Understanding Physicians' Adoption Of Electronic Medical Records: Healthcare Technology Self-Efficacy, Service Level And Risk Perspectives

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Abstract

Most developed countries across the globe are deploying electronic medical record (EMR) as one of the most important initiatives in their healthcare policy. EMR can not only reduce the problems associated with managing paper medical records but also improve the accuracy of medical decisions made by physicians and increase the safety of patients. Considering that physicians are the primary users of EMR, their willingness to use EMR is a critical success factor for EMR implementation in a hospital. This study aims to extend an individual-level information technology adoption model by incorporating three additional variables to investigate whether the individual characteristics of a physician affect EMR adoption. A field survey is conducted with a total of 217 physicians from 15 different academic medical centers and metropolitan hospitals for six weeks. Then, the Structural Equation Modeling (SEM) analysis results indicate that perceived service level is an important antecedent of perceived usefulness. Healthcare technology self-efficacy, perceived risk, and perceived service level are also important antecedents of perceived ease of use. This study is concluded with implications for academics, hospital managers, governments, and medical information service providers.

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Understanding physicians' adoption of electronic medical records: Healthcare technology self-efficacy, service level and risk perspectives

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ABSTRACT

Most developed countries across the globe are deploying electronic medical record (EMR) as one of the most important initiatives in their healthcare policy. EMR can not only reduce the problems associated with managing paper medical records but also improve the accuracy of medical decisions made by physicians and increase the safety of patients. Considering that physicians are the primary users of EMR, their willingness to use EMR is a critical success factor for EMR implementation in a hospital. This study aims to extend an individual-level information technology adoption model by incorporating three additional variables to investigate whether the individual characteristics of a physician affect EMR adoption. A field survey is conducted with a total of 217 physicians from 15 different academic medical centers and metropolitan hospitals for six weeks. Then, the Structural Equation Modeling (SEM) analysis results indicate that perceived service level is an important antecedent of perceived usefulness. Healthcare technology self-efficacy, perceived risk, and perceived service level are also important antecedents of perceived ease of use. This study is concluded with implications for academics, hospital managers, governments, and medical information service providers.

1. Introduction

Recent years, many developing countries have actively implemented from the paper-based medical record to electronic medical record (EMR), even to the exchange of electronic medical record plan. This type of change can be seen in most of the countries worldwide including USA from 2004 to 2014, China from 2004 to 2006, Canada from 2001 to 2010, Australia from 2004 to 2007, UK from 2000 to 2010, Hong Kong from 1991 to 2006, and Korea from 2006 to 2010 [21]. To participate in this important medical movement, Taiwan has promoted the adoption of EMR by government since 2010. Further, Taiwan hospitals can be mainly divided into four levels including academic medical centers, metropolitan hospitals, local community hospitals, and physician clinics & dental clinics pending on the completeness of the medical services rendered and the mission to handle the improvement of Taiwan medical research and development. In 2015, a total of 399 hospitals accounting for 80.4% of all hospitals, announced that they have implemented electronic medical records technology to provide the services to their patients [11]. This fact also indicates the popularity that the physicians use the electronic medical records in the medical centers and metropolitan hospitals to deal with the associated healthcare processes [11].

In fact, EMR development progresses in five sequential stages and they include automated medical records, computerized medical records, EMR, electronic patient records, and electronic health records (EHR) [58]. EMR applications are mostly used to support clinical records, take care of patient treatments, make medical decisions, and handle related practical applications [55]. Moreover, these applications can be classified into four types in handling record health information (such as treatment notes and reminders), health record management (such as laboratory or radiology tests), order management (such as templates and/or drag in phrases), and associated electronic communications and connectivity (such as electronic medication lists) [31]. In other words, EMR can be employed to improve medical quality [5], reduce the associated risks of adverse drug events in inpatient and ambulatory settings, enhance the patient safety, facilitate the delivery

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of medical care [61], and certainly lower the medical costs [44].

In this subject field, many empirical studies have aimed to explore the EMR adoption from different perspectives, such as analyzing or investigating it at the individual level or organizational level [20]; in an informational, technology, or system perspective [8]; to improve the healthcare technology self-efficacy [14]; to study the different personal characteristic such as gender [14]; and to identify the subject differences such as physicians [20,35], nurses [56,57], nursing students [32], patients [43], and general public [8,56].

Physicians are the most important users of EMR in the hospital. In specific, physicians can easily create, access, distribute, and share patient records with physicians, patients, and other parties in the healthcare industry. However, during EMR implementations, many physicians are experiencing technical glitches (e.g., system crash and poor interface design), operational inefficiency, data errors, and system incompatibility issues [18]. Moreover, physicians worry about autonomy loss or changes in power structure [48]. The Centers for Disease Control and Prevention surveyed office-based physicians and determined that about 20% of these physicians used fully functioning EMR by 2011 [24]. Lack of physician support is a major barrier to the widespread adoption of EMR. To increase the physicians' intention of adopting EMR, the first and foremost requirement is to change their attitude and have their continuous support because they are the primary users of these systems [54].

In addition, some empirical studies tried to explore how to promote physicians' willingness to adopt EMR [39,33]. One approach is to demonstrate the usefulness of EMR for physicians, such as supporting clinical treatment [5] and reduce the medical errors [16]. Other approaches may include involving physicians in the system development process [39, 55], offering ease-of-use EMR applications (e.g., clinical support or electronic referral), enhancing patient information security [3], streamlined communication between physicians and patients [46], and good return of investment. Another approach is to understand the individual characteristics of physicians and to assess their potential influence on the acceptance of IS [29]. With the understanding of the individual differences among physicians, EMR can be customized to fit their personal needs. However, the current literature lacks the use of personalized approaches to influence physicians to adopt EMR [33]. Several scholars have suggested that EMR adoption be examined from the characteristics of physicians, such as age, computer sophistication [61], accessibility [29], perceived technical barriers [31], anxiety [1], and perceived threats to professional autonomy [59]. Previous research has shown that IS studies need to carefully evaluate the potential influence of unique contextual issues that exist in the medical industry on system adoption [29].

