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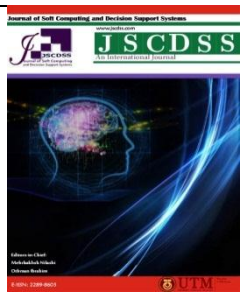

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# Prioritizing Critical Factors to Successful Adoption of Total Hospital Information System

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**Abstract**

Although the benefits of adopting Hospital Information System (HIS) innovation are well known, only a few hospitals in Malaysia have actually adopted it. Surprisingly, there is scarcity of study specifically in the context of Malaysia related to Total Hospital Information System (THIS) adoption. Therefore, the aim of this study is to provide more insight regarding the THIS adoption in the context of Malaysia and as well to explore the potential factors that are connected to the hospitals' adoption of THIS technology. To this end, this study developed a conceptual framework on the basis of Technology Organization Environment (TOE) for the adoption of THIS by Malaysian hospitals. Accordingly, a Fuzzy AHP model is developed to determine the weights of factors in the three categories for the THIS adoption. These factors are identified and compared by hospital experts and decision makers, who are fully familiar of THIS technology with also professional management and decision-making experience in the healthcare industry. Then fuzzy AHP is applied to compute the weights of incorporated factors in the THIS adoption model. This can result at fostering the uptake of HIS and facilitating its reluctant trend by improving the decision of hospitals towards THIS adoption.

Keywords: Total Hospital Information System, Hospital, TOE framework, Fuzzy AHP

## 1. Introduction

Physicians and patients today are encountering great pressures from the healthcare setting. In the perspective of physicians, their irritation is originating from heavy patient's loads, administrative tasks, and losing patient care decision control (Lee and Ramayah et al., 2012). While patients are complaining that during the medical interaction, more consideration should be provided on them (Kassirer, 2000; Sulaiman and Wickramasinghe, 2014). Therefore, there are more demanding on electronic services from patients to be given by physicians. But unfortunately, the healthcare industry has been criticized for being slow in the adoption of technology to support delivery of care (Wickramasinghe, 2000; Stegwee and Spil, 2001; Suomi, 2001; Menachemi and Burke et al., 2004; Wager and Lee et al., 2005).

In Malaysia, people are acquiring a broad range of healthcare services in a low price. But according to Lee et al. (2012), "factors like changing pattern of death causing diseases from infectious diseases to chronic diseases, population structure, lifestyle, and healthcare service expectation from the people have distorted the status quo". Furthermore, there is an increasing rate of Malaysia healthcare expense which has been occurring every year (Ahmadi et al., 2015). In this regard, there is a big pressure on Malaysia government to enhance the quality of healthcare and reduce the cost (Lee and Ramayah et al., 2012). Hence, to overcome these issues there are several projects developed by the Malaysian government with the aim of also promoting and maintaining the wellness of citizens and to provide greater access to healthcare information.

Hence, to overcome and solve such challenges, several projects have been inaugurated by the Malaysian government for the purpose of also delivering higher access to healthcare information and improving the wellness of citizens. Telemedicine is one of the domains that has been targeted for drastic improvement (Abdullah, 2008; Lee and Ramayah et al., 2012).

In addition, the Lifetime Health Plan (LHP) is amongst the four key projects which concentrate on fostering healthcare platform to permit the general hospitals to give personal LHP to the public. Under the LHP project, Hospital Information System (HIS) is introduced to commence the process of digitalization within the healthcare sector (Abidi, Goh et al., 1998; Mohd and Syed Mohamad, 2005; Ismail and Abdullah et al., 2013; Ahmadi et al., 2014a; Ahmadi et al., 2014b).

In Malaysia, three types of hospital information system introduced under the Telehealth project in Malaysia: Total Hospital Information System (THIS), Intermediate Hospital Information System (IHIS), and Basic Hospital Information System (BHIS) (Hassan, 2004; Mohan and Razali Raja Yaacob, 2004; Lee, Ramayah et al., 2012; Ismail, Abdullah et al., 2013). HIS decision applications are according to the number of beds that the particular hospital has. THIS gives an integrated system whereas BHIS is the lowest and

limited system. THIS implementation is for tertiary hospitals with over 400 beds. In Malaysia the intention of the Ministry of Health (MOH) on implementation of THIS is proven to be beneficial; even though, the task could be risky but the overall advantage of having extensive system as is priceless (Kensing, Sigurdardottir et al., 2007; Ismail, Jamil et al., 2010). However, as of now, out of thirty public tertiary level hospitals in Malaysia, 16% are fully equipped with THIS implemented and the rest are delaying in adopting the THIS technology (Sulaiman and Alias 2006; Sulaiman, 2011; Lee, Ramayah et al., 2012; Ismail, Abdullah et al., 2013; MOH-Malaysia, 2014). Hence, this indicates that THIS diffusion is still in its early stage in Malaysia and there is slow rate of adoption among tertiary hospitals.

