R^2 = 0.75), respectively. All of the hypotheses from 8 to 13 were supported. It was found that the system use (β = 0.209, $p < 0.001$, R^2 = 0.75), information quality (β = 0.557, $p < 0.001$, R^2 = 0.75), service quality (β = 0.562, $p < 0.001$, R^2 = 0.75), communication (β = 0.211, $p < 0.001$, R^2 = 0.75), compatibility (β = 0.419, $p < 0.001$,

TABLE 5: Hypothesis testing.

Hypothesis	Path			Standardised estimate	SE	CR	*p*	Decision
H1	IM	<---	EE	-0.575	0.025	0.174	0.862	Unsupported
H2	IM	<---	PE	†	†	†	†	†
H3	IM	<---	SI	-0.054	0.032	0.148	0.882	Unsupported
H4	IM	<---	FC	-0.208	0.023	0.203	0.840	Unsupported
H5	IM	<---	BI	-0.209	0.063	-5.287	*	Supported
H6	IM	<---	UA	0.480	0.019	0.331	0.741	Unsupported
H7	IM	<---	US	-0.317	0.028	0.078	0.937	Unsupported
H8	IM	<---	SU	0.209	0.029	5.363	*	Supported
H9	IM	<---	IQ	0.557	0.047	8.883	*	Supported
H10	IM	<---	SQ	0.562	0.032	6.436	*	Supported
H11	IM	<---	C	0.211	0.046	7.538	*	Supported
H12	IM	<---	CP	0.419	0.081	6.021	*	Supported
H13	IM	<---	TR	-0.020	0.090	7.437	*	Supported

IM, information matrix; EE, effort expectancy; PE, performance expectancy; SI, social influence; FC, facilitating conditions; BI, behavioural intention; UA, user attitude; US, user satisfaction; SU, system use; IQ, information quality; SQ, system quality. C, communication; CP, compatibility; TR, trialability; SE, standard error; CR, construct reliability.

*, $p < 0.001$.

†, Hypothesis dropped because of low reliability.

$R^2 = 0.75$) and trialability ($\beta = -0.020$, $p < 0.001$, $R^2 = 0.75$) variables had a significant impact on implementation of SCT. However, it should be noted that trialability had a negative impact on SCT implementation.

Discussion

This study has identified variables that contribute to the critical factor analysis for the implementation of SCT in healthcare institutions. Furthermore, the study provides insights into the body of knowledge regarding the implementation of SCT in healthcare institutions. The structural equation modelling (SEM) was based on 15 relationships of the initial variables. Information quality has a significant impact on the implementation of SCT in public healthcare, with the significant value of $p < 0.001$, $\beta = 0.557$ and $R^2 = 0.75$. Also, service quality has a significant impact on the implementation of the SCT in public healthcare, with the significant value of $p < 0.001$, $\beta = 0.562$ and $R^2 = 0.75$. The researcher found that service quality and information quality have a significant relationship towards the implementation of SCT in healthcare. The research confirms that enforcing service quality and information quality requires a stern policy to be able to implement a sound usage of the SCT. Mardani et al.[41] affirmed that regardless of whether a service is supplied by internal agencies or outsourced to third parties, policies and procedures should direct the service provider. Service quality allows for the evaluation of the quality of ICT services supplied by healthcare professionals. Although Smart Card Technology has been implemented in the banking industry for a while for clients and bankers. Such lessons can be applied to the healthcare sector for healthcare professionals and patients to deliver quality healthcare which benefit both parties. Therefore, service quality becomes relevance for the implementation of SCT in public healthcare. Thus, proper policies are needed to guide the operational mandate and quality of services of healthcare providers that will enhance the effective usage of smart card technologies.

The researcher performed an inferential statistic based on the structural equation model to test all the factors that support and have a significant effect on the implementation of SCT in the public healthcare sector. It was discovered that BI, system usage, information quality, system quality, communication, compatibility and trialability are the critical factors and variables discovered in the study that support the implementation of smart card technologies in the public healthcare as equally discovered.

The researcher strongly believes that the findings discovered in the studies solidly confirm the implementation of the HUTAUT model and the DeLone and McLean (2003) IS success model on effective system use. Notwithstanding the above researcher's works, it was deduced that there exists conformance between their studies and the findings derived from these studies. The researcher equally believes that factors such as communication, compatibility and trialability support the DoI.

