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ORIGINAL PAPER

Critical Factors Influencing Hospitals' Adoption of HL7 Version 2 Standards: An Empirical Investigation

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Abstract Industry predictions focus on future e-hospitals that will integrate all stakeholders into a seamless network, allowing data to be shared. The Health Level Seven (HL7) is a standard for the interchange of data within the healthcare industry. It simplifies communication interfaces and allows the interoperability among heterogeneous applications. Although the benefits of adopting HL7 are well known, only a few hospitals in Taiwan have actually adopted it. What are the reasons behind the hospitals' lack of intention to adopt HL7? Most prior studies on HL7 have focused on technical issues and general overlooked the managerial side. This has caused a lack of understanding of factors influencing hospitals' decision on HL7 adoption. In fact, main reasons behind a hospital's decision on whether to adopt an innovative technology are more often related to organizational than purely technical issues. Hence, we pay our attention to these organizational considerations over HL7 adoption. Based on the Innovation Diffusion Theory, we proposed a research model to explore the critical factors influencing Taiwan hospitals' adoption intention of HL7. 472 questionnaires were distributed to all accredited hospitals in Taiwan and 122 were returned. The valid response rate was 25.21% (119). Factor analysis, logistic regression and Pearson Chi-square test were conducted to verify the research model. The results showed that environmental pressure, top management attitude towards HL7, staff's technology capability, system integrity, and hospital's scale were critical factors influencing hospitals' intention on whether to adopt HL7. The research findings provided the government, the healthcare industry, the hospital administrators and the academia with practical and theoretical references. These factors should be considered in planning promotion plan to encourage hospital adoption of HL7. This study also opens up a new research direction as well as a new viewpoint, and consequentially improves the completeness of related researches in the medical informatics discipline.

Keywords Healthcare information standards · Health Level Seven (HL7) · Electronic Medical Record (EMR) · Electronic Healthcare Record (EHR) · Innovation Diffusion Theory (IDT)

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Introduction

Industry predictions focus on future e-hospitals that would integrate all stakeholders into a seamless network, allowing data to be shared (1). This would benefit Electronic Health Record (EHR) improvement and gradually underlined the importance of a healthcare information standard (2). The

Health Level Seven (HL7) is one of the most well-know standards for electronic data exchange within the healthcare industry. Its primary purpose is to simplify communication interfaces and allows interoperability among heterogeneous healthcare applications. In Taiwan, HL7 originated from the government project of "National Information Infrastructure (NII)" and was implemented in 1994. In the requested proposal of the "Telemedicine Application Pilot System", it was suggested that HL7 and the Digital Imaging and Communications in Medicine (DICOM) should be adopted in the medical information exchange in order to reduce the complexity of interface design, and to facilitate information exchange among various healthcare information systems. HL7 regulates most of the medical administration management, clinical message exchange formats and rules, trigger events and data types. Meanwhile, the standards enable different manufacturers to design the application interfaces that allowed different hospital application systems to perform data exchange, such as applications in the fields of telehomecare or telemedicine (2).

In the United States, even though HL7 utilization rate is very high, the standard had still not been adopted universally by hospitals (3). In Taiwan, the development of HL7 has focused mainly on defining the standard applied in the local medical industry. Most of the projects are small, and the main purpose of the adoption only means to demonstrate the feasibility and scalability of HL7 in a variety of hospital settings.

Exchanging medical information is important in a wireless local area network for a healthcare system (4), a mobile healthcare delivery system (5), a telehomecare system (6) and a geographic information system (GIS) for public health (7). Adopting the HL7 standard could reduce the complexity of communication interfaces employed by different systems. However, the adoption of a standard inevitable also has some impacts on the existing practices of an organization. This might explain the slow progress of HL7 adoption in Taiwan. Unfortunately, unless widely appreciated, the benefits of the HL7 standard could not be full realized (8).