The questions in this research are shaped as: (a) what factors significantly influence the organizational adoption of THIS? (b) what are the weights of factors that significantly influence the organizational adoption of THIS?

## 2. Literature review

### *2.1 The Malaysia healthcare context*

Malaysia is an example of a developing country that is progressing in its electronic health (e-health) initiative by having the healthcare information system placed under the government's vision 2020 plan (Mohan and Razali Raja Yaacob, 2004; Sulaiman and Wickramasinghe, 2014). The healthcare reform initiative, known as the Telemedicine Blueprint under the Multimedia Super Corridor (MSC) project, has been launched since 1997 to reform the Malaysia healthcare system (Sulaiman and Wickramasinghe, 2014). Therefore, the focus of the future healthcare system will be on people and services, where the use of technology will act as the key enabler to provide an accessible, integrated, high-quality and affordable healthcare system that is recognized as one of the world's best (Mohan and Razali Raja Yaacob, 2004).

Furthermore, according to Sulaiman (2011) and Wickramasinghe (2000), it is important for the public hospitals to perform efficiently whilst providing excellent services to the public as the revenues from general taxation have been used to subsidize health services (Chee and Barraclough, 2007). Hence, it is important to undertake the research investigating the effective strategy that can be made to foster the THIS adoption among hospital organizations. Thus, by providing the mature model associated with its potential factors makes decision makers more knowledgeable to improve the THIS adoption and take a course of action accordingly.

#### *2.1.1 Definition of Total Hospital Information System*

The Total Hospital Information System (THIS) is a computerized hospital information system aimed at providing a paperless environment (Sulaiman, 2011). The central objective of having THIS is to provide an integrated care delivery system capable of information sharing, automation of work processes, provide greater efficiency, better storage of data and use of data for relevant medical statistical or research purposes (Abdullah, 2008; Sulaiman and Wickramasinghe, 2014). Swanson (1994) classified IS innovations into three types: Type I innovations are confined to the technical tasks; Type II innovations support business administration; and Type III innovation are embedded in the core of the business. According to this typology, THIS is deemed as a Type III innovation, in a sense that THIS is embedded in firm's core business processes (making the information sharing through whole the departments) and covers all aspects of hospital's operations, both clinical and non-clinical.

### 2.1 Theoretical Foundations

Since THIS is a new technology in Malaysia tertiary hospitals and is defined as a computerized hospital information system aimed at providing a paperless environment (Sulaiman, 2011), it is fundamentally organizational innovation. Hence the organizational innovation adoption theories can be potentially useful to our proposed new THIS adoption model.

In the following, the suitable organizational IT adoption theory for this study will be discussed and justified. Subsequently, our proposed conceptual research framework explaining organizational decision to adopt THIS will be presented and demonstrated.

#### *2.1.1 Technology-Organization-Environment Framework*

To study adoption of general technological innovations, Tornatzky and Fleischer (1990) developed the TOE framework, which identifies three aspects of a firm's context that influence how it adopts and implements technological innovations; external environmental context, technological context, and organizational context. Tornatzky and Fleischer (1990) suggest that, the technology adoption that takes place at the organization-level may be influenced by factors that pertain to those contexts.

Extant research has demonstrated that the TOE framework has a broad applicability and possesses explanatory power across a number of technological, industrial, and national/cultural contexts.

TOE framework provides detailed that firm should consider when studying components that influence adoption of technological innovation.

Technological context describes both internal and external technologies relevant to the organization. In other words, this context includes existing technologies as well as the technologies to be adopted. Its main focus is on how technological characteristics can influence the adoption process (Tornatzky, Fleischer et al., 1990). The organizational context describes the characteristics of an organization that constrain or facilitate adoption of



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technological innovations. Examples of organizational characteristics include: firm size, organization structure (centralization, complexity, and formalization), top management support, the quality of human resources and the amount of slack resources available internally.

The external environmental context is the arena in which a firm conducts its business, such as the industry it belongs to, its competitors, regulations, access to resources supplied by others, and governments with which it interacts. In addition to external factors from environment, prior studies found other factors that pertain to the environmental context, including, customer readiness and vendor support. Therefore, the TOE framework is an appropriate and comprehensive theoretical guideline for studying the factors that affect organizational adoption of IT innovation. Thus, upon theoretically examining the TOE framework, it is believed that three dimensions including technology, organization, and environment are well suited and can elucidate the facilitators and inhibitors of THIS adoption.

## 3. Our conceptual research framework

Based on our theoretical foundation that in the last section was discussed, the research model for this study is proposed which is shown in Fig. 1. As it can be seen, the model posits predictors for THIS within hospital's contexts that influence its adoption: technology, organization, and environment. Factors that pertain to each context are identified based on TOE framework with an attempt on reflection to the prior HIS adoption studies. The next section articulates and justifies the identified potential factors through detail pertain to TOE context.