The goal of this study attempts to build and empirical validate a theoretical model on physicians adopting EMR based on the healthcare technology self-efficacy, perceived service level, and perceived risk perspectives. Further, our study place a focus on individual-level of physician, and this is mainly due to the fact that past studies had presented some interesting findings individual level factors and also the importance to investigate the significant influence on physicians' intention to use/adopt the EHRs (individual level factors) than organization-level factors proposed by the study of Gagnon et al. [20]. By doing so, deeper insights obtained from analyzing the causal relationships between these factors can provide more valuable lessons for hospitals to increase the acceptance rate of EMR by physicians and most importantly to contribute the CS&I readers to develop additional studies in this subject area.

The remainder of this paper is organized as follows: Section 2 discusses the current and previous studies related to EMR adoption and proposes the research hypotheses of this study. Next section presents our proposed research model and method. The demographic analysis, reliability and validity tests, data analysis results using structural equation modeling are covered accordingly in Section 4. Section 5 provides the summary, highlights the contribution of this research, and discusses the research limitations, future directions and research implications. The last section concludes this study.

2. Literature review

2.1. Adoption of EMR by physicians

As per earlier discussion, previous studies attempted to identify the key factors affecting the EMR adoption from different perspectives by physicians [27,57]. For example, Hossain et al. [27] based on Unified Theory of Acceptance and Use of Technology (UTAUT) to investigate the physicians' adoption of EHR systems in Bangladesh [27]. Vitari and Ologeanu-Taddei [56] studied such factors as anxiety, self-efficacy, trust, misfit and data security had indirectly significant influence on intention to use EHR by physicians. Further, Emani et al. [16] demonstrated the usefulness and satisfaction of EMR direct impacted on the adoption of outpatients' EMR by 1075 physicians. Sherer et al. [47] collected big empirical dataset to analysis physicians' subject, after passage of the HITECH Act, coercive forces, normative force, and mimetic forces effect on EHR usage. Dobrzykowski and Tarafdar [12] based on coordination viewpoint to examine how information sharing, shared values, and physicians' performance influenced on EMR use [12]. Hsieh [28] explored the physicians' acceptance factors of EMR exchange based on decomposed theory of planned behavior model with such factors as perceived risk and institutional trust. Mishra et al. [38] showed that physician community identity was correlated with EMR assimilation. Lehmann and Hsiung [33] indicated that financial factors were significantly involved with the decision to adopt EMR in small practice. Venkatesh et al. [54] determined that demographics and performance expectancy could affect EMR usage behavior. Sykes et al. [51] investigated how such factors as gender, age, neuroticism, conscientiousness, openness to experience, agreeableness, and extraversion could influence the satisfaction of physicians and patients. Following up the same research direction, Yeager et al. [61] emphasized that age, training, and computer sophistication were influential factors for adopting EMR. Sherer [48] showed that pressure construct (such as coercive, mimetic, and normative pressures) was also correlated with the adoption intention. Ilie et al. [29] investigated how accessibility (such as physical and logical dimensions) could affect the physicians' decision to use EMR. Jha et al. [31] explored EHR adoption based on perceived barriers and satisfaction viewpoints.

Aggelidis and Chatzoglou [1] also reported that self-efficacy, anxiety, and training could influence the physicians' intention of adopting EMR. Walter and Lopez [59] explored how perceived threat to professional autonomy could influence the intention to use EMR. Davidson and Heslinga [10] utilized technology-use mediation and communities of practice viewpoints to understand EMR acceptance through action research. Liu and Ma [36] examined the effect of perceived service level on the intention to use EMR based on a technology acceptance model (TAM). Table 1 summarizes previous studies examining the influences of varying individual characteristics on EMR adoption.

2.2. Perceived service level

Perceived service level refers to the physicians' perceived service conditions of EMR system, and it comprises multidimensional factors, such as good stability of EMR systems, easy presentation of hand drawing functions, strong standardization of system interfaces, easy creation of templates and/or drag in phrases, convenient searching capability about medical database and/or statistical data, rapid recording procedure of the information on patients (such as past medical history, family medical history, laboratory test results, and/or radiology test results), and good information exchange and sharing of EMR across different hospitals [13,23,26].

Perceived service level is a critical criterion to assess the service performance of IS [50]. Marketing-related research has justified that

Table 1
Previous EMR adoptions by physicians.

Study	Theory	Method	Variable
Hossain et al. [27]	Unified Theory of Acceptance and Use of Technology (UTAUT)	Survey Sample = 249 physicians	DV: behavioral intention, and use behavior IV: performance expectancy, effort expectancy, social influence, facilitating condition, personal innovativeness in IT, and resistance to change
Vitari and Ologeanu-Taddei [56]	Technology Acceptance Model (TAM),	Survey Sample = 1741 clinical staffs (physicians, paraprofessionals, and administrative personnel)	DV: intention to use, ease of use, usefulness, IV: anxiety, self-efficacy, trust, misfit and data security.
Sezgin et al. [45]	Mobile Health Technology Acceptance Model (M-TAM)	Survey Sample = 128 physicians	DV: performance expectancy, effort expectance behavioral intention IV: social influence, compatibility, technical support and training, perceived service availability, result demonstrability, personal innovativeness, mobile anxiety, mobile self-efficacy, and habit
Emani et al. [16]		Survey Sample = 1075 physicians	DV: satisfaction with the outpatient EHR. IV: physician age, gender, race, specialty (primary care, medical specialty, and surgical specialty), number of outpatients seen per week, number of outpatient hours worked per week, practice size
Sherer et al. [47]	Institutional theory	Survey Sample = 4699 physicians (2008)/ 4512 physicians (2012)	DV: adopt EHRs IV: physicians subject, after passage of the HITECH Act, coercive forces, normative force, and mimetic forces CV: controls: age, size, practice type, region, urbanization, competition income
Dobrzykowski and Tarafdar [12]	Coordination in the healthcare delivery process	Survey Sample = 310 physicians	DV: information sharing, shared values, physicians' performance IV: EMR use CV: teaching status, and bed size
Liu and Cheng [37]	Dual-factor model	Survey Sample = 158 physicians	DV: Intention to use mobile EMR MV: Perceived threat, perceived useful (PU), and perceived ease of use (PEOU) IV: Perceived mobility
Gagnon et al. [19]	Technology Acceptance Model (TAM), extended TAM, psychosocial model, and integrated model	Survey Sample = 157 physicians	Model 1 TAM DV: Behavioral intention to use EHR MV: PU IV: PEOU Model 2 Extended TAM DV: Behavioral intention to use EHR MV: PU and PEOU IV: Computer self-efficacy and demonstrability of results Model 3 Psychosocial model DV: Behavioral intention to use EHR IV: PEOU, social norm, and professional norm Model 4 Integrated model DV: Behavioral intention to use EHR IV: Demonstrability of results, PEOU, social norm, and professional norm
Mishra et al. [38]	Identity theory	Survey Sample = 206 physicians	DV: EHR assimilation IV: Care provider identity and physician community identity MV: Perceived government influence
Venkatesh et al. [54]	Theory of acceptance and use of technology	Survey Sample = 141 physicians (longitudinal study)	DV: Behavioral intention and use behavior IV: Performance expectancy, effort expectancy, social influence, and facilitating conditions MV: Gender, age, experience, and voluntariness of use
Sykes et al. [51]		Survey Sample = 151 physicians/8440 patient	DV: EMR system use and performance (patient satisfaction) IV: Characteristics of individual, technology perception, and social network centralities
Egea and González [15]	TAM	Survey Sample = 254 physicians	DV: Perceived risk, institutional trust, perceived usefulness, perceived ease of use, attitude towards usage, and usage intentions of electronic health care records (EHCR) IV: information integrity
Rao et al. [41]		Survey Sample: Physician Masterfile of the American Medical Association	DV: Barriers to the adoption and use of EHR IV: Availability of EHR functionalities, functionality use, effect of the EHR on the practice, and quality of patient care
Yeager et al. [61]		Survey Sample = 1724 physicians (Florida)	DV: Adoption IV: Doctor age, training, computer sophistication, practice size, and practice setting MV: Doctor practices (high volume elderly)
Ilie et al. [29]	Individual-level IT adoption models	Survey Sample = 199 physicians	DV: PU, PEOU, attitude, and behavioral intention IV: Physical accessibility and logical accessibility
Jha et al. [31]		Survey Sample = 1132 physicians	DV: EHR adoption IV: Perceived barriers and satisfaction

