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Evaluation of the adoption of Health Information Technology

Marina Juliana Gonçalves and Claudia Aparecida de Mattos *

Centro Universitário FEI; Av. Humberto de Alencar Castelo Branco, 3.972 - São Bernardo do Campo – SP; Brazil

***correpondente** author (Claudia Aparecida de Mattos – cmattos@fei.edu.br)

Abstract: The adoption of health information technology (HIT) has increased considerably, contributing to better communication between physicians and patients and providing technological bases for learning and institutional improvement. This type of technology brings many challenges; therefore, understanding its adoption and assimilation is important to assess its potential for engendering desirable outcomes in health management. The assimilation of health information systems should be highlighted as their importance in health organisations is now recognised as a key facilitator assisting in providing better health outcomes. Thus, this study aimed to analyse HIT adoption based on models such as Technology, Organisation and Environment (TOE), which analyses at the organisational level, with other models, such as the Technology Acceptance Model (TAM), which analyses at the individual level, and the assimilation of the adopted technologies.

Keywords: Health Information Technology; Adoption; Assimilation; Technology; Organisation and Environment; TOE; TAM

1. Introduction

According to Leslie and Paradis (2018) [1], the 2009 Affordable Care Act in the United States encouraged the use of health information technology (HIT) to achieve improved health outcomes. The rational use of technology implies selecting which technologies should be financed and identifying the conditions or subgroups in which they should be used to make the health system more efficient in protecting and restoring the health of the population, an objective linked to the concept of cost-effectiveness.

Leslie and Paradis (2018) [1] and Dobrzykowski et al. (2015) [2] emphasise that an information technology (IT) system should be used to manage the information required by health professionals to perform activities effectively and efficiently, facilitate communication, integrate information and coordinate actions among multiple members of the professional healthcare team, while also providing resources for financial and administrative support. Elliott et al. (2014) [3] and Rejeb et al. (2017) [4] argue that many health organisations consider the application of IT fundamental to improve health management.

Sulaiman and Wickramasinghe (2014) [5] and Kim et al. (2019) [6] mention that one of the aspects required for the successful adoption of IT is its assimilation. IT Assimilation is the extent to which the use of technology becomes widespread in organisational projects or work processes and routine in the activities of those projects and processes [7]. The assimilation of HIT systems should be highlighted, as their importance in health organisations is now recognised as a key facilitator to assist in providing better health outcomes. According to Sulaiman and Wickramasinghe (2014) [5], the introduction of new technologies begins with great enthusiasm, but many organisations fail to maintain the new technology, often due to gaps in the assimilation of technological innovation, as the initial acquisition of technology does not always lead to its sustained use.

Sockolow et al. (2016) [8] reported that with the increasing adoption of interactive systems in healthcare, it is necessary to ensure that the benefits of such systems are formally assessed. Traditionally quantitative research approaches have been used to gather evidence on the measurable outcomes of health technology. Qualitative approaches have also been used to analyse how or why certain interventions worked or did not work in

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specific health contexts. Sockolow et al. also mentioned that mixed methods of research provide a framework for conducting quantitative and qualitative analyses in a single study.

Lilford et al. (2014) [9] stated that it is possible to establish a relationship between IT in health organisation and cost-effectiveness to understand how the use of such technologies benefits the health sector. They also stated that it is possible to evaluate the implementation, adoption, assimilation and effectiveness of technologies as they are introduced in hospitals.

Faber et al. (2017) [10] mentioned that IT innovation in organisations, including hospitals, constitutes a decision-making process involving two parties. First, a formal adoption decision must be made by key decision makers to buy, adopt and acquire an innovative technology and to make it available to the organisation. This must be followed by decisions by local users, such as medical professionals, whether to actually use this innovation, and if so, how to use it. In this context, HIT raises many challenges, and understanding its adoption and assimilation is an important factor to leverage the potential of HIT in health management through research addressing this issue. Based on the abovementioned information, there is a gap in the literature regarding HIT assessment models.

To this end, the objective of this study was to propose a framework for evaluating HIT and integrating different adoption models, such as Technology, Organisation and Environment (TOE) and the Technology Acceptance Model (TAM), aimed at evaluating HIT at different stages: adoption, implementation and assimilation.

2. Materials and Methods

According to Sedig, Naimi and Haggerty (2017) , the adoption of HIT has grown considerably, contributing to better communication between physicians and patients and providing technological bases for learning and institutional improvement. This type of technology brings many challenges, highlighting the importance of understanding its adoption and assimilation to leverage its potential in health management.