### *3.1 Intent to Adopt THIS*

The research model proposes the intent to adopt THIS as a dependent variable. This captures the level of intent an organization has to adopt THIS.

### *3.2 Independent Variables*

As seen in the research model, independent variables are categorized in three contexts of the TOE framework: 1) Organizational 2) Technological and 3) Environmental. As was mentioned earlier variables associated with each context was identified based on TOE framework, with respect to findings from prior HIS studies that have deployed the respective theory in the adoption context. The justification of the three contexts incorporated with respective variables in line with HIS innovation adoption studies have been provided in the following section.

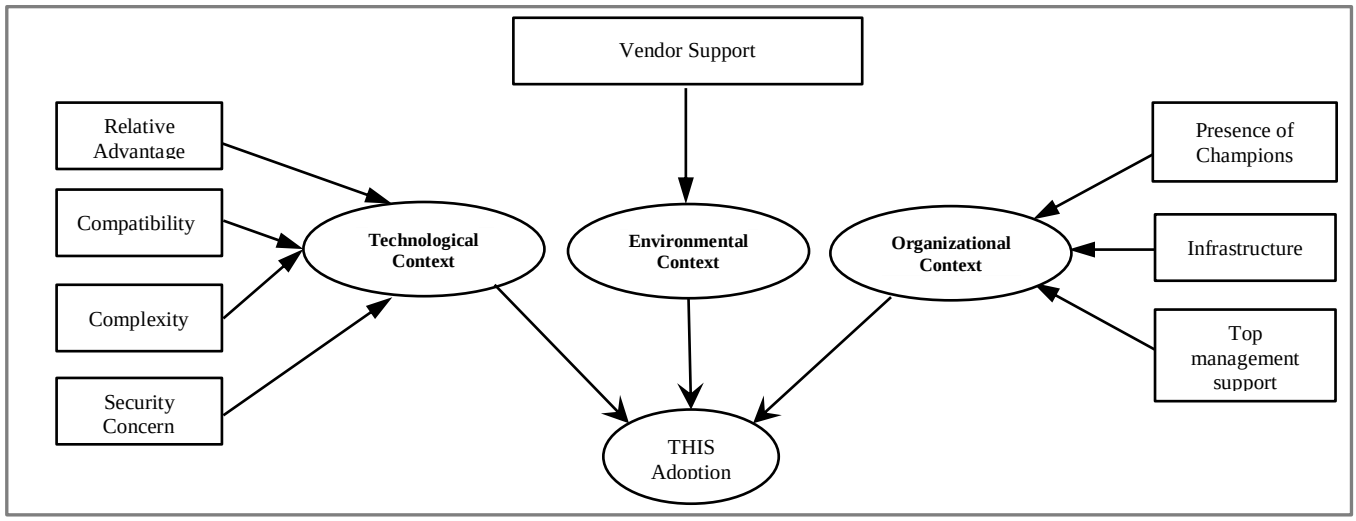


**Fig.1 .** Conceptual research framework.

#### *3.2.1 Technological context*

Technological context (Rogers Everett 1995) describes the innovation characteristics that has been used by various studies in prior IT innovation affecting the organizational adoption. In our study, four innovation characteristics have been identified in the context of THIS including relative advantage, compatibility, complexity and data security. Rogers (1995) suggests five variables regarding the innovation features which are composed of relative advantage, compatibility, complexity, observability, and trailability. Nevertheless, in an attempt by reviewing the IT innovation and more importantly by the prior HIS adoption studies, it identified only three as for relative advantage, compatibility, and complexity that are significant and frequently motivated the intention of organization to adopt the HIS. In addition to the innovation characteristics, this study added another variable as data security. In prior HIS studies, data security has been found by various researchers as a significant barrier that inhibits organization from the adoption of HIS (Soliman and Janz, 2004; Chang, Hwang et al., 2007; Lin, Lin et al., 2012; Luxton, Kayl et al., 2012; Lian, Yen et al., 2014).

#### *Relative Advantage of THIS*

Relative advantage considers the degree to which innovation is perceived as being better than its precursor (Rogers Everett 1995). Lin et al. (2012) in his study of HIS,



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emphasized that Health Level Seven (HL7) would simplify the communication interfaces and allow interoperability among the heterogeneous healthcare application. According to Chang et al. (2006), operating costs nowadays become a big concern due to increasing the competition among hospitals. Relative advantage refers to checking that the adoption of HIS can reduce hospital operating costs and obtain the relative operational benefits for a given hospital. Innovation diffusion theory suggests that the relative advantage of an innovation positively influences an organization's propensity to adopt the innovation.