(*continued on next page*)

Table 1 (*continued*)

Study	Theory	Method	Variable
Aggelidis and Chatzoglou [1]	TAM	Survey Sample: 283 hospital personnel (among 30 physicians)	DV: Attitude and behavioral intention IV: PU, PEOU, social influence, facilitating conditions, self-efficacy, anxiety, and training
Walter and Lopez [59]	IT acceptance models	Survey Sample = 203 physicians	DV: Intention to use IV: Perceived threat to professional autonomy, PU, and PEOU
Davidson and Heslinga [10]	Technology-use mediation and communities of practice	Action research	
Liu and Ma [36]	TAM	Experimental Sample = 79 senior students from a medical school	DV: Behavioral intention IV: Perceived service level, PU, and PEOU

Note: DV: dependent variable; IV: independent variable; MV: moderator variable; CV: control variable.

perceived service level can be employed to evaluate service performance; thus, a model with the perceived service level correlated with perceived usefulness (PU) and perceived ease of use (PEOU) based on the performance-satisfaction perspective is constructed [7]. In addition, Liu and Ma [36] adopted the experiment method to demonstrate the effects of perceived service level on PU and PEOU, and that study was supported by 79 senior medical students. From the preceding discussion, the following hypotheses are proposed:

Hypothesis 1. Physician's perceived service level has a significant influence on the PU of EMR.

Hypothesis 2. Physician's perceived service level has a significant influence on the PEOU of EMR.

Perceived service quality can directly affect perceived behavioral control, thereby increasing the intention to use the system [22]. The responsiveness, reliability, and accessibility of IS are examples of perceived service qualities [52]. Reinforcement may include such items as responsiveness, reliability, and accessibility of the application service of EMR. Consequently, the following hypothesis is proposed:

Hypothesis 3. Physician's perceived service level has a significant influence on the intention to use EMR.

2.3. Healthcare technology self-efficacy

In fact, physicians tend to voluntarily use EMR in spite of the government mandates [1]. For this reason, physicians' self-efficacy of using EMR may play a critical role on adopting the EMR [45,56]. In addition, physician is fully confident that she/he has the needed capability to use the EMR system autonomously [59].

In the field of IS, a number of research and studies had proved that self-efficacy [4] and computer self-efficacy [9] are actually the key antecedents significantly affecting the technology adoption. Some recent studies also demonstrated that self-efficacy had created the influence on EMR's adoption by physicians. For example, Liu et al. [35] employed mobile self-efficacy to examine the technological stresses generated from using mobile electronic medical records. Vitari and Ologeanu-Taddei [56] uncovered that self-efficacy had influenced the physicians' intention to use EMR. Further, Jha et al. [31] showed that approximately 60% of physicians deem that computing skills are one of major barriers to EMR adoption. As a result, the perceived computer self-efficacy of a physician has created a positive effect on EMR usage [61].

However, Anderson and Agarwal [2] argued that medical information is sensitive by nature, and consequently emotion factors need to be considered on using the medical information. Moreover, self-efficacy researches focusing on the healthcare related topic should take the medical domain into account. Therefore, Rahman et al. [40] proposed healthcare technology self-efficacy (HTSE), and referred it to as "individuals' perceptions about their capabilities to use the healthcare technologies (i.e., heart rate monitor or portable ECG monitor) or accept these services using the healthcare technologies (i.e., EHR system). " (p.14).

In this study, healthcare technology self-efficacy (HTSE) refers to the physician perceptions about their abilities to use EMR system in handling the healthcare processes of a hospital. Previous empirical studies also demonstrated that self-efficacy may significantly influence on PEOU of physicians using EMR [19,56]. In addition, Rahman et al. [40] reported healthcare technology self-efficacy would indirectly affect on the intention to use healthcare technology. Dutta et al.[14] adopted empirical data to support healthcare technology self-efficacy had positively and directly influence on individuals' PEOU. Increasing the degree of easiness for physicians to use EMR appears to be more important than PU. Thus, we propose that:

Hypothesis 4. The healthcare technology self-efficacy of physicians has a significant influence on the PEOU of EMR.

