A Structural Equation Model for implementation of Smart Card Technology in public healthcare

Lario Malungana  
UNISA, lario.lalie@gmail.com

Lovemore Motsi  
UNISA, motsil@unisa.ac.za

Follow this and additional works at: https://digitalcommons.kennesaw.edu/acist

Part of the Health Information Technology Commons


This Event is brought to you for free and open access by the Conferences, Workshops, and Lectures at DigitalCommons@Kennesaw State University. It has been accepted for inclusion in African Conference on Information Systems and Technology by an authorized administrator of DigitalCommons@Kennesaw State University. For more information, please contact digitalcommons@kennesaw.edu.
A Structural Equation Model for implementation of Smart Card Technology in public healthcare

Lario Malungana, College of Science, Engineering and Technology, University of South Africa, 
33904464@mylife.unisa.ac.za, Lario.lalie@gmail.com

Lovemore Motsi, College of Science, Engineering and Technology, University of South Africa, 
MotsiL@unisa.ac.za

ABSTRACT

The improvement of health care, efficiency, safety, and quality of delivery and access for patients is highly portrays a rather significant increase in public healthcare. The emergence of this proliferation of healthcare technology is then expected to grow. The researcher seeks to investigate the factors that influence the implementation of SCT in SA public healthcare institutions. A quantitative research method approach was used. Respondents were selected using the purposive sampling method. Using a self-administered questionnaire completed by 406 healthcare professionals from Steve Biko academic hospital, Tshwane District hospital, Kalafong hospital and Pretoria West Hospital were analysed. The structural equation modeling (SEM) and principal component analysis (PCA) methods in statistical package for social sciences (SPSS) were used to analyse the data. The factor analysis in this study used 15 variables were used for the conceptual framework. The study recommends that a framework for the implementation of SCT be developed in public healthcare.

Keywords
Smart Card Technology, Healthcare, Structural Equation Modeling

INTRODUCTION

The developments in South Africa’s public health system have resulted in the rapid application of technology in a variety of fields in the public health sector. Information and communication technology (ICTs) have been used in healthcare as new development to alleviate the burden on the delivery of affordable patient healthcare (Sezgin & Özkan-Yıldırım, 2016). As a result, the eHealth strategy is posing a serious threat to the South African healthcare system (Dehling & Sunyaev, 2014). The South African government recently passed the National Health Insurance Bill (NHI), which aims to improve the quality of healthcare (Minister, Phaahla, Society & Everyone, 2019). Emerging developments like the Internet of Things (IoT) and the Fourth Industrial Revolution (4IR) are helping to accelerate the use of Smart Card Technology (SCT) in the healthcare sector (Peters, 2017). Studies conducted in various developing countries such as Rwanda, Ethiopia, and Botswana reported that the use of ICTs in healthcare
delivery leads to better healthcare facilities (Shaltoni, Abdullah, 2015; Chauhan, Agarwal & Kar, 2016; Nzuki & Mugo, 2014). Furthermore, for some years now, the idea of having a complete medical record on smart card-based technology has been studied (Smart Cards and Healthcare Providers, 2013). More than a decade ago, countries like Hungary, France, and Spain developed computer systems that could store medical histories on a smart card (SC) (Hussain et al., 2016). The United States of America, on the other hand, has yet to implement such a system on a nationwide scale.

Asemahagn (2017) established that manual data input at Nairobi hospitals was prone to human mistakes. In addition, there was a pressing need for IoT adoption to address issues like these. Poor record-keeping creates unnecessary delays for patients, according to Adebayo & Ofoegbu, (2014). Patients’ folders go missing or are misplaced from time to time, and instead of informing the patient, healthcare personnel simply let the patient wait. Worst-case scenario, the patient’s medical history is lost, which can lead to additional issues, including wrong diagnosis and, in rare cases, death (Sethia, Gupta & Saran 2019). Also, South Africa has the potential to improve the delivery of healthcare services while also enhancing efficiency and lowering the costs of manual systems currently in use. According to Qureshi & Shah (2015), countries such as Saudi Arabia are using smart cards in healthcare to improve their healthcare systems. However, healthcare technologies remain a problem in developing countries such as Ethiopia, Malawi, Zambia, Zimbabwe, and Swaziland, resulting in poor healthcare delivery (Nyasulu & Chawinga, 2018). In South Africa, there has been no scholarly research on the use of Smart Card Technology to provide healthcare to patients and sharing benefits among healthcare professionals (nurses). As a result, it has been noted that a new study for developing a framework for SCT in public healthcare for professionals should be carried out. Furthermore, the importance of strengthening security, traceability, a healthcare professional’s previous history or recorded activities on patient treatment, and the quality of service provided by the healthcare delivery system should be acknowledged.

In this study, three theories have been applied, the Healthcare Unified Theory of Acceptance of User Technology Model (HUTAUT) (2018), the DeLone and McLean IS Success Model (2003), and the Diffusion of Innovation Theory (DoI) (2003). The study addresses a fragmented view of the factors affecting the implementation of SCT in public healthcare. However, when integrated, the theories provide a considerable and much more interesting perspective on the viewpoint of the phenomenon. The potential user of any given SCT will undoubtedly assess the possible benefits and losses before going through the various steps described in the sequential model. Along the way, he or she will be subjected to pressure from individuals inside and outside the organization. This study attempts to address the research gap by first focusing on the development of a theoretical framework for the implementation of Smart Card Technology (SCT) in public healthcare in South Africa.