Chang et al. (2006) found out that HIS improve the quality of patient care and also can increase the productivity of the hospital staff. Moreover, study conducted by Hsiao et al. (2009) concerned the Mobile Nursing Information System (MNIS) for nursing environment asserted that through the more timely dissemination of medical record and information, decision making support would be inspired and hence the quality of care is improved (Hsiao, Li et al., 2009).

*Compatibility of THIS.*

DOI theory defines compatibility as the extent to which an innovation is perceived as consistent with the values, experience and needs of potential adopters (Rogers Everett, 1995). Innovation diffusion theory suggests that compatibility of an innovation with values, experiences, and needs has a positive relationship with innovation adoption. According to Thong (1999), compatibility is an important consideration in an organization's IT innovation adoption decision, because with a high level of compatibility, the organization needs to make minimal adjustments and changes, which implies less resistance to adoption. Compatibility has been identified as the critical factor influencing organization's decision about the innovative technology adoption (Grover, 1993; Dedrick and West, 2003; Nelson and Shaw, 2003; Wongpinunwatana and Lertwongsatien, 2003). With the new technology available today, more complex systems can be designed. Powerful software tools and hardware, at lower prices, reliable networking and standards add new prospects in this field (Tachinardi, Gutierrez et al., 1993). Picture Archiving and Communication Systems (PACS), Radiology Information Systems (RIS), Clinical Information System (CIS), Laboratory Information System (LIS), Nursing Information System (NIS) and Pharmacy Information System (PHS) examples of HIS sub systems that are slowly being incorporated into fully integrated systems (Tachinardi, Gutierrez et al., 1993; Ismail, Abdullah et al., 2013). Consequently, the level of system compatibility is a key factor in the technical dimension.

*Complexity of THIS*

According to Tornatzky and Klein (1982) and Rogers (1983), complexity is the extent to which an innovation is perceived as relatively difficult to understand and use. An innovation could be considered as complex by some firms who lack associated knowledge and skill, nevertheless not complex by some firms who have the necessary knowledge and skill.

Public healthcare sector specially the hospitals has complex system and has more complex workflows than other healthcare providers (Ismail, Abdullah et al. 2013). The modern medical environment is now experiencing major transformation in its IT base with increasing in technological complexity and handling more patients with fewer resources, and resulting in higher demands on medical practitioners (Hajdukiewicz, Vicente et al., 2001). Furthermore, with respect to IT innovation studies (Grover 1993), technological innovations are generally considered complex products, possessing unfamiliar attributes to the adopting unit.

*Data Security of THIS*

Data security is one of the major concerns in adopting Information and Communication Technology (ICT) in the healthcare industry (Tyrrell, 2002; Ting, Kwok et al., 2011). According to Lin et al. (2012), medical behavior is closely related to a patient's personal life and safety, privacy, that the healthcare provider should pay special attention to information security and accuracy, striving the rule out any possible errors.

Considering the IT innovation adoption, the reliability of network and information security are key factors (Ratnasingham 1997; Soliman and Janz 2004). Study conducted by Khoumbati et al. (2006) examining the factors influencing Enterprise Application Integration (EAI) in the context of healthcare, they stated that security and confidentially are the issues that requires immediate consideration. According to the case study conducted by the Sulaiman (2011) in the tertiary hospitals of Malaysia, the level of security concern was high in HIS due to the fear of breach of patient's privacy. Luxton et al. (2012) found out that security problems are the most important issues in the context of a distribute environment; this is particularly true for hospitals because healthcare data requires a more secure environment for storage and retrieval.

*3.2.2 Organizational Context*

Characteristics of an organization would affect the technological innovation of an organization (Tornatzky, Fleischer et al. 1990). According to the TOE framework, it suggested three contexts affecting the adoption of technological innovation with regard to organizational context (Tornatzky, Fleischer et al. 1990). Based on an attempt reviewing the IT innovation adoption, three characteristics recognized as the most frequently important features of organizational context that positively influence the adoption decision process. These features are presence of champions (Zmud 1984; Beath 1991; Tan and Teo 1998; Teo, Wei et al., 2003), IS infrastructure (Teo, Lim et al., 1999; Chau and Tam 2000; Lee and Shim, 2007; Bardach, Huang et al., 2009), and top management support



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(Premkumar and Roberts, 1999; Kambil, Kamis et al., 2000; Beatty, Shim et al., 2001).

*Presence of Champions*

A champion is defined as a management level person who recognizes the usefulness of an idea to the organization and leads authorities and resources for innovation throughout its development and implementation (Meyer, 2000). This factor has been more emphasized by (Lee and Shim, 2007), studied the RFID innovation in the hospital setting. They stated that the characteristic of management who ultimately make the adoption decision is more important than any other factor in the adoption process. They found that presence of champions is the critical factor affecting the adoption of RFID.