2.4. Perceived risks

Since the healthcare industry needs to take the importance of individual privacy (i.e. patient privacy) and personalization perceptions (i.e. physicians' and clinical staffs' perceptions) into consideration, one of the important constructs is perceived risk [62]. In this study, perceived risks refer to the physicians' perceived risks and/or uncertainties using EMR in the healthcare processes of hospital, and such risks may include some physical, time, financial, product, performance, social, and/or psychological risks. Previous researches have attempted to explore the perceived risks on EMR usage or intention by either using the empirical data [15,28,37], or conducting the literature reviews [62]. In general, prior studies showed that perceived risk plays a negative role on the EMR adoption [62].

EMR share data across parties in the healthcare industry and pose many potential information privacy and security issues, such as unauthorized access and tampered patient data [3]. These issues can lead to disputes and/or lawsuits [2]. Consequently, many physicians consider EMR adoption a potential threat to their profession. Egea and González [15] indicated that, in using EMR, physicians may focus on such factors as privacy, psychological, and performance risks. Hsieh [28] assessed psychological, privacy, and performance risks to represent the perceived risk of physicians in the EMR exchange context. Perceived risk results in the slow EMR adoption by physicians.

The perceived risks of information users can have negative influences on PU and PEOU [17]. Online shoppers who have high perceived risks of buying from several selective vendors may find their website not useful and difficult to use. Physician's perceived risk of using EMR will reduce the intention to use EMR or increase the resistance to using EMR [28]. Liu and Chen [37] identified that physician's perceived loss of professional autonomy or power had a negative influence on the PU of mobile EMR with the empirical data support. Physicians who have high perceived risks of using EMR in daily operation are likely to have low PU and PEOU. Thus, we propose that:

Hypothesis 5. Physician's perceived risk has a significant influence on the PU of EMR.

Hypothesis 6. Physician's perceived risk has a significant influence on

the PEOU of EMR.

2.5. Technological perception

Zhao et al. [62] introduced the traditional adoption theory suggesting that PU and PEOU play an important role on investigating the healthcare technology adoption. Prior studies have demonstrated that PU and PEOU can effectively predicate a favorable attitude toward the using EMR and the creation of a behavioral intention to use it. PU and PEOU have positive influences on physician's intention to adopt EMR [1] and their actual use [29]. Physicians are unaccustomed to changing their behavior because of job specificity [39]. Thus, the PU of EMR should be improved to convince physicians to adopt the systems [51].

Liu and Cheng [37] demonstrated that physician's PEOU created positive influences on their PU of mobile EMR, and PU and PEOU significantly influenced the intention to use mobile EMR. Johnson et al. [30] indicated that physician's PEOU had an influence on PU, and PU and PEOU together directly influenced the intention to use evidence-adaptive clinical decision support systems. Gagnon et al. [19] used four models (such as TAM, extended TAM, psychosocial model, and integrated model) to explore EHR acceptance by physicians. Their study also supported a PEOU effect on PU, and two critical factors (PU and PEOU) further influenced physician's intention to use her. Ilie et al. [29] stated that these two variables could significantly affect the intention to use her. Aggelidis and Chatzoglou [1] discovered that PEOU and PU were positively correlated with behavioral intention. Sykes et al. [51] indicated that PU directly influenced EMR system use.

Physicians are creatures of habit and do not like to change their routine handwriting medical records [39]. In other words, physicians do not want to spend additional time and effort learning how to use the EMR system. PU and PEOU have positive effects on physician's attitude toward EMR and the intention to use it. Thus, the following hypotheses are proposed:

Hypothesis 7. Physician's PEOU of EMR has a significant influence on the PU of EMR.

Hypothesis 8. Physician's PEOU of EMR has a significant influence on the attitude toward EMR.

Hypothesis 9. Physician's PU of EMR has a significant influence on the attitude toward EMR.

Hypothesis 10. Physician's PU of EMR has a significant influence on the behavioral intention to use EMR.

Hypothesis 11. Physician's attitude toward EMR has a significant influence on the behavioral intention to use EMR.

3. Research methodology

3.1. Research design

The survey method was adopted to collect data from physicians who had used or was using EMR. We sent out our surveys to 258 physicians from 15 metropolitan hospitals and academic medical centers for six weeks. These medical care providers were selected based on the list of metropolitan hospitals or academic medical centers that had been reported implementing EMR. EMR system adoption is often related to hospital size because of the budget and technical skills involved [25]. A study has shown that medical service providers with more than 150 patients are likely to adopt EMR [42]. Therefore, we decided to sample metropolitan medical care providers that met these criteria. A total of six academic medical centers and nine metropolitan hospitals participated in this study. A total of 232 surveys were returned. After removing 15 invalid surveys, we entered 217 data sets (84.1% return rate) into the statistical analysis. Table 1 presents the demographic data of these participants.

3.2. Measurement of variables

Perceived service level refers to the physicians' perceived service conditions of EMR system, and that comprises such multidimensional factors as good stability of EMR systems, easy presentation of hand drawing functions [23,26]. Churchill's [6] five-point Likert scale, ranging from 1 (indicating strongly disagree) to 5 (indicating strongly agree), was used to measure perceived service level. Healthcare technology self-efficacy was defined as the physician perceptions about their capabilities to use EMR system in dealing with the healthcare processes of a hospital, and the scale developed in this study can be referred to Rahman et al. [40] and Compeau and Higgins [9], which was measured using a 10-point scale, ranging from 1 (indicating strongly unconfident) to 10 (indicating strongly confident). Perceived risk refers to physicians' perceived risk and uncertainty using EMR in handling the healthcare processes of a hospital and it includes such factors as physical, time, financial, product performance, social, or psychological risks. Finally, the perceived risk scale proposed by Stone and Gronhaug [49] is employed using a five-point Likert scale.

The mediated variables included PU, PEOU, and attitude toward EMR adoption. PU referred to physician's subjective perception of the capability to search clinical information and learning medical knowledge through EMR systems. PEOU referred to physician's perceived perception of the simplicity, clearness, and easily using of EMR systems to accomplish a task. The PU and PEOU scales proposed by Venkatesh and Davis [53] were employed with a five-point Likert scale. In this study, attitude toward EMR referred to the positive or negative physician's perception of using the EMR system, and the scale modified from Lord [34] employed a five-point Liker scale.

Intention to use EMR was the dependent variable. The intention to use EMR referred to physician's subjective intention to use EMR systems. The intention to use EMR scale was also proposed by Venkatesh and Davis [53], which employed a five-point Likert scale.