The adoption of HIT needs rigorous assessment, which requires addressing technology-, human- and organisation-related problems (Yusof et al., 2008) . According to Baker (2011), there are numerous models of technology adoption [TOE, Theory of Planned Behaviour (TPB), Diffusion of Innovation (DOI), TAM, TAM2, Unified Theory of Acceptance and Use of Technology (UTAUT)]. These can be used to conduct analyses at both the organisational and the individual levels, as suggested by Oliveira and Martins (2011) . However, for the adoption of technology to be successful, the implementation of the system must become routine, i.e. it must become an important part of the value-chain activities. This is none other than the definition of technology assimilation (Sulaiman and Wickramasinghe, 2010) , When health technologies are adopted, their rational use can be measured through cost-effectiveness, a tool that uses both monetary and non-monetary data to aid in decision-making.

2.1. Technology Adoption Models

The study by Freedman et al. (2018) discussed the impacts related to the adoption of HIT, such as electronic medical records (EMRs). This study focused on analysing patient safety indicators and reported that EMRs reduce the likelihood of adverse events related to patient safety, particularly in less complex cases.

One way of understanding the adoption of new technologies and their critical factors is through models of IT adoption in organisations. Oliveira and Martins (2011) reported that among the many theories used in the field of information systems, the most widely used for analysing IT adoption are:

Technology, Organisation and Environment (TOE)
Theory of Planned Behaviour (TPB)
Technology Acceptance Model (TAM)
Technology Acceptance Model 2 (TAM2)
Unified Theory of Acceptance and Use of Technology (UTAUT)

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Diffusion of Innovation (DOI)

However, it must be noted that only the DOI and TOE models are intended for analyses at the organisational level, whereas others (TAM, TAM 2, TPB and UTAUT) are intended for analyses at the individual level (Oliveira and Martins, 2011) .

2.1.2. HIT Adoption Models

Angst and Agarwal (2009) stated that in the emerging context of health digitisation, electronic records constitute a significant technological advancement in the way medical information is stored, communicated and processed by the various parties involved in providing healthcare. This characteristic engenders challenges related to its adoption by healthcare organisations. Therefore, it is particularly relevant to better understand the adoption of new technologies in healthcare to enable the application of frameworks such as TOE an TAM.

According to Handayani et al. (2017) , hospital management and IT developers should have a better understanding of non-technological factors to better plan IT implementation. It is essential to involve the management to ensure that IT implementation has the desired impact and provides benefits for both the users and the hospitals.

Alkraij et al. (2016) used the TOE framework to conduct a survey in health organisations, in which 17 factors related to the adoption of HIT for healthcare-related data were identified. The results demonstrated a list of key factors related to different aspects that affect decision-making about health data standards in organisations. The technological factors include the complexity and compatibility of health data standards, IT infrastructure, uncertainties regarding costs, system integration and improved use of advanced systems. The main organisational factors include the lack of proper policies and procedures and an information management plan, resistance to change and data analysis. The main environmental factors include the lack of a national regulatroy body and a data exchange plan, the national health system and a shortage of professionals.

According to Yusof et al. (2008) , the adoption of health information systems (HIS) requires a rigorous assessment, which should address technology-, human- and organisation-related problems. Although the current evaluation methods can be used to evaluate the different aspects of HIT, there was scope for further improvement. This led to the establishment of HOT-fit, a new framework for human, organisational and technology adequacy assessment, which was developed after a critical assessment of the results of the existing HIS evaluation studies. HOT-fit is based on previous information system assessment models, mainly the IS Success Model and the IT Organisation Adjustment Model.

Research conducted by Sulaiman and Wickramasinghe (2014) addressed the importance of adoption and assimilation of HIS in a hospital. In their study, a conceptual framework for HIS was created, which was derived from a combination of previous research by those authors. It presents a systematic focus on assimilation facilitating the preservation of HIT use in hospitals. In addition, the framework also identifies the stages of assimilation and the different components of adoption—technology, organisation and environment—that act as facilitators for the successful assimilation of HIS innovation.

The assimilation of HIS is considered extremely important for the solving problems of adoption and institutionalisation of HIT in organisations. Therefore, it is necessary to explore the possibility of assimilation using a systematic approach, which will ultimately result in the good use of these systems in healthcare facilities.

Assimilation can be defined as a series of steps, starting from the initial assessment of the potential of the organisation's system to be used for its formal adoption. During this process, the implementation of the system becomes routine and an important part of value-chain activities (Sulaiman and Wickramasinghe, 2010) [5].