**BACKGROUND**

Delivery of quality health care is a constitutional obligation in South Africa. As a result, the government implemented numerous programs to improve health care, efficiency, safety, and quality of delivery and access for all users. Despite the government's efforts to improve the quality-of-service delivery in healthcare settings, media, and community. Department of Health reports in 2014 revealed that services in public health institutions were still falling short of fundamental care requirements and patient expectations (Health, 2019). Many of the problems in the South African healthcare system can be traced back to the apartheid period (1948–1993) in which the healthcare system was highly fragmented, with discriminatory effects, between four different racial groups (black, mixed-race, Indian, and white). To make this situation worse, the apartheid regime created ten Bantustans (so-called ethnic homelands) into which Africans were forced to live. There was a health department in each of them, as well as professional groups. Due to a lack of funding, health system delivery deteriorated, and impoverished populations were disproportionately affected. Huge efforts have been made to improve the quality of healthcare delivery in South Africa since the 1994 elections, but several issues have been raised by the public regarding public institutions. Healthcare professionals are frequently cited in the media as being unable to provide timely and efficient healthcare
services, in part due to poor records administration. As a result of the inability to recover documents or the loss of medical files, patients must wait a long time to be helped. In such instances, healthcare professionals are unable to assist patients.

Despite the value of the medical records, frequent mismanagement still exist, preventing healthcare professionals from accessing information regarding earlier diagnoses, treatments, and prescriptions. In addition, these medical records can be lost permanently if they are not properly managed. According to the Department of Health (DoH) and Human Services (2006), one out of every seven files in healthcare institutions in the United States is missing. Furthermore, medical records are particularly significant in hospitals because they are required for the verification of background information (Marutha & Ngoepe, 2017). Medical errors may be avoided if clinicians have access to and the competence to apply clinical informatics successfully, according to (Babalola, Idowu, Ademolu, Olukunle, & Rahman, 2020). As a result, medical doctors in South Africa admitted to making medical errors due to a lack of access to and use of clinical informatics in the administration of drugs to patients.

Information and Communication Technology (ICT) strategies appear to be one of the vital core elements in operations and improving healthcare delivery throughout the world. In addition, ICT has been used as a tool to deliver quality products, decisions making, and maintain customer loyalty by many organizations. Patient's access to health records has been advocated with legal support to actualize this right. Patients, on the other hand, would like to see their medical records. Access to personal information contained in medical records was experienced by respondents to lead to a perceived increase in knowledge about the clinical conditions and enhanced the sense of control of care. Smart Card Technology (SCT) in healthcare can help to minimize wait times and complaints among healthcare personnel (Yarbrough & Smith, 2007). Whereas complaints seem valid to citizens, the role of healthcare professionals may not be clear due to the amount of work healthcare professionals are going through daily since they have to adopt new technologies.

Bandyopadhyay and Sen (2018) state the use of Smart Cards and the introduction of a related back-end system should be mitigated to facilitate better access to healthcare. Several challenges may exist which require the use of technology properly whilst continuously monitoring and evaluating the healthcare professionals to comply with the new technology to efficiently deliver healthcare services (Nilsen, Stendal and Gullslett, 2020). In most countries where the implementation of Smart Cards was successful, interaction and relationship management were required between the implementors and management to encourage full cooperation of the parties involved through the development of an enabling theoretical framework for the benefit of both the patients and health care professionals in South Africa.

**PROBLEM STATEMENT SMART CARD TECHNOLOGY**

Hussain, Ariyachandra and Frolick (2016), confirmed the use of various information systems within public healthcare has become a challenge that affects its efficiency and effectiveness. Various factors need to be considered when implementing technology systems. Marufu & Maboe (2017) indicated that healthcare information systems become more sophisticated as a result, they must be built to support the demands of patients and healthcare professionals. Over 500 000 patients have registered in the City of Johannesburg’s electronic health record system known as eHealth@Joburg. This system is also referred to as e-health. Furthermore, the Department of Health (South Africa) has postponed the implementation of the Smart Card because not all eHealth system implementations have been acknowledged. However, other metro municipalities struggle to implement eHealth technologies such as Smart Card Technology (Nilsen, Stendal and Gullslett, 2020). For example, China effectively implemented smart health by addressing infrastructure, pharmaceutical availability, and other healthcare personnel skills.
According to Hung, Tsai and Chuang (2014), the quality of services offered by healthcare professionals has an impact on the provision of basic healthcare (nurses). Healthcare services continue to be harmed as a result of a lack of sufficient health skills and drugs, which could lead to a delay in the implementation of SCT. In addition, healthcare professionals in South Africa must register with the South African Nursing Council to practice after obtaining their degrees. Ayodele (2011) states that the cost of implementing hospital information systems in low- and middle-income countries is often prohibitive. As a result, significant finance is required for the system’s successful completion. Some countries have very rudimentary approaches to data storage and retrieval (Kushniruk et al., 2013). This is evidenced by the existence of various healthcare facilities that offer these services. (Renuka, Kumari and Li (2019) found that, while health information technology offers numerous benefits, it also has many drawbacks, such as a lack of transparency in the management of prescription errors. Medication documentation errors in patients can be a major source of adverse drug reactions. To conservative paper files, providing great healthcare and access to data through the SCT is essential since it saves time. 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 clinical control of information and quality care of health services by the Department of Health in 2012. In addition, the National Digital Health Strategy for South Africa, 2019-2024, was developed in collaboration with other government departments. The aim was to strengthen digital health governance structures, create robust integrated platforms for the development of information systems, and establish the necessary broadband network infrastructure (Health, 2019). The objective of this research, as previously stated, is to develop a theoretical framework for the implementation of Smart Card Technology (SCT) in South African public healthcare. The study will shed light on further factors that influence healthcare professionals' use of smart cards to improve delivery services in the public sector.