Although the benefits of HL7 are well known by practice, only a small number of hospitals in Taiwan had actually adopted it. What are the reasons behind the hospitals' lack of intention to deploy it? Prior studies on HL7 or healthcare information exchange focused largely on technical challenges, such as designing the algorithm and the interface engine for parsing messages, or establishing the middleware for exchanging the specific healthcare information (2,9–11). Most of them included no managerial issues, explored little about the decision makers' concerns over HL7 adoption. However, the main concerns of a hospital' decision on whether to adopt an innovative technology, such as a healthcare information standard, were often related to organizational issues, rather than purely technical problems. It was important to understand the concerns of the decision makers, and therefore, this study intended to explore these organizational considerations and managerial viewpoints with regard to HL7 adoption. In addition, there are many differences between HL7 version 2 standards (V2.X) and version 3 (V3), with the latter being more complicated than the former. In terms of adoption status and ratio V2.X surpasses V3. Therefore, this study only focuses on HL7 V2.X standards, rather than HL7 V3. HL7 mentioned in this paper refers only to the HL7 V2.X standards.

Literature review

The health level seven standard

The inter-organizational systems have been rising and flourishing in response to globalization. These systems not only facilitate cross-organizational cooperation by establishing relations, but also accelerate the opportunities for the member companies to gain competitive advantages (12). Information technology (IT) opens up new possibilities for e-health (13), and the proper adoption of IT by a hospital can significantly improve the quality its healthcare offerings (14). The daily operations of a hospital patient registration, admissions, referrals, insurance claims and the statutory notification of infectious diseases are now highly dependent on IT. All these demands have triggered information interchange among numerous heterogeneous healthcare applications. Healthcare information interchange makes previously inaccessible data available to clinical processes and physicians, enabling an acquisition of more complete information (15). Therefore, an increasing number of hospitals had implemented innovative technologies and medical information-related standards, mainly to improve the delivery of their healthcare services and operational performance, especially in terms of heterogeneous information exchange. HL7 is one of the well-known standards for this type of text and numeral-related data exchange. Future e-hospitals will integrate all the stakeholders into a seamless network, allowing data to be shared (1). HL7 provides an important foundation for future electronic medical records (EMR) implementation and system integration. The adoption of HL7 is also closely related to the development of EHR.

Many HL7 standard advocates established the HL7 framework in 1987. HL7, referring to the 7th layer of the Open System Interconnection (OSI) model that corresponds to the application layer, was created and defined to facilitate data sharing across different platforms. In Version 2.X, HL7 uses a message as vehicle and communicates via the Electronic Data Interchange (EDI). Every medical-related behavior represents a trigger event, and was then transformed into a message. The packet of messages consists of different meaning segments

separated by <CR> and a segment is divided into more detailed fields, components and sub-components. As a rigorous and open standard, HL7 clearly defines the basic data of a patient and his/her relevant medical information along with detailed regulations regarding what data needed to be transmitted.

Health information standards (such as HL7 and DICOM) are key to the U.S. and other countries in quest of creating an aggregated, patient-centric electronic health record, interchanging data among independent sites that were involved in a person's care, and creating a population database for health or infectious disease surveillance and for bioterrorism defense (16). This viewpoint presents the importance and value of adopting healthcare information standards. Many countries in European Union, North America, and Asia haven been working on integrating healthcare enterprise (IHE) since 1997, aiming to increase the interoperability among heterogeneous applications in order to achieve EMR, EHR and patient health record (PHR) in the future. More and more venders, healthcare providers, and scholars are putting effort in exploring how to implement HL7 after year 2000. According to the online search by the Google Scholar searching engine, more than 7-thousand HL7-related articles were written between 2000 and 2010, and about 40% of them were published after 2007, indicating its academic value and practices had gained an increase of interest over the years. However, the majority studies focused mainly on technical issues, leaving the managerial issues, especially the factors influencing hospitals' decision on HL7 adoption untouched. Hammond (1995) also pointed out that some problems and issues affecting the progress and acceptance of health information standards are et to be solved (16). Therefore, identifying the critical factors influencing hospitals' decision on HL7 adoption would help us understand the concerns of the healthcare providers and increase the acceptance of health information standards.

Apart from government involvement, we believed that there are still other factors influencing a hospital's decision regarding weather to adopt HL7. Moreover, as the government intends to use healthcare information standards as a way to promote EMR, EHR, or paperless policy, it has become even more pressing to understand hospital decision makers' concerns over HL7. As prior research on HL7 or healthcare information standards paid little attention to the managerial side of HL7 adoption, we approached the issue from an organizational viewpoint by exploring the crucial factors influencing hospitals' decisions regarding whether to adopt HL7.