Technology implementation with the focus on healthcare professionals to use in public healthcare. However, this study does not rule out the implementation in private healthcare, as the system of admission, for example, is more or less the same as public healthcare. Therefore, lessons can be drawn in both institutions of healthcare to best implement healthcare technologies. Another recommendation is that the study can be extended to include the comparison of healthcare professionals and patients by making a comparison in developed countries and less developed countries. Although smart card itself is fairly old as it has been used in the banking environment, future studies should incorporate this portion as several healthcare workers experience difficulties in the implementation of technology. The study's findings discovered that for a framework for the implementation of SCT discovered seven out of the 13 hypotheses were supported. The first hypothesis was unsupported. This suggests that EE does not have a significant impact on the implementation of SCT ($\beta = -0.575$, $p = 0.862$, $R^2 = 0.75$). The second hypothesis was dropped because of low reliability. The third and fourth hypotheses (SI and FC effect on implementation of SCT) were no supported ($\beta = -0.054$, $p = 0.882$, $R^2 = 0.75$ and $\beta = -208$, $p = 0.840$, $R^2 = 0.75$, respectively). Hypothesis 5 which states that BI has a significant impact on the implementation of SCT was supported ($\beta = -0.209$, $p < 0.001$, $R^2 = 0.75$), suggesting an inverse relationship between the two variables. Hypotheses six and seven (user attitude and user satisfaction effect on the implementation of SCT) were unsupported ($\beta = 0.480$, $p = 0.741$, $R^2 = 0.75$ and $\beta = -0.317$, $p = 937$, $R^2 = 0.75$, respectively). Hypotheses 8 through 13 were all supported. It was found that System Use ($\beta = 0.209$, $p < 0.001$, $R^2 = 0.75$), Information Quality ($\beta = 0.557$, $p < 0.001$, $R^2 = 0.75$), Service Quality ($\beta = 0.562$, $p < 0.001$, $R^2 = 0.75$), Communication ($\beta = 0.211$, $p < 0.001$, $R^2 = 0.75$), Compatibility ($\beta = 0.419$, $p < 0.001$, $R^2 = 0.75$) and Trialability ($\beta = -0.020$, $p < 0.001$, $R^2 = 0.75$) variables had a significant impact on the implementation of SCT. In the end, the findings of this study noted that the effect of trialability on implementation is negative.

The research did not compromise patients' privacy, but a series of ethical considerations was considered, such as the handling of confidentiality of patient data that is necessary to collect. Another area in the study was keeping confidential information about participants by keeping the questionnaire answers highly anonymous. The researchers must protect the respondents by paying attention to the rights, keeping ethical issues checked and protecting the integrity of the data collected.[57] Lastly, ethically related questions were credible to the research work at hand and authenticated, if need be.

Limitations of the study

As this study was cross-sectional, it was unable to conclude causation. In addition, the COVID-19 pandemic was very high during the collection of data, and not all healthcare professionals in the identified hospitals were able to complete the questionnaire survey. In conclusion, it is required for management to support the healthcare professionals at all costs to avoid workloads that will hamper the delivery of healthcare services. Further studies need to evaluate the usability of technology in the Tshwane hospitals.

Future works

In this study, the use of the TAM as a framework would be recommended to measure the level of adoption and the impact use of SCT in public healthcare.

Conclusion

This study investigated the adoption of SCT in public healthcare and provided recommendations through its analysis performed. The study provides an insight for understanding the used models and theories selected, such as the modified HUTAUT model, the Delone and McLean model and DoI theory, which are all valid in this type of analysis. As previously stated, intriguing departures from the model were discovered and justified. Using relevant literature, these was explained fully. In this study, descriptive statistics presented the mean, median, mode, standard deviation and variance of the data. Furthermore, descriptive statistic shows the age of the respondents, and the graphs of gender distribution among the respondents were tested. Finally, SEM was applied to the data. The research found that seven hypotheses (BI, system use, system quality, information quality, communication, compatibility and trialability) were supported for the study. On the other hand, the PE hypothesis was not dropped because of low reliability, and five hypotheses (EE, SI, FC, user satisfaction and user attitude) were therefore not supported for the study. Therefore, this study will help to develop more relevant technology in public healthcare.

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Competing interests

The author has declared that no competing interests exist.

Authors' contributions

L. Malungana conceptualized the idea and wrote the first draft of the article. L. Motsi reviewed the first and final drafts of the article.

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Data availability

Data used in this study will be made available upon reasonable request to the author.

Disclaimer

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