SMART CARD TECHNOLOGY (SCT)

A smart card is a device that has an embedded integrated circuit, a secure microcontroller or equivalent intelligence, and internal memory or a single memory chip with no other functionality (Ray et al., 2020). In the current study, figure 1 below illustrates Smart Card Technology which is used as a tool for authentication mechanisms (Yeh, Lo, Wu, Yang & Liaw, 2012). A smart card also has built-in computer chip memory, or a microprocessor, that allows it to process or store data.

In Germany, for example, the electronic health card was introduced as the basis of the eHealth infrastructure (Wirtz, Mory & Ullrich, 2012). According to Barbosa, Takako and Sadok (2020), there are challenges in interfacing with human users and other systems. However, the lack of data support and confidentiality leads to authenticity (Keliris,
ISO/IEC 7816 is the main document that specifies standards for the physical properties of contact smart cards (Ivanović & Raković, 2019). Similarly, ISO/IEC 14443 and ISO/IEC 15693 also define standards for contactless smart cards.

Smart cards come complete with an operating system stored on the chip’s read-only memory (ROM). The operating system is used for each application, the available Random-Access-Memory (RAM) and Electrically-Erasable-Programmable-Read-Only-Memory (EEPROM) for the implementation and execution of the standard pre-programmed instruction set (Keliris et al., 2013).

As shown in figure 2, SCT is a tool composed of hardware and software (Alam & Ali, 2016). The hardware for SC consists of a reader and a chip. In healthcare, professionals are the main users of the SCT tool. Every health professional has a terminal (Kawthankar, Joshi, Ansari & Dmonte, 2018). Most SCs contain client software components that may depend entirely on the database server and associated databases (Usman, Madu & Alkali, 2019). Instead of leaving the dependency problem, an additional control structure can be added to manage queries.

Model View & Controller (MVC) is a software design pattern used to develop a user interface. Also, components communicate with the device data model through a controller mechanism in the MVC pattern (Kardas & Tunali, 2006). Thus, user interfaces such as forms and associated dialogs are found as an independent relational database stored in the SCT data model.

THEORETICAL FRAMEWORK

This study will provide different contexts and methods to measure different variables with different models. This research draws on all three models, namely the Healthcare Unified Theory of Acceptance of User Technology Model (HUTAUT) (2018), the DeLone and McLean IS Success Model (2003), and the Diffusion of Innovation Theory (DoI) (2003). The objective of this study aims to develop a framework for the effective implementation of Smart Card Technology in the South African public healthcare sector. The following sub-objectives will address the main objective of the study. As a result, it will determine variables and related factors that affect the adoption of the SCT implementation within public healthcare. This study will further develop an accurate information quality that influences the SCT implementation in public healthcare and determine if these variables can be used to develop a conceptual framework for the implementation of SCT in public healthcare.

Based on the Figure. 3 of the research model below, the following hypothesis is to be tested in this study
H1  Effort Expectancy is expected to have a positive effect on the implementation of SCT in healthcare.
H2  Performance Expectancy (PE) is expected to have a positive effect on the implementation of SCT in healthcare.
H3  Social Influence is expected to have a positive effect on the implementation of SCT in healthcare.
H4  Facilitating Conditions is expected to have a positive effect on the behavioral intention to implement SCT in healthcare.
H5  Behavioural intention is expected to have a positive effect implementation of SCT in healthcare.
H6  User Attitude has a positive effect on the implementation of SCT in healthcare.
H7  User satisfaction has a positive effect on the implementation of SCT in healthcare.
H8  System use has a positive influence on Smart Card Technology implementation in healthcare.
H9  Information quality is expected to have a positive effect on user satisfaction to implement SCT in healthcare.
H10 Systems quality has a positive effect on the implementation of SCT in healthcare.
H11 Service Quality is expected to have a positive effect on user satisfaction to implement SCT in healthcare.
H12 Communication is expected to have a positive effect on the implementation of SCT in healthcare.
H13 Compatibility is expected to have a positive effect on the implementation of SCT in healthcare.
H14 Trialability is expected to have a positive effect on the implementation of SCT in healthcare.
H15 Implementation of Smart Card Technology has a positive influence on healthcare.