Innovation diffusion theory

The Information Technology Innovation Research (ITIR) involves the understanding of the factors that enable or inhibit the adoption and diffusion of an emerging IT-based process or product within a group of its potential adopters. Studies on technology innovation have become increasingly popular as IT continues its relentless March into almost every aspect of an organizational life, and as innovation itself have taken on greater importance as a driver of organizational competitiveness (17). For example, Kimberly & Evanisko (1981) and Thong (1999) found that an organization's decision to adopt innovative technology is under the influence of the characteristics of the top managers, organizational concerns and environmental conditions (17–19).

Rogers (1983, p.11) defined an innovation as "*an idea, practice, or object that is perceived as new by an individual or other unit of adoption*" (20). It implied that, apart from IT, there are still other objects that qualified as a type of innovation (19). Rogers' Innovation Diffusion Theory (IDT) is applied extensively to comprehensively explain and predict the adoption and diffusion of a new technology (21). Moreover, Rogers (2003) pointed out that, when an organization intends to adopt an innovation, it has to take its attributes into account, as well as other factors such as top management, organization and environment (17,22). Cooper and Zmud (1990) found that the organization and tasks affect the innovative technology acceptance (23). Grover and Goslar (1993) indicated that the firms' concerns over innovative technology adoption and implementation are subject to the influence of environmental, organizational, and technology-related factors (24).

Characteristics of the environment and technology

According to the IDT, there are five major innovation attributes: relative advantage, complexity, compatibility, trialability, and observability (20,22). To accept an innovation is for its potential accepter to recognize these attributes. Previous studies defined these five innovation attributes as the critical indicators of the degree of innovation acceptance (20,22). Moore and Benbasat (1991) enhanced explanation power of the IDT in the context of IS adoption (25). They deleted the trialability, and proposed an addition of 4 variables, namely image, voluntariness, result-demonstration, and visibility. In addition, result-demonstration and visibility were separated from observability. In the end, they concluded eight variables (attributes) were related to innovation technology adoption decisions. The majority of previous researches were based on IDT or its refined models. Most of them also concluded that adoption attitude towards innovation technology is a complicated decision for organizations. It is believed that other variables, with relation to the increase of explanation power, should also be added. Besides, many researchers indicated that organizational and environmental characteristics are critical factors (19,26–28). Accordingly to Tornatzky and Klein (1982), complexity and compatibility were also factors

of critical influence (29). This view was shared by O'Callaghan et al. (1992), Premkumar et al. (1997) and Thong (1999) (19,30,31).

Prior researchers presented that the pressure of partners and competitors is a primary factor to drive small or medium-sized enterprises' adoption of EDI (24,27,28,31). Kimberly and Evanisko (1981) reported that organizations tend to adopt an innovative technology when facing intense competition from the industries (18). Moon & Bretschneider (1997) and Kuan & Chau (2001) suggested that the pressure from government on an innovative technology promotion would significantly affect an organization's adoption of IT (28,32). The reliability of network and information security are also key factors in considering IT adoption, according to Soliman & Janz (2004) and Ratnasingham & Swatman (1997)(33,34). Given that medical behavior or process is closely related to a patient's personal life and safety, privacy, the healthcare provider should pay special attention to information security and accuracy, striving to rule out any possible errors.

Therefore, we included three factors related to environmental characteristics, which are governmental, industrial, and vender/association considerations. Regarding the characteristics of technology (HL7), we listed three factors: complexity, compatibility, and security.

Characteristics of the organization and the top management

The fact that an organization's characteristics would affect its attitude towards innovative technology were well demonstrated by prior researches. The attitude of top management towards IT, IT-related knowledge and experience, the scale of an organization and staff's IS capability were factors frequently discussed in previous studies (for example, (17,19,24,31–33,35,36)). Thong and Yap (1995) argued that top managers' attitude would influence the adoption of an innovation technology, especially when they had certain IT-related knowledge or experiences and understood advantages and disadvantages of IT (37). Moreover, an organization requires an appropriate size in order to maintain sufficient resources or capabilities of handling possible risks (17,19,27,32,36,37). Therefore, an organization's size or scale and its information capability could affect its decision on adopting or implementing innovative technology (17).