4. Results

After receiving the questionnaires, 41 invalid or incomplete questionnaires were eliminated. The valid sample comprised 217 questionnaires, and the response rate was 84.11%.

4.1. Demographic analysis

Table 2 shows the demographic data analysis results. Of the 217 respondents sampled, male physicians comprised the majority of the sample (68.7%). On average, the age of the respondents was 31 years old to 40 years old (51.6%). In terms of education level, most respondents had an undergraduate degree (79.3%). The clinical experience of most respondentsrangedfrom6 years to 10 years (32.7%), and 40.5% of the respondents had an experience with computers for more than13 years. The participants in this study comprised 36.4% of doctors in charge, and almost half of them were from the Department of Medicine (46.1%). The respondents who served in metropolitan hospitals accounted for approximately 60.8%. Table 2 presents the other details.

4.2. Reliability and validity tests

4.2.1. Reliability test

The constructs were analyzed for reliability and validity. The results are provided in Table 3. The Cronbach's Alpha of each construct exceeded 0.78, which indicated that the scales had good consistency and reliability.

4.2.2. Content validity

All questionnaires were theoretically examined and reviewed by a panel of medical experts and management IS scholars to assess the

Table 2
Demographic analysis.

Demographics		No.	%	Demographics		No.	%
Previous experience with computer	1–3 years	12	5.5	Department	Department of Medicine	100	46.1
	4–6 years	34	15.7		Department of Surgery	40	18.4
	7–9 years	29	13.4		Department of Orthopedics	14	6.5
	10–12 years	54	24.9		Department of Obstetrics and Gynecology	8	3.7
	More than13 years	88	40.5		Department of Pediatrics	11	5.1
Title	Professor of Treatment	37	17.1		Ophthalmology	4	1.8
	Doctor-in-charge	79	36.4		Otolaryngology	2	0.9
	Chief Resident	20	9.2		Dentistry	2	0.9
	Resident	40	18.4		Other	36	16.6
	Other (Intern, Physician Associate)	41	18.9	Hospital level	Academic medical center	85	39.2
					Metropolitan Hospital	132	60.8

Table 3
Results of reliability and validity tests.

Construct	Item	Average	Standard deviation	Factor loading	Cronbach's Alpha
Perceived service level	PSL1	4.028	0.707	0.792	0.887
	PSL2	4.005	0.677	0.795	
	PSL3	3.991	0.653	0.760	
	PSL4	3.889	0.768	0.719	
	PSL5	3.502	0.800	0.706	
	PSL6	3.797	0.742	0.762	
	PSL7	3.442	0.804	0.744	
Healthcare technology self-efficacy	CSE1	4.959	2.632	0.807	0.947
	CSE2	4.599	2.533	0.844	
	CSE3	6.000	2.323	0.676	
	CSE4	6.479	2.377	0.840	
	CSE5	6.940	2.073	0.886	
	CSE6	6.940	2.021	0.910	
	CSE7	6.871	2.060	0.859	
	CSE8	6.429	2.083	0.782	
	CSE9	6.295	2.202	0.824	
	CSE10	6.548	2.121	0.835	
Perceived risk	PPR1	3.184	0.934	0.833	0.782
	PPR2	3.401	0.839	0.826	
	PPR3	2.926	0.889	0.806	
PU	PU1	3.760	0.672	0.729	0.935
	PU2	3.747	0.717	0.780	
	PU3	3.779	0.698	0.780	
	PU4	3.880	0.663	0.730	
PEOU	PEU1	3.562	0.744	0.800	0.877
	PEU2	3.387	0.875	0.829	
	PEU3	3.470	0.720	0.807	
	PEU4	3.664	0.682	0.767	
Attitude toward EMR	ATT1	3.774	0.687	0.777	0.877
	ATT2	3.829	0.683	0.779	
	ATT3	3.488	0.714	0.656	
	ATT4	3.972	0.600	0.730	
Intention	BI1	3.839	0.643	0.762	0.882
	BI2	3.949	0.668	0.752	

fitness of each question, the correctness of semantic expressions, and the appropriateness of phrasing. Pretest was administered to several members of the medical staff to identify possible problems with the research design before conducting the formal survey. Thus, content validity was ensured.

4.2.3. Construct validity

All measurements of the research constructs were modified based on the scales provided/developed by previous studies. Given that translation of scales was involved, exploratory factor analysis was conducted. Kaiser-Meyer-Olkin measures of sampling adequacy were larger than 0.88, and Bartlett's test of sphericity achieved a significant level. Consequently, the null hypothesis was rejected, and the tests were appropriate for performing factor analysis.

Principal component analysis was conducted to extract common factors to verify the variance explained by each item based on eigenvalue and explained variance (%), and all variables were more than0.67. The factor loading of different constructs was significantly low. Accordingly, the correlation of different constructs was low, which indicated that each construct reached discriminant validity.

4.3. Structural equation modeling (SEM) test results

Using SEM for data analysis requires such steps as checking normality, independence, homogeneity, and multicollinearity. Four criteria fitted with the basic presuppositions. SPSS 15.0 and AMOS 18 were used to conduct path analysis. The analysis results showed that the chi-square/degree of freedom (d.f.), normed fit index (NFI), incremental fit index (IFI), comparative fit index (CFI), and root-mean-square error of approximation (RMSEA) values achieved goodness of fit (Table 4). In addition, the goodness of fit index (GFI) and adjusted GFI (AGFI) values achieved an acceptable fit. However, the root-mean-square residual (RMR) value was 0.077, which was higher than 0.05. The RMR value is easily influenced by units of measurement. Thus, the RMR value of ten tends to vary.