METHODOLOGY

This study used the quantitative-based method, the target group of respondents were healthcare professionals (nurses). In this research, the identified theories surrounding the problem concerning the implementation of Smart Card Technology were identified. A total of four hundred and six (406) questionnaires were self-administered and completed from Steve Biko Academic hospital, Tshwane District hospital, Kalafong hospital, and Pretoria West hospital which were analysed. The respondents were selected using the purposive sampling method. During the phase of the pilot study, a total of 50 respondents from the Steve Biko Academic hospital participated. The objective of the pilot study was to determine the clarity, comprehensiveness, and appropriateness of the questions which were designed. Cronbach’s alpha-based test was carried out to identify the reliability of the constructs. Constructs that had a weak value were dropped from the proposed research model.

Measurements Items

Based on the outcome of the study, the following constructs were considered in the possibility of the development of a framework for the implementation of SCT in public healthcare: Seven of the thirteen (13) hypotheses were supported by the model. The first hypothesis (H1) was not supported. Six items for Effort Expectancy (EE1) namely, my interaction with the SCT would likely be clear and understandable, I believe it would be easy for me to become skillful at using the SCT, I believe I would find the SCT easy to use, learning to operate the SCT is easy for me, the smart card is not technically complicated, and I can delete the previous history in the smart card. For Performance Expectancy (PE2) the items were asked for management measurement on staff performance, I believe the smart...
card is user-friendly, there is a high speed of internet service which will enable the implementation of SCT, and technical issues are addressed within 24 hours. Systems already integrated, and the viability of user systems manuals will improve system performance. Social Influence (SU3) used the following items Healthcare professionals are who are important should use the SCT to update the information, Healthcare professionals think they understand the use of the SCT. I think healthcare professionals will use the SCT. Using the SCT will influence the usage of technology in healthcare. SCT usage improves the image out there for healthcare professionals and SCT usage improves the quality of work provided to patients. Facilitating conditions (FC4) measured items were: ICT departments are available to aid healthcare professionals about the SCT. Is there available infrastructure to support the use of SCT. In case the system downtime is there a backup plan to assist the healthcare professionals. Are all connectivity issues fully addressed for SCT usage, does the hospital have available resources to access training for SCT usage and Are there enough working tools to assist the healthcare professionals with the usage of SCT.

Behavioural intention (BI5) had the following items I think other doctors can use the smart card, I will keep using the SCT, I believe other hospitals can use the smart card. I others excited too about using the smart card, and I am aware of the easy ways in using the SCT and I am willing to use SCT if the features are easy. User Attitude (UA6) measured the items: I will use smart card technology if the system is not difficult to use, Healthcare Professionals understand the SCT better, learning to operate the smart card technology, performing tasks is straightforward, correction of errors and the patient’s history is available and visible.

Service quality (SQ7) was measured by the response time offered by ICT is available, do the ICT department keep the users/healthcare professionals informed of downtime, whether ICT is willing to solve problems related to connectivity, there is enough knowledge and understanding about SCT, available for convenient hours such as 24 hours and sufficient resources to assist the healthcare professionals all the time. The other construct is System Use (SU8) with the following questions SCT is easy to use, SCT is easy to be found from the website. I find it easy to get any information related to healthcare, using SCT does not require a lot of effort and the SCT does not frustrate my work and SCT is easily situated on the website. Information quality (IQ9) construct had the following items information loaded in the SCT is accurate, SCT information is reliable and useful for reporting, patients provide relevant quality information to be loaded in SCT, SCT is easy to understand, the information provided in the SCT is easy to be used by other healthcare professionals and the information loaded into the SCT meets the requirements for healthcare. User Satisfaction (US10) measured the following items the overall quality of SCT is better, I prefer assessing healthcare information using the SCT, I prefer accessing information loaded in the SCT for assistance, using SCT to obtain patient information is adequate for healthcare assistance, I will continue using the SCT in healthcare and the overall expectation with the SCT is helpful. System Quality (SQ11) measured, the Department of Health supports the SCT, and the Department of Health website advertised the SCT to the public for easy to learn, I find it easy to access the SCT, using the Department of Health website does not require a lot of efforts, using the Department of Health website is not often frustrating and the Department of Health is easy to use.

The communication (Comm12) measured items I believe all communication processes for Smart cards are available to improve information delivery services, I believe regular training through seminars; open days enhance the easier implementation of smart technology and hence improve healthcare service delivery, I believe top management's commitment to staff development will enable SCT implementation, I believe regular training through seminars; open days enhance the easier implementation of smart technology and hence improve healthcare service delivery, I feel before the implementation of SCT, users must receive sufficient computer literacy and other IT related communication and I understand that fair communication is addressed with all healthcare professionals. Compatibility (Compa13) measured I believe management's decision will implement smart technology will influence staff to use technology, I believe all I systems managers should be involved in the implementation of smart card technology, I expect Stakeholder engagements to address issues, I believe management must listen to all the healthcare professional’s thoughts and feelings about the smart card technology, I believe All issues regarding the smart card decisions have been settled and provision of wide solutions in place and I believe Decision making an impact on smart card usage for healthcare professionals. Trialability (Tri14) measured the following items I believe the experience of using the SCT will be exciting, If implemented, I want to be the first one to use the Smart Card technology, and I am aware of the limited time regarding operational learning, and I believe the adoption of the smart cards will be very easy, I will attend the trial sessions to understand how the system works and I understand.
that smart card technology is an innovation. Implementation of Smart Card (IMPSCT15) had the following items: I believe the implementation of Smart card technology in healthcare requires all bodies, I am aware of communication awareness of smart card usage, I believe user satisfaction is measured for smart card, I believe smart card implementation will improve the quality of healthcare and I am aware that documentation will not be lost after the smart card implementation.