In the organizational dimension we included two factors, namely the staff's technological capability and the scale of the hospital. With regard to the characteristics of top management, we adopted two factors: the attitude towards IT and IT-related knowledge and experiences.

Materials and methods

The research framework and hypotheses

Based on Rogers' IDT, we proposed a research framework to explore the critical factors influencing a hospital' HL7 adoption from the organizational viewpoint. The research framework consists of four constructs (dimensions) and ten independent variables. The initial research hypotheses are as follow: H1a–H1c explored environment-related characteristics, H2a–H2c technology-related characteristics, H3a–H3b top managers-related characteristics, and H4a–H4b organization-related characteristics.

Characteristics of the environment: Hypotheses H1a–H1c

Hospitals strive to improve their performance in many ways. Some hospitals might need to adopt the medical information standard in order to enjoy the benefit of easier data exchanges as their partners or cooperating hospitals have already introduced such standard. This viewpoint is in consistence with prior researches regarding a firm's adoption of inter-organizational systems (IOS) and EDI (33,35,38). Hospitals also face a strict policy constraint enforced by governmental agencies. Moon & Bretschneider (1997) and Kuan & Chau (2001) suggested that the government's facilitation or reward-giving would affect whether an organization to adopt an innovation technology (28,32). Premkumar and Roberts (1999) indicated that an organization's consideration about whether to adopt an innovation technology was affected by whether the supplier offered a rebate or encouragement (36). Kimberly and Evanisko (1981) argued that organizations tended to adopt a new technology when they faced competition from other businesses (18). Grover & Goslar (1993), Iacovou et al. (1995), Premkumar & Ramamurthy (1995), Premkumar et al. (1997) and Kuan & Chau (2001) had proved that the pressure to compete has an effect on organization's intention to adopt EDI (24,27,28,31,35). An information standard provides a foundation for EDI adoption, since the EDI emphasizes information exchange, interoperability and system integration. Therefore, we referred to EDI-related studies to construct the research hypotheses in the dimension of environmental factors. We inferred that the pressure to compete within the industry, the push and the pull of the environment would affect hospitals' adoption of HL7. The hypotheses of H1a-H1c are as follow:

H1a: Governmental promotion is a significant HL7 adoption differentiating factor; specifically, higher levels of governmental promotion increase the likelihood of a hospital' adoption of HL7.

H1b: Intra-industrial pressure is a significant HL7 adoption differentiating factor; specifically, higher levels of industry pressure increase the likelihood of a hospital' adoption of HL7.

H1c: External support is a significant HL7 adoption differentiating factor; specifically, greater levels of external support increase the likelihood of a hospital's adoption of HL7.

Characteristics of technology: Hypotheses H2a–H2c

Compatibility and complexity have been identified as the critical factors influencing organization's decision about the innovative technology adoption or implementation (19,20,22,31,36,38,39). Agarwal and Prasad (1997) also reported that, in relation to the internet usage behavior of an organization, compatibility affects the decision to adopt an innovation technology (21). In summary, an innovative technology with higher compatibility with existing systems, practices, working experiences and with lower complexity to implement, would be easier to be accepted by potential adopters (31,33,38,40,41). Therefore, we concluded that higher compatibility and lower complexity would enable the adoption of an innovative technology. Angeles et al. (2001) indicated that security is also a significant factor affecting IT adoption (42). To the hospitals, the healthcare information standard or HL7 represents an innovative technology. We therefore inferred that complexity, compatibility and information security would affect hospitals' adoption of HL7. The hypotheses H2a–H2c are as follow:

H2a: Complexity is a significant HL7 adoption differentiating factor; specifically, lower levels of complexity increase the likelihood of a hospital' adoption of HL7.

H2b: Compatibility is a significant HL7 adoption differentiating factor; specifically, higher levels of compatibility increase the likelihood of a hospital' adoption of HL7.

H2c: Security is a significant HL7 adoption differentiating factor; specifically, higher levels of security increase the likelihood of a hospital' adoption of HL7.