In other hand, in prior IT innovation studies, it was consistently found that the presence of champion facilitated the adoption of a new technology by providing the necessary motivation and effort to initiate the adoption. (Beath, 1991). Hence, the existence of a champion has been found to be a significant factor in the successful adoption and implementation of IS.

*Infrastructure*

IS infrastructure refers to the existence of sophisticated telecommunication and database facilities within the firm (Grover 1993). IT innovation literature strongly proposes that any technological innovation adoption should be based on a firm's technological strengths (Rogers and Shoemaker, 1971; Maidique and Zirger, 1984; Huang, Ou et al., 2006).

IS infrastructure includes the tangible resources which includes infrastructure components such as hardware and software. According to Ross et al. (1996), with IS infrastructure the importance of a sharable platform and technology is essential for integrating systems in the organization in order to make IS applications more cost effective especially in the area of operations and support. Furthermore, increasing use of sophisticated IS infrastructure can lead to enormous advantage to clinical workflow (Bardach, Huang et al., 2009).

Public hospitals in developing countries faced some issues regarding infrastructure. According to Zhu et al. (2006), within the technological context of the firm, developing countries have less developed IS infrastructure. Ismail et al. (2013) surveyed some tertiary public hospitals throughout Malaysian context to identify the critical issues and challenges in the adoption and implementation of HIS. They found that infrastructure is one of the most critical issues in the country that need to be considered.

*Top Management Support*

Top manager's support refers to whether or not the top managers understand the nature and functions of HIS innovation and therefore fully support the development of it (Lian, Yen et al., 2014). According to recent review of IT adoption literature by Jeyaraj et al. (2006), top management support is one of the three best predictors for IT innovation adoption by organizations. In the healthcare domain and context of HIS, top management found to be crucial for the introduction of PACS (Chang, Hwang et al., 2006). They emphasized, top management support critically affects the decision for the PACS adoption.

*3.2.3 Environmental context*

According to Tornatzky and Fleischer (1990), factors that pertain to environmental context influence organizational adoption of technological innovation. By reviewing the organizational adoption of HIS studies, external environment were found that consisting of the support from the external environment (vendors) which is significant factors that affect adoption of the HIS.

*Vendor Support*

Vendor support is defined in terms of the ability of the external HIS vendor or supplier to provide support (adapted from Liu, 2011). The 1990s, brought about an increasing number of participants in the vendor community that developed various clinical applications which made healthcare products more widely available and affordable (Friede, Blum et al., 1995). Vendor support has been discovered as one of the external environmental factors (Yang, Kankanhalli et al., 2013); by taking the perspective of TOE framework, it has been empirically supported in many studies of HIS innovation the imperative positive role of vendor support in organizational adoption of HIS (Chang, Hwang et al., 2007; Hsiao, Li et al., 2009; Liu, 2011; Ismail, Abdullah et al., 2013; Sulaiman and Wickramasinghe, 2014).

## 4. Methodology

The purpose of this study is to identify, explain and evaluate the potential factors that affect hospitals adoption decision of THIS with regards to Malaysian public hospitals.

In the current study, we follow the definition of THIS according to Sulaiman (2011) as "information system aimed at providing a paperless environment that has been designed to provide numerous values to the healthcare community and indirectly provide benefits to the patients." To the best of researchers' knowledge, as of now, there are lack of studies that investigate imperative factors that can affect the adoption of THIS as of its early stage of diffusion with respect to Malaysian hospitals.

According to the definition of THIS, we confine our search to obtain the suitable research papers for our study. Hence, the papers that was not contained our THIS definition was excluded from our review analysis. To obtain a comprehensive bibliography of research papers on HIS adoption the following electronic journal databases were searched:

- Science direct
- IEEEXplore Digital Library
- SpringerLink



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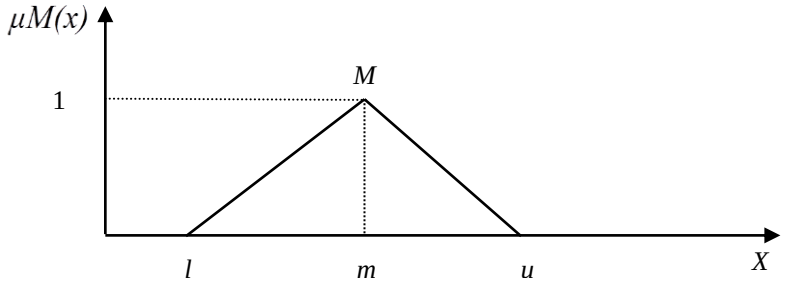
- Emerald
- ProQuest
- JSTOR
- ProQuest

After identifying the potential factors that affect hospitals adoption decision of THIS with regards to Malaysian public hospitals, we evaluate the identified factors using fuzzy AHP.