Figure 3: Final SCT Implementation Framework

**Research Design**
To answer research questions and test stated research hypotheses, the study will employ an explanatory design. To achieve the strategic goals of the study, structured questionnaires were distributed through online and physically to the healthcare professionals. Many studies have employed this strategy in the past, and it has been determined to be an appropriate design for cause-effect relationship studies (Jewer, 2018)

**Research Approach**
In this study, quantitative research methods was used. The information gathered through Likert Scale questionnaires was transformed into a dataset that can be evaluated using quantitative models like correlation and linear multiple regression analysis. Obtaining a huge number of responses from Steve Biko academic hospital, Tshwane District hospital, Kalafong hospital and Pretoria West Hospital. This study, was limited to quantitative technique only. This is due to COVID-19 pandemic as data was collected from that time using the online survey.
Target Population and Sample Selection

The target population of this study is hospitals, out 31 hospitals found in Gauteng province, the study was limited to only four. Tshwane, however, there are seven hospitals, including one academic hospital (Steve Biko Academic Hospital), two district hospitals (Pretoria West Hospital and Tshwane District Hospital), and one tertiary hospital (Kalafong Hospital). It should be noted that the province has a mix of academic and district hospitals as well as municipal clinics. For the benefit of this study, the focus was only on healthcare professionals who work at the four identified hospitals.

Healthcare professionals were always busy due to the influx of patients in hospitals. Therefore, it was practically impossible to engage them to fill out a questionnaire at the workplace due to issues such as the COVID-19 pandemic. Furthermore, the data collection in this study was structured and used a self-administered questionnaire for the identified hospitals. The researcher will choose a sample size from the target population that is large enough to be representative of the entire population of study subjects on his or her initiative. Furthermore, the purposive sampling technique was used.

RESULTS AND FINDINGS

Descriptive analysis

The influence factors for SCT usage used descriptive statistics which included the mean, minimum, maximum, and skewness values used to analyze. It also considers the distribution of the data collected. The middle of the available range is represented by the mean value. Skewness is a measure of asymmetry in a set of statistical data from the normal distribution. Skewness is classified into two types: negative and positive (Pallant, 2020). Table 1 below summarizes the results of the descriptive statistics extracted from SPSS.

Table 1 Construct Descriptive Statistics

<table>
<thead>
<tr>
<th>Construct</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort Expectancy</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.540</td>
</tr>
<tr>
<td>Performance Expectancy</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>0.308</td>
</tr>
<tr>
<td>Social Influence</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.282</td>
</tr>
<tr>
<td>Facilitating Conditions</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.196</td>
</tr>
<tr>
<td>Behavioural Intention</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.222</td>
</tr>
<tr>
<td>User Attitude</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.477</td>
</tr>
<tr>
<td>Service Quality</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.003</td>
</tr>
<tr>
<td>System Use</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.156</td>
</tr>
<tr>
<td>Information Quality</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.250</td>
</tr>
<tr>
<td>User Satisfaction</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>-0.162</td>
</tr>
<tr>
<td>System Quality</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>-0.015</td>
</tr>
</tbody>
</table>
The results show that all factors except for system quality had a minimum of 2, which represents disagreement. This suggests that while system quality was the only element with at least one respondent strongly disagreeing regarding its importance in the implementation of SCT in health care institutions, none of the respondents strongly disagreed with the rest of the questions. In terms of maximum value, all factors had a maximum value of 5, which indicates that they strongly agree. This means that all factors had at least one respondent who strongly agreed with the role that these factors play in the implementation of SCT. These minimum and maximum statistics indicate that the majority of respondents agreed or strongly agreed to the questions about the role of each factor in the implementation of SCT; however, the mean and skewness statistics must be interpreted to be more confident in this conclusion.

Table 1 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 agree and strongly agree with the questions asked about the role of each factor in the implementation of SCT in healthcare institutions. To further cement this conclusion skewness statistics were analyzed and the results in Table 1 have a negative skewness score, indicating that most of their data points are aligned to the right side of the mean value (the side with agreeing and strongly agree). This means that for these factors majority of the respondents agreed and strongly agreed with the questions asked about the role they play in 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 agree or strongly agree and those who disagree or strongly disagree. Furthermore, there could be more respondents who are neutral to the questions asked about the role of communication and service quality in the implementation of SCT. Performance expectancy had a high positive skewness value of 0.308, meaning that most respondents disagree and strongly disagree with the questions asked about its role in the implementation of SCT in healthcare institutions. Negative skewness was highest for effort expectancy (-0.54), followed by user attitude, social influence, information quality, behavioural intention, and SCT implementation (-0.477, -0.282, -0.250, -0.222, and -0.213, respectively). The least negative skewness values are -0.015 and -0.056, respectively, for system quality and trialability. In summary, respondents agree or strongly agree that the factors investigated in this study play a role in the implementation of SCT in healthcare institutions.