Much of the literature on the implementation of HIS states the need to assimilate innovation. In a study by Littlejohns, Wyatt and Garvican (2003) on the implementation of HIS in which HIT was evaluated, three-quarters of the studied systems in various hospitals were unsuccessful, without any evidence that the system actually improved the productivity of healthcare professionals. Those hospitals undoubtedly suffered an

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assimilation failure during the implementation and operation of their HIS. According to De Leeuw et al. there is no digital knowledge and hardly any formal basic digital education or training. Therefore, negative attitudes towards technology use and a lack of digital literacy contributed to people avoiding the use of HIT.

Zhu, Kraemer and Xu (2003) identified three stages of HIT assimilation—initiation, adoption and incorporation into a routine. These stages cover most aspects of the stages of assimilation of technological innovation, considering 'initiation' the first stage of the assimilation stage, followed by a stage involving the successful use of the acquired technology, and finally a stage of incorporation of the HIT into a routine, which is the last stage of the dissemination of innovation, up to a point wherein the use of the HIS becomes part of the organisation's business processes and management systems. Further, the adoption of innovation does not necessarily mean that the technology is widely used in the organisation.

Table 1 shows a compilation of the above-mentioned HIT assessment models along with a summary of their respective definitions.

Table 1. Compilation of HIT Evaluation Models.

HIT EVALUATION MODEL	REFERENCE	DEFINITION
HOT-fit	Yusof et al. (2008)	HOT-fit, devised by Yusof et al. (2008), is a structure based on human, organisational and technological adjustment, created after conducting a critical evaluation of the results of the existing HIT assessment studies.
HOTE	Marques et al. (2010)	HOTE is defined as the intersection between the HOT-fit (Yusof et al. 2008) and TOE frameworks (Tornatsky and Fleischer, 1990), with the addition of environmental context to the analysis and the evaluation of human, technological, organisational and environmental factors.
ASSIMILATION	Sulaiman e Wickramasinghe (2014)	Assimilation can be defined as a series of steps, starting from the initial assessment of the potential of the organisation's system to be used for its formal adoption. During this process, the implementation of the system becomes a routine and an important part of value-chain activities.

Starting from a review of models of technology adoption and models for assessing health technologies, an evaluation framework was elaborated that sought to combine the models discussed in the literature.

Table 2. Constructs and Variables.

THEORY	VARIABLES ANALYSED	REFERENCES
TOE	**T** - Communication infrastructure, compatibility, perceived benefit, safety, perception of cost reduction, system navigation. **O** - Involvement of senior management, financial resources, technological skills. **E** - Pressure from the competitive environment.	Tornatzky and Fleischer, 1990;
TAM	Ease of access, relationship, information quality, reliability, punctuality, compatibility, access, authorisation.	Davis, 1989; Venkatesh;
ASSIMILATION OF TECHNOLOGY	- Incorporation of the use of technology into a routine.	Sulaiman e Wickramasinghe (2014) ;

3. Materials and Methods

After reviewing multiple case studies through qualitative analysis, the present study evaluated the process of technology adoption in three hospitals in Brazil. The data were collected through semi-structured interviews conducted with hospital professionals, and documents were analysed, including reports, presentations, performance indicators, procedures and software that interfaced with the technological tools. Yin (2004) [29] reported

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that it is essential to develop a protocol for the study to establish the researcher's relationship with the environment to be researched. This protocol is more than an instrument because it contains the procedures and rules that must be followed for developing the research. Figure 3 presents the research protocol that validates the framework proposed in this study.

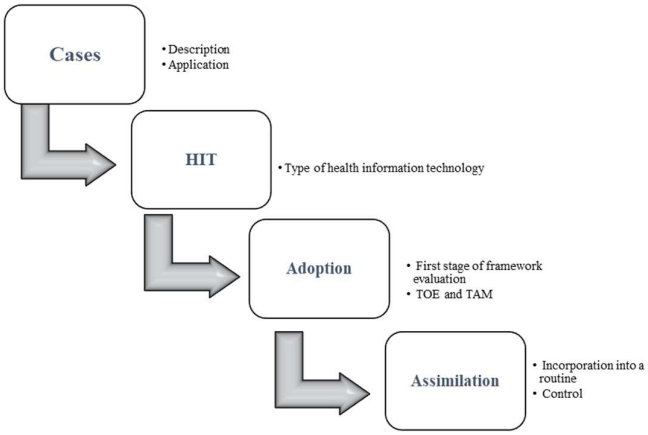

Figure 1. Research Protocol.