Characteristics of top management: Hypotheses H3a–H3b

Prior researches had proved that top managers' attitudes towards an innovative technology and their IT-related knowledge and experiences, or lack of it affected the organization's decision regarding the adoption of an innovative technology (19,37). Organizations found it hard to support the strategy of innovative technology adoption if the executives of the organization were unwilling to do so or did not have a comprehensive understanding of it. The executives of the organization would gain an insight into the advantages and then supported the adoption of an innovative technology should he or she have more innovative technology related knowledge and a positive attitude toward it (19,37). We therefore inferred that the characteristics of top managers would affect hospitals' adoption of HL7. The hypotheses H3a–H3b are stated below:

H3a: Top management attitude towards IT is a significant HL7 adoption differentiating factor; specifically, stronger top management attitude towards IT increase the likelihood of a hospital' adoption of HL7.

H3b: Top management knowledge of IT is a significant HL7 adoption differentiating factor; specifically, stronger top management knowledge about IT increase the likelihood of a hospital' adoption of HL7.

Characteristics of the organization: Hypothesis H4a–H4b

An organization that adopted an innovative technology successfully and gained benefits from it relied heavily on its staff having sufficient innovation knowledge or technology capability (19,22). Organizations' rich experience, fueled knowledge and a framework of integrated technologies would support their continuous adoption or integration of the related knowledge about innovative technologies (43). The scale or size of the organization also influenced its decision on whether to adopt an innovative technology according to IDT-related researches (17,31,37). In general, large organizations had more resources to invest in innovation implementation and more staff to carry out related tasks (17,22). We therefore inferred that the characteristics of the organization had an effect on hospitals' adoption of HL7. The hypotheses H4a–H4b were introduced as follows:

H4a: Staff's technology capability is a significant HL7 adoption differentiating factor; specifically, stronger staff's technological capability increase the likelihood of a hospital' adoption of HL7.

H4b: A hospital's size was a significant HL7 adoption differentiating factor; specifically, larger scale increased the likelihood of a hospital' adoption of HL7.

Questionnaire design and field survey setting

The questionnaire was developed based on literature. Apart from the item regarding hospital's scale (to classify the

three levels, namely district hospital, regional hospital and medical center), all other items were measured with a Likert five-point scale. The initial questionnaire, including dimensions and 26 items, was reviewed in terms of its content and semantics by two IS scholars and ten directors of hospital IS departments to confirm the content validity and face validity. The research objects were all national accredited hospitals in Taiwan. According to the Department of Health (DoH) year-2007 survey, there were 472 accredited hospitals by the end of the year (44), which were the samples of the questionnaire survey. 122 vice presidents, directors, or staff members, who were involved in the decision making or responsible for healthcare information standards implementation projects, helped to complete the questionnaires. The valid response rate was 25.21% (119).

Results

In order to confirm the sample's representativeness, we referred to Armstrong and Overton (1977) to compare the data collected from the first and second stages (before and after resenting questionnaires to non-respondents) of questionnaire distribution (45). The respondent hospitals' scales and differences in questionnaire item responses were compared in order to evaluate whether there was a non-response bias, and to confirm the representativeness of the responses. A Chi-square test was conducted on the hospital respondents' hospital scales and the *p*-value was greater than 0.05, indicating no significant difference between the groups of the stages. A *t*-test on each item also appeared non-significant. Such results showed our samples were of adequate representativeness.

The profile of the majority of the respondents revealed that 86 (72.3%) were directors working in the IS department, and 32 (26.9%) were between 41 and 45 years old. Most of them (34.5%) had 4 to 6 years' experience in the current positions. More detailed demographic information was shown in Table 1. In terms of hospital scale, there were 14 (11.8%) medical centers, 42 (35.4%) regional hospitals and 63 (52.9%) district hospitals. Regarding the adoption of HL7, we referred to Hu et al. (2002) suggestion and divided adoption status into two groups: 'has adopted' (group 1) and 'has not not yet adopted' (group 2) (46). Seventeen (14.3%) hospitals had adopted HL7, and 102 (85.7%) hospitals had not yet adopted it. The result was shown in Table 2.

Reliability and validity

Reliability means the stability and consistency of a scale. Cronbach's α is a relatively widely adopted measure of reliability, sometimes being regarded as the lower bound of reliability. Hair et al. (2006) suggested that the lower limit of the alpha coefficient is 0.7, and 0.6, which is also acceptable in an exploratory research (47). The alpha coefficients of the items were at least close to 0.6, and some of them reached 0.9. The result represented an acceptable reliability and internal consistency.