### Reliability

In 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 is reliable or not. This was done using different data themes applied such as expectancy level, usability, communication, and trialability were applied. The corrected item-total correlation (cut-off 0.50: Hair et al., 2014). In this study, the reliability or accuracy of the questionnaire was tested using SPSS Cronbach's Alpha (α), also known as the alpha coefficient. Cronbach's Alpha is a number ranging from 0 to 1 (Pallant, 2020). Acceptable Cronbach's alpha values range from 0.70 to 1.0 (Pallant, 2020); a low alpha value could be because of a low number of questions, poor interrelatedness between items, or heterogeneous constructs. When the Cronbach alpha value is greater than 0.7, it indicates that the research instrument or construct is reliable (Pallant, 2020). Table
2. 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 suggested by Pallant (2020); therefore, the research instrument was deemed reliable.

### Table 2: Reliability Analysis

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>Cronbach's Alpha Based on Standardized Items</th>
<th>N of Items</th>
<th>Acceptance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>.929</td>
<td>.927</td>
<td>97</td>
<td>Good</td>
</tr>
</tbody>
</table>

## Structural Equation Modeling (SEM)

Confirmatory factor analysis was run in AMOS 23.0, using the maximum likelihood estimation. This is to confirm the components or variables concluded after the exploratory factor analysis. According to Arbuckle (2013), factor loadings with critical ratios (CR) above 1.96 are significant at the 0.5 level and show a reasonable fit to the data. The CFA indicated that the critical ratios are significant because they are all above 1.96. Results from the CFA showcase the factor loadings and their corresponding ratios. After the removal was done the final CFA model was run. The model showed acceptable indices: x²= 4.490, df = 3; chi sq/df = 3.163; P = 0.122; GFI = 0.955; AGFI = 0.905; CFI = 0.976; RMSEA = 0.43; PCLOSE = 0.316. The final CFA model presents 47 items and 13 variables. This demonstrates the thoroughness of the iterative process. It is important to note that the EE variable was left with two items; however, due to its theoretical significance and the content validity of the two items, it was decided that the variable is maintained. In the SCT model (figure 4), it can be noted that the factor loadings were more than 0.400 (table 3).

Following the development of the structural model, the relationships that existed between constructs were examined. The summary extract from AMOS output for the standardised significance levels obtained after running the structural model is shown in table 2. These levels depict the hypothesised relationships between the latent variables that comprise the underlying causal structure of SCT implementation. Wahab, Kadir, Tomari and Jabbar (2014) recommended that a threshold of 1.96 be obtained for the values of the critical ratio (CR) to determine the significance of the hypothesised relationship. This means that for a hypothesis to be significant or supported, its constructs must have a critical ratio value greater than 1.96; otherwise, the hypothesis is rejected. The results of the hypotheses tests are shown in table 3.

### Hypothesis Testing

The model (figure 4 and table 3) showed support for 7 out of the 13 hypotheses. The first hypothesis was unsupported. This suggests that effort expectancy does not have a significant impact on the implementation of SCT (β = -0.575, p =0.862, R² = 0.75). The second hypothesis was dropped due to low reliability. The third and fourth hypotheses [Social influence and facilitating conditions effect on implementation of SCT] were not supported (β = -0.054, p =0.882, R² = 0.75 and β = -208, p =0.840, R² = 0.75 respectively).

Hypothesis 5 which states that Behavioural Intention has a significant impact on implementation of SCT was supported (β = -0.209, p<0.001, R² = 0.75) suggesting an inverse relationship between the two variables. Hypotheses 6 and 7 [User Attitude and User Satisfaction effect on implementation of SCT] were unsupported (β = 0.480, p=0.741, R² = 0.75 and β = -0.317, p=937, R² = 0.75) respectively.

Hypotheses 8 through to 13 were all supported. It was found that System Use (β = 0.209, p<0.001, R² = 0.75), Information Quality (β = 0.557, p<0.001, R² = 0.75), Service Quality (β = 0.562, p<0.001, R² = 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 Implementation of SCT. It must be noted however, that the effect of trialability on implementation is negative.