4.4. Hypothesis testing

Fig. 1 and Table 5 show the SEM test result with standardized estimates for the strength of each hypothesized relationship. The perceived service level ($\beta = 0.358$, $p < 0.001$) and physician's PEOU of EMR ($\beta = 0.608$; $p = 0.000 < 0.001$) had positive influences on the PU of EMR. However, perceived risk did not reach a significant level on the PU of EMR ($\beta = 0.039$, $p = 0.481$). As a result, H1 and H7 were supported, whereas H5 was rejected. Perceived service level ($\beta = 0.303$, $p < 0.001$) and healthcare technology self-efficacy ($\beta = 0.092$, $p < 0.001$) also had significantly positive influences on the PEOU of EMR. By contrast, perceived risk ($\beta = -0.104$, $p < 0.05$) had a significantly negative influence on the PEOU of EMR. Therefore, H2, H4, and H6 were all supported. The attitude toward EMR was also affected by the PU ($\beta = 0.290$, $p < 0.001$) and PEOU of EMR ($\beta = 0.242$, $p < 0.001$). Consequently, H8 and H9 were supported. PU ($\beta = 0.288$, $p < 0.001$) and the attitude toward EMR ($\beta = 0.702$, $p < 0.001$) had significantly positive influences on the intention to use EMR. Thus, H10 and H11 were also supported. However, H3 was rejected ($\beta = -0.016$, $p = 0.809$). From the preceding discussion, except for H3 and H5, all other hypotheses were supported.

Table 4
Validity test of SEM.

Indicator	Chi-square/ d.f.	GFI	AGFI	NFI	IFI	CFI	RMR	RMSEA
Value	1.097	0.884	0.851	0.924	0.993	0.993	0.077	0.021

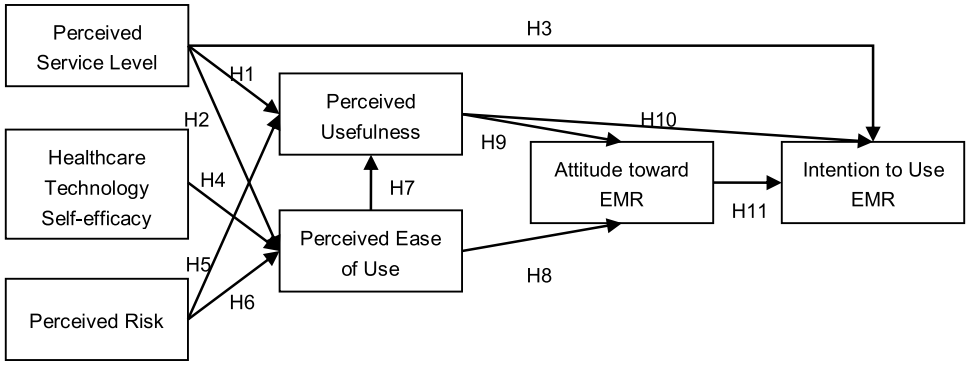

Fig. 1. Research model.

5. Discussion

5.1. Summary and contributions of the research findings

5.1.1. Physician's perceived service level positively influences their PU and PEOU of EMR

The analysis results of this study showed that perceived service level had a significant effect on the PU of EMR. When physicians perceived a good service quality of EMR, physicians easily perceived the usefulness of EMR. Liu and Ma [36] described physician's acceptance of EMR application service systems as an antecedent of the PU. As discussed previously, EMR provides information exchange across hospitals and sharing of medical records at the same time. However, paper medical records could only be retrieved/accessed by one physician at one time, and other physicians simply could retrieve the same paper medical record at the same time. In practice, this study observed that physicians did worry about the computer crash problem or other uncertain situations while using EMR services. However, physicians also considered that exchanging information or sharing the service aspects of EMR were more important than dealing with the aforementioned problems. To this end, EMR systems could provide good information-exchanging and service-sharing functions, and those did affect physician's PU of EMR.

This study also determined that physician's perceived service level of EMR was good and significantly affected the PEOU of EMR. This study considered such attributes as reliability, responsiveness, and stability to measure the perceived service level. In terms of clinical practice, if physicians perceived the system as accurate and reliable and could provide a rapid response for regular searching, recording, downloading medical information, or inputting medical orders, then physician's perceived service level while using the EMR process was very good.

5.1.2. Physician's perceived service level of EMR insignificantly influences their intention to use EMR

Physician's perceived service level of EMR insignificantly affected the intention to use EMR. Considering that physicians had a high level of professional autonomy [59], hospitals tended to adopt/exercise an encouraged attitude for physicians to use EMR systems. Zhao et al. [62] also supported the finding that the role of perceived service tends to be confusing and is unclear onto the healthcare technology adoption.

Most physicians remained accessing/using paper medical records to check/examine the state of an illness. In Taiwan, EMR is actually in the promoting and/or counseling phases. Most hospitals give physicians the alternatives for them to select between EMR and paper medical records. For this reason, the service level of EMR had no direct correlation with the intention to use EMR. However, physician's perceived service level indirectly influenced the intention to use EMR through PEOU, PU, and the attitude toward EMR adoption. Physicians changed their habit of reviewing paper medical records and performed treatment judgment, ward round, and surgery through the EMR system support. The PU, PEOU, and physician's convenience of using EMR could influence their original attitude and intention to use EMR.

5.1.3. Healthcare technology self-efficacy of physicians significantly positively influences their PEOU of EMR

The analysis results showed that the healthcare technology self-efficacy of physicians significantly affected their PEOU of EMR. The result of this study is similar to the finding obtained from the studies of Dutta et al. [14], Vitari and Ologeanu-Taddei [56] and Gagnon et al. [19]. Interviewed physicians indicated that the barriers of healthcare

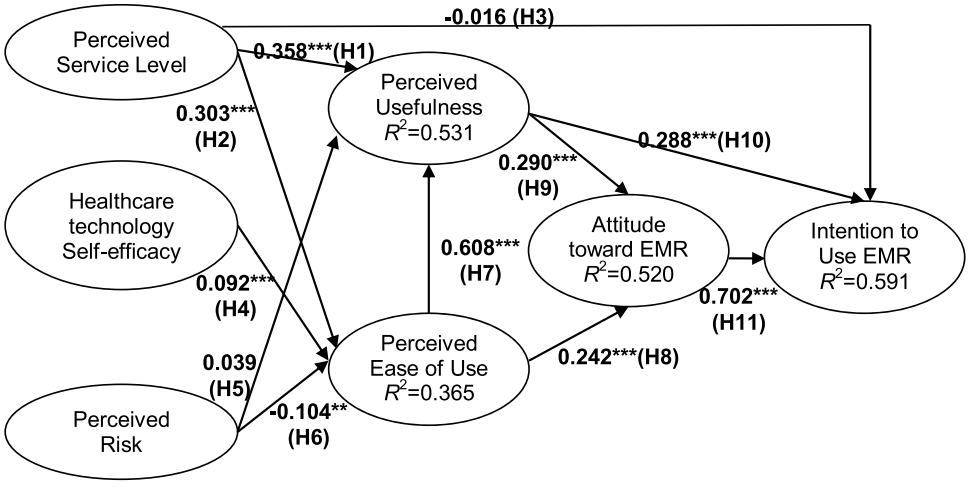

Fig. 2. Analysis Results.