In this study, the initial scale was verified by scholars and industry experts in order to confirm its content validity and face validity. The principal components analysis, the equamax rotation and criterion of the eigenvalue greater than 1 were applied to reduce and extract factors. The value of the KMO was 0.78 and the sphere test of Bartlett (χ^2= 2008.46, df=435, p<.000) revealed the correlation coefficient matrices of the population were with common factors (better for factor analysis) and the variance of accumulation for factors was 67.1%.

In addition, Hair et al. (2006) suggested an appropriate factor loading value of should be 0.50 when the sample size is 120 (47). According to the factor analysis, the factor loading value was at least close to 0.55, and some of them were as high as 0.88. Finally, seven factors were extracted via the equamax rotation. Obviously, the results presented a good convergent validity and discriminate validity.

Refine research model and revise hypotheses

The factor analysis successfully reduced the number of factors and 7 factors was extracted and renamed for the logistic regression analysis for the verification of the research model and hypotheses. The fact that the dependent variable consisted of only two groups ("has adopted HL7" and "has not yet adopted HL7") suggested a logistic regression analysis (47). Hosmer and Lemeshow-test was conducted to verify the differences between these two groups. A *p*-value of 0.256 indicated that the given two groups could be clearly divided (47). The accuracy rate of discrimination was 87.4%. A Pearson Chi-square value of 7.519 with a *p*-value of 0.023 (p<0.05) revealed that hospital scale is a critical influencing factor for HL7 adoption. Also, we applied the backward stepwise logistic regression to verify other hypotheses. The logistic regression analysis revealed four significant variables, namely environmental pressure, top management attitude towards HL7, staff's technology capability, and system integrity. The remaining three variables did not reach statistical significant in the logistic regression analysis. They were pull of the environment, push of the environment and security. The final research model was shown in Fig. 1. In addition, the Wald coefficients of the factors indicated that system integrity (with the highest Wald coefficient of 8.937) was the most crucial factor among hospitals' considerations of HL7 adoption. The results of the logistic regression analysis were detailed in Tables 2 and 3.

Table 1 Respondent characteristics

(*N*=119)			
Items	Categories	Frequency	Percentage (%)
Hospital level	Medical center	14	11.8
	Regional hospital	42	35.3
	District hospital	63	52.9
Ownership type	Public hospital	35	29.4
	Private hospital	78	65.5
	Military hospital	6	5
Respondents' age	Less than 30 years old	24	20.2
	31 to 34 years old	17	14.3
	35 to 40 years old	30	25.2
	41 to 45 years old	32	26.9
	46 to 50 years old	11	9.2
	Over 50 years old	5	4.2
Position	Vice president	3	2.5
	Director of IS department	74	62.2
	Others	42	35.3
Gender	Male	93	78.2
	Female	26	21.8
Length of service (current position)	Less than 3 years	33	27.7
	4 to 6 years	41	34.5
	7 to 10 years	21	17.6
	11 to 13 years	10	8.4
	14 to 17 years	9	7.6
	Over 18 years	5	4.2