Figure 4. SCT Implementation Structural Model
Table 3. Hypothesis Testing

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Path</th>
<th>Standardised Estimate</th>
<th>S.E.</th>
<th>C.R.</th>
<th>P</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>IM</td>
<td>&lt;-- EE</td>
<td>-0.575</td>
<td>0.025</td>
<td>0.174</td>
<td>0.862</td>
</tr>
<tr>
<td>H2</td>
<td>IM</td>
<td>&lt;-- PE</td>
<td></td>
<td></td>
<td></td>
<td><strong>Hypothesis dropped due to low reliability</strong></td>
</tr>
<tr>
<td>H3</td>
<td>IM</td>
<td>&lt;-- SI</td>
<td>-0.054</td>
<td>0.032</td>
<td>0.148</td>
<td>0.882</td>
</tr>
<tr>
<td>H4</td>
<td>IM</td>
<td>&lt;-- FC</td>
<td>-0.208</td>
<td>0.023</td>
<td>0.203</td>
<td>0.840</td>
</tr>
<tr>
<td>H5</td>
<td>IM</td>
<td>&lt;-- BI</td>
<td>-0.209</td>
<td>0.063</td>
<td>-5.287</td>
<td>***</td>
</tr>
<tr>
<td>H6</td>
<td>IM</td>
<td>&lt;-- UA</td>
<td>0.480</td>
<td>0.019</td>
<td>0.331</td>
<td>0.741</td>
</tr>
<tr>
<td>H7</td>
<td>IM</td>
<td>&lt;-- US</td>
<td>-0.317</td>
<td>0.028</td>
<td>0.078</td>
<td>0.937</td>
</tr>
<tr>
<td>H8</td>
<td>IM</td>
<td>&lt;-- SU</td>
<td>0.209</td>
<td>0.029</td>
<td>5.363</td>
<td>***</td>
</tr>
<tr>
<td>H9</td>
<td>IM</td>
<td>&lt;-- IQ</td>
<td>0.557</td>
<td>0.047</td>
<td>8.883</td>
<td>***</td>
</tr>
<tr>
<td>H10</td>
<td>IM</td>
<td>&lt;-- SQ</td>
<td>0.562</td>
<td>0.032</td>
<td>6.436</td>
<td>***</td>
</tr>
<tr>
<td>H11</td>
<td>IM</td>
<td>&lt;-- C</td>
<td>0.211</td>
<td>0.046</td>
<td>7.538</td>
<td>***</td>
</tr>
<tr>
<td>H12</td>
<td>IM</td>
<td>&lt;-- CP</td>
<td>0.419</td>
<td>0.081</td>
<td>6.021</td>
<td>***</td>
</tr>
<tr>
<td>H13</td>
<td>IM</td>
<td>&lt;-- TR</td>
<td>-0.020</td>
<td>0.090</td>
<td>7.437</td>
<td>***</td>
</tr>
</tbody>
</table>

*** = p<0.001

DISCUSSION AND ANALYSIS

Using descriptive statistics, the researcher investigated and analysed a summary of information on the distribution and central tendency of continuous variables. The influence factors for SCT usage used descriptive statistics which included the mean, minimum, maximum, and skewness values used for analysis. In addition, it understands 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 (Pallant, 2020). Skewness is classified into two types, namely negative and positive skewness (Pallant, 2020).

Two types of screening were conducted that is responses screening (which included checking for missing data and unengaged responses) and variable screening. Twenty-three (23) responses were removed from the dataset due to missing data. The missing data were more than a third of the responses that were supposed to be provided, hence, it was appropriate to remove them. Sixteen (16) other incomplete responses were identified, but, since they had only one or two missing values, they were replaced with the median (Howell, Abdelhamid, Sharman & Das, 2016a). Unengaged responses were checked. Unengaged responses refer to situations where respondents only tick a specific number throughout the questionnaire or a majority of the questions in the questionnaire (Ahmed, 2017). Thirty-six (36) responses were removed due to unengaged responses. To check for unengaged responses, the standard deviation of the responses was checked according to the rows. All rows whose standard deviations were below 0.5 were removed (Belayneh, Woldie, Berhanu & Tamiru, 2017). The normality of the data was checked using skewness and kurtosis methods as suggested by (Anwar, Noorman Masrek & Johari Abdullah Sani, 2017). The variables’ normality is acceptable when the skewness and kurtosis fall between -2 and +2. Items that violated the assumption of normality were removed (EE1, EE3, PE1, PE6, SI2, SI6, FC5, BI5, SQ1, CP5, TR2, and IM3).
The degree of approximation of repeated measurements under the same conditions is referred to as scale reliability. It is used to assess scale consistency and stability, and it can change over time and between respondents. External and internal reliability are both included in the term reliability. The former refers to the consistency of the constituents in the scale's items, while the latter pertains to inter-rater and inter-rater reliability. At this stage, the internal consistency of the scale items was assessed. In this study, the acceptable reliability coefficient is above 0.700. In this section, the reliability of all the scales is presented to demonstrate chronologically the reason for the removal of some scales and even a variable. In this section, the Item-Total statistics tables are presented including the prevailing and final reliability coefficient after some items were removed.

Factor analysis is used for determining the nature of the latent constructs that underpin the variables of interest (Finney, 2019). Factor analysis, according to Chattopadhyay (2018) 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 (Howard & Lee, 2016). Factor analysis is a data reduction technique attempts to identify a small number of variables (Chattopadhyay, 2018). 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 principal components analysis (PCA) method. PCA’s goal is to find a sequence of orthogonal factors that represent the directions of the greatest variance (Liu, Zhang, Tao, Wang & Lu, 2016). PCA 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 output was extracted and explained: correlation matrix, Kaiser-Meyer-Olkin and Bartlett’s test, Factor Extraction, and Rotated Pattern Matrix.

EFA was conducted using maximum likelihood with Promax rotation to determine if the items loaded well on the variables and correlated adequately. Maximum likelihood estimation was chosen to determine the unique variance among items and the correlation between factors. Pallant (2020) highlights that a Maximum Likelihood also provides a goodness of fit test for the factor solution. Promax was chosen due to Bartlett’s test of sphericity and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was assessed. The results revealed a KMO is 0.949 and Bartlett’s test is significant at α=0.000 with a chi-square of 20225.791, indicating the suitability of conducting exploratory factor analysis (Kaiser, 1974). Items that did not show high loadings were removed (EE4, IQ6, SYQ4, and SYQ5).