Table 5
Hypotheses test results.

Hypothesis	Relationships	Estimate	S.E.	C.R.	*p* Value	Hypothesis Status
H1	PSL→PU	0.358	0.077	4.676	0.000***	Support
H2	PSL → PEOU	0.303	0.064	4.768	0.000***	Support
H3	PSL → Intention	−0.016	0.065	−0.241	0.809	Not Support
H4	HTSE → PEOU	0.092	0.018	5.032	0.000***	Support
H5	PR → PU	0.039	0.055	0.704	0.481	Not Support
H6	PR → PU	−0.104	0.047	−2.227	0.026**	Support
H7	PEOU → PU	0.608	0.091	6.708	0.000***	Support
H8	PEOU → Attitude	0.242	0.059	4.125	0.000***	Support
H9	PU → Attitude	0.290	0.051	5.722	0.000***	Support
H10	PU → Intention	0.288	0.073	3.935	0.000***	Support
H11	Attitude → Intention	0.702	0.109	6.469	0.000***	Support

** $p < 0.01$,.

*** $p < 0.001$; PSL = perceived service level; HTSE = healthcare technology self-efficacy; PR = perceived risk; PU = perceived usefulness; PEOU = perceived ease of use; S.E. = standard error; C.R. = Construct reliability.

technology self-efficacy, such as typing challenge (such as the typing speed was slow for entering medical orders in Chinese), additional tools to support reading, or extra capability to search EMR (templates and/or drag in phrases) would influence EMR usage. If physicians had high computer literacy or information literacy or possessed high determination to learn the EMR system, then they would be able to reduce the barriers of inputting medical records, operating the user interfaces, or drawing a body graph to pinpoint the medical problems. The practical interview responses with statistical results implied that, if a physician had high healthcare technology self-efficacy, then the physician perceived the convenience and PEOU of EMR, such as the ease of copying, storing, and editing medical records, searching for research data, and rapidly recording sub-information (past patient history, family history of disease, and laboratory and examination data), as well as the absolve time in handwriting or looking over medical records.

5.1.4. Physician's perceived risk of EMR negatively influences their PEOU of EMR

The analysis results of this study indicated that physician's perceived risk of EMR insignificantly affected their PU of EMR. That is, physicians did not regard the perceived risk of EMR to have an effect on the PU of EMR systems. The interviewed physicians for this study stated that, if the privacy control of EMR was not well developed, then the EMR would be subject to tampering by other people and have a strong possibility to lead to medical disputes. The perceived risk of EMR was correlated with the PU of EMR. Nevertheless, EMR is an important health policy in Taiwan, and the government encourages hospitals to adopt EMR because of its influence on applying medical revenues for the National Health Insurance (such as advance the date of the declaration of medical points and increase the quota temporary payments of effectiveness for a given period of time). Although physician's perceived risk of EMR was high, the perceived risk did not affect the PU of EMR. However, Egea and González [15] uncovered that perceived risk of EMR was negatively and indirectly influence on PU of EHR through the trust factor.

By contrast, perceived risk had a significant negative effect on the PEOU of EMR from the obtained analysis results. When physician's perceived risk of EMR was high, their intention to use EMR would decrease. Physicians were worried about the potential losses during using EMR systems, and these losses might include loss of work efficacy, reduction in treatment time, or increase in workloads. Several hospitals had already implemented EMR systems, but they still asked physicians to handle their tasks in dual process (paper medical records and EMR) during the introduction stage of EMR implementation. To this end, physicians must input the medical orders on EMR after diagnosing disease conditions, printing medical records, and pasting them back to the paper medical records. In clinical practice, physicians faced the risk of spending much time to complete the medical orders for diagnosing each patient when the aforementioned dual process were implemented in the hospital. This dual process would not only increase the workloads for diagnosis but also severely reduce the treatment effectiveness and efficiency. Physicians had a number of risks, including limited time for performing medical practice, additional workloads incurred, and reduced expected efficacy, which led to considerable discontent in the use of EMR systems. Thus, physician's perceived risk of EMR would indeed negatively affect the PEOU of EMR.

5.2. Research limitations and future directions

This study adopted the convenient sampling method as the survey instrument, and this is mainly because the aforementioned method is cost-effective and has been universally used in IS research. The subject of this study was physicians who actually using EMR systems in the 15 metropolitan hospitals and academic medical centers but did not encompass all four levels hospitals. However, the Department of Health at Taiwan does promote the use of electronic medical record across all level of hospitals. In addition, the use of electronic medical records in local community hospitals and physician clinics will become more and more common in the future. For this reason, the domain to conduct future researches may need to include local community hospitals and physician clinics at Taiwan, and by doing so, the research results may be more comprehensive to provide deeper insights about physicians' adopting EMR.

Second, this research primary subjects are physicians. However, the organizational atmosphere/ environment and operating culture of hospitals are not the same, which may create an effect to impact the validity of physicians' answers to the questionnaires. In addition, the different system's difference of implementing EMR would affect the physician perceived risk and service level of using EMR. In addition, the degree of the heavy workloads of physicians may create additional impact onto their attitude and intention to employ EMR [60]. Future study can extend research subjects to include other medical/clinical staffs with high frequency of using EMR (such as medical technicians and nurses), and by doing so, it will definitely help to understand the full picture of the hospital's adoption of EMR.

Third, EMR exchange can significantly improve onto the clinical quality and hence reduces the associated medical costs. However, physicians who were interviewed in this study indicated that the interface of EMR exchange/implementation is not so friendly to access in Taiwan. At present, the format and style of electronic medical record interfaces developed by the Department of Health not only request the physicians to provide the signatures which tends to be a rather tedious procedure, but also it contains the fragmented data which are not in the form of a continuous medical record of patient-centered data. As a

result, the availability of user-friendly EMR exchange/interface and a consistent form of continuous medical records with patient-centered data are more important topics to ensure and improve the physicians' adopting EMR. Unfortunately, designing questionnaire items of perceived service level fails to take these aforementioned topics into consideration. For this reason, future study may need to involve the utilization of more related variables such as interface with and implementation of EMR.

Fourth, same as other survey studies, this study adopted self-reported questionnaire, and that may lead to social desirability bias. In specific, physician of this research may be provided with socially desirable responses instead of asking them to choose the suitable responses that are reflective of their true feelings. Therefore, social desirability bias could also affect the results obtained in this study. Future studies can try to change the research method, for example adopting biometric analysis (such as MRI), to reduce the possible occurrence of this aforementioned bias.

5.3. Research implications

5.3.1. Implications to practitioners such as hospital managers, government agents, and medical information service providers

In practice, the findings presented in this study had several useful implications for hospital managers, government agents, and medical information service providers. For hospital managers, a physician plays an important role and has a dominant power during the implementation of EMR in the hospital. The hospital managers can understand how physician's individual characteristics of can influence EMR acceptance is critical to success, such as implementation and/or adoption. Three comments could be made here for the hospital managers. First, a good service level of EMR should emphasize on such factors as friendly user interfaces, well-guarded privacy of EMR, high security protection of EMR systems, and the desired stability of EMR systems to respond to the treatment needs of physicians. Second, increasing on-the-job training through an e-learning platform to increase the computer skills of physicians is another critical success factor. In the hospital, physicians are usually busy with such tasks as medical services, medical teaching, medical research, and even hospital administration. In other words, physicians almost have no extra time to learn how to use EMR systems. Consequently, most physicians ask their assistants to participate in the educational training of EMR systems. Another possible reason may be because physicians work too much, which may cause a certain level of inability to concentrate on learning. To deal with this aforementioned problem, e-learning may be a good alternative. By doing so, physicians can use their time efficiently and flexibly to join related computer courses or EMR courses to improve their computer literacy and increase their acceptance of EMR systems. Third, if the hospital conducts paper medical records and EMR for a certain time period, then hospital managers can take advantage of the assistants of physicians to support the handling of past medical orders, thus preventing the additional working time and workload spent/handled by physicians because of the adopting EMR systems.

For government agents, the Department of Health strongly promotes the EMR system adoption by hospitals, and physicians are the major users of EMR in each hospital. Understanding how the individual factors of physicians can influence the use of EMR is important for EMR to be successfully implemented. According to the analysis results related to healthcare technology self-efficacy, perceived risk, and perceived service level, government agents can better comprehend the different characteristics and attributes of physicians. Currently, the promotion of EMR systems by the government is usually oriented from the legal and supervision perspectives. However, the focus needs to be placed on the system requirement and the opinions of physicians to enhance the usefulness of the system. EMR system implementation can also contribute to the improvement of medical quality, which will indirectly influence the effectiveness of the National Health Insurance Policy.

For medical information service providers, this study revealed that healthcare technology self-efficacy, perceived risk, and perceived service directly or indirectly influenced the intention to use EMR systems. Medical information service providers should carefully analyze the computer skills of physicians and the system requirement through practical observation or interview or usability test methods. The practical observation method may be applied to the processes of medical services, medical teaching, medical research, and even hospital administration. Physicians are the key subjects for understanding the system requirements of EMR. However, interviewing physicians is difficult because their tasks are heavy, and they usually have no free time to accept the interview. Physician's assistants may be good alternatives for understanding physician's requirements of EMR or their habits of entering medical orders. Designing EMR system prototypes and performing usability test are requirements for a successful EMR system implementation. Decreasing the gap between physician's habits and the function of EMR systems can truly improve the perceived service level of EMR systems. The possible functional modular to improve physician's inherited habits may include changing the on-site system screen to accommodate personal habits, and drug phrase can be set freely for a convenient entry of medical orders. The high service level of EMR and perceived risk are also critical factors for medical information service providers to work further to provide the EMR systems with such attributes as stability, reliability, responsiveness, and ease of use.

5.3.2. Implications to academia

For academia, this study demonstrated that physician's perceived service level had a significant influence on their PEOU and PU of EMR but had no direct influence on their intention to use EMR. However, the statistical analysis demonstrated that physician's perceived service level indirectly influenced their intention to use EMR through the mediated effects of PU and PEOU. This result was rather different from the results of previous related studies in the area of IS acceptance/adoption. This study inferred that the characteristics of the medical industry and physician's working environment of were unique. Thus, the obtained finding showed that physician's perceived service level indirectly influenced their intention to use EMR systems. Perceived risk is also an important variable in the medical IS study. However, previous related studies have not explored how perceived risk influenced the willingness of healthcare workers to use medical-related information system in general, with a special focus on physicians in particular. This study tended to fill this research gap. By doing so, this study revealed that the perceived service level and perceived risk of physicians presented valuable variables. The results of this study could help other scholars understand the role of these two variables and how they affected the individuals working in the medical industry to adopt IS.

In addition, this study discovered that the healthcare technology self-efficacy creates a significant effect onto PEOU of EMR based on the physicians' empirical data. In Taiwan, medical school had developed some EMR-related courses such as medical chart writing and general medical management which only provides some basic training for medical students to use EMR effectively. Consequently, the additional curricular supports of EMR-related courses may be needed to promote the necessary experience for physicians to effectively utilize the EMR (such as interface and implementation) in their hospitals.

6. Conclusions

This study conducted a field survey to extend technology adoption models by incorporating additional individual characteristics based on physicians' viewpoint. In specific, to react to and expand the study of Zhao et al. [62] indicating that the role of perceived service is still unclear or confusing in terms of the healthcare's adopting EMR, this study tried to identify the role of perceived service to fill this aforementioned research gap. Further, this study also tried to incorporate the healthcare technology self-efficacy perspective which is rather different

from some previous studies applying the traditional concept of self-efficacy or computer self-efficacy in the medical or healthcare industry. Finally, this study adopted the variable of healthcare technology self-efficacy which is more suitable for the medical industry in particular. In fact, few previous studies have explored how perceived risk influenced the willingness of healthcare technology adoption. As per earlier discussion, those prior studies usually focus more on general publics or patients, this study provide a different research avenue by placing an emphasis on physicians in the healthcare environment.

Conflict of interest

The authors verify that there is no conflict of interest against the policy of Computer Standards & Interface.

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