In this study, we prefer Chang's (Chang, 1996; Chang, 1992) extent analysis method because the steps of this approach are easier than the other fuzzy AHP approaches. To understand the fuzzy multi criteria methods, firstly we will explain the fuzzy logic below, then, as an example fuzzy AHP process will be defined.

### *4.1 Fuzzy Set*

In real life applications, multi attribute decision-making can face some practical problems because of the existence of vagueness and uncertainty in decision-making process. For those cases, fuzzy multi attribute decision making methods are developed to provide an easy way to deal with vague, imprecise data or knowledge. Fuzzy set is utilized to deal with vagueness and uncertainty of human thought in industry, nature and humanity ((Nilashi et al., 2014a; Nilashi et al., 2011; Nilashi et al., 2014b; Nilashi et al., 2011b; Bagherifard et al., 2014). Zadeh first introduces the fuzzy set theory in 1965. In this theory a fuzzy set M in a universe of discourse X is represented by a membership function $\mu M(x)$, which assigns to each object $x$ in $X$ a grade between [0,1]. A triangular fuzzy set can be represented by ($l$, $m$, $u$) (see Fig. 2) where $l$ indicates the lowest possible value, $m$ the middle value, and $u$ the upper possible value.




**Fig, 2.** A triangle fuzzy number M.

Thus, μ$M(x)$ can be defined the as:

$$\mu M(x)=\begin{cases}0, & x<l,\\ \dfrac{x-l}{m-l}, & l\le x\le m,\\ \dfrac{u-x}{u-m}, & m\le x\le u,\\ 0, & x\ge u,\end{cases} \quad (1)$$

### *4.2 Fuzzy AHP*

The degree of possibilities of each alternative is based on the fuzzy AHP of Changs extent analysis. According to the results of pair-wise comparisons, the corresponding triangular fuzzy numbers are replaced with the linguistic evaluations. The steps for AHP process are given in following steps (Chang, 1992).

The value of fuzzy synthetic extent with respect to the *ith* is defined as:

$$S_i=\sum_{j=1}^{m} M_{g_j}^{i} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_j}^{i}\right]^{-1} \quad (2)$$

To obtain $\sum_{j=1}^{m} M_{g_j}^{i}$, the fuzzy addition operation of $m$ extent analysis values for a particular matrix is performed such as:

$$\sum_{j=1}^{m} M_{gj}^{i}=\left(\sum_{j=1}^{m} l_j,\sum_{j=1}^{m} m_j,\sum_{j=1}^{m} u_j,\right) \quad (3)$$

.

and to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gj}^{j}\right]^{-1}$, the fuzzy addition operation of $M_{gj}^{j}$ ($j$ = 1,2, . . . , $m$) values is performed such as:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1}=\left(\frac{1}{\sum_{i=1}^{n} l_i},\frac{1}{\sum_{i=1}^{n} m_i},\frac{1}{\sum_{i=1}^{n} u_i}\right) \quad (4)$$

and then the inverse of the vector above is computed, such as:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}=\left(\sum_{i=1}^{n} l_i,\sum_{i=1}^{n} m_i,\sum_{i=1}^{n} u_i,\right) \quad (5)$$

As $M_1=(l_1,m_1,u_1)$ and $M_2=(l_2,m_2,u_2)$ are two triangular fuzzy numbers, the degree of possibility of $M_2=(l_2,m_2,u_2) \ge M_1=(l_1,m_1,u_1)$ is defined as:

$$V(M_2\ge M_1)=sup(y\ge x)[min(\mu M_1(x),\mu M_2(y))] \quad (6)$$

and can be expressed as follows:

$$V(M_2\ge M_1)=hgt(M_1\cap M_2)=\mu_{M_2}(d) \quad (7)$$



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$$= \begin{cases} 1, \text{ if } & m_2 \geq m_1 \\ 0, \text{ if } & l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2)-(m_1 - l_1)}, & otherwise \end{cases} \quad (8)$$

In Fig. 3, we can observe that d is the ordinate of the highest intersection point D between $\mu M_1$ and $\mu M_2$. To compare $M_1$ and $M_2$, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

The degree possibility for a convex fuzzy number to be greater than k convex fuzzy $M_1$(i=1,2,k) numbers can be defined by

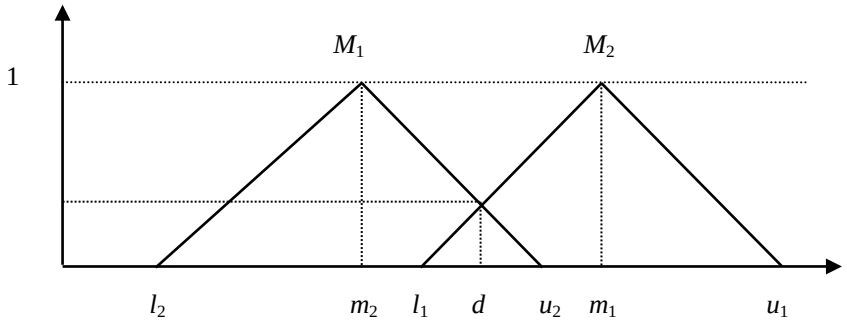


**Fig. 3.** The intersection between $M_1$ and $M_2$

Assume that

$$d(A_i) = min\, V(S_i \geq S_k) \text{ for } k = 1,2,...,n; k \neq i \quad (9)$$

Then the weight vector is given by

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T \quad (10)$$

where $A_i = (i=1,2,...,n)$ are $n$ elements.