**ETHICAL CONSIDERATION**

The University of South Africa guidelines for research involving humans will be completed for ethical consideration. The researcher was granted permission from the Department of Health to conduct research in four selected hospitals. The research mostly addressed patient’s privacy and adhered to ethical considerations such as the handling of the confidentiality of patient data that needs to be collected. Furthermore, the researcher was required to keep respondents’ personal information private by making the questionnaire responses as anonymous as possible. According to Creswell (2018), researchers must protect respondents by paying attention to their rights, keeping ethical issues checked and protecting the integrity of the data collected. Lastly, ethically linked questions were found to be relevant to the research study at hand and if necessary, validated.
RESEARCH LIMITATIONS

This study expands the knowledge regarding a framework for the implementation of Smart Card Technology in public healthcare. The development of this framework will be detailed and reliable due to the validated variables in the study. Through the robust statistical techniques such as the SEM applied in the study, the analysis of data used was therefore appropriate. However, this study has attended to many issues through the desired sample of a questionnaire-based survey. There are several limitations that should be considered whilst interpreting the findings such as the limited population based on the healthcare professionals found within one district. Another limitation in this study was the challenge regarding the availability of healthcare professionals due to the covid infection rate which was being experienced during the collection of data. It was equally difficult to compare this research to previous studies conducted in the healthcare sector. For example, most studies that were conducted were focused only on patients also, in cases where studies on smart cards were conducted much focus was on its functionality such as privacy and security. The issues of privacy and security have been extensively dealt with in this study too but using the identified theories and models. Nonetheless, this demonstrates the study’s uniqueness in this region of the world.

FUTURE RESEARCH

A study conducted by FTI Consulting, (2019) found that five barriers exist to the implementation of healthcare technology such as Smart Card Implementation in the South African public healthcare. These barriers such as user resistance depend on implementation levels by healthcare professionals or management. As a result, there is averseness to move to new ways of doing things. This is a serious problem among many health professionals. Amongst others, poor governmental decisions remain a problem, such as political interest and job insecurities, and further detailed research incorporating these aspects in this area is required. This could mean that in terms of healthcare technologies such as the SCT in particular, the implementation should be explored for future studies. Additionally, although this study includes important variables, other studies could focus on variables such as resistance levels to the implementation of technologies in the African context. Furthermore, a mixed-method approach could be used to explore research factors intensely to understand the problem in more detail. Although this study focused mainly on the implementation of Smart Card Technology in healthcare in South Africa, a conceptual model could be applied by other researchers, and it could also provide a strong theoretical foundation for further studies on the implementation of Smart Card Technology in other areas based on the African context. This is due to several issues such as the availability of infrastructure and networks in some of the rural areas.

This study was about technology implementation in public healthcare with a focus on healthcare professionals. However, this study does not rule out the implementation thereof in private healthcare as the system of admission for example is more or less the same as in 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 comparing developed countries and less developed countries. Although smart cards in themselves are fairly old as it has been used in the banking environment for quite some time.

The findings for the collected data for a framework for the implementation of SCT discovered that 7 out of the 13 hypotheses were supported. The first hypothesis was unsupported. This suggests that Effort Expectancy 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 due to low reliability. The third and fourth hypotheses [Social Influence and Facilitating Conditions’ effect on implementation of SCT] were no supported ($\beta = -0.054$, $p = 0.882$, $R^2 = 0.75$ and $\beta = -0.208$, $p = 0.840$, $R^2 = 0.75$ respectively). Hypothesis 5 which states that Behavioral Intention has a significant impact on the implementation of SCT was supported ($\beta = -0.209$, $p < 0.001$, $R^2 = 0.75$), which suggests an inverse relationship.
between the two variables. Hypotheses 6 and 7 [User Attitude and User Satisfaction effect on 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 to 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 implementation of SCT. In the end, the findings of this study noted that the effect of trialability on implementation is negative. Furthermore, factors influencing the implementation of SCT in public healthcare have been explored intensively therefore, the use of structural equation modeling (SEM) for study analysis has also added more weight. In addition, the research model was examined by applying the SEM to bring robustness to the statistical technique.

**CONCLUSION**

The findings of this study addressed the critical success factors that led to the development of a framework for the implementation of Smart Card Technology in public healthcare in South Africa. Overall, the modified HUTAUT model, D & M model, and DoI theory were used as underpinning theories of this study, and the developed proposed framework was evaluated and validated using structural equation modeling. The study's conclusions were supported by a literature review. The mean, median, mode, standard deviation, and variance of the data were presented using descriptive statistics in this study. Descriptive statistics were also utilised to investigate the respondents' ages, gender, education levels, and work experience. Graphs and pie charts were used to present these variables. Finally, structural equation modeling was applied to the data. The performance expectancy hypothesis (HK), on the other hand, was dropped due to its low reliability for this study. As a result, the study's five hypotheses Effort Expectancy (H1), Social Influence (H3), Facilitating Conditions (H4), User Attitude (H6) and User Satisfaction (H7) were not supported. The framework for the implementation of Smart Card Technology in public healthcare in South Africa as shown in (Figure 6.1) was then developed by combining all of the accepted hypotheses Behavioural Intention (H5), System Use (H8), Information Quality (H9), System Quality (H10), Communication (H11), Compatibility (H12) and Trialability (H13). Further research is needed to expand this study into private healthcare and to look at the impact of the constructs that were removed from it.

**REFERENCES**