The adoption of HIT requires a rigorous assessment, in which technology-, human- and organisation-related factors must be addressed. Although the current assessment methods can be used to analyse different aspects of health technology, there remains scope for further improvement. In this context, the framework discussed in this study (Table 2) is proposed as a new analysis structure. The framework was evaluated in three cases to assess its applicability to the decision-making process of adopting health technology.

3.1. Cases Analysed

The first phase of the research protocol was carried out using the criteria for selecting the organisations established and supported by Hannah, Ball and Edwards (2009) .These criteria include a description of the organisation chosen for the study and the characterisation of the HIT that impacts medical procedures. The cases defined with their respective adopted technologies are presented in Table 3.

Table 3. —Profiles of the Cases.

CASE	ORGANISATION	TYPE OF HEALTH INFORMATION TECHNOLOGY
A	Public teaching hospital	Cognitive system—drug management and monitoring platform
B	Mixed public–private hospital	Cognitive system—sepsis management platform
C	Mixed public–private hospital	Cognitive system—sepsis management platform

3.2. Health Information Technology (HIT)

In the second stage of the research protocol, we attempted to understand the technologies adopted.

- Drug monitoring platform: with the data generated, drug dosages are controlled individually for each patient.
- Sepsis platform: the IT used is an artificial intelligence system that manages risks through autonomous learning and is connected in real time to the hospital's databases, systems and equipment that generate and record information.

3.3. Technology Adoption Environment (Adoption)

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In case A, the adoption of the drug monitoring platform was one of the several strategies aimed at identifying and improving care in a high-risk population. The ultimate aim was to prevent adverse events and thereby improve clinical and surgical outcomes. In cases B and C (digital sepsis platform), the reasons behind these hospitals adopting the technology were as follows: reduce mortality from sepsis, reduce costs and introduce innovation. Variables related to the technological infrastructure were discussed and aligned with the needs of the technologies adopted, but organisational issues (such as changes in processes) were seldom discussed. Nevertheless, several processes were modified. In cases B and C, technology providers acted directly in the implementation of the platform and modified several processes, but the interviews showed that these changes were not evident in the adoption process.

The second questionnaire refers to the TAM framework. It was sent to the nursing staff of the three studied hospitals. Herein, the aim was to evaluate adoption with a focus on individuals. In all cases, initially, the professionals meant to frequently use the technology had difficulties with it. The need for training and involvement of system users compromised the acceptance of the technology at an early stage in all three hospitals.

3.4. Assimilation

In case A, the assimilation process was discussed with the users of the technology (physician, anaesthesiologist, nurses and echocardiography specialist). The users emphasised how the use of drug monitoring technology became a part of the work processes and activities conducted by the team. It is of the utmost importance to highlight that the respondents mentioned the ease of use of the technology and their confidence in the information obtained from it. Additionally, the users emphasised the impact on their activities and the improvement in their work performance. The users highlighted the reduction of physical and mental effort in carrying out their activities and the usefulness of the adopted technology. When discussing the details of the technology, it was noted from the reports that assimilation can also be observed from the breadth and depth of the use of IT in the processes involved, reflecting how widely and extensively IT is used in the analysed hospitals. It was observed that during the interviews, users notice the aspects of ease of use and impact on processes (before the implementation of the drug monitoring technology, one person, an administrative assistant, was responsible for entering patient data, but with the use of the new technology, the data are now stored on a card and transferred directly to the hospital's EMR system).

In cases B and C, the benefits noted by users after the implementation of the technology were related to procedural changes, time-saving and management benefits, but when assessing the technology, the focus was on the effectiveness of the protocol.

4. Results

Based on the application of the proposed framework in cases A, B and C, it was observed that the variables of TOE, TAM and assimilation models are not taken into account in the decision-making process. These variables are discussed, but they are not acted upon in an integrated way, nor are they incorporated into a systematic assessment of the technologies. In all three cases, the interviewees discussed the impacts of these variables when questioned and described in detail the importance of each one in the assimilation of new technologies. However, when making decisions regarding the adoption of the technology, hospitals only conduct comparative effectiveness studies, highlighting randomised clinical trials.

In case A, the analysis underwent economic cost-effectiveness modelling. In cases B and C, only technical-scientific advice was assessed. According to the results obtained, the application of the framework presents adherence as a tool for evaluating HIT. Reinforcing the importance of this tool, the interviewees highlighted the need to address issues in health management that go beyond randomised trials.