Via normalization, the normalized weight vectors are $W = (d(A_1), d(A_2), ..., d(A_n))^T$, where $W$ is a non-fuzzy number.

### *4.3 Proposed MCDM model and evaluating the THIS adoption factors*

Multi-criteria decision making (MCDM) is the most well-known decision making, and it is a branch of Operations Research (OR), which deal with decision problems under a number of decision criteria (Triantaphyllou, 1998). MCDM is a normative way of decision-making where there is one decision maker with multiple criteria problem. Its aim is to consider the way the decision maker looks at the multi-criteria problem. In order to do that, a mathematical model must be constructed, since the amount of information in multi-criteria problem is too much for a human to make the whole process. This can be best done by letting decision maker focus on smaller parts of the problem. The way the decision maker looks at the multi-criteria problem is also defined as the decision maker specific data.

Among MCDM techniques, AHP can effectively handle both qualitative and quantitative data and also it is easier to understand (Ibrahim et al., 2011; Nilashi and Janahmadi, 2012; Salahshour et al., 2015; Nilashi et al., 2015; Nilashi et al., 2014). However, for decision making in many practical situations, the preference of human in MCDM modeling for the problem is uncertain and assigning exact numerical values to the comparison judgments for decision makers be unfavourable and difficult and it is often criticised due to lack consistent of human judgment. Although using values of 1–9 as discrete scale for performing pairwise and analysis has the advantage of simplicity, a decision maker may avoid giving sharp answers like giving the maximum point in comparisons may to express the strength of her/his preferences. In addition, for a decision maker it is extremely difficult to provide exact pairwise comparison judgments.

In addition, determination and evaluation of the factors can be affected by characteristics of the decision makers. For example, some pessimistic people may avoid giving sharp answers like giving the maximum point in comparisons. On the other hand, a very optimistic person can easily give highest point even though it is not that much important. Thus, these conditions create fuzziness in decision making process.

Thus, in these situations, AHP is ineffective when applied to ambiguous problems and it has been highly recommended by researchers to apply fuzzy AHP as an extension of conventional AHP and employ fuzzy set theory to handle uncertainty and overcome this limitation. Hence, fuzzy AHP is developed to overcome all these weaknesses. Fuzzy AHP is an extension of classical AHP method in case the fuzziness of the decision makers is considered (Ahmadi et al., 2014a; Ahmadi et al., 2014b). In this study, AHP method will be handled due to its help for well structured group discussion with pair-wise comparison. Fuzzy AHP is more popular compared to AHP method, since it provides a pair-wise evaluation between alternatives by using fuzzy numbers, which gives more sensitive results. Therefore, fuzzy AHP is more suitable for this case, since the location factors are determined based on human decisions. To determine the weights of critical



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factors incorporated in the conceptual framework, the following steps as shown in Fig. 4 are considered.

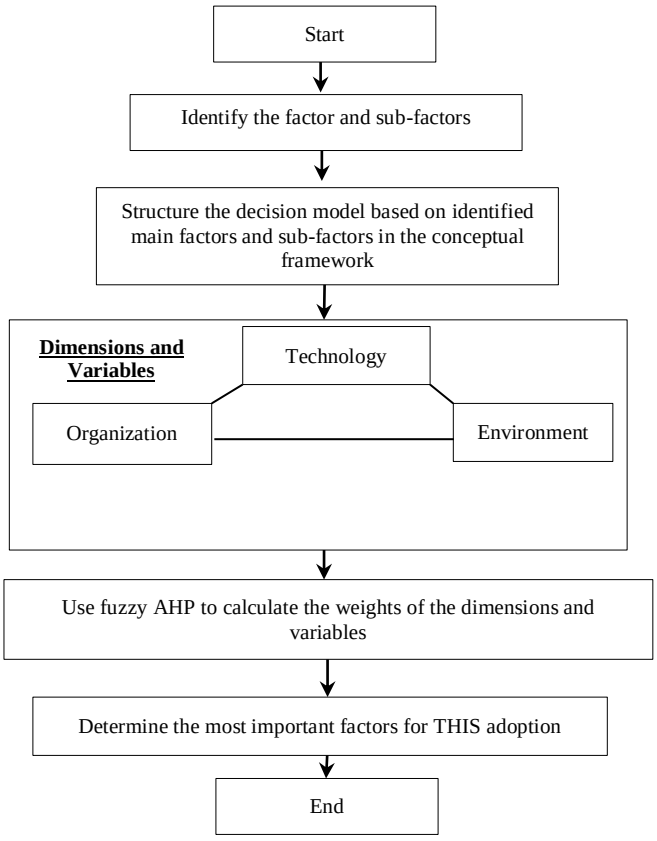


**Fig. 4.** Research flow for MCDM model.

**Table 1.**

Sample characteristics.