Discussion

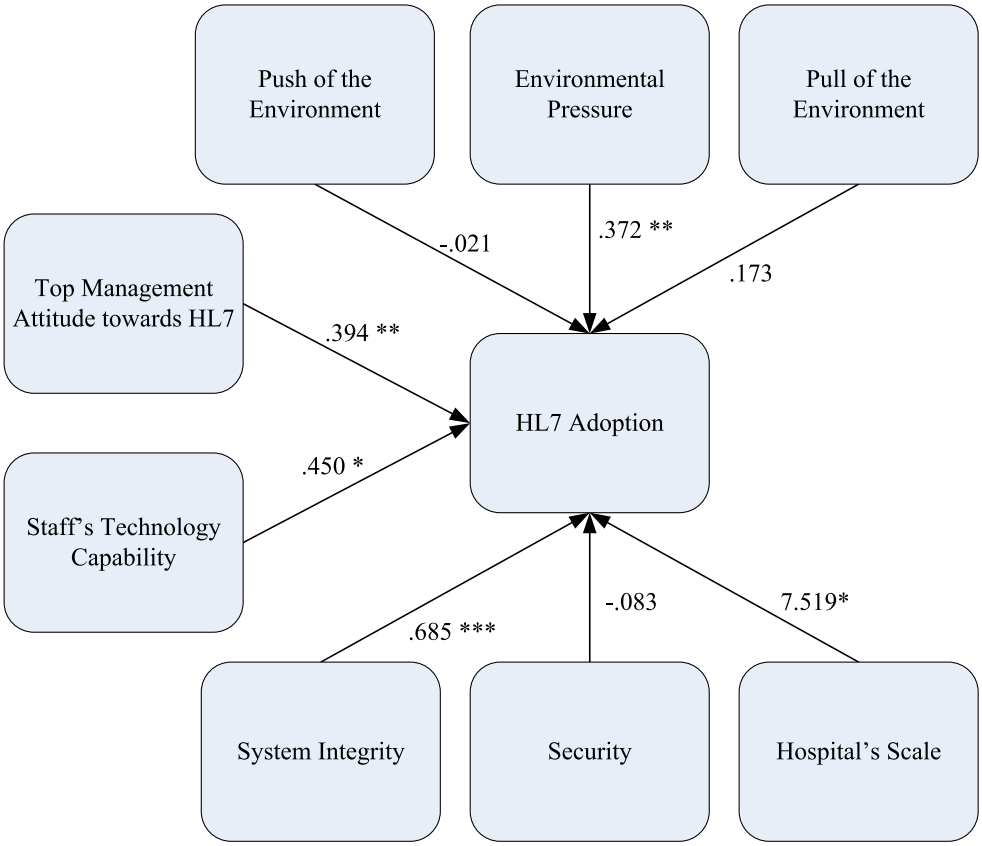
Five factors, namely environmental pressure, system integrity, top management attitudes towards HL7, staff's technological capability, and hospital scale, were identified to influence a hospital's HL7 adoption decision. Environmental pressure represented intra-industrial competitions and governmental involvement. When the main competitor or the majority of competitors had implemented or prepared to adopt HL7, it would create an intra-industrial competition that promoted a hospital's decision to adopt HL7. In other words, the intensity of competition positively affected a hospital's willingness to adopt HL7. By the same token, if the government set related policies to request hospitals to use HL7 format at patient referring (referred file), insurance fee claiming from the Bureau of National Healthcare Insurance (BNHI-DoH), infectious disease reporting to Center for Disease Control (CDC-DoH), or provided promotion program or rewards to encourage HL7 adoption could result in the majority of hospitals to adopt HL7.

Moon & Bretschneider (1997) and Kuan & Chau (2001) pointed out that organizational considerations are under the influence of government promotion, as well as subject to the pressure within the industry (28,32). The majority of the

Table 2 Hospitals adoption HL7 phase and current status

Adoption	Category of adoption states	N (%)
Adopter hospitals	Already implemented and used HL7.	13 (10.9%)
	Identified and secured budget and technology source for HL7 implementation.	4 (3.4%)
Non-adopter hospitals	Submitted a formal adoption proposal for founding agency's review	0
	Designated individuals or a task force to evaluate potential adoption.	12 (10.1%)
	Informally discussed potential adoption but no concrete action taken HL7.	43 (36.1%)
	Though about potential adoption but decided not to pursue HL7 at present.	47 (39.5%)
Overall		119 (100.0%)

Fig. 1 Final research model



Note: 1. *** P-value < .001, ** P- value < .01, *P-value < .05
2. Hospital's Scale was analyzed with a Person Chi-Square test.

hospitals that had already adopted HL7 had also participated in the HL7 promotion programs or projects initiated by the Taiwan government. They were obliged to implement HL7 because they received funds from it. In general, hospitals seem reluctant to adopt HL7, because implementing it means the devotion of more time and effort in order to modify the system or organize training programs, creating more work and pressure. Moreover, some of the hospitals expressed that they were totally not aware that the government was advocating HL7, and they did not understand related governmental policies and implementation procedures.