Adoption and assertive assimilation are extremely important for the better use of any technologies deployed in organisations, and methods of adoption, such as TOE and TAM,

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must be understood jointly, seeking as much assimilation as possible. In line with Yusof et al. (2008) [12], the adoption of HIT requires a rigorous assessment, and it is necessary to address technology-, human- and organisation-related issues. Current evaluation methods can be used to evaluate different aspects of HIT but leave room for improvement, thereby necessitating a new structure of human, organisational and technology adequacy assessment developed after a critical analysis of the results of the HIT evaluation studies conducted so far. The TOE and TAM theoretical models, as discussed by Marques et al. (2010) [26], are presented as approaches that assist in understanding the implemented technologies, and they are useful in examining the factors that affect IT assimilation and the results obtained. Combining the models of technology adoption allows efforts to be directed toward obtaining better results from HIT investments. When applying this framework in hospitals to evaluate their adopted technologies, it was found that several points could be improved by applying a broad technology assessment framework.

In case A, it could be observed that several types of impacts on management were not incorporated into the assessment. During the interviews, organisational aspects, such as process improvement and general improvement with visual management, which impact costs, were not raised or discussed in the decision-making process. The technological aspects for the implementation of this platform were not evidenced as the monitoring system did not require any communication infrastructure. Nevertheless, other technologies that were currently analysed required an understanding of the technological aspects.

In cases B and C, the interviewees reported a lack of professionals qualified to operate the system. In other words, there were problems in academic training, which can hinder the adoption of new health technologies. This may be because medical and nursing schools do not train students to deal with new ITs.

Similarly, in case A, there was no formal health technology assessment model capable of bringing to the decision-making process a holistic view of the factors that impact the implementation and use of new technologies in healthcare.

In the cases studied, the interviewees mentioned the benefits of the visual management brought by the implemented technologies. However, this was an organisational variable that was not included in the evaluation aimed at discussing the implementation of the technology and its incorporation into a routine. It was observed that this organisational dimension was not captured in the process. Thus, when the framework proposed in this study was discussed with the professionals, it was agreed upon that the evaluation currently performed needed to be more rigorous and that it was necessary to address technology-, human- and organisation-related problems.

Cases indicated that the analyses made by the hospitals regarding the adoption of ITs cannot explain all the phenomena associated with this adoption. This is due to the complexity of the adoption processes, particularly because they involve people and interfere with their cognitive perceptions, which are not always governed by organisational interests (rather, they are affected by individual and cultural issues). On the other hand, the failure to explain all the phenomena associated with the adoption of these technologies may also be due to the strongly dynamic and evolutionary nature of ITs, which change technological paradigms very quickly and create new fields of research.

Results of an in-depth interview study showed through the application of the framework that the assessment of HITs is a multidisciplinary field with clinical, social, ethical and economic implications deriving from the development, dissemination and use of health technology, demanding models that actually assist in the evaluation of technologies while capturing this multidisciplinary nature.

5. Conclusions

Healthcare represents an important social and economic challenge faced by every country. The rising cost of healthcare, combined with the ageing and the constant growth of the population, influence health demands and dictate the need for new, more advanced scientific solutions. This requires the implementation of new health technologies that contribute to patient safety, assist in the decision-making process of physicians and support

the health management process. The effective implementation of HIT is related not only to technical complexity but also to social and organisational factors, which have a significant impact on the results. Based on the general objective of the research - to analyse HIT adoption by combining adoption models such as TOE and TAM - it was found that the models presented complement each other because analysis factors that are lacking in a given model are present in other models. Therefore an evaluation structure involving a combination of the TOE, TAM and assimilation models with a cost-effectiveness analysis can be way to improve technology management in health organisations.

One limitation of this study is the qualitative nature of the research, meaning that the results obtained cannot be generalised because the present study is based on only three cases involving the implementation of health technologies. Another limitation is the representativeness of individual speech in relation to a larger collective. In an attempt to minimise the impacts of these limitations, secondary data, project reports and contacts with technology suppliers were used to support the evaluation of the integrated models proposed in this study.

For future studies, a longitudinal study of health technology projects is suggested, applying the integrated concept of technology adoption and assimilation models, as well as a cost-effectiveness analysis, allowing the evaluation of technological tools in health management to be formalised. Future research may also focus on a quantitative study to validate the assimilation factors discussed throughout the present study. The adoption of a model combining organisational, social and technological factors, enabling a careful assessment of the benefits, risks and economic impacts of health technologies, would be fundamental in assisting decision makers about the adoption, alteration or exclusion of these technologies in their systems.

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