| | Respondent characteristic | Frequency | Percentage |
|---|---|---|---|
| Age group | 26-31 | 2 | 11.11% |
| | 31-39 | 6 | 33.33% |
| | 39-45 | 3 | 16.66% |
| | 45-58 | 7 | 38.88% |
| Gender | Female | 8 | 44.44% |
| | Male | 10 | 55.55% |
| Level of education | Bachelor‘s | 3 | 16.66% |
| | Master‘s | 5 | 27.77% |
| | Higher | 10 | 55.55% |
| Roles of respondents | Chief Information Officer | 2 | 11.11% |
| | Chief Medical Informatics Officer | 3 | 16.66% |
| | Chief Executive Officer | 5 | 27.77% |
| | Chief Technology Officer | 2 | 11.11% |
| | IT director | 3 | 16.66% |
| | senior clinicians | 2 | 11.11% |
| | HIS department staff | 1 | 5.55% |
| Years of experience in the healthcare industry | Above 10 years | 1 | 5.55% |
| | 7~9 years | 2 | 11.11% |
| | 4~6 years | 3 | 16.66% |
| | 1~3 years | 4 | 22.22% |
| | Less than 1 years | 8 | 44.44% |
| Responding executives‘ seniority in the healthcare industry | Above 26 years | 2 | 11.11% |
| | 21~25 years | 3 | 16.66% |
| | 16~ 20 years | 2 | 11.11% |
| | 11~15 years | 3 | 16.66% |
| | 6~10 years | 2 | 11.11% |
| | Less than 5 years | 6 | 33.33% |



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After identifying the potential factors that affect hospitals adoption decision of THIS with regards to Malaysian public hospitals, we evaluate the identified factors using fuzzy AHP. In the current study, the data collected from 18 experts who are as decision makers that are wholly familiar with the HIS. Thus, as the objects of the questionnaires used in our study are the experts and not the users, therefore, the sample size of 18 experts would be sufficient for data collection purpose and the hybrid MCDM model implementation. Table 1 provides the sample characteristics of the type of respondents for this study.

By using fuzzy AHP, weight of eight selected factors was calculated that is shown in Table 2. As can be seen, for the dimensions, the first rank is Technology with the weight 0.502, the second rank for Organization with approximately weight of 0.304 and third rank for Environment with the weight of 0.194. According to the sub-factor weights presented in Table 2, it can be seen that the weights of factors are Relative Advantage (0.114), Compatibility (0.493), Complexity (0.209), Security Concern (0.184), Infrastructure (0.227), Presence of Champions (0.345), Top Management Support (0.428) and Vendor Support (1).

**Table 2**

The local weights of factors and sub-factors along with global weights of sub-factors.

| Factors and local weights | Sub-factors | Weights |
|---|---|---|
| Technology (0.502) | Relative Advantage | 0.114 |
| | Compatibility | 0.493 |
| | Complexity | 0.209 |
| | Security Concern | 0.184 |
| Organization (0.304) | Infrastructure | 0.227 |
| | Presence of Champions | 0.345 |
| | Top Management Support | 0.428 |
| Environment (0.194) | Vendor Support | 1 |

## 5. Conclusion

This study on the basis of secondary data provided a literature review and proposed a proposed framework relevant to the context of Malaysia public hospitals in successfully adopt the THIS innovation. Hence, this would give a better understanding of the THIS and address issues pertaining to its adoption in the hospital level.

Three major contexts of Technology, Organization, and Environment were highlighted to have significant effect on the overall adoption of THIS.

The results of fuzzy AHP survey revealed that the experts in the THIS field believed, these factors should not be overlooked by managers of hospitals in which the adoption of THIS is related to more considering of these factors. In addition, from the results, it was found that the experts are more concerned about Technology, as the weight of this dimension is substantially higher than those of other dimensions. Therefore, the results of this study provide guidance to hospital administration level specially the top management in HIS field identifying the important factors for decision-making in selecting the appropriate way for THIS adoption, preparing appropriate mitigation strategies and contingency plans prior to entering into THIS and helping hospital parties to reach their intended goals with greater efficiency. At the end, the current study hopes to add some more knowledge into the theoretical aspects of specific type of IS in the healthcare industry and also shed some light for prospective researchers by giving the future direction in examining the trend of THIS innovation adoption.

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