In the technology dimension, compatibility and complexity were merged into one factor under the new title of "system integrity" which achieved a level of significance in the logistic regression analysis. Most respondents expressed that the implementation of HL7 was incompatible with their existing IT architectures regarding hardware, software, applications or networks and introducing HL7 into the exiting practice was complex for their IS staff. These were the factors inhibiting hospitals' decision to adopt HL7. This result was in consistence with prior IDT-related studies. Sobol et al. (1999) indicated that staff's IT knowledge and capability critically influenced medical computerized system implementation (48). In other words, if hospitals' staff were more knowledgeable about IT, there would be fewer advocator obstacles and lesser user resistance against innovative

Table 3 Results of logistic regression analysis

Dependent Variables	β coefficient	S.E.	Wald	p-value
Pull of the environment	.173	.118	2.168	.141
Environmental pressure	.372	.125	8.937	.003**
Push of the environment	−.021	.112	.036	.849
Top management attitude towards HL7	.394	.151	6.755	.009**
Staff's technology capability	.450	.196	5.271	.022*
System integrity	.685	.180	14.452	.000***
Security	−.083	.161	.268	.604

***p value<.001, **p value <.01, *p value<.05

technology implementation. Therefore, in the case of HL7 implementation, if it showed higher compatibility and lower complexity, and aided by sufficient IS staff and staff's IS capabilities, a hospital was more likely to accept it.

Premkumar & Roberts (1999) pointed out that before proceeding into the adoption of an innovative technology, enterprises would normally wait and see to clear their concerns over information security and system integrity (36). According to the logistic regression analysis, the information security didn't achieve a significant level. The existing practice regarding uploading the files of insurance fee claims (electronic claim operation) was operated via a national health information network (HIN) and a health insurance information network. Both were established on the government-owned Government Service Network-Virtual Private Network (GSN-VPN). The private nature of a VPN meant that the data travelling over the VPN was not generally visible to, or was encapsulated from, the underlying network traffic. In general, GSN-VPN provided appropriate information security for HIN and the health insurance information network. Therefore, security was not a critical influencing factor in the decision of HL7 adoption.

Moreover, this research also found top management attitudes toward HL7 a critical factor. This echoed prior IDT-related studies (such as (20,22,37,49)). The top mangers (decision makers) were more willing to adopt and accept a new technology if they were more knowledgeable about IT.

The 17 hospitals that had adopted HL7 included 5 medical centers, 7 regional hospitals, and 5 district hospitals. All of the district hospitals were affiliated with medical centers. A Pearson Chi-square test concluded that a hospital's scale influenced its adoption of HL7. This result was also in consistence with prior studies, and reflected the current status. Previous researchers had proved that an organization's scale was positively related to its usable resources (19,36,37). In general, abundant resources increase the chance of innovative technology being adopted. Therefore, higher hospital scale does increase the likelihood of a hospital to adopt HL7 as evidenced in our study.

Conclusion

Although the benefits of HL7 are well known, few hospitals in Taiwan have currently had it in place. Prior studies of healthcare information exchange in general missed out on the exploration of managerial issues. They focused mainly on either technical issues (2,9–11,50,51) or the nature of medical information (16), and failed to explain why there was a lack of intention to the adoption of HL7. Hospitals' concerns over whether to adopt the HL7 standard were not addressed. Hence, we conducted an empirical study to explore this particular issue and found that environmental pressure, top management attitudes toward HL7, staff's technological capability, system integration, and hospital's scale were the critical factors affecting the hospitals' decisions on adopting this healthcare information standard. In terms of academic contribution, this study, based on IDT, a well-known theory in the IS discipline, widened its applicability to the area of medical informatics and healthcare industry. Apart from extending the application domain or the IS theory, we also improved the completeness of related researches. Our research results shed some light for the government and the healthcare information industry on the concerns the healthcare providers had when making adoption decisions on healthcare information standards adoption. The government administration could refer to our study to develop better and more extensive HL7 promotion strategies and plans. In fact, in addition to ensuring the integration and interoperability of heterogeneous systems within hospitals, a healthcare information standard could also speed up the realization of paperless workflow and e-hospital, leading a hospital to a better future. The adoption of HL7 also enables the information sharing of EMR and EHR among healthcare providers. We believe that sharing patient medical information is beneficial not only to the public, but also to the hospitals and the healthcare insurers.

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