Impact of Task, Structure, and Environment on Electronic Health Record Adoption, Use, and Interoperability in Hospitals

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Stuart M. Speedie, PhD, Adviser

June 2010

Acknowledgements

First of all, I would like to give my deep thanks to Dr. Stuart M. Speedie, my academic advisor. He allowed me to study health informatics and also financially supported me. I learned his teaching philosophy, knowledge, and research method during my study. Without his help and support, I might not have finished my dissertation. Thank you, Dr. Speedie, for all you have done for me. You will always be my respected teacher.

I would also like to thank Dr. Laël C. Gatewood, the chair of my Ph.D. dissertation committee; Dr. Jeffrey S. McCullough, School of Public Health; and Dr. Martin LaVenture, Director of the Center for Health Informatics, Minnesota Department of Health, for serving on my Ph.D. dissertation committee. Although they had their own busy schedules, they willingly helped me complete my dissertation.

My personal thanks should be given to Dr. Donald P. Connelly, faculty in the Health Informatics Graduate Program, who gave me a research opportunity and thereby provided financial support as well. I also would like to express my special gratitude to Dr. A. Marshall McBean and Dr. Bryan E. Dowd, Department of Health Policy and Management, School of Public Health. Dr. McBean taught me personally and academically and gave me lots of research opportunities analyzing Medicare claim data. Dr. Dowd helped to open my eyes in the field of health informatics. I owe these three so much more than I can pay back over the course of my life.

I would also like to give my gratitude to the Health Informatics Graduate Faculty: Dr. Linda Ellis, Dr. Stanley Finkelstein, Dr. John Faughnan, Dr. Jeffrey Hertzberg, Dr. Bonnie Westra, Dr. Terrence Adam, Dr. Julie A. Jacko, Dr. James R. Fricton, Dr. Layne Johnson, and Dr. Genevieve Melton-Meaux. During my study, they taught me both directly and indirectly which contributed to the expansion of my academic knowledge of health informatics.

I would also like to thank Chief Information Officers (CIOs) and IT Department managers in Korean hospitals who willingly participated in the survey. Especially, I thank Mr. Sung-Jeek Jung, director of the IT Department of Ilsan Hospital, the National Health Insurance Corporation. He introduced me to many CIOs, specifically the Korea Information Technology of Hospital Association (KITHA). I would like to thank the member hospitals of KITHA for their help through posting my research study into their main homepage website and voluntary participating in the survey. I also thank Dr. Young-Ho Oh and Dr. Na-Mi Hwang at the Korea Institute for Health and Social Affairs and Dr. Yong-Kyoon Lee at the Korean Institute of Hospital Management who always encouraged and supported me.

I also thank the many fellow student colleagues who helped and supported me during my study, Dr. Nawanan Theera-Ampornpunt, Dr. Hojung Yoon, Mr. Joel Ackerman, Mr. Jeff Gao, Miss Kanaporn Tansriprapasiri, Mr. Stephen Yeboah, Ms. Resty Namata, and Miss SungRim Moon in the Health Informatics Graduate Program, and Mrs. Jing Du, Mr. Jinhyung Lee, and Mrs. Jeehae Kim in the Department of Health Policy and Management, School of Public Health.

Much credit should be given to Miss Jessica Whitcomb-Trance at the Institute for Health Informatics (IHI) who corrected the grammar in my Ph.D. thesis manuscript. Christina M. Davenport, JD, at the University of St. Thomas School of Law also gave me good comments on my Ph.D. thesis. Mr. Wenjun Kang, staff at the IHI and Ph.D. candidate in the Department of Biostatics assisted me with downloading several important datasets for my thesis from websites located in South Korea. I also thank Mrs. Jiayan Huang, a M.S. graduate in Biostatistics in the School of Public Health, who gave me several statistical consultations.

I would like to deep thank Dr. Han Joong Kim, the current President of the Yonsei University in Korea, who was my academic advisor in the Public Health Graduate Program and encouraged me throughout my studies. I also would like to thank Dr. Kyu Sik Lee and Dr. Eun Woo Nam, Department of Health Administration at the College of Health Sciences, Yonsei University, who always encouraged and supported me a lot. Dr. Young Moon Chae and Dr. Woojin Chung, Public Health Graduate Program of Yonsei University, also gave me good advice on the life of foreign studies. I also cannot forget much help from one of my closest friends, Dr. Jae Sung Park, Department of Health Care Administration at Kosin University in Korea.

Lastly, I would like to thank my father-in law, Mr. Kwang-Hae Lim, and mother-in law, Mrs. Myung-Ja Park, who supported me a long time. I would like to thank my four sisters and two brothers for their endless love and encouragement, especially my two older sisters, Mrs. Kyoung-Sook Park and Mrs. Kyoung-Hee Park. In the U.S., I met a wonderful American family, Mrs. Colleen Diffely-Sullivan, Mr. Michael J. Sullivan, and their two children, Aaron and Ashley. I was not lonely because of them. I would also like to thank Dr. Harry Hull, Mrs. Suzi Henrichs, Mr. Ray Sandborgh, and Mrs. Anita Sandborgh who were always with my family. Lastly, I would like to express tremendous gratitude to my wife, Dongock Im, and two children, Sur-Hi, and Alexander Joonseo. Sorry for the long delay in my study and thank you so much for your solid support. I love all of you so much. Thank you, God, for giving me this great achievement.

Young-Taek Park
June, 2010

Dedication

I would like to dedicate this Ph.D. dissertation to my mother, Ock-Jin Kim, who is always praying for my safety and well-being, and my father, Wee-Sun Park, who passed away when I was a young child. My mother has put her everything into my education and well-being since I became handicap, due to a big traffic accident, at the age of five. Sorry Mother, for giving you so many worries and concerns. You don't have to worry so much about me anymore! I still feel my father's deep love for me and keep several memories that I had with him. Father, I remember you made a wooden kite reel for me. After you left for heaven, it was broken. I could not fix it without you. Thank you, both of you, for giving me the joy of life…

Abstract

A paradigm in the field of Heath Informatics which has been taken for granted up until this point may be disappearing and a new paradigm may begin to take shape as paper-based medical record (PMR) systems are changing to the electronic health record (EHR) systems. Although the PMR has played a critical role in recording patient's clinical information, now many studies report that EHR systems improve quality of care beyond PMRs. For this reason, the governments across the world have initiated various approaches accelerating EHR adoption, use, and interoperability. However, there has been a paucity of studies explaining which factors affect EHR adoption, use, and interoperability in hospitals. The objective of this study is to predict and investigate those factors.

This study used a non-experimental, retrospective, cross-sectional study design to measure hospitals' internal features. Specifically, this study conducted a nationwide EHR survey with the IT departments in South Korean hospitals by using online surveys from April 10 to August 3, 2009. It used Generalized Estimating Equations, an extension of the Generalized Linear Model, to interpret EHR system adoption and interoperability, and General Linear Mixed Model for the use of EHR systems.

With respect to EHR system adoption, this study found that 1) the likelihood of EHR adoption increases as a hospital's task complexity - measured by the number of medical specialties - IT infrastructure, and organic structural characteristics, and environmental complexity - measured by the number of hospitals within the local area - increases and 2) there were significant interaction effects between task complexity and structural features. Assuming that a hospital adds additional medical specialties, the likelihood of adopting

an EHR system of the hospital increases under the decentralized decision-making system, but decreases under the centralized decision-making system. The likelihood decreases under a high level of IT infrastructure, but increases under a lower level of IT infrastructure. For the hospitals' EHR use, there was not any relationship between EHR use and proposed hospital's internal features. Thus, alternative measures of EHR use and internal features were suggested. For EHR interoperability, this study found that 1) the likelihood of having EHR interoperability increases as task complexity and organic managerial features increases, and 2) two interaction effects were reported. Assuming that a hospital adds additional medical specialties, the likelihood of having EHR interoperability of the hospital increases at a high level of IT staff specialization, but decreases at a lower level of IT staff specialization. At a high level of environmental complexity with more than average number of hospitals within the local area, the likelihood of having EHR interoperability of the hospitals located in the area increases as IT staff specialization increases. However, the likelihood decreases as IT staff specialization increases at a lower level of environmental complexity with less than average number of hospitals within the local area.

In conclusion, this study verified that hospitals' task, structure, and environmental features were critical factors affecting the EHR system adoption and interoperability. However, these factors did not affect EHR use. Different approaches measuring EHR use and hospitals' various internal features were recommended. This study's results can provide health informaticians, hospital IT managers, and health politicians with new information about EHR system adoption, use, and interoperability for their innovative decision-making.

Table of Contents

Appendices

List of Tables

List of Figures

CHAPTER I INTRODUCTION

1.1. Recent central phenomena in hospitals

Medical care generates an extraordinary amount of data, almost all of which has been in paper-based medical records. Once patients visit healthcare organizations, a variety of patient information, such as family histories, clinical histories, lab results, x-rays, and billing records are collected and recorded. This information is used to treat the patient if he or she revisits the organization. Traditionally, paper-based medical records have incorporated vast amounts of patient information and have had a dominant role in medical care.

Thomas S. Kuhn, in his book *The Structure of Scientific Revolution*, defined a scientific paradigm as a belief verified and shared in a specific generation. He stated that a paradigm gradually shifts to the next paradigm through revolutionary activities when new scientific discoveries are found.[1] For example, many people once believed that our earth was the center of the universe, but we now know differently.

Already we are beginning to see a paradigm shift in the field of health informatics as more hospitals computerize diverse patient medical records. One of the major trends recently evolving in South Korean hospitals is replacing the paper-based medical records (PMR) with electronic health record (EHR) systems. Many hospitals are adopting EHR systems for diverse functionalities such as reminders, alerts, scheduling, and decision supports, and they are increasing their capacity for healthcare information exchange (hereafter interoperability) between many systems.

The EHR system was first introduced into South Korean hospitals in 1995.[2] According to a study conducted by Park (2005) and his colleagues, by 2004, 13.3 percent (4/30) of teaching hospitals in Korea had fully adopted and 53.3 percent (16/30) had partially adopted an EHR system. Full and partial adoption of an EHR system in non-teaching, general hospitals was at 7.6 percent (7/92) and 30.4 percent (28/92) respectively. Park and his colleagues' study, which focused on hospitals with at least 100 beds, had a 43.1 percent response rate: 122 hospitals participated in the study out of a general hospital population of 282 hospitals.[3] In a nationwide survey conducted in 2004, the EHR adoption rates for inpatients and outpatients were 19.6 percent (62/324) and 20.7 percent (65/324) respectively. This study targeted 1,289 hospitals, of which 324 hospitals responded.[4] According to a study conducted in 2003, 63.7 percent of primary care clinics were adopting electronic medical record (EMR) systems. The study randomly selected 2,000 primary care clinics from the roster of primary care clinics put out by the Korean Medical Association; 525 primary care clinics participated in the survey (26.3% response rate).[5] According to a study on the use of EHR functionalities and EHR interoperability in Korea, the EHR system performed multiple functions – such as drug interaction alert (52.9% of the hospitals), drug dose alert (52.4%), clinical pathways (42.3%), drug allergy alerts (25%), and clinical guidelines (20%) – and interoperability operations – such as provider-provider connection (54.5%), connection with external organizations such as pharmacies (44.0%) and sending e-mail (18.8%), and integrated medical records with other hospitals (4.2%).[6] This study surveyed medical record administrators of medical record departments in general hospitals in 2005 and there was a 59.8% (55/92) response rate.

EHR adoption, use, and interoperability in Korea are expected to continually increase judging from changes occurring in the Unites States. According to a recent study systematically reviewing research studies completed between 1994 and 2005 in the U.S., hospitals' EHR adoption rates have been predicted to reach between 20 and 40 percent.[7] Another recent study shows that 11 percent of hospitals had fully implemented and 57 percent had partially implemented the EHR system in 2007.[8] With respect to use of EHR systems, Felt-Lisk found that hospitals used various EHR functionalities: "electronic lab results" (88% of hospitals), "electronic clinical notes" (59%), "electronic images available throughout hospital" (50%), and "electronic lab orders" (49%).[9] This study conducted a nationwide survey to hospitals about the use of EHR functionality by asking if clinicians at the hospital used any of a list of electronic health record capabilities. Gans and his colleagues showed which functions of EHR were used in the medical group practice level. They found that medical groups used "patient demographics", "visit/encounter notes", and "patient medications/ prescription" (p. 1327). EHR systems with drug formularies were implemented least often, at around 65 percent of respondent EHR systems. The highest functionality, at 100 percent, was a function providing patient demographic information.[10] With respect to interoperability of an EHR system, according to a foundation for e-health initiative which has conducted an annual nationwide survey for health information exchanges since 2004, the percentage of transmitting data among healthcare organizations was "laboratory result 34% of the time", "outpatient episodes 32% of the time", and "emergency department episodes 30% of the time". Study subjects participating in data exchanges were hospitals (71%), primary care physicians (74%), community health centers (69%), and specialty care physicians (66%).[11] Adler-Milstein and her colleagues investigated the degree of healthcare information exchanges among healthcare organizations and found that nearly 40 percent of respondents did not get any healthcare information exchanges and 50 percent of the rest of the respondent group had only partial information exchanges in place in the form of “test results”, “inpatient data”, “medical history”, and “outpatient data” (p.65). [12]

This transition from PMR to EHR systems occurs for several reasons such as increased managerial efficiency and increased effectiveness of healthcare associated with EHR systems. A patient’s clinical information such as past and current health status can be easily accessible to the authorized medical professionals to enable their best decision-making. Various functionalities in EHR systems make it possible for medical providers to access updated patient information. According to a study in Korea that evaluated the effect of EHR systems on nursing documentation by comparing documentation before and after EHR adoption, EHR systems significantly increased direct patient care time and decreased the time needed for nurses to document patient data.[13] Another study in Korea compared the volume of data on patient care between PMR and EHR systems by comparing data before and after implementing the EHR system. There was not any decrease in the data volume.[14] A study recently conducted in Korea shows that the quality of documentation on “the existence of the record” and “level and agreement of information” was better under an EHR system than PMR system.[15] Pizziferri, et al, conducted a pre-post motion study after implementing an EHR system. They observed 20 physicians working at five primary care clinics and found that physicians thought EHR improved quality of care, access to patient information, and communication with patients.[16] Wong, et al, investigated the impact of computerized documentation on nursing and patient care time in intensive care units, and they found that EHR adoption in intensive care units reduced documentation time by 10.9 percent and increased direct patient care time by 8.8 percent.[17] According to a comprehensive literature review study, many studies showed that EHR systems were accurate, reliable, and relevant to patient care. [18, 19] Hospital administrations using IT and replacing the paper medical record systems with electronic record systems not only simplify their work process, they also save time and space in healthcare organizations.

There are many obstacles and barriers preventing the adoption of the EHR system, use, and interoperability. Many physicians are worried about data entry, implementation costs, security issues, and confidentiality of patient information when they use electronic medical records systems.[20] Interface issues incorporating all current diverse systems, such as laboratory systems and pharmacy systems, into EHR systems may be another obstacle to implementing EHR systems.[21] As mentioned in an empirical study by Payne et al, factors such as "leadership", "application functionality", "speed", and "data availability" may be other technical issues.[22] These issues set forth a question: how can we encourage EHR adoption, use, and interoperability by organizations?

There are many different approaches to eliminating these obstacles and barriers to EHR system adoption and use. One approach is encouraging EHR adoption and use through various governmental initiatives that are part of the process moving toward producing better health outcomes. Recent government initiatives are good examples. In December 2005, the Korean government's Ministry of Health and Welfare (MOHW) founded "the Center for Interoperable EHR (CiEHR)" to support EHR technology development and adoption in hospitals.[23] The CiEHR is a governmental research institute that supports the MOHW as they develop core EHR technologies for private and public sectors. [24]

Changes occurring in the U.S. are even stronger and more practical than those in Korea. The U.S. federal government has made an effort to increase IT adoption, use, and interoperability using stimulus money, especially for "meaningful use" of certified EHRs. The Center for Medicare and Medicaid Services (CMS) and the Office of the National Coordinator for Health Information Technology (ONC) are now developing and proposing a definition of the meaningful use of certified EHR technology. They are considering that "meaningful use" of certified EHR should improve "health care quality", "efficiency", and "patient safety" and have the functionality areas of "disease management", "clinical decision support", "medication management", "support for patient access to their health information", "transitions in care", "quality measurement and research", and "bi-directional communication with public health agencies".[25] In February 2009, President Barack Obama signed the American Recovery and Reinvestment Act (ARRA). The ARRA supports IT and EHR use and interoperability to produce better health outcomes through using and sharing health care information.[26] The Department of Health and Human Services (DHHS) is implementing the Health Information Technology for Economic and Clinical Health (HITECH) Act to encourage IT adoption, use, and interoperability, including EHR systems, as a part of the ARRA,. The DHHS has allocated approximately $19 billion to support its specific plans, $17 billion of which would be used for physicians and hospitals. Starting in 2011, physicians and hospitals using "meaningful use" of a certified EHR system would receive part of the allocated money.[26] This initiative could persuade many healthcare organizations and professionals to adopt and use EHR systems, which would result in expected positive outcomes. However, these governmental initiatives may not be enough to accelerate EHR adoption, use, and interoperability unless we understand the fundamental mechanism at the healthcare organizational level better. This is because many cultural or behavioral barriers may exist in organizations.[27]

Another complementary approach would be to conduct empirical studies to develop a better understanding of why organizations adopt and use EHR systems in order to encourage EHR adoption and use. What differentiates organizations that do move quickly from those that do not? Users of these results such as hospitals managers, health informaticians, and politicians can use the study outcomes to eliminate obstacles and to stimulate factors accelerating EHR system adoption and use. There are still many unknown factors, and thus the research questions for this study focus on the latter complementary approach.

There have been a relatively small number of studies that relate hospital factors to EHR system adoption, use, and interoperability in Korea. This is because South Korea has a short history of EHR adoption. By applying the American Hospital Association's (AHA) EHR definition, Park (2006) surveyed Korean general hospitals. In 2005, The Korean Hospital Association (KHA), the Korean Society of Medical Informatics (KOSMI), and the Health Insurance Review & Assessment Service (HIRA) conducted a nationwide survey regarding hospitals' IT status. Although the survey comprehensively incorporated hospitals' structural factors and EHR adoption, the study only reached the descriptive analysis level on EHR adoption. There have been several other studies on EHR or IT adoption in Korea. However, they have mainly focused on factors such as changes in the number of medical record administrators after the computerization of medical records,[28] nurses' experience after implementing hospital information systems,[29] a case study from a university hospital after implementing an EMR system,[30] and satisfaction with the EHR system.[31] Therefore, it is necessary to conduct a study investigating factors affecting EHR adoption, use, and interoperability in healthcare organizations.

Although there have been several studies on factors and barriers related to EHR adoption, use, and interoperability conducted outside of South Korea, they have several limitations. First, most of these studies asked for opinions about factors that are barriers to EHR adoption, such as financial resources, concerns, or worries about patient confidentiality issues, staff resistance, fear of computers, training and education issues on new systems, and maintenance of the system.[32]

Second, other than studies on EHR adoption, there has been a lack of studies focusing on how the use of EHRs and their interoperability are related to organizational factors. EHR use and interoperability are concepts recently introduced, and thus, their theoretical conceptualization and their relationships with other constructs are less developed.

Third, studies of EHR adoption and use utilizing theoretical concepts at an organizational level are rare. Many scholars in health informatics and management information systems (MIS) have studied why people accept technology and what factors affect an individual's technology acceptance. Common theories these studies use are Fishbein and Ajzen's Theory of Reasoned Action (TRA), Davis's Technology Acceptance Model (TAM), and Ajzen's Theory of Planned Behaviors (TPB).[34] However, those studies focused mainly on individuals. Many hospitals are now implementing various IT systems. Why are some hospitals beginning to install EHR systems while others are not? A mechanism explaining technology acceptance model at the individual level may not work at the organizational level because hospital level factors are quite different from individual factors, and decision-making regarding adoption of an EHR system is determined at the organizational level. In Korea, decisions such as adopting an EHR system are indeed made at the organization level by the hospitals and clinics. EHR adoption, use, and interoperability at the organizational level needs to be studied and applied using current theoretical perspectives developed from outside the academic field of health informatics, like the technology acceptance model does at the individual level. Studies which use a theoretical perspective are useful for predicting expected outcomes. They can provide us with a more fundamental mechanism for phenomena occurring in healthcare fields.

The objective of this study is to investigate organizational characteristics of hospitals that affect EHR system adoption, use, and interoperability. The results may be used to support various governments' political initiatives through better understanding of obstacles and barriers to EHR adoption, use, and interoperability. By eliminating those fundamental obstacles and barriers identified throughout this study, hospitals and governments can accelerate EHR adoption, use, and interoperability, which could bring greater managerial efficiency and healthcare effectiveness. This in turn should result in better health outcomes.

1.2. Significance of the work

First, this work has crucial implications for hospital management because it can tell us which factors are related to EHR adoption, use, and interoperability and what the precursor conditions are. None of the previous studies in Korea investigated the relationship between these three constructs and organizational factors. The results may act as a catalyst for decision making concerning acquiring and using EHR systems in Korea.

Second, it may enhance healthcare policymakers' understanding of hospitals' EHR adoption and use behaviors. Identifying related factors is important because actual benefits from the system would occur through hospitals' adoption of the system, its use, and healthcare information exchanges with other organizations. Using information derived from this study, they may design more effective and efficient strategies for achieving their IT diffusion policy goals.

Third, this study can contribute to theory building on IT adoption, use, and interoperability at the organizational level. A significant number of studies have focused on individual adoption behaviors, but relatively few studies have tried to investigate organizational adoption in health informatics based on theoretical models from other fields.

Fourth, this study will provide important information on EHR-related issues that can be used for international comparisons. There have been relatively few opportunities to see fellow nations' statuses regarding EHR adoption, use, and interoperability issues. Through understanding how hospitals responded to EHR adoption in other countries, we can acquire some knowledge about hospitals' behaviors. This kind of knowledge can be used for IT dispersion in the healthcare industry.

This study expects that its results will provide hospital managers, scholars, and politicians working in health informatics fields with useful information on factors affecting EHR adoption, use, and interoperability in hospitals. This study also expects that its results can be used to eliminate some of the barriers to adopting EHR systems and to accelerate EHR system adoption and use, which will indirectly contribute to improvement of health outcomes in healthcare organizations.

CHAPTER II BACKGROUND AND LITERATURE REVIEW

2.1. Study setting

The study setting is South Korea (hereafter Korea). Korea is a country located on the southern half of the Korean Peninsula in East Asia. It is bordered by North Korea to the north and neighbored by China to the west and Japan to the southeast.[34] Its capital is Seoul. Korea is 38,023 square miles,[35] which is smaller than half the size of the state of Minnesota (86,943 square miles)[36] in the United States. Its population was 48.6 million in 2008,[37] which is almost 10 times that of Minnesota's population (5.2 million)[38] during the same year. Korea consists of 16 states: 1 Special District City (Seoul), 6 Metropolitan Cities, and 9 Provinces (Figure 1).

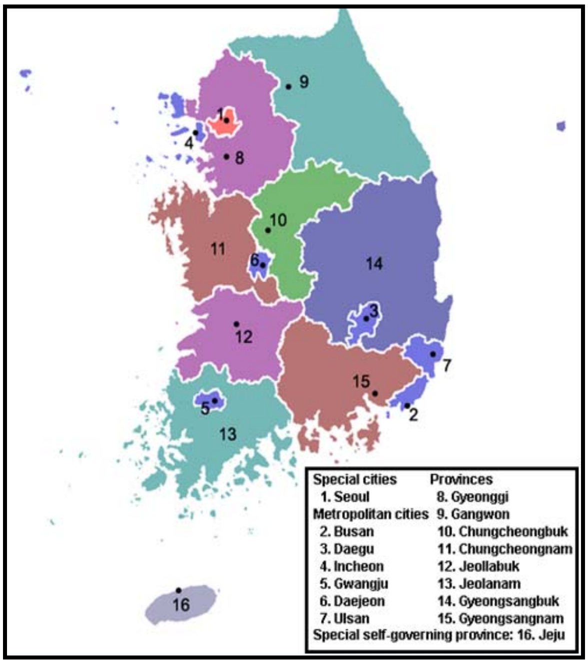

Figure 1. Map of South Korea with province identified [39]

The Korean government introduced an initial health insurance system in 1977, and implemented a compulsory health insurance program for the entire population in 1989. The financial resources of the insurance system consist of contributions paid by the insured, their employers, and government subsidies. There were three kinds of health insurance schemes before 2000. One was for ordinary employees, another for government and private school employees, and the third was for self-employed persons and rural area residents. However, these three types of insurance schemes were combined into one insurance system in 2000 and have since been managed by the National Health Insurance Corporation.

Despite the government's involvement in controlling the insurance system there was no law or regulation on electronic medical documents or records in Korea before 2003. The Korean government revised the Medical Act on March 30, 2003 to say that healthcare organizations can create and keep electronic medical documents[40] (in addition to the paper medical records and documents) that have a written signature from the healthcare provider that is applied under the guidelines of the Digital Signature Act. The Korean Medical Law currently notes that "medical professions or founders of healthcare organizations can create and keep electronic documents called 'Electronic Medical Records' having a written signature applied by [under the guideline of the] Digital Signature Act although there is the rule of section 22."[41] The rule of section 22 requires healthcare providers to keep various medical patient care documents with their signatures.

This law is now applied to all hospitals. There are several types of hospitals in Korea. Korean Medical Law divides hospitals into three categories: 1) general hospitals,

hospitals with 100 or more beds and at least eight clinical departments (e.g. internal medicine, general surgery, pediatrics, obstetrics and gynecology, imaging medicine, emergency medicine, and clinical pathology), 2) hospitals (hereafter, this study will use the term, "small hospital" to represent "hospital" under the definition of the Korean Medical Law, in order to avoid terminological confusion with a general term "hospital"), medical facilities accommodating 30 or more beds, (this includes dental hospitals and hospitals of oriental medicine), and 3) long-term care hospitals, facilities which are under the control of the Social Welfare Law and which provide long-term care.[42]
Approximately twenty percent of these hospitals have now adopted EHR systems. However, there has been a paucity of studies about how a hospital's structural characteristics affect that hospital's EHR system adoption, use, and interoperability. Information about the past status of hospitals that have adopted EHR systems can support the decision to adopt the system of hospitals that have not adopted an EHR system. The following sections will describe how current empirical studies define and measure EHR adoption, use, and interoperability. Then theories that can help explain why organizations make decisions to adopt and use EHRs will be reviewed. Finally specific factors that are derived from these theories and that are demonstrated to have an impact on such decisions will be reviewed.

2.2. EHR adoption, use, and interoperability

This section briefly reviews how current empirical studies define and measure the concepts of EHR adoption, use, and interoperability at the hospital level.

2.2.1. EHR adoption

The AHA performs an annual survey of hospital information technology adoption, including EHR adoption. It measures EHR adoption at one of three levels: full implementation, partial implementation, or no EHR system implementation.[8,43] The survey provides a definition of an electronic health record system, but does not provide a formal definition of adoption.

DesRoches and her colleagues surveyed the adoption of the EHR system in primary care clinics. They categorized two types of EHR systems: a basic EHR system and a fully functional system. They measured EHR adoption by looking at whether primary care clinics acquired and implemented an EHR system, but they also did not define the concept of EHR adoption.[44] Although they measured EHR adoption only in primary care clinics, but not hospitals, they set forth an example of how current studies measure EHR systems in healthcare settings.

Jha and his colleagues conducted a nationwide survey of hospitals in which they investigated the adoption rate of EHR systems in hospitals in 2008. They also did not formally define adoption, but they categorized it as: basic or comprehensive EHR system adoption, adopting an EHR system, and no adoption. They defined a comprehensive EHR system as a system in which all of the hospital's clinical department units have implemented an EHR system with various clinical functionalities. A basic EHR system is one in which only part of the hospital's clinical units have implemented an EHR system. If any part of the hospital units had begun to implement an EHR system, they considered those cases as adopting an EHR system. If they did not have any EHR system, then they labeled the hospital as not adopting.[45] These studies define the concept of EHR adoption in a hospital as any actual acquisition and implementation of an EHR system by any department in the hospital.

2.2.2. EHR use

The above-mentioned study conducted by DesRoches and her colleagues also focused on EHR system use measured as self-reported utilization of system functions. According to their study, 4% of physicians were using a fully functional EHR system of which 97% of respondents reported that they are using all the functions in the system at least some of the time. Thirteen percent of physicians were using a basic EHR system and more than 99% of those physicians reported that they are using all the functions at least some of the time.[44]

Most current studies have defined "EHR use" as the existence of implemented functions in accordance to the Medical Group Management Association (MGMA).[46] For an example, Jha and his colleagues measured use of an EHR system as whether or not it had specific functionalities such as clinical guidelines, clinical reminders, drug-allergy alerts, and drug-allergy interaction alerts.[45] In 2003, IOM suggested that an EHR system can be used primarily for patient care delivery, patient care support processes, other administrative procedures, and secondarily for education and clinical research. They also set forth that an EHR system should have core functionalities such as decision-support, results management, electronic communication and connectivity.[47] Recently, the CMS and the ONC defined the meaningful use of an EHR system as the existence and/or reported use of decision-support, clinical pathways, and interoperability.[48] These studies have not presented clear definitions but rather have relied on self-reports of the functions of an EHR system that are in place and being used by hospital personnel.

2.2.3. EHR interoperability

The Healthcare Information and Management Systems Society (HIMSS) defines interoperability as "the ability of health information systems to work together within and across organizational boundaries in order to advance the effective delivery of healthcare for individuals and communities." [49] The U.S. Government Accountability Office defines interoperability as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged (p.1)." [50] Bouhaddou and his colleagues also define interoperability as "the ability of two or more health care information systems to exchange information and to use the information that has been exchanged (p.174)."[51] These definitions clearly illustrate that EHR interoperability is the ability of an EHR system to exchange patient information with other systems.

The National Library of Medicine (NLM) and Health Level 7 (HL7) developed a survey that measured interoperability by asking "what type(s) of information are being exchanged?" The respondent answered the question with either a yes or no on each clinical item, such as family or patient history, patient condition summary, discharge summary, and other lab and procedures. [52] Using such a measure, the e-Health Initiative characterized interoperability of EHRs in 2007 as exchange of laboratory result (34%), outpatient episodes (32%), and emergency care episodes (30%).[11] This study could not find any other previous studies operationally defining and measuring interoperability in hospitals.

2.3. Theoretical background

There are many organizational theories which can provide insight into why organizations make decisions to implement and use EHRs. This study selected two of these theories because they are particularly applicable to our research question. This section will introduce those theories, their critical concepts, and arguments.

2.3.1. Contingency theory

The basic ideas of contingency theory were introduced by Lawrence and Lorsch.[55] They found that environmental uncertainty was associated with structural differentiation such as departmentalization and the division of labor. This structural differentiation was also inversely related to integration. Organizations having high integration efforts achieved high performance as measured by profit changes, sales volumes, and manager's subjective appraisals.[53] Based on these findings, they argued that organizations would be effective in achieving their performance goals when their internal features, such as subunits, and their processes, such as integration efforts, are consistent with external environments.[53] Jay Galbraith (1973) stated that "there is no one best way to organize", but that "any way of organizing is not equally effective."[54] This means that organizational performance depends on various structural factors including environment. Scott (2003) explains this theory with this hypothesis: "organizations whose internal features best fit the demand of their environments will achieve the best adoption" (p.96).[55]

However, some scholars use a slightly different terminology, strategic contingency theory, when intra-organizational changes occur in response to the environment. For example, Hickson and his colleagues note that "the theory relates the power of a subunit to its coping with uncertainty, substitutability, and centrality, through the control of strategic contingencies for other dependent activities, the control resulting from a combination of these variables" (p.216).[56] D. Knoke also illustrates strategic contingency theory with intra-organizational or subunit changes caused by external environment. Organizational environments affect organizations having many subunits. Subunits that prove more successful in dealing with the environment will achieve greater dominance over other subunits and the organization's resources and will have a greater effect on organizational rules and procedures.[57] For example, if legal claims from consumers occur frequently in an organization, the legal subunit manager can take a dominant position and critically affect other subunits that are producing and maintaining products. As an example of contingency theory, Orlikowski and Barley state that "the more complex and unpredictable the technology, the more likely were organizations to adopt an organic rather than a mechanistic structure" (p.148).[58] What does this theory tell us about adoption of an EHR system? This study argues that there are certain hospital internal features that promote and correspond well with EHR adoption, use, and interoperability. Hospitals with those characteristics are more likely to adopt an EHR system and use the system more than the other hospitals without those characteristics. The arguments regarding these predictions will be described in the next section in detail.

2.3.2. Contingency theory constructs

There are three theoretical concepts frequently dealt with in contingency theory: task, structure, and environment. These concepts can be analyzed into several further theoretical constructs. For example, task can be broken down into task complexity, uncertainty, and interdependency. Among the several task constructs, only task complexity is applicable to our research question because EHR adoption, use, and interoperability may be critically affected by task complexity, as illustrated by Scott (2003) and Flood (1987).

With respect to hospital structure and environmental factors, four constructs from contingency theory focusing on IT departments in hospitals are applicable: decentralization of decision-making, IT staff specialization, IT infrastructure, and organic form (versus mechanical form). This is because these four constructs are frequently mentioned as important factors related to affecting an organization's technology use.[55,59,60] Additionally, this study also included one environmental factor, environmental complexity, because the constructs above do not cover environmental factors.

Task complexity: Task or technology includes the hardware to make products and the knowledge of employees in the organization (Scott, 2003). Harvey investigated the relationship between organizational task and organizational structure using 43 industrial organizations and found that organizations producing specific products had a higher number of subunits, levels of authority, and ratios of managers and supervisors to total personal than the others.[61] These studies tell us about that the various task characteristics that are a major determinant of organizational structure, which is described in the following sections.

Decentralization of decision-making system: Decentralization of decision-making generally means that the authority to make decisions is dispersed throughout many employees.[62] By giving managerial decision-making power to appropriate managers, organizations can achieve managerial efficacy and organizational effectiveness. Decentralization of decision-making can be a major determinant of organizational technology adoption. Hage and his colleague defined decentralization as the extent to which employees can participate in decision-making about important organizational programs and policies.[63] In a study, they measured the degree of participation of department heads in an organization's staff hiring, promotion, program, and policy, and found that the degree of decentralization of decision-making was positively associated with an organization's innovation. They measured innovation as the rate of new program adoption for a certain period of time.[63] In another study, they studied work processes and organization structure using organizations related to healthcare and interviewed supervisory personnel at managerial levels. They found that organizations with routine work-flow had the greater centralization of decision-making system.[64] These study results indirectly suggest that hospitals with decentralized decision-making systems may be more likely to have complex workflow processes and environments in which innovation can frequently occur.

Specialization: Daft defined specialization as the extent to which organizational tasks are divided into subunits according to their specialties and responsibilities.[65] Scott illustrated specialization as the degree to which positions in an organization can be grouped into a certain unit based on similarity of goals, work processes, consumer types, locations, etc.[55] Thus, specialization is related to organizational departmentalization or subunit as well as the organizational structure. Specialization is sometimes called the "division of labor" in organization studies.[65]

There have been many studies on the relationship between specialization and organizational structure. Main study trends focus on the relationship between specialization and span of control and between specialization and organizational integration or coordination. This is because if specialization increases, then an organization is subdivided into subunits. While narrowing down tasks into subunits increases work efficiency by giving employees a narrow span of control through limiting their cognitive capacities, the organizations are more likely to experience difficulty of control and to confront conflict issues due to increased departmentalization. [66] They thus need more coordination and integration.[67] Consequently, in contingency perspective, organization efficiency is high when an organization emphasizes coordination or integration under high specialization. If hospitals are more specialized, then they may be more likely to adopt an EHR system for integration because EHR systems have various coordination functions.

Infrastructure: In the studies of the contingency theory, the construct of infrastructure have not been well developed and studied. Fombrun only defined "infrastructure" as interconnected core structure that an organization has to deal with and engage in to maintain its works over time.[68] He included all feasible sets of resources related to an organizations' production into the boundary of infrastructure, including technology and the various schemes of task. Due to the lack of an empirical study in this area, this study cannot predict a trend. However, in the contingency perspective, high IT infrastructure may promote an EHR system adoption because if hospitals have a high degree of IT infrastructure, then their past experience acquired from previous IT installation may help them to more easily adopt an EHR system.

Organic or mechanical structure: Burns and Stalker (1961) devised the concept of mechanical or organic structural forms through the observation of twenty industrial firms.[69] They conceptualized two types of organizational structures: organic or mechanical. Burns and Stalker observed that the mechanical organizational structure achieves the best performance under a stable environment. The organic structure is preferred when there is a high level of environmental change.[69] According to their conceptualization, organic organizations tend to have the following characteristics: decentralization of decision-making, flexible rules and procedures, frequent mutual reliance among employees, frequent upward or lateral communications, voluntary participation of extra activities among employees, and so on. In contrast, organizations are considered mechanical if their organizational structures do not have these characteristics. These characteristics are briefly presented in Table 1.

This study asserts that hospitals with a more organic management structure may be more likely to adopt an EHR system because implementation of new technology, such as EHR systems, requires acceptance of diverse ideas or needs from employees internally and externally through lateral communications, which corresponds to the general characteristics of organic management structure. Further specific predictions related to this construct will be argued in the following section.

Table 1. Characteristics of mechanical and organic organizational forms

Items	Mechanical form	Organic form
Communication	Hierarchical emphasis – predominantly vertical communication	Horizontal emphasis – high level of lateral communication within organizational networks
Decision	Centralized decision-making	Decentralized decision-making
Roles	Well-defined specialized roles	Loosely defined and less specialized roles
Rules	High reliance on standardized rules and procedures	High reliance on mutual adjustment between co-workers

Source: J. Child (2005), p.26.

Environmental complexity: Tung (1979) defined environmental complexity as "the number and heterogeneity/diversity of factors and components that the focal unit has to contend with in decision making" (p.675). She analyzed 64 departmental units of 21 companies and found that departments become more organic in structure as environmental complexity increases.[70] Clark and his colleague defined environmental complexity as the "degree to which factors in the organization's environment are few or great in number and similar or different from one another."(p.29)[71] Duncan set forth the components of external environment increasing complexity as customers, suppliers, competitors, and political issues.[72] Using these components, he conceptualized environmental complexity as the simple-complex dimension based on the number of components and static-dynamic dimensions, changing characteristics of these components over time. Thus, environmental complexity generally means the degree to which an organization has to deal with various internal and external factors and resources surrounding it. Previous studies have shown that environmental complexity affects organizational structure, but they do not describe how environmental complexity affects technology adoption such as EHR adoption. This prediction will be argued and described in a following section.

2.3.3. Task-Technology fit model

The Task-Technology Fit (TTF) model was proposed and developed by Goodhue and Thompson. [73] The TTF model assumes that individuals perform best when their task fits well with available technology.[74] Goodhue and his colleague analyzed users of 25 different information technology systems from two companies and investigated whether TTF status affects organizational performance. They found that TTF status impacted the quality of data, timeliness, and the IT system's relationship with users and was positively associated with organizational performance measured by perceived effectiveness and user productivity. [75] Ammenwerth and her colleagues investigated TTF status among individual users, their tasks, and technologies in hospitals. They observed a nursing documentation system used in dermatologic, pediatric, and psychiatric wards. They found that immediately after adopting the nursing documentation system, TTF status in the dermatologic and psychiatric wards was better than that of the pediatric ward. [76] These studies indirectly suggested that hospitals with high task complexity would adopt and use EHR systems because high task complexity fits well with information processing capabilities of EHR systems. High task complexity requires hospitals to use coordinated care due to the task complexity. An EHR system can help them to provide such coordinated care because it has various coordination functions.[77] If hospitals with lower task complexity invest in an EHR, it will be an over-investment and result in managerial inefficiency.

2.4. Factors that influence EHR adoption, use and interoperability

In this section, this study will look at the previous studies related to EHR adoption, use, and interoperability. It provides the opportunity to see other factors affecting EHR adoption, use, and interoperability.

2.4.1. Factors that influence EHR adoption

Schoenman conducted a national survey of rural hospitals (sample size 238) and found that stand-alone, small size, and critical access hospitals were less likely to adopt an EMR system than other hospitals.[78] Although the study was a nationwide survey, the study was limited by the fact that it only looked at rural hospitals. McCullough analyzed data from various sources including the HIMSS's Dorenfest dataset and found that the scope of services was not related to information system adoption (p.96, p.157).[79] The AHA conducts an annual survey of hospitals' information technology. According to a report conducted in 2007, the main factors affecting EHR adoption were the size of hospital, location of hospital (urban or rural), and teaching status.[8] Jha and his colleagues investigated EHR system adoption in U.S. hospitals through a comprehensive nationwide survey and also illustrated factors affecting the EHR system adoption in which hospital size, teaching status, affiliation status, urban location, and existence of coronary care units were related to EHR adoption. One of the most important barriers to

EHR system adoption was the financial issue of purchasing an EHR system.[45] These empirical studies suggest that various structural factors such as size, affiliation status, hospital location, and teaching status are possible predictors of EHR adoption.

Simon and colleagues also investigated organizational factors affecting EHR adoption in office practices. They found that practices affiliated with hospitals and practices teaching medical students are more likely to adopt EHR systems. [80] Healthcare Financial Management Association surveyed senior healthcare finance executives at hospitals to investigate barriers to EHR adoption. They received the following responses: "lack of national information standards and code sets" (62%), "lack of available funding" (59%), "concern about physician usage" (51%), and "lack of interoperability (50%)" (p. 2).[81] This study suggests that the relevance of perceived barriers to adopting an EHR system may be another critical factor influencing EHR adoption in hospitals.

2.4.2. Factors that influence EHR use

Miller and his colleagues surveyed physicians and EMR managers in 30 physician organizations to investigate barriers affecting the use of EMR systems. They did not provide a formal definition of the use of EMR systems, but measured it by whether an EMR system had the following functions: record viewing capability, documentation and care management, ordering, messaging, analysis and reporting, patient-directed functionality, and billing. They reported that patient-directed functions such as e-mail messaging, reminders, and scheduling were very limited compared to the use of the other functions. The main barriers to EMR use were mostly financial issues, such as investment costs, low rate of return, and time costs, and additional technological issues, such as the difficulties of technology management and support and the negative attitude of physicians (p.119).[82]

Jha and his colleagues also studied the use of EHR systems in hospitals. They measured the use of EHR systems by the presence or absence of various EHR functions. There was a high variation in functions reported. Many EHR systems provided access to test and imaging results, but did not report using decision-support functions such as clinical guidelines, clinical reminders, or drug alerts. They reported EHR system adoption and hospital characteristics, but did not report how they were related to the use of EHR systems.[45] These study results indicate that there has been a relative paucity of studies investigating how organization factors affect EHR system use. This might be due to the difficulty of defining the concept of EHR system use. Some studies have investigated barriers to EHR system use, but findings are similar to the ones in which factors affect EHR system adoption.

2.4.3. Factors that influence EHR interoperability

Disclosure of patient and provider information, financial burden, additional work load, and training issues for interoperability may be some critical factors affecting EHR interoperability. The CMS and the Substance Abuse and Mental Health Services Administration had a conference on January 24-25, 2007, in which they discussed interoperability issues in health information systems for mental health, Medicaid, and treatment for substance abuse. They concluded that major barriers to interoperability were fear of provider performance and patient privacy disclosure, financing restraints, and additional work.[83] The Health Sciences Center at the University of Colorado investigated the interoperable status of EHR systems in post-acute care and long-term care facilities and found that physicians' usage and costs related to interoperable EHR development and training issues due to high turnover rates were considered important factors affecting interoperable EHR adoption and development.[84]

Collaborations and coordination among the users, department managers, and related people may be other critical factors affecting EHR interoperability. D. Brailer reported lessons learned from the failure of the Santa Barbara County Care Data Exchange project that started in 1999 and ended in 2006. He emphasized the importance of an organic or bottom-up approach to the HIE project with a human factors focus reflecting end-user's needs, considerations of workflow and stakeholder diversity.[85] Miller and his colleague described two successful health information exchange projects. According to their report, two regional health information organizations (RHIOs), the Indiana Network for Patient Care and the Northwest (Spokane, WA) RHIOs, have had successful HIE projects. Both RHIOs allow local healthcare providers to access patient information such as lab tests and medications and use them for patient care. One important factor to the success of the HIE project reported by authors was voluntary collaboration of participating organizations and provider networks.[86] Although interoperability is a characteristic of an EHR and HIE is the process of exchanging information between systems which is not necessarily electronic, but hopefully electronically interoperable, there is a common characteristic in which both need members' collaboration and cooperation for success. These studies suggest that stakeholders' participation, coordination among participants, and organic structure of hospitals may be critical factors affecting EHR system interoperability. Without collaboration and coordination of diverse professional groups in hospitals, hospitals may not be willing to develop interoperable EHR systems. Collaboration efforts from local provider networks may be as important for EHR interoperability as cooperation of professional groups in hospitals.

These empirical studies also suggest that there might be some common characteristics affecting EHR adoption and EHR interoperability. For example, hospitals may hesitate to seek health information exchange due to a lack of funding or concerns about disclosure of individuals' information. These barriers were also found in a study on factors affecting IT adoption such as EHR systems.[87,88] Although the studies provide information on barriers to EHR interoperability, the information is often the opinion of experts and seldom the results from empirical studies.

2.4.4. Summary of factors influencing EHR adoption, use, and interoperability

First, EHR systems or IT adoption was negatively associated with stand-alone, small size, critical access hospitals, but positively associated with teaching status of hospitals, high IT infrastructure, large size, urban location, and high case mix index (complexity of patients treated). Second, EHR systems or IT adoption was not significantly associated with high-tech services of hospitals, scope of services, types of services. Third, EHR systems or IT adoption may be negatively associated with hospitals having the following characteristics: lack of available funding, and concern about physician usage on the system. Fourth, EHR adoption, use, and interoperability may be positively associated with a hospital's internal collaboration of employees and community network's cooperation.

2.5. Theory-based factors that influence EHR adoption, use, and interoperability

Based on findings from the literature and both contingency theory and Task-technology Fit Model, this study argues that EHR adoption, use, and interoperability is a function of a hospital's task complexity, decentralization of decision-making, IT staff specialization, IT infrastructure, organic structural forms, environmental complexity, and their interactions.

Task complexity: In task-technology fit perspective, an EHR system fits well in hospitals with high task complexity. Hospitals having high task complexity will require high information processing demands, which will lead the hospitals to invest more in information technologies including EHR systems because investment in an EHR system increases the hospital's capacity to deal with more complex information processing. In contrast, hospitals with a lower task complexity would not have as great a need to invest in an EHR system because the lower information processing demands associated with lower task complexity would make it an unnecessary investment. If they invest some financial resources into an EHR system, this would result in inefficient resource use. For this reason, they would not invest in an EHR system. A hospital's task complexity would be one of the critical factors of EHR adoption, use, and interoperability. Wang and his colleagues analyzed data from 1,441 hospitals and investigated factors affecting adoption of clinical information systems. They found that a case mix index (a measure of complexity of patients treated) was related to the adoption of the clinical information system.[89] The case mix index can be considered as a proxy variable for task complexity of this study. Their study result provides us a meaningful indication that task complexity measured by the diversity of the medical specialties may also be related to EHR adoption, use, and interoperability.

Decentralization of decision-making: In contingency theory perspective, an EHR system fits well in hospitals with decentralization of decision-making system in terms of adoption, use, and interoperability. Suppose there are hospitals that allow departmental managers to actively participate in the hospitals' major decision-making. These hospitals would have a more decentralized decision-making system. Hospitals where this is not allowed have what is called a centralized decision-making system. The possibility of delivery of new ideas and suggestions including installation of EHR systems to a high level manager or chief executive officer would more frequently occur in a higher decentralized system because the lower level managers have more influence. We can see evidence of this in studies in which IT innovation more frequently occurs in decentralized decision-making systems. Damanpour conducted a meta-analysis investigating the relationship between organizational factors and innovation and found that centralization of decision-making was negatively related to organizational innovation.[134] Accordingly, it is possible that hospitals with decentralized decision-making systems would be more likely to adopt and use an EHR system than the other hospitals.

IT staff specialization: Moch and his colleagues investigated factors facilitating the adoption of innovation through analyzing data from 489 hospitals. The two dependent variables were the adoption of a new medical technology system for diagnosis and treatment and the adoption of an electronic data processing system for hospital management. One of the major independent variables was specialization measured by the number of medical specialty areas. They found that specialization was significantly associated with information system adoption.[90] Thus, this study proposes that hospitals with specialization would be more likely to adopt and use EHR systems.

IT infrastructure: In hospitals with high IT infrastructure, their employees certainly would have more experience from previous and current IT implementations. This can accelerate a hospital to adopt an EHR system compared to hospitals without IT infrastructure and experience. Empirically, Chau and his colleagues investigated factors affecting the adoption of IT innovation and found that there was a positive, but not significant relationship between current IT infrastructure and the adoption of IT innovation.[91] However, Anderson and her colleagues found that current IT infrastructure was significantly associated with EMR adoption in primary care clinics.[92] Although the unit of analysis was primary care clinics, their study indirectly suggests that IT infrastructure may also influence adoption of an EHR system in hospitals just as it does for EMR systems in primary care clinics.

Organic or mechanical forms: A hospital is an organization composed of diverse specialties and different departments. Installation and use of EHR systems inevitably require cooperation among various organizational subunits. They also need to coordinate with diverse subunits through frequent lateral communication. If the installation of an EHR system is mandated by a top manager without consideration of users' needs or opinions, then there would be a high possibility of failure. In contrast, hospitals with an organic network structure characterized by horizontal communication or network-based installation of EHR systems have a higher possibility of reflecting user-level needs because frequent horizontal communication can reflect their needs into the EHR system. Aiken and Hage analyzed a panel data from 16 health and welfare organizations and investigated the relationship between organic structural characteristics and organizational innovation. They measured organic features by the diversity of occupational structure, extra activity of staff members, frequency of meetings, upward communications, inter and intra-departmental communications and innovation by the number of new programs and services previously successfully implemented. They found that organic structural features were positively related to innovation.[93] Meadows investigated organic features of small group structure based on the Burns and Stalker's concept and innovativeness, which was measured by group members' perception on innovativeness of their work process and management and found a similar result.[94] Hull and his colleague analyzed data from 110 factories and found that innovation, measured by the number of patent applications adjusting for the number of employees, was high when there was a more organic rather than a mechanical socio-technical structure. They measured organic features by hierarchical levels, centralization of decision-making, degree of control, and no flexibility of waiting-time in assembly line, which was negatively associated with organizational innovation.[95] Thus, adoption and use of an EHR system would be more likely to occur in an organically structured hospital rather than a mechanically structured hospital.

Environmental complexity: In a contingency theory perspective, EHRs fit well in hospitals with high environmental complexity for the following reason. Under a highly competitive environment, hospitals are more likely to invest in IT because of high competition. If they did not invest in IT, they would fall behind other hospitals and other competition. Thus, hospitals located in highly complex environments with many competitors may be more likely to adopt and use an EHR system simply to keep up with the competition.

Burke, et al investigated the relationship between a hospital's IT adoption and market competition. The study used the 1999 Dorenfest database and the 1998 American Hospital Annual Survey and found that a hospital's market competition measured by the Herfindahl Hirschman Index (HHI) is related to IT adoption measured by administrative, clinical, and strategic IT.[96] Baker, et. al., investigated the relationship between Health Maintenance Organization (HMO) market share and technology adoption measured by MRI availability per 1,000 populations and found that HMO market share was negatively related to technology adoption.[97] Friedman and his colleagues, through surveying informants such as the chief executive officer and chief financial officer in hospitals, studied the relationship between technological and environmental factors with respect to adopting new medical technology and MRI acquisition. The study looked at 94 hospitals, 52 of which were in California and 42 of which were in either Oregon or Washington. They found that under a turbulent environment (California), hospitals with early MRI adoption were significantly affected by technological competition, measured through hospitals adopting similar technologies. However, under a stable environment (Oregon/Washington), technologic competition did not play an important role in MRI adoption.[98]

These studies indirectly suggest a possible explanation of the relationship between technology adoption and market competition. Adopting information technologies may increase a hospital's competitive value because there is the possibility of better quality of care and greater managerial efficiency. This gives a good impression to consumers who often believe that modern technologies produce a higher quality of care. Hospitals located in less competitive environments thus have less motivation to invest in IT, including EHR systems, compared to hospitals located in competitive environments. Therefore, environmental complexity measured by market competition may be positively related to EHR adoption, use, and interoperability.

Task complexity/structure interaction: Scott reports that organizations with high task complexity are more likely to have structural specialization and decentralization (Scott, 2003). This is because delegating some authority and responsibility through specialization and decentralization would be better for performance when an organization's task complexity is high. When organizations have specialization and decentralization, organizational innovation is more likely to occur. From an organizational perspective, introducing EHR systems can be seen as an innovative action, and thus, specialized and decentralized hospitals may be more likely to adopt an EHR system. In contrast, highly centralized hospitals may be less likely to adopt an EHR system. Brynjolfsson and Hitt (2000), through conducting a survey of approximately 400 firms, found that the degree of IT use had a positive relationship with the degree of authority delegation to individual employees or teams.[99] Thus it is expected that task complexity may affect EHR adoption, use, interoperability through various structural characteristics of hospitals proposed in this study.

Environmental complexity/structure interaction: Pfeffer and his colleagues, analyzed data from 38 small manufacturing organizations in order to investigate the relationship among technology, organization structure, and environmental competition. They found that environmental competitiveness affects production technology, such as the number of products, designs, and production processes. Moreover, the relationship between organizational structure and production technology was dependent on environmental competitiveness. The number of products increases as departmentalization increases under competitive environment.[100] This study indirectly suggests that there may be some relationship among technology, structure, and environment. Although this study was not concerned with EHR adoption, the study suggests that one needs to consider the diverse relationship between environment and organizational structure with respect to EHR adoption, use, and interoperability.

Summary of prediction: With respect to the relationship between the three outcome variables and theoretical constructs proposed in this study, the following relationships were expected. EHR system adoption, use, and interoperability will be positively related to task complexity, decentralization of the decision-making system, IT staff specialization, IT infrastructure, an organic structural management style, and environmental complexity in hospitals. There will be interaction effects between technology and structure and between structure and environment with respect to EHR adoption, use, and interoperability.

2.6. Conceptual model

The following section describes how this study conceptualized each construct from theories and empirical studies and set forth the final conceptual model for this study. A. Kazley and her colleague studied organizational and environmental determinants of

EMR adoption and developed a conceptual model for her study based on the resource-dependent theory.[101] The resource-dependence theory explains organizational changes with power-dependence relationships between organizational factors with external environment. They conceptualized that EMR adoption is a function of organizational and environmental factors (Figure 2). Although their study focuses on EMR adoption, the conceptual model can be used for predicting EHR adoption since the concepts are so similar.

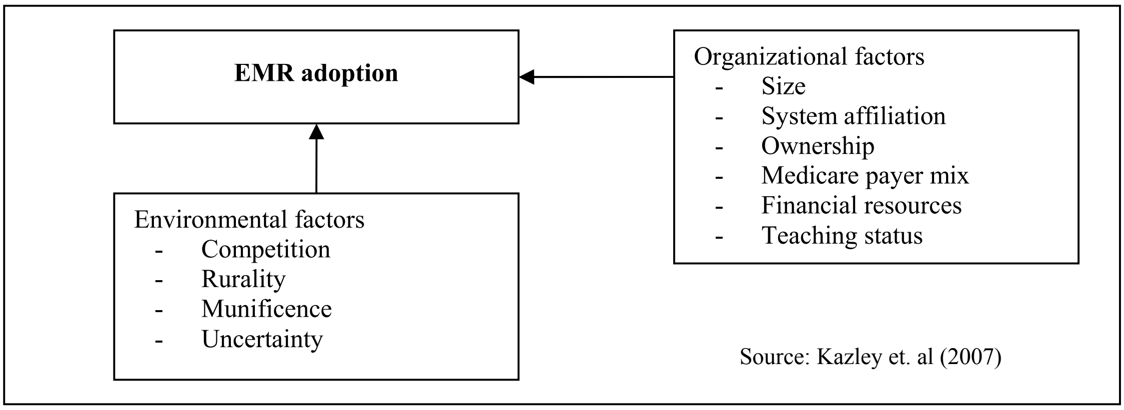

Figure 2. A conceptual model explaining technology adoption

D. Blumenthal and his colleagues also proposed a conceptual model explaining HIT adoption and use. They argued that HIT adoption and use are critically affected by technology, organizational factors, legal and regulatory factors, and financial incentives (Figure 3). This conceptual model is similar to the Kazley model because legal, regulatory, and financial incentives from governmental regulation settings can be considered as one of the environmental factors.

These two conceptual models suggest that EHR system adoption and use are a broad function of organizational structure, technology, and environmental factors. However, these conceptual models have several limitations. First, these models cannot explain organizational changes (e.g. adopting EHR systems) occurring due to intra-structural factors. For example, some hospitals may adopt an EHR system because they need to deal with high information processing occurring from high task complexity. Task characteristics can be a critical factor affecting EHR adoption and can replace the construct of technology as in Figure 3.

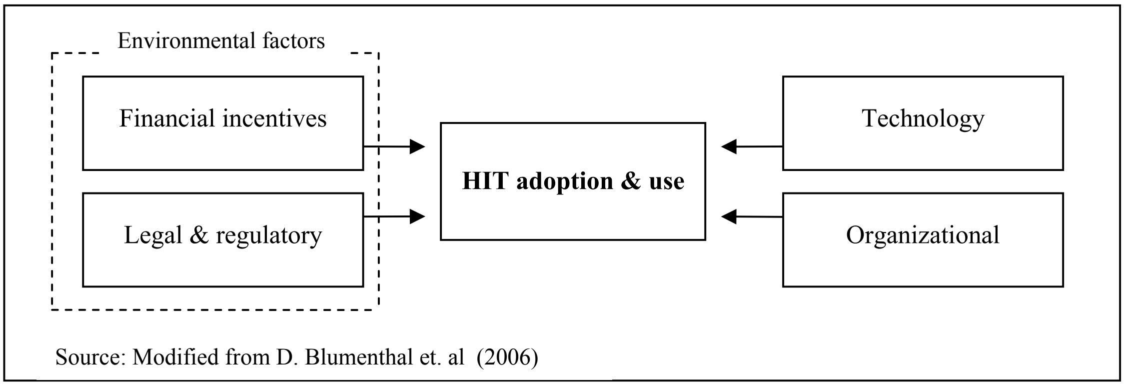

Figure 3. A conceptual model explaining HIT adoption & use

Both constructs have indeed been studied with an interchangeable concept in organization theory (Scott, 2003). To this point, incorporating a TTF model would be useful to overcome this limitation because the model directly explains the relationship between task and technology, which is in this case EHR adoption in hospitals (Figure 4).

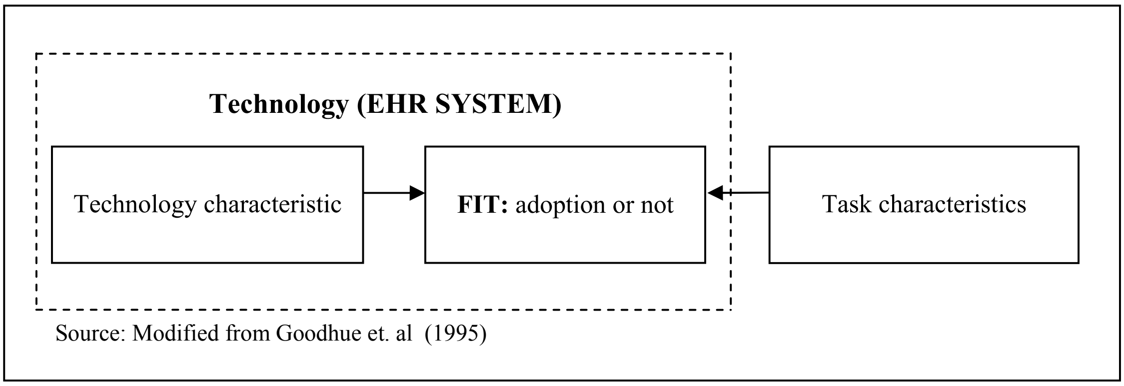

Figure 4. Application for EHR adoption using TTF model

Second, these models also did not consider any interaction effects among those constructs. Several empirical studies have shown that organizational structures are critically affected by task and environmental factors. For example, Flood and her colleagues assert that tasks in the work procedure and the environment are major determinants to hospital structure (Flood, et al., 1987, p.26). Barley (1990), by citing Woodward's argument, noted that tasks on production systems are direct determinants of organizational features such as the formalization of regulations and procedures, span of control, and centralization of decision-making authority.[102]

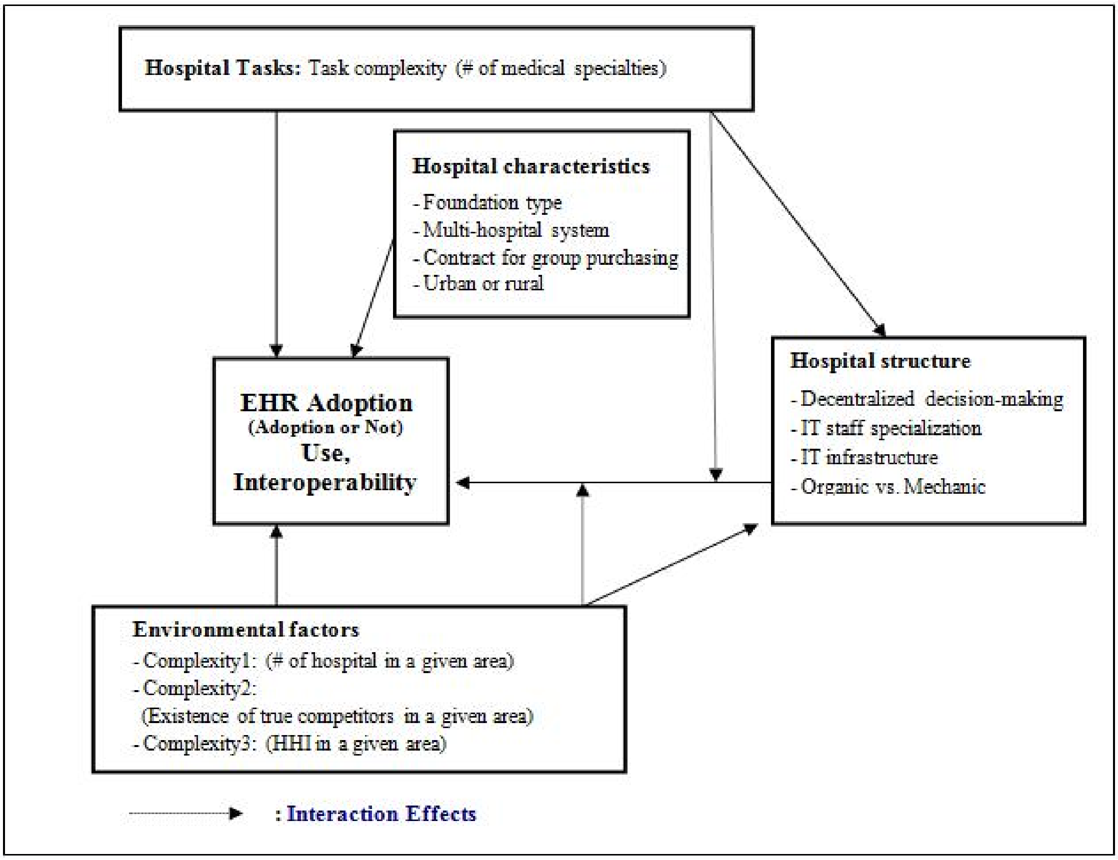

Figure 5. Conceptual model

One way to overcome the second limitation is by incorporating contingency theory into the model because contingency theory assumes some relationship between task and structure and environment and structure. Incorporating these conceptual models and limitations mentioned above produces a new conceptual model (Figure 5). Constructs illustrated in the model were discussed in the literature review and proposed in the hypotheses.

2.7. Objectives, specific aims, and hypotheses

The objective of this study is to explain Korean hospitals' EHR adoption, use, and interoperability by examining the influence of a number of hospital-related factors including hospital task, structure, and environment derived from both theoretical models and prior research. This study has the following specific aims and hypotheses.

1) Specific aim 1: To assess the relationship between internal features of hospitals (task, structure, and environment) and EHR adoption after adjusting for hospital characteristics.
HA1: Hospitals with high task complexity were more likely to adopt an EHR system.
HA2: Hospitals with decentralized decision making, high IT staff specialization, high IT infrastructure, and an organic managerial structure (versus mechanical structure) were more likely to adopt an EHR system.
HA3: Hospitals with high environmental complexity were more likely to adopt an EHR system.
HA4: The relationship between task complexity and EHR adoption would be dependent on hospital structure.

HA5: The relationship between hospital structure and EHR adoption would be dependent on environmental complexity.

2) Specific aim 2: To assess the relationship between internal features of hospitals (task, structure, and environment) and EHR use after adjusting for hospital characteristics.

HU1: Hospitals with high task complexity were more likely to use an EHR system.

HU2: Hospitals with decentralized decision making, high IT staff specialization, high IT infrastructure, and an organic managerial structure were more likely to use an EHR system.

HU3: Hospitals with high environmental complexity were more likely to use an EHR system.

HU4: The relationship between task complexity and EHR use would be dependent on hospital structure.

HU5: The relationship between structure and EHR use would be dependent on environmental complexity.

3) Specific aim 3: To assess the relationship between internal features of hospitals (task, structure, and environment) and EHR interoperability (hereafter: interoperability) after adjusting for hospital characteristics.

HI1: Hospitals with high task complexity were more likely to have interoperability.

HI2: Hospitals with decentralized decision making, high IT staff specialization, high IT infrastructure, and an organic managerial structure (versus mechanical structure) were more likely to have interoperability.

HI3: Hospitals with high environmental complexity were more likely to have interoperability.

HI4: The relationship between task complexity and interoperability would be dependent on hospital structure.

HI5: The relationship between structure and interoperability would be dependent on environmental complexity.

CHAPTER III RESEARCH METHODS

3.1. Research design

This study uses a non-experimental, retrospective cross-sectional study design to investigate the relationship between internal features of hospitals including environment and EHR adoption, use, and interoperability (Figure 6).

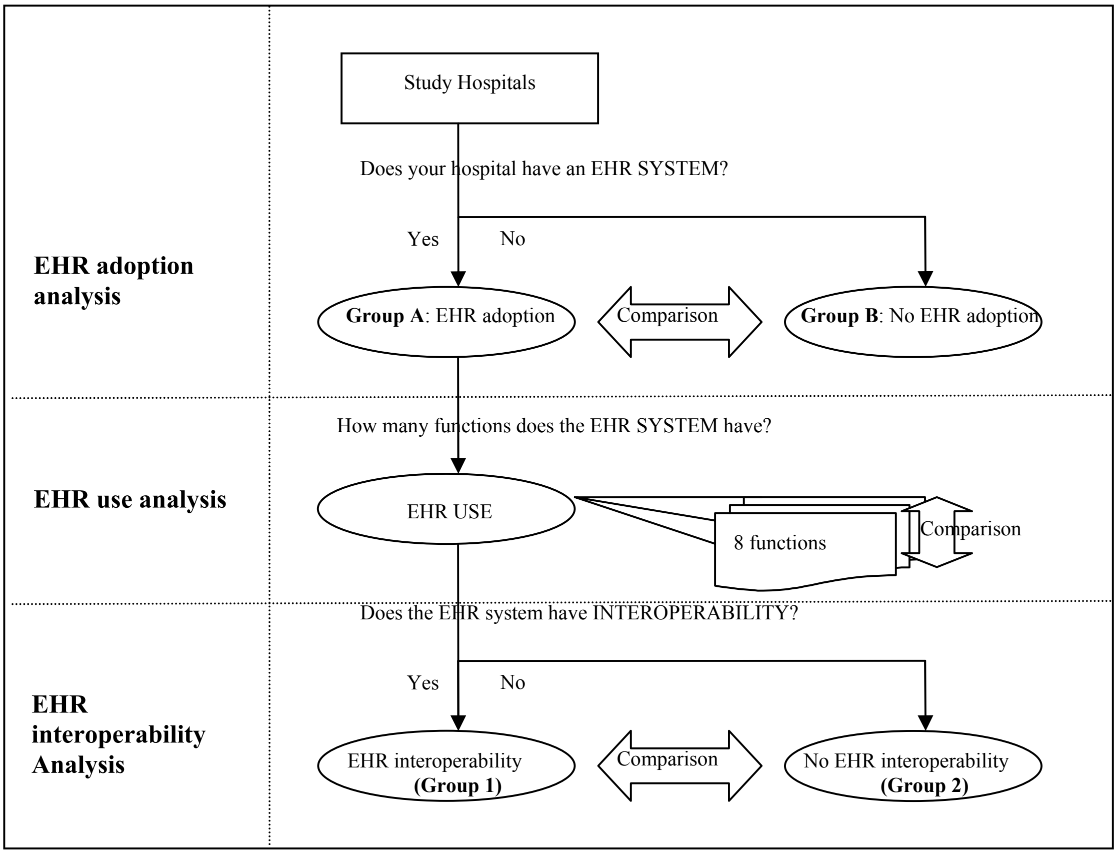

Figure 6. Study design flow chart

There are three outcome variables: EHR adoption, use, and interoperability. After categorizing the hospitals into two groups (those which have adopted and those which have not adopted an EHR system) and measuring possible causal factors retrospectively, this study compares those factors between the two groups. In the case of EHR use and interoperability, this study selects and analyzes only those hospitals which have adopted an EHR system. The following sections will describe the details of the research design.

3.2. Study population

This study's unit of analysis is the individual hospital. According to the hospital roster booklet[103] published by the Korean Hospital Association (KHA), there were 1,928 hospitals of all kinds as of December 31, 2007. These included 335 general hospitals, 852 small hospitals, 495 long-term care hospitals, 132 mental hospitals, 57 geriatrics hospitals, 22 rehabilitation hospitals, 19 veterans' hospitals, and 6 ophthalmic hospitals. In addition, there were 10 hospitals that were run directly by the central government for special purposes: 4 hospitals for pneumoconiosis, 3 hospitals for tuberculosis, and 3 hospitals for leprosy.

Among these hospitals, this study excludes the hospitals directly run by the central or local governments and military hospitals because the governmental decision-making on EHR adoption would affect all those hospitals equally. This would result in a high correlation of those constructs among these hospitals. Second, this study also excludes long-term care hospitals, mental hospitals, and geriatric hospitals because most of them are regulated under the Social Welfare Law and the Mental Health Law in Korea, which has slightly different structural requirements than hospitals under the Medical Law. For instance, Social Welfare Law and Mental Health Law are more lenient than Medical Law when it comes to regulating the hiring of medical staff. Third, this study also excludes hospitals based on single specialties such as rehabilitation or ophthalmic hospitals. They were also structurally different from the majority of general hospitals and small hospitals because they were providing only specific specialty care services.

Table 2. Basic characteristics of hospitals in South Korea (beds)

Hospital size	All hospitals	General hospitals	Small hospitals
Hospital population	1,063	285	778
Beds			
Mean	187.8	411.7	105.8
Median	118.0	297.0	87.0
Max	2,200.0	2,200.0	559.0
Min	30.0	100.0	30.0
Std Dev	215.3	302.6	69.0
Bed size			
30 – 99	45.0	0.0	61.5
100 - 199	25.6	17.2	28.5
200- 299	15.7	36.0	8.2
300 -399	2.5	6.3	1.2
400 -499	3.1	10.2	0.5
500 -599	2.8	10.2	0.1
600 -699	1.2	4.6	0.0
700 -799	1.0	3.9	0.0
800 -899	1.5	5.6	0.0
900 -999	0.9	3.5	0.0
1,000 +	0.7	2.5	0.0

After excluding those hospitals and hospitals that were no longer running, there were a total of 1,063 general hospitals and small hospitals as of September 3, 2008. This study set these hospitals as the target population. There were 285 (26.8%) and 778 (73.2%) general hospitals and small hospitals respectively (Table 2). Overall, there was an average of 187.8 beds per hospital. The average number of beds in general hospitals was 411.7, with a maximum of 2,200 beds and a minimum of 100 beds. The average number of beds in small hospitals was 105.8, with a maximum of 559 beds and minimum of 30 beds.

Table 3. Basic characteristics of hospitals in South Korea (foundation type)

Hospital foundation type	General hospitals		Small hospitals		All hospitals	
	N	%	N	%	N	%
Private-individual	66	23.2	582	74.7	648	61.0
Public	219	76.8	196	25.3	415	39.0
Total	285	100.0	778	100.0	1,063	100.0

There were 648 private-individual hospitals, 61.0% of the total hospital population; there were 415 public hospitals, 39.0% of the population (Table 3).

Table 4. Basic characteristics of hospital in South Korea (geographic distribution)

Location	All hospitals		General hospitals		Small hospitals	
	N	%	N	%	N	%
N	1,063	100.0	285	100.0	778	100.0
State						
01STATE (Seoul)	170	16.0	55	19.3	115	14.8
02STATE (Busan)	83	7.8	26	9.1	57	7.3
03STATE (Daegu)	80	7.5	9	3.2	71	9.1
04STATE (Daejeon)	22	2.1	7	2.5	15	1.9
05STATE (Ulsan)	30	2.8	3	1.1	27	3.5
06STATE (Gwangju)	43	4.0	18	6.3	25	3.2
07STATE (Incheon)	47	4.4	11	3.9	36	4.6
08STATE (Gyeonggi-do)	192	18.1	46	16.1	146	18.8
09STATE (Gangwon-do)	37	3.5	14	4.9	23	3.0
10STATE (Gyeongsangnam-do)	100	9.4	23	8.1	77	9.9
11STATE (Gyeongsangbuk-do)	56	5.3	16	5.6	40	5.1
12STATE (Chungcheongnam-do)	39	3.7	9	3.2	30	3.9
13STATE (Chungcheonbuk-do)	32	3.0	10	3.5	22	2.8
14STATE (Jeollanam-do)	68	6.4	18	6.3	50	6.4
15STATE (Jeollabuk-do)	55	5.2	14	4.9	41	5.3
16STATE (Jeju-do)	9	0.8	6	2.1	3	0.4
Urban or rural						
Rural	588	55.3	156	54.7	432	55.5
Urban	475	44.7	129	45.3	346	44.5

Many hospitals are located in or near Seoul, the capital of South Korea. There are 192 (18.1%) hospitals located in Gyeonggi-do, the state nearest to Seoul. There are 170 (16.0%) hospitals in Seoul. Nineteen percent of all general hospitals and 14.8% of all small hospitals are located in Seoul. Approximately forty-five percent of hospitals are located in urban areas and the rest, 55%, are located in rural areas (Table 4).

3.3. Definition of an EHR system

There is a clear difference between an EMR and an EHR. An EMR is an electronic record of the patient's clinical information electronically generated by encounters at one particular healthcare provider, legally replacing a paper medical record. An EHR is an electronic record of the patient's healthcare information generated and aggregated by one or more encounters of all of the care delivery organizations.[104,105,106] The EHR is a broader concept than the EMR. However, many scholars use the terms interchangeably because the meanings are similar enough for the purposes of clinical research. For clarity of expression, this study assumes that EHR includes EMR.

According to the academic field of computer science, a computer system is defined as a system that consists of hardware and systems software working together to run various application programs.[107] Thus, this study descriptively defines an EHR system as an electronic hardware and software system that creates, stores, and manages patient clinical information by running various application programs in hospitals.

3.4. Data collection using survey instrument

This study developed a new survey instrument based on current relevant survey instruments to address its hypotheses. The following sections describe the details of the descriptive definitions and measures of each construct used in this study.

3.4.1. Measuring EHR adoption, use, and interoperability

EHR adoption: This study descriptively defines "adoption" of an EHR system as the actual acquisition and implementation of an EHR system and operationally measures

EHR "adoption" as one of three levels: 'fully implemented', 'partially implemented', or 'not implemented'. The study borrows questions on EHR adoption from the 2006 American Hospital Association's IT survey[43] and the 2005 IT survey in Korea.[108] In order to confirm their adoption status, this study follows Blumenthal's (2006) idea of asking hospitals when they installed their EHR system (i.e. introduction year) and how they installed it (i.e. internally developed, outsourced, or purchased).[109]

For purposes of addressing the hypotheses, this study uses a binary variable: either hospitals adopted an EHR system in any one of their clinical departments (e.g. hospital ward or outpatient clinic) or they did not adopt and HER system in any department (Table 5). The rationale is that hospitals with partial or full EHR adoption have a common feature, which is the presence of an EHR system. This feature clearly distinguishes hospitals that have not adopted an EHR system from those that have. The objective of this study is to see how organizational and environmental factors affect adoption. Therefore, partial and full adoption is grouped together as "adoption" because they have similar characteristics which hospitals that have not adopted EHR do not have.

EHR use: This study descriptively defines "use" as the EHR functions that a hospital has implemented, and this study operationally measured "use" as the number of reported installed EHR functions. The study borrows questions on EHR use from the 2006 American Hospital Association's IT survey, which included of 17 EHR functionalities.[43] This study modifies and reduces the questions about EHR functionalities to 11 by combining similar functions into single categories in order to simplify the questionnaire and reduce redundancy (Table 5).

The functions this study uses are "access to current medical records (observations, orders)", "access to medical history", "access to patient flow sheets", "access to patient demographics", "order entry or results review (lab)", "order entry or results review (any radiology report)", "order entry (real time drug interaction alerts)", "other clinical alerts", "clinical guidelines and pathways", "patient access to electronic records", and "patient support through home-monitoring (including self-testing, and interactive patient education)". This study asked the respondents whether these 11 functions were "fully implemented," "partially implemented" or "not implemented". However, this study used 8 core functions in the final analysis excluding access function on medical records, medical history, and patient demographics because they are general functions of EHR systems.

These responses were transformed into a numeric scale for measuring hospitals' EHR use. The study gave a weighted value of 1.0 for full implementation, 0.5 for partial implementation, and 0 for no implementation for each of the 8 functionalities. Then the resulting values were summed to create a single numerical value for each hospital's EHR use. The numeric values ranged from zero to eight.

EHR Interoperability: This study descriptively defines "interoperability" as the capacity of an EHR system to exchange healthcare information electronically with other hospitals. Interoperability was measured based on the ability to electronically exchange clinical information following HIMSS's definition and NLM and HL7's survey instrument developed and used by Braithwaite's, W.R., et. al. in 2005.[52]

Table 5. Measuring EHR adoption, use, and interoperability

Construct	Survey Question(s)	Original Survey Measure	Study Scale	Hypothesis*
EHR Adoption	Q5_1. Hospital wards EHR system	1. fully 2.partially implemented, 3. not implemented	Binary (anyone is in 1,2, then adoption= 1, 0 in otherwise)	HA 1-5
	Q5_2. Outpatient EHR system	1. fully 2.partially implemented, 3. not implemented		
EHR Use	Q6_1. Access to current medical records	0: no, 0.5: partial, 1: full use	Numeric (Sum of all 11 items)	HU 1-5
	Q6_2. Access to medical history			
	Q6_3. Access to patient flow sheets			
	Q6_4. Access to patient demographics			
	Q6_5. Order entry or results review – Lab			
	Q6_6. Order entry or results review – Rad.			
	Q6_7. Order entry - Drug interaction alerts			
	Q6_8. Other clinical alerts			
	Q6_9. Clinical guidelines and pathways			
	Q6_10. Patient access to electronic records			
	Q6_11. Patient support (e.g., education)			
EHR Interoperability	Q7_1. Patient history (family, patient)	1.fully, 2.partially exchanged, 3. not exchanged	Binary (anyone is in 1,2, then interoperability=1, 0 in otherwise)	HI 1-5
	Q7_2. Patient summary (meds, etc.)			
	Q7_3. Discharge summaries			
	Q7_4. Laboratory information			
	Q7_5. Imaging information			
	Q7_6. Pharmacy information			
	Q7_7. Others			

* HA, HU, and HI mean all hypotheses related with EHR Adoption, Use, and Interoperability, respectively

There were 22 capabilities in the original survey instrument, but this study modified and reduced the number to 7 because the original instrument had too many irrelevant specific survey items including public health and clinical trial areas. This study asked whether the EHR system of respondents' hospitals had the capability to transmit and receive 7 categories of clinical information electronically from other clinics or hospitals and whether they were "fully exchanged", "partially exchanged", or "not exchanged". The seven categories this study used are patient history (family, patient), patient summary (conditions, meds, and allergies), discharge summaries, laboratory information, imaging information, pharmacy information, and other. These 7 categories are each categorized as: fully exchanged, partially exchanged or not exchanged. However, the study finds that many hospitals did not report any interoperability so the data distribution was heavily centered on zero and one. Thus, this study transforms the numeric scale to a binary value to address this issue; hospitals with no interoperability were given a score of zero, and hospitals with any rating of either partial or full interoperability were given a score of one (Table 5).

The rationale for this rescaling is that hospitals with partial or full EHR interoperability have a common characteristic just like hospitals with full or partial adoption. Hospitals should be grouped based on existence of interoperability in order to see how other factors affect that feature. This categorization is also compatible with the definition of EHR interoperability as the ability to perform healthcare information exchange with other systems. Therefore, this study categorizes the respondents as either having interoperability or not.

Finally, this study also considered information exchange methods. Among hospitals reporting partially or fully exchanging patient's information, this study only counts them as having EHR interoperability if they use the following information exchange tools: e-mail with attached document, internet access to patient records, a patient card system such as IC card, health information technology system to system, and others. This is because this study descriptively defines EHR interoperability as the capacity of an EHR system to exchange healthcare information electronically with other hospitals like mentioned above.

3.4.2. Measuring hospital internal features

The following section will describe the details of information on hospital internal features, especially conceptual definition and its measurement in this survey instrument starting with hospital basic characteristics.

Hospital basic characteristics: The variables considered as basic hospital characteristics were foundation type, affiliation status such as multi-hospital system, contracts for group purchasing and patient delivery, and urban or rural location. Of these basic characteristics, this study only collects information on affiliation status and contract status with other hospitals through this survey (Table 6). Affiliation status is yes if the hospital is part of a multihospital system and no if the hospital is not part of a system. The other information is collected through different information sources and will be described in the next section.

Table 6. Hospital basic characteristics included in the survey

Construct	Question	Measure	Scale	Hypothesis[1]
Affiliation	Q2. Multihospital system	1: Yes, 0: No	Binary	HA, HU, HI
Contract for group purchasing	Q3. Multihospital system	1: Yes, 0: No	Binary	HA, HU, HI

[1] HA, HU, HI stands for hypotheses related with adoption, use, interoperability, respectively

Decentralization of decision-making: This study descriptively defines the de-centralization of decision-making as the degree to which CIO or IT department managers participate in important hospital decision-making. This is measured by the reported degree of management participation of the CIO or IT managers in the hospital's decision-making regarding new employee hiring, current employee promotions, new programs, and new policy, as suggested by Hage and Dewar (1973).[63] This study uses a five-level Likert scale to measure the degrees of management involvement. Each gradation is given a numeric value (one to five) and the values for each question are averaged to provide a final value to represent the hospital's decentralization of decision-making.

IT Staff specialization: This study descriptively defines IT staff specialization as a hospital's investment and support in human resources in the IT department and measures the reported number of employees in charge of IT work in hospitals, which follows Mintzberg's perspective of viewing job specialization as "depth" to the control over an organization's work (p.69).[110]

This study initially asked the respondents to report the number of employees working in the IT department with each of the following educational backgrounds: physician, nurse, medical technician, management major, computer science major, etc. both before and after EHR adoption. However, the survey results find that most employees are in the category of computer science majors and there are no employees in most of the other categories. To accommodate this finding this study combines all employees together rather than separating them by specialty (Table 7). This study also finds that some hospitals that did not have an IT department recorded their number of IT employees as zero. In that case, this study allocates one IT employee to the hospital because all hospitals have at least one person in charge of IT and EDI for billing and reimbursement procedures in Korea. When the primary investigator contacted each hospital, this was verified by the administrative managers in these hospitals.

To incorporate this measure into the hypothesis testing this study divides the number of total IT employees by the number of beds and multiplied by 100. The rationale for standardizing IT staff using bed size is because the number of IT employees increases as the number of beds increases.

Table 7. Measures of factors affecting EHR adoption, use, and interoperability

Construct	Question	Measure	Scale	Hypoth esis[3]
	Hospital structural factors			
Decentralization of Decision-making	Q9_a1. IT manager's involvement: hiring	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always	Numeric (average)	H2, H4
	Q9_a2. IT manager's involvement: promotion			
	Q9_a3. IT manager's involvement: new rules			
	Q9_a4. IT manager's involvement: new policies			
IT staff Specialization (**Before** EHR adoption)	Q10_a1. No of IT staff majoring medicine	Numeric	Numeric (sum of all staff from a1 to a6/bed *100)	H2, H4
	Q10_a2. No of IT staff majoring nursing	Numeric		
	Q10_a3. No of IT staff majoring management	Numeric		
	Q10_a4. No of IT staff majoring medical technology	Numeric		
	Q10_a5. No of IT staff majoring computer science	Numeric		
	Q10_a6. No of IT staff with the other major	Numeric		
IT Infrastructure[2] (**Before** EHR adoption)	Q4_a1. Existence of Outpatient CPOE[1]	0: no, 1: yes	Numeric (counting from a1 to a8)	H2, H4
	Q4_a2. Existence of Inpatient CPOE	0: no, 1: yes		
	Q4_a3. Existence of Pharmacy dispensing system	0: no, 1: yes		
	Q4_a4. Existence of Patient dis. processing system	0: no, 1: yes		
	Q4_a5. Existence of Clinical laboratory system	0: no, 1: yes		
	Q4_a6. Existence of Radiology department system	0: no, 1: yes		
	Q4_a7. Existence of Intensive Care Unit system	0: no, 1: yes		
	Q4_a8. Existence of Administrative procedures system	0: no, 1: yes		
Organic structural form	Q12_1: Hierarchic structure of control	1-5 numeric	Numeric (average)	H2, H4
	Q12_2: Emphasis on formal communication channels	1-5 numeric		
	Q12_3: Strong insistence on a uniform managerial style	1-5 numeric		
	Q12_4: Adopt true and tried management principles	1-5 numeric		
	Q12_5: Strong emphasis on always getting personnel	1-5 numeric		
	Q12_6: Tight formal control	1-5 numeric		
	Q12_7: Emphasis on getting line and staff personnel	1-5 numeric		

[1] Order Communication System (OCS) in Korea is almost the same term as Computerized Physician Order Entry (CPOE) System in the U.S. For the convenience of expression, this study interpreted OCS as CPOE.
[2] The system means whether each system is connected to hospital information system.
[3] H2, H4 stands for hypotheses related with adoption (HA2, HA4), use (HU2, HU4), interoperability (HI2, HI4)

IT infrastructure: This study defines IT infrastructure as the physical and institutional structures related to information technology needed for the operation of an organization. IT infrastructure is measured by whether the following 8 areas are supported by the Hospital Information Systems (HIS): outpatient computerized physician order entry system (CPOE), inpatient CPOE, pharmacy drug management and dispensing system, patient charging processing, clinical laboratory work, radiology work, intensive care unit, and administrative procedures (Table 7). This study only counts the sub-systems which existed before EHR adoption in order to see their impact on EHR adoption.

Organic hospital structure: This study descriptively defines organic hospital structure as the degree to which a hospital emphasizes lateral communications, flexibility of rules and regulation, and informal managerial control in its structure. On the contrary, this study uses the term mechanical hospital structure to describe hospitals with fewer of these features. Organic hospital structure is measured by whether the hospital had a more mechanic structure or a more organic structure, following Burns & Stalker's (1961) construct. Questions on hospital structure are taken from Covin (1988)[111] and Kwon (2003)[112] which were developed based on suggestions by Burns & Stalker (1961). This study uses seven questions measuring the hospitals' structure as either organic or mechanic using a five-point Likert scale. Each gradation is assigned a numeric value (one to five) and they are averaged across all items to provide a final value to represent the hospital's structure (Table 7).

3.4.3. Pilot survey

After developing the preliminary survey instrument, this study conducts a pilot survey of five IT managers in Korea. There are several comments in the pilot survey. One significant comment is that the term EMR was more widely used in Korea than EHR. Other comments are that the survey needed to focus more on IT standards and to include the respondent's job title. Informants suggested several minor changes regarding the translation of terms. Overall, respondents who participated in the pilot survey said that there are few problems with the survey instrument. This final questionnaire used in the study reflects all comments from respondents who participated in the pilot study.

3.4.4. Survey data collection

This study distributed the survey to IT departments in the Korean hospitals that made up the target population. The survey respondents were chief information officers or IT department managers. However, in hospitals with no IT department, this study allowed the director of the administrative office to complete the survey because those directors know when the hospital purchases new hardware and software programs. Moreover, they are in charge of the electronic data interchange (EDI) process of requesting medical claim reimbursement to the HIRA.

All survey data is collected through a website developed by the author. Before beginning the development of the website and survey instrument, the author submitted this study's proposal to the Institutional Review Board (IRB) at the University of Minnesota (UMN) and received an official letter from IRB on February 10, 2009. The official IRB response letter reported that this study did not need approval because the subjects were hospitals rather than human subjects.

After hearing back from the IRB, the author developed the website and survey instruments for the study. The main homepage server was located at the UMN (http://www.tc.umn.edu/~park0601/). However, since the UMN did not provide application programs for database management such as SQL, this study used a local server owned by a private company in Korea for all data storage. In order to prevent unauthorized access to the survey instrument, this study created a password which allowed only eligible persons to access the survey instrument.

On April 5, 2009, the author sent a one-time postal mail containing the access password and a cover letter introducing the survey purpose and the website to the CIO or manager of the IT department and the directors of administrative offices in each of the target hospitals. This study assumes that the hospitals that participated in the survey agreed to participate in the survey, and those who chose not to participate in the survey did not agree to participate in the survey. In the letter, this study introduced the primary investigator and explained the study purpose, data confidentiality, and participation method. The hospitals' mailing addresses were obtained from the KHA. During the survey period, this study called or emailed the hospitals who participated in the survey to inform them that their surveys were successfully completed on the website and to deliver the author's personal thanks for their participation.

To increase the response rate, this study directly contacted some hospitals' IT departments and administrative offices by calling the telephone numbers listed in the booklet from the KHA. Since there were too many hospitals for the author to contact individually, the author randomly selected two hospitals per local area, based on hospital address in the alphabetical order and called one of them. If he was not able to get through to the hospital staff, then the other hospital was contacted.

The Korea Information Technology of Hospital Association (KITHA) was contacted and their support was obtained. Thus, this study was able to advertize and request participation for this survey through their website (http://www.kitha.or.kr/index_1.asp). The KITHA is a professional association composed of CIO and IT managers from 138

Korean hospitals. However, this study only contacted 106 hospitals because there were many special hospitals such as veteran hospitals and long-term care hospitals that were members of the KITHA. The KITHA also provided the author with the contact information for the CIOs and IT managers of the member hospitals. After obtaining this information, the author called each CIO and IT manager and sent e-mails requesting his or her participation in the survey.

3.5. Additional data collection

The study needed to collect other information that was not part of the survey, such as task complexity, market competition, number of beds, hospital types, and number of hospitals in the local area. This study did not include these variables into the survey because current government agencies and several professional associations already had comprehensive datasets. Therefore, this information was gathered from other sources. The following section describes the details of the descriptive definitions and measures of constructs or confounding variables, and source of information used in this study starting with hospital basic characteristics.

General characteristics: Foundation type was categorized as public or private hospital (Table 8). The study used the term private hospital to describe individual or private hospitals and the term public hospital to describe all other hospitals. This study considered hospitals as urban if they were located in one of 6 metropolitan areas or Seoul, and considered all other locations as rural. Information regarding the hospitals' foundation types (private or public) and location was obtained from the KHA's website (http://www.kha.or.kr/).

Table 8. Hospital basic characteristics using other information sources

Covariates	Measure	Scale	Hypothesis[1]	Source of Information
Foundation	1. Private, 2. Public	Binary	HA, HU, HI	Korea Hospital Association
Location	1. Urban, 0. Rural	Binary	HA, HU, HI	Korea Hospital Association

[1] HA, HU, HI stands for hypotheses related with adoption, use, interoperability, respectively

Task complexity: This study descriptively defined task complexity as the degree of hospital task diversity and measured it by counting the number of specialty services the hospital provides. Scott defined task complexity as the number of various inputs that should be managed at the same time to produce outputs in organization.[55] The average number of specialties per hospital using the dataset from KHA was 13.1 with a maximum of 27 and a minimum of 1 (Table 9). However, this study excluded five medical specialties (tuberculosis medicine, nuclear medicine, emergency medicine, preventive medicine, and industrial medicine) because small hospitals rarely, if ever, offered these specialties.

Table 9. The number of specialties in study hospitals

Number of specialties	General hospitals		Small hospitals		ALL	
	N	%	N	%	N	%
Specialty distribution						
1 - 3	0	0.0	27	18.2	27	7.6
4 - 6	0	0.0	54	36.5	54	15.2
7 - 9	10	4.8	52	35.1	62	17.4
10-12	30	14.4	13	8.8	43	12.1
13-15	39	18.8	2	1.4	41	11.5
16+	129	62.0	0	0.0	129	36.2
N	208		148		356	
Mean	18.0		6.1		13.1	
Median	18.0		6.0		12.0	
Max	27.0		14.0		27.0	
Min	8.0		1.0		1.0	
Std.	5.3		2.7		7.4	

*: 27 medical specialties (internal medicine, pediatrics, neuroscience, neuropsychiatry, dermatology, surgery, thoracic surgery, orthopedics, neurosurgery, plastic surgery, obstetrics, ophthalmology, ENT (ear nose and throat), urology, tuberculosis, rehabilitation medicine, anesthesiology, diagnostic radiology, treatment radiology, clinical pathology, anatomical pathology, family medicine, nuclear medicine, Emergency medicine, occupational and environmental medicine, dentistry, and preventive medicine).

In addition in general hospitals and small hospitals, the minimum number of specialties is determined by the number of beds. This is because Korea defines ‘general hospital’ as medical facilities providing health care services with more than 100 beds and more than 7 specialties. Among those must be three of internal medicine, surgery, OBGN, pediatrics, and the hospitals must also include imaging medicine, anesthesiology, and laboratory medicine or pathology. In addition, the general hospitals must have at least 9 specialties if they have more than 300 beds. Korea defines ‘hospital’ (“small hospital” in this paper) as medical facilities providing health care with more than 30 beds. Thus, there is a high correlation among bed size, hospital type, and the number of specialties. In order to reduce the multicollinearity introduced by these relationships, this study excluded number of beds and hospital types (general hospitals or small hospital) from the model. Information regarding the hospitals’ specialties was obtained from the KHA’s website (http://www.kha.or.kr/).

Environmental complexity: This study defined environmental complexity as complexity of environmental components influencing a focal hospital, such as diverse healthcare providers, following Cannon and his colleagues’ perspective.[113] It was measured as: 1) the number of hospitals in a given geographic area, 2) true competitor status based on a difference of the number of beds between any two hospitals. If the difference between any two hospitals was less than 50 beds, this study counted both hospitals as true competitors of each other in a given area, and 3) the Herfindahl-Hirschman Index (HHI) (Table 10).[114]

Information on the number of beds in hospitals was obtained from the HIRA website (http://www.hira.or.kr/cms/rb/rbb_english/index.html). This information was not used directly in the study, but indirectly used for calculating HHI and identifying true competitors and standardizing IT staff specialization. In case of environmental factors such as number of hospitals within a local area, this study used local addresses to determine locality.

Table 10. Measures of environmental complexity

Construct	Description	Scale	Hypothesis
Environmental Complexity 1	No. of hospital in a given area	Numeric	HA3, HA5 HU3, HU5 HI3, HI5
Environmental Complexity 2	Existence of True competitor	Binary (1: true competitor, 0: no true competitor) ($\|d\|=(bed_i-bed_j)$) bed_i: bed size of hospital i if $\|d\| <= 50$ then hospitals i, j will be counted as 1; Else both i&j are counted as 0)	HA3, HA5 HU3, HU5 HI3, HI5
Environmental Complexity 3	Market competition	Numeric number HHI[1]= $\sum_{i=1}^{n}(bed_i / tbed)^2$ n: the number of hospitals in a local area bed_i: bed size of hospital i tbed: total bed in a local area	HA3, HA5 HU3, HU5 HI3, HI5

[1] The Hirschman- Herfindahl Index (HHI) measuring market competitions
* All information came from other source (but not the survey)

3.6. Statistical data analysis

Study variables and their associations with EHR adoption, use, and interoperability are first cross-tabulated and then tested one at a time using t-test of the mean difference or non-parametric method, such as Wilcoxon's rank sum test. Overall, this study uses Generalized Estimating Equations (GEE), an extension of the Generalized Linear Model (GLM),[115] and General Linear Mixed Model (GLMM) to examine the proposed hypotheses.

Two things critically affect why this study chooses GEE and GLMM. First, this study has a hierarchical (multi-level) or cluster correlated data. Each hospital is nested within an environment (or a local area). For example, the environmental variables of the hospitals within a local area have the same values, such as number of hospitals (environmental complexity measure). Since they can equally affect other hospital constructs within the same local area, this kind of dataset inevitably causes a correlation issue within the same cluster and, thus, needs different statistical approaches. Second, this study has three outcome variables with two different scales of outcome measures: one (the use of EHR) is numeric values and the two others (adoption and interoperability) are a binary value. GEE and GLMM can resolve issues caused by both the correlation concern and the two scales of outcome variables.

The method of GEE is indeed frequently used to analyze correlated datasets having hierarchical, nested, or longitudinal data structure, especially if response variables are on a binary scale.[116] GLMM is a general statistical approach dealing with the correlation issue arising in a hierarchical data structure, especially if the scale of the outcome variables is numeric.[117] The next section discusses specific statistical considerations for the data analysis of two different outcome variables.

Finally, there are several reasons that this study uses GEE and GLMM, but not Survival Analysis or Path Analysis, as the final analytical methods. This study uses retrospective cross sectional survey data and, thus, it does not fit well in Survival Analysis which requires a longitudinal data structure. Some variables of this study have longitudinal data structure, but the majority of the variables are measured in a cross-sectional fashion. Path Analysis can be another alternative for the final data analysis because it is a kind of extension of regression analysis.[118] However, this study adopts a regression model because this study uses several binary variables in a hospital's general characteristics and hierarchical data structure, which is described in the following paragraph. Path analysis does not resolve these issues yet.

3.6.1. Binary outcome variables: EHR adoption and interoperability

There are also two different analytical approaches when we have a correlated dataset such as cluster, hierarchical, or longitudinal structure and its outcome variable is binary: marginal-effect models and random-effect models.[119, 120] The former method uses GEE. It is sometimes called population-averaged models.[121] This can be achieved using the GENMOD procedure with a logistic link function and the repeated-statement in SAS. The latter one, random-effects models, is called generalized linear mixed models or multilevel models[119] and can be analyzed using the NLMIXED procedure with random statement in SAS. Both are appropriate analytical methods for this study because they deal with correlation issues arising from environmental factors in this study and binary outcome variables.

The following describes how marginal-effect models and random-effect models differ and why this study chooses marginal-effect models using GEE. Suppose Y_{ij} has only two possibilities (Y_{ij} = 1: EHR adoption, Y_{ij} = 0: no EHR adoption) and X_{ij} is a design matrix of hospital covariates with 1xK vector and $\beta_{0,}$ β_1 are intercept and Kx1 vectors of estimates of covariates where the j-th hospital is located at the i-th environment (i=1 to n, j=1 to m). Thus, the expected EHR adoption rate equals $p_{ij}=P(Y_{ij}=1)$. A marginal logistic regression model is formulated[120] by:

$$\text{Logit}(p_{ij}) = \beta_0 + \beta_1 X_{ij},\ \text{Var}(Y_{ij}) = p_{ij}(1- p_{ij}),\ \text{where Corr}(Y_{ij}, X_{ik}) = \alpha$$

α: a constant or a working correlation matrix

In this model we assume that any correlation between two hospitals from the same environment is identical and any correlation between two hospitals located in different environments is considered independent because of clustered correlated characteristics.[120] Thus, we need to adjust for the correlation between hospitals from the same environments. By specifying a correlation structure, the model reflects the non-independence of observations.[115] This means that a group effect is not explicitly expressed in the model, but the correlation of the measurements is explained through a covariance matrix.[121] The interpretation of the regression coefficients is affected by the actual averages of the observation effects of the variables across the environments. [120]

In contrast, a random effect model assumes that heterogeneity exists across the cluster which in this case is environment. A random effect model is expressed[120] by:

$$\text{Logit}(P(Y_{ij} = 1) \mid u_i) = \beta_0 + \beta_1 X_{ij} + u_i, \text{ with } u_i \sim N(0, \sigma^2).$$

This model explicitly models heterogeneity with the subject specific environmental probability.[121] By introducing a random effect term, u_i where the variance σ^2 measures the degree of heterogeneity in the probability of EHR adoption, and the model can get the regression coefficient adjusting for the correlation from environments.[120] Thus, marginal model differs from random-effect model, but they reflect the correlation issues into the model in a different way.

This study chooses marginal-effect models using GEE for several reasons. First, the focus of this study is to predict and use the average odds ratios of the two hospital groups, adopting and not adopting an EHR system and having and not having EHR interoperability, but not the individual hospital's odds ratios. Second, explicitly accounting heterogeneity from environment subject to subject is not the chief interest of this study. This study only needs to adjust for the correlation between hospitals within the same local area to investigate the relationship between outcome variable and proposed constructs. In both cases, the marginal-effect model using GEE is recommended over the random-effect model in literature,[121,115] and, thus, this study selects the marginal-effect model. The interpretation of the regression coefficient of a marginal effect model is analogous to the standard logistic regression.

3.6.2. Numeric outcome variable: EHR use

With respect to the use of EHR outcome variables, this study used a GLMM and the specific method of analysis was as follows.

Model explanation: this study has a nested data structure. Hospitals are nested within each environment. Hospitals within the same environment may be correlated to each other. General Linear Mixed Model (GLMM), with fixed effects and random effects in the same model, takes into account the variance-covariance structure to produce more efficient coefficient estimates. A simple linear regression model is:

$$Y_{ij} = \alpha_0+\alpha_1*X_{ij}+\varepsilon_{ij} \text{ ………. (E1)}$$

Y_{ij} represents the outcome variable for the j-th hospital within the i-th environment, α_0 is the intercept, α_1 is a vector of fixed effects with design matrix X_{ij}, and ε_{ij} is an unknown random error. The GLMM extends the simple model to a model with a random effect parameter specific to environment and an unknown random error. The mathematical notation of GLMM is:

$$Y_{ij} = \alpha_0+\alpha_1*X_{ij}+\beta_i+\varepsilon_{ij} \ldots\ldots(E2)$$

The model shows the fixed effect component $\alpha_1 X_{ij}$ (contribution of independent variables to the variation of dependent variables) and the random effects component β_i (a correlation among outcomes within environment). According to GLMM, $\beta_i \sim N(0, \sigma_{envir.}^2)$ and $\varepsilon_{ij} \sim N(0, \sigma_e^2)$, $Var(Y_{ik}) = \sigma_{envir.}^2+\sigma_e^2$ and $Cov(Y_{ij}, Y_{ik}) = \sigma_{envir}^2$. Thus, $Corr(Y_{ij}, Y_{ik}) = \sigma_{envir.}^2/(\sigma_{envir.}^2 +\sigma_e^2)$, which is constant. This means that the variance of any hospital within an environment (local area) is equal to $\sigma_{envir.}^2 +\sigma_e^2$, and the covariance of any two hospitals within an environment (or local area) is equal to $\sigma_{envir.}^2$. This corresponds to a model with compound symmetry (or exchangeable) variance-covariance structure in a general linear model (GLM).

Main Effect of task, structure, and environment: the main effects of task, structure, and environment on the use of EHR were examined without any interaction terms. To determine whether the environment affects the use of EHR, this study tested whether there is a random intercept effect in the model.

Full model: $Y_{ij} = \alpha_0+\alpha_1*X_1+\alpha_2*X_2+\alpha_3*X_3+\alpha_4*X_4+\beta_i+\varepsilon_{ij} \ldots\ldots\ldots(E3)$

Reduced model: $Y_{ij} = \alpha_0+\alpha_1*X_1+\alpha_2*X_2+\alpha_3*X_3+\alpha_4*X_4+\varepsilon_{ij} \ldots\ldots(E4)$

Where i=environment (local area) and j = hospital within each local area.

Y_{ij}=the use of EHR (or interoperability) of hospital j at local area i,

X_1= the vector of task variables

X_2= the vector of structural variables

X_3= the vector of environment characteristics

X_4= the other hospital covariates (e.g., bed)

β_i = environment-specific random intercept for environment i

ε_{ij} = random error term for hospital j in environment i

According to statistical theroy, $\beta_i \sim N(0, \sigma_{envir.}^2)$, $\varepsilon_{ij} \sim N(0, \sigma_e^2)$, and if what we are testing is a hypothesis: H_0: $\sigma_{envir.}^2 = 0$ versus H_a: $\sigma_{envir.}^2 > 0$. If $\sigma_{envir.}^2 = 0$ after testing likelihood ratio test, then β_i is constant. This means that we need a reduced model (E4). If not, we need a random effect model (E3).

Analysis of any interaction effects: to see the interaction effects between each construct and the use of EHR, this study included an interaction term into the model with the main variable. For example, with respect to HU4, the interaction terms between task and four structural variables were added to the model:

(1) If there is no environmental random effect, then the equation would be:

$$Y_{ij} = \alpha_0 + \alpha_1 * X_1 + \alpha_2 * X_2 + \alpha_3 * X_3 + \alpha_4 * X_4 + \alpha_5 * X_1 * X_2 + \varepsilon_{ij} \text{ ....(E5)}$$

(2) If there is significant environmental random effect, then the equation would be:

$$Y_{ij} = \alpha_0 + \alpha_1 * X_1 + \alpha_2 * X_2 + \alpha_3 * X_3 + \alpha_4 * X_4 + \alpha_5 * X_1 * X_2 + \beta_i + \varepsilon_{ij} \text{ ......(E6)}$$

In the model, $\alpha_5 * X_1 * X_2$ represents the interaction terms between task and four structural variables. Although there are significant main effects for task and any of the structural variables, the interaction between task and each of the structural variables was tested in the model.

3.6.3. Handling multicollinearity issue

A multicollinearity issue occurs when the model incorporates highly correlated independent variables. This issue leads to an increased variance of parameter estimates, which reduces the significance of individual independent variables. This occurs even though the overall model's p-value is very low. Thus, it would result in a biased estimate of the regression coefficient without resolving multicollinearity issues. For those reasons, this study examined the correlation between independent variables before fitting them into the model. If some variables are highly correlated to each other ($r>0.6$), then this study eliminated one of those variables.

3.6.4. Procedures for any interaction terms of regression model

Several scholars on statistics and related studies have recommended mean centering when researchers have any interaction terms of numeric variables in the regression models.[122,123] Mean centering means subtracting the mean of a variable of a study subject from all observations of the variable and using the subtracted value in the regression model. There are two main reasons for recommending this procedure.

First, including two variables with multiplication into the model may cause multi-collinearly issues. Researchers may avoid this issue by using mean centering in the model. Second, logical and easy interpretation of the regression coefficient of the interaction term is available because researchers can assume appropriate levels of boundary of the mean centered variable. Thus, this study will use mean centered values only if the proposed model has any interaction terms.

For the visual representation of any interaction terms of the proposed models using graphs, this study used SAS (version 9.2) and the website of Academic Technology Services at the University of California in Los Angeles (UCLA).[124] This study downloaded their initial SAS codes on visualizing interactions and modified those codes for this study's purpose.

3.7. Reliability test on survey instruments

This study used two important constructs that were subjectively measured: decentralization of decision-making and organization structure. The former was measured using four questions which were asked both before and after EHR adoption. The latter was measured by seven questions asked only after EHR adoption. This study looked at the reliability of those variables using the Cronbach's alpha. The Cronbach's alpha measures the internal consistency of reliability, which is how well a group of independent variables measures a construct.[125] The Cronbach's alpha of the constructs measuring decentralization of decision-making in the past and present were 0.870 and 0.861 respectively. The Cronbach's alpha for organizational structure was 0.716 (Table 11).

Table 11. Reliability of subjective survey questions

Constructs	Initial no. of items	Final no. of items	Cronbach's alpha
Decentralization of decision-making (past)[1]	4	4	0.873
Decentralization of decision-making (current)	4	4	0.847
Organizational structure	7	7	0.718

[1] Only asked to the hospitals adopting EHR systems

The recommended level of Cronbach's alpha differs between scholars, but Nunnally sets forth the recommended level as 0.7 in the case of preliminary research.[126] Kwon, citing

Van de Ven and Ferry (1980), noted that having more than 0.6 of Cronbach's alpha would be enough in a case of exploratory research or if the unit of analysis is not the individual, but the organization (Kwon, 2003). This study is exploratory study and the unit of analysis is organization. Thus, this study argues that Cronbach's alpha is high enough for this study, and included all questions in the analysis.

3.8. Correlation analysis among the variables

The purpose of this study is to investigate the impact of hospitals' internal features, such as task, structure, and environmental factors on EHR adoption, use, and interoperability. To analyze the relationship using multivariate regression, the relationship among predictor variables should be independent because some dependent relationships result in multicollinearity, which affects significance and interpretation of the regression coefficients. In order to prevent this problem, this study investigated the relationship among independent variables and excluded the variables that had high correlation and were less important from the model.

Table 12 shows the Spearman's correlation among dependent and independent variables. Compared to the Pearson's correlation, measuring the linear relationship between two variables when the variables have an equal-appearing intervals scale, Spearman's correlation is calculated based on using non-parametric methods of association.[127] This study used Spearman's correlation to check multicollinearity issues among the variables because some of the variables in general characteristics were measured with a binary scale and the distribution of some variables could not be assumed as normality. Among the variable, HHI was highly negatively correlated with the number of hospitals within a local area (r=-88). Bed size was also highly correlated with the number of medical specialties. Thus, this study excluded these variables from the final regression model.

Table 12. Correlations between variables of all study hospitals

Spearman Correlation Coefficients, N = 352
Prob > |r| under H0: Rho=0

	Adoption	Bed	Foundation	Multihospital	Contract	Urban	Medical Specialty	Decentralization	Specialization	IT infrastructure	Organic structure	True competitor	Hospital within area	HHI
Adoption	1.00													
Bed	0.11	1.00												
	0.05													
Foundation	0.06	-0.51	1.00											
	0.30	<.0001												
Multihospital System	0.04	0.28	-0.48	1.00										
	0.47	<.0001	<.0001											
Contract for Group purchasing	0.15	0.10	-0.06	0.19	1.00									
	0.01	0.06	0.24	0.00										
Urban (vs. Rural)	0.08	0.05	0.07	-0.04	-0.01	1.00								
	0.12	0.39	0.18	0.46	0.81									
Medical Specialty	0.12	0.85	-0.53	0.27	0.13	0.07	1.00							
	0.03	<.0001	<.0001	<.0001	0.01	0.20								
Decentralization	0.13	0.15	-0.04	0.05	0.03	0.07	0.19	1.00						
	0.01	0.00	0.45	0.33	0.60	0.21	0.00							
Specialization	0.01	-0.13	0.01	0.00	0.05	0.15	0.05	0.25	1.00					
	0.92	0.02	0.86	1.00	0.35	0.00	0.35	<.0001						
IT infrastructure	0.45	0.38	-0.27	0.14	0.22	0.01	0.42	0.03	-0.05	1.00				
	<.0001	<.0001	<.0001	0.01	<.0001	0.85	<.0001	0.63	0.35					
Organic structure	0.18	-0.07	0.12	0.04	0.04	-0.04	-0.10	0.01	0.00	0.01	1.00			
	0.00	0.18	0.03	0.49	0.45	0.43	0.05	0.88	0.99	0.83				
True competitor	-0.04	-0.55	0.38	-0.20	-0.12	0.04	-0.45	-0.07	0.06	-0.16	0.08	1.00		
	0.47	<.0001	<.0001	0.00	0.03	0.46	<.0001	0.19	0.29	0.00	0.16			
Hospitals within Local area	0.10	0.03	0.07	-0.07	0.07	0.15	0.02	0.05	0.19	0.06	-0.01	0.30	1.00	
	0.07	0.62	0.17	0.20	0.18	0.01	0.67	0.37	0.00	0.24	0.82	<.0001		
HHI	-0.04	0.04	-0.11	0.12	-0.05	-0.06	0.06	0.02	-0.06	-0.06	-0.03	-0.40	-0.88	1.00
	0.41	0.41	0.04	0.03	0.38	0.27	0.24	0.67	0.25	0.28	0.57	<.0001	<.0001	

Table 13 shows the relationship among EHR use, EHR interoperability, and other variables. With respect to the analysis of EHR use and interoperability, this study only selected hospitals that adopted an EHR system and checked correlation among the variables. There were 158 hospitals with an EHR system. The HHI still had high correlation with the number of hospitals within a local area (r=-0.85) and, thus, this study excluded this variable from the regression analysis, but included the number of hospitals within a local area.

Table 13. Correlations between variables of hospitals only having EHR adoption

Spearman Correlation Coefficients, N = 158
Prob > |r| under H0: Rho=0

	USE	Interoperability	Foundation	Multihospital sys.	Contract	Urban	Specialty	Decentralization	Specialization	IT Infrastructure	Organic Structure	True Competitor	Hospitals Within area	HHI
EHR USE	1.00													
Interoperability	0.18	1.00												
	0.02													
Foundation	-0.02	-0.12	1.00											
	0.78	0.14												
Multihospital System	0.22	0.09	-0.55	1.00										
	0.00	0.29	<.0001											
Contracts	0.19	0.20	0.02	0.18	1.00									
	0.02	0.01	0.83	0.03										
Urban (vs Rural)	-0.02	0.03	0.03	-0.03	-0.10	1.00								
	0.83	0.69	0.74	0.76	0.22									
Specialty (task Complexity)	0.13	0.27	-0.57	0.41	0.20	0.04	1.00							
	0.10	0.00	<.0001	<.0001	0.01	0.62								
Decentralization	0.00	0.06	-0.14	0.09	0.04	0.03	0.32	1.00						
	0.98	0.43	0.08	0.28	0.66	0.68	<.0001							
Specialization	0.03	0.13	-0.11	0.15	0.05	0.08	0.15	0.28	1.00					
	0.72	0.10	0.15	0.06	0.57	0.32	0.06	0.00						
Infrastructure	0.09	0.01	-0.14	0.20	0.07	-0.10	0.11	-0.08	-0.05	1.00				
	0.24	0.88	0.08	0.01	0.35	0.20	0.18	0.35	0.55					
Organic structure	0.00	0.04	0.15	-0.02	-0.04	-0.07	-0.10	-0.13	-0.06	-0.01	1.00			
	0.95	0.63	0.06	0.76	0.61	0.41	0.20	0.12	0.43	0.91				
True competitor	-0.07	-0.16	0.42	-0.23	-0.07	0.01	-0.56	-0.10	0.02	-0.08	0.07	1.00		
	0.39	0.05	<.0001	0.00	0.37	0.89	<.0001	0.22	0.77	0.31	0.35			
Hospitals within Local area	0.02	-0.02	0.17	-0.07	0.04	0.09	-0.10	0.11	0.19	-0.08	-0.07	0.28	1.00	
	0.84	0.77	0.03	0.40	0.61	0.28	0.20	0.16	0.02	0.29	0.41	0.00		
HHI	0.02	0.06	-0.24	0.14	-0.02	0.01	0.21	-0.02	-0.01	0.06	-0.04	-0.42	-0.85	1.00
	0.82	0.46	0.00	0.08	0.78	0.87	0.01	0.78	0.88	0.45	0.59	<.0001	<.0001	

CHAPTER IV RESULTS

4.1. General characteristics of study hospitals

Table 14 shows the general characteristics of the study hospitals. A total of 356 hospitals responded to the survey, which was a 33.5 percent response rate from the 1,063 total hospitals. Four hospitals were excluded from the analysis because they adopted an EHR system at the time of their establishment and this study needed information on hospital status before adopting an EHR system. Thus, a total of 352 hospitals were analyzed for this study.

Table 14. Basic characteristics of study hospitals

Basic characteristics	All hospitals
Study hospitals analyzed	352.0
Response rate (%) [1]	33.5
% of private hospitals	40.6
% of multihospital systems	46.6
% of contract for patient delivery or group purchasing	83.2
% of urban location	88.4
State location	
01STATE (Seoul)	19.0
02STATE (Busan)	8.5
03STATE (Daegu)	5.4
04STATE (Daejeon)	1.7
05STATE (Ulsan)	3.1
06STATE (Gwangju)	5.1
07STATE (Incheon)	3.1
08STATE (Gyeonggi-do)	11.7
09STATE (Gangwon-do)	4.8
10STATE (Gyeongsangnam-do)	9.7
11STATE (Gyeongsangbuk-do)	5.4
12STATE (Chungcheongnam-do)	4.6
13STATE (Chungcheonbuk-do)	3.1
14STATE (Jeollanam-do)	8.2
15STATE (Jeollabuk-do)	4.8
16STATE (Jeju-do)	1.7

[1]Total hospital population=1,063, responding hospitals=356. This study excluded 4 cases having an EHR system with their establishment.

There were 143 private-individual hospitals (40.6%) and 164 hospitals (46.6%) maintaining a multi-hospital system. Eighty-three percent of the study subjects had contracts with other hospitals for group purchasing and patient delivery. Nineteen percent (67) and 11.7 percent (41) of study hospitals were located in Seoul and Gyeonggi-do province, respectively.

4.2. EHR adoption

4.2.1. Hospital characteristics by EHR adoption

This section describes the general characteristics and structural features by an EHR adoption status (Table 15). Forty-five percent of the study hospitals (158) reported adopting an EHR system. Hospitals reporting the contract with other hospitals for patient delivery and group purchasing had higher EHR adoption rates than hospitals without any contracts (48.1% vs. 28.8%, p=0.0065). When defining urban and rural area based on metropolitan cities, EHR adoption rate was higher in hospitals located in urban areas than hospitals in rural areas (47.8% vs. 26.8%, p=0.0134).

Table 15. Basic characteristics of study hospitals by EHR adoption status

Basic characteristics		Adopting EHR system	Not adopting EHR	N	p-value [1]
% of an EHR system adoption status		44.9	55.1	352(100.0)	-
Foundation	Private	48.3	51.7	143 (100.0)	0.2937
	Public	42.6	57.4	209 (100.0)	
Multihospital systems	Yes	47.0	53.1	164 (100.0)	0.4669
	No	43.1	56.9	188 (100.0)	
Contract for group purchasing	Yes	48.1	51.9	293 (100.0)	0.0065
	No	28.8	71.2	59 (100.0)	
Location	Urban	47.3	52.7	311 (100.0)	0.0134
	Rural	26.8	73.2	41 (100.0)	

[1] Chi-square test

Table 16 presents hospitals' internal features by EHR adoption status. Task complexity of hospitals was significantly related to EHR system adoption (p=0.0293). The table also shows the CIO or IT manager's participation in decision-making by EHR adoption status. This CIO or IT manager's participation in decision-making was measured with a five-point Likert scale; a higher number means that IT managers participate more actively in the hospital's overall decision-making processes. Hereafter it will be labeled a de-centralized decision-making system when IT managers do actively participate and a centralized decision-making system when they do not. The average score of four measures of decentralization of decision-making in hospitals with an EHR system before they adopted the system was significantly higher than those of hospitals who have not adopted an EHR system, 3.20 and 2.91, respectively (p=0.0137). The score was significantly higher for hiring (p=0.0330) and promotion (p=0.0030) for hospitals that have adopted an EHR system.

Table 16. Hospital's internal features by EHR adoption status

Basic characteristics		Adopting EHR system	Not adopting EHR	N (%)	p-value†
Total		158	194	352	-
Task	# of medical specialties[1]	13.12	11.62	352	0.0293
Structure	Decision making (average)	3.20	2.91	352	0.0137
	Hiring	2.99	2.63	352	0.0330
	Promotion	2.72	2.22	352	0.0034
	Program	3.93	3.87	352	0.2456
	Policy	3.15	2.93	352	0.1611
	IT staff specialization[3]	1.69	1.56	352	0.9157
	IT infra-structure	7.87	6.45	352	<0.0001
	Organic structure	2.74	2.48	352	0.0009
Environment	Having true competitors				
	Yes	43.22	56.78	199 (100.0)	0.4724
	No	47.06	52.94	153 (100.0)	
	HHI score	0.30	0.32	352	0.4128
	# of hospitals within the area	8.83	7.64	352	0.0712

[1] # of the medical specialties adjusting for the type of hospitals and bed size (see, research method section)
[2] A 10-standards item used (yes: if there is at least one standardized IT item, no: otherwise)
[3] Standardized using bed size: the number of IT staff/bed*100
† p-value of Wilcoxon's Rank Sum test or chi-square test

The number of IT infrastructure items was significantly higher in hospitals with an EHR system (7.87) than in hospitals without an EHR system (6.45) ($p<0.0001$). This study also examined whether hospitals with an organic management structure were more likely to adopt EHR systems following Burns and Stalker's definition (1961). Their arguments were strongly supported in this case. Organic structure was measured on a Likert scale with most mechanical (least organic) structure having a value of 1 and the most organic structure having a value of 5. Thus, a high number means that the hospital had a more organic structure. The average scores of hospitals with an EHR system were significantly more organic (2.74) than those without an EHR system (2.48) ($p=0.0009$). The average number of hospitals within the local area of hospitals with an EHR system was marginally higher than those of hospitals without an EHR system, which were 8.83 and 7.64 respectively ($p=0.0712$).

4.2.2. EHR adoption and task complexity

This section describes the results of the logistic regression analyzing the relationship between task complexity and EHR system adoption before (Model 1) and after (Model 2) controlling for hospital covariates.

Hypothesis Addressed:
HA1: Hospitals with high task complexity were more likely to adopt an EHR system.

For a 1-unit increase in task complexity measured by the number of medical specialties, the odds of EHR adoption were estimated to increase by a multiplicative factor of 1.062

after controlling for hospital covariates. Among hospital covariates, hospitals with private foundation (versus public) and with contracts for patient delivery, group purchasing (versus not having any contract) were significantly more likely to have higher odds of adopting an EHR system (Table 17).

Table 17. Impact of task complexity on EHR adoption

Independent variables	Model 1 (Odds ratio)	Model 2 (Odds ratio)
Foundation type (private) (ref=public)		2.261*
Multi-hospital system (yes) (ref=no)		1.320
Contracts with other hospitals (group purchasing, etc.)(ref=no)		2.181*
Location (urban) (ref=rural)		1.284
Task Complexity (# of specialties)	1.036*	1.062*

* < 0.05, ** < 0.005

4.2.3. EHR adoption and hospital structure

This section describes the results of the relationship between EHR adoption and hospital structure before (Model 1) and after (Model 2) controlling for hospital covariates.

Hypothesis Addressed:
HA2: Hospitals with decentralized decision making, high IT staff specialization, high IT infrastructure, and an organic managerial structure were more likely to adopt an EHR system.

A one-unit increase in IT infrastructural items leads to an increase by a factor of 3.123 in the odds of adopting an EHR system after controlling hospital covariates. The predicted odds of adopting an EHR system increase to 1.717 times multiplicatively for a 1-unit increase in the score of hospital organic form (Table 18).

Table 18. Impact of hospital structure on EHR adoption

Independent variables		Model 1 (Odds ratio)	Model 2 (Odds ratio)
Foundation type (private) (ref=public)			2.258**
Multi-hospital system (yes) (ref=no)			1.168
Contracts with other hospitals (ref=no)			1.494
Location (urban) (ref=rural)			1.347
Structure before EHR adoption	Decentralization of decision-making system	1.259*	1.242
	IT staff specialization	1.078	1.039
	IT infra-structure	2.901*	3.123*
	Organic structure	1.871**	1.717**

* < 0.05, ** < 0.005

4.2.4. EHR adoption and environment

This section investigates the relationship between EHR adoption and environmental complexity before (Model 1) and after (Model 2) controlling for hospital covariates (Table 19). This study selected three variables representing environmental complexities: HHI, true competitor, and the number of hospitals within the local area. However, as mentioned in the research method section, there was a high correlation between HHI and the number of hospitals within a local area so the model only includes the number of hospitals within the local area. In order to define the local area, this study used administrative district which is equivalent to counties in the United States.

Hypothesis Addressed:
HA3: Hospitals with high environmental complexity were more likely to adopt an EHR system.

Environmental complexity significantly impacted EHR adoption before and after controlling for hospital covariates. After controlling for hospital covariates, the odds of

EHR adoption were estimated to be increased by 4.0% for a unit increase in the number of hospitals within a local area.

Table 19. Impact of environmental complexity on EHR adoption

Independent variables	Model 1 (Odds Ratio)	Model 2 (Odds Ratio)
Foundation type (private) (ref=public)		1.419
Multi-hospital system (yes) (ref=no)		1.348
Contracts with other hospitals (group purchasing, etc.)(ref=no)		2.360*
Location (urban) (ref=rural)		1.376*
Environmental complexity (All hosp. within the local area)	1.040*	1.040**

* < 0.05, ** < 0.005

4.2.5. EHR adoption, task, structure, and environment

Traditional contingency theory argues that organizations that have more complex tasks are more likely to decentralize their decision-making systems. If this argument is true, then there should be a relationship between EHR adoption and the four constructs of the hospital structure measure. This study examined if these kinds of arguments are supported in hospitals adopting EHRs by testing the following two hypotheses.

Hypothesis Addressed:
HA4: The relationship between task complexity and an EHR system adoption were dependent on hospital structure.
HA5: The relationship between hospital structure and an EHR system adoption were dependent on environmental complexity.

Table 20 presents the results of analyses investigating whether hospital structural factors work as moderators between task complexity and EHR adoption and between environmental complexity and EHR adoption. The results show that hospital structural factors had no significant moderating effect between environmental complexity and EHR adoption, but did have some significant effects between task complexity and an EHR system adoption.

Table 20. Impact of a hospital's internal features on EHR adoption

Independent variables		Odds ratio
Intercept		0.230**
Foundation type (private) (ref=public)		2.356**
Multi-hospital system (yes) (ref=no)		1.117
Contracts with other hospitals (group purchasing, etc.)(ref=no)		1.443
Location (urban) (ref=rural)		1.232
Task complexity	# of specialties	1.026
Structure before EHR adoption	Decentralization	1.199
	IT staff Specialization	1.132
	IT infra-structure	2.820*
	Organic structure	1.656**
Envir. Complexity	All hosp. within area	1.059
Task complexity*Structure		
Task*Decentralization		1.059**
Task*IT staff Specialization		1.010
Task*IT infrastructure		0.952*
Task*Organic structure		1.010
Environmental complexity*Structure		
All hosp. within area*Decentralization		1.014
All hosp. within area*Specialization		0.993
All hosp. within area*IT infrastructure		0.960
All hosp. within area*Organic structure		0.984

* < 0.05, ** < 0.005, Note: all numeric values were analyzed using mean centered predictors

For the interaction effect between task complexity measured by the number of medical specialties in a hospital and decentralization of decision-making score of IT managers or CIOs, the impact of task complexity on the odds of adopting an EHR system critically relies on decentralization of decision-making system. The logistic regression models the log odds of a response (a probability of an event versus non-event) as a linear combination of the predictors.[128]

Using this linear relationship, Figures 7 and 8 illustrate the association among task complexity, decentralization of decision-making score, and the log odds of adopting an EHR system. Under a highly decentralized decision-making system, which is the right side of its mean centering points (X2=0), the log odds of adopting an EHR system increase as task complexity increases (Figure 7).

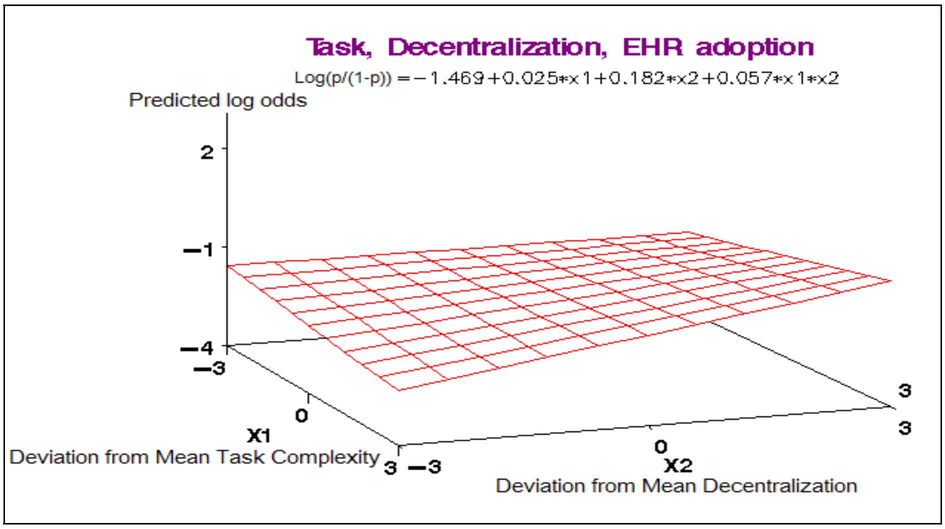

Figure 7. Task complexity, decision-making structure, EHR adoptions 1

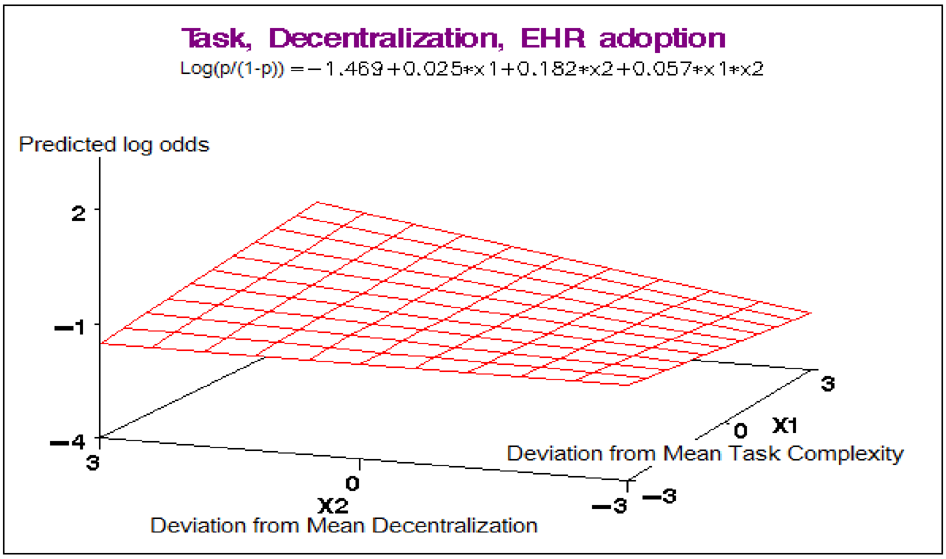

Figure 8. Task complexity, decision-making structure, EHR adoptions 2

However, under a highly centralized decision-making system which is moving to the right side from its mean centering points (X2=0), the log odds of adopting an EHR system decrease when task complexity increases (Figure 8).

With respect to the interaction effect between task complexity and IT infrastructure, the impact of task complexity on the odds of adopting an EHR system is dependent on the level of IT infrastructure. When we observe a moving direction from its mean centering points (X2=0), the log odds of adopting an EHR system in hospitals decreases as task complexity increases under a high level of IT infrastructure which is above the average of the group (Figure 9).

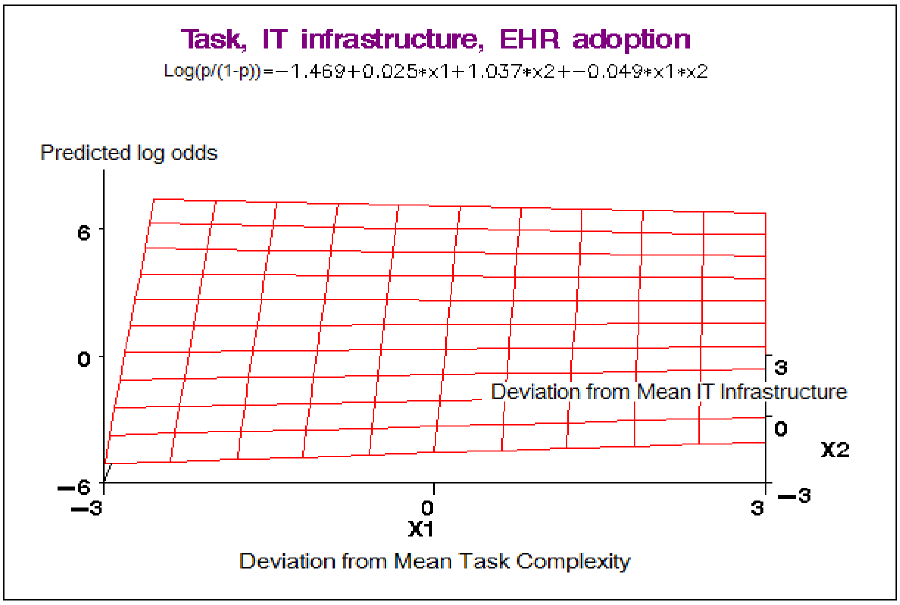

Figure 9. Task complexity, IT infrastructure, EHR adoptions 1

However, compared to this direction, the log odds of the adoption of an EHR system slightly increases as task complexity increases under a lower level of IT infrastructure which is below the average of the group (Figure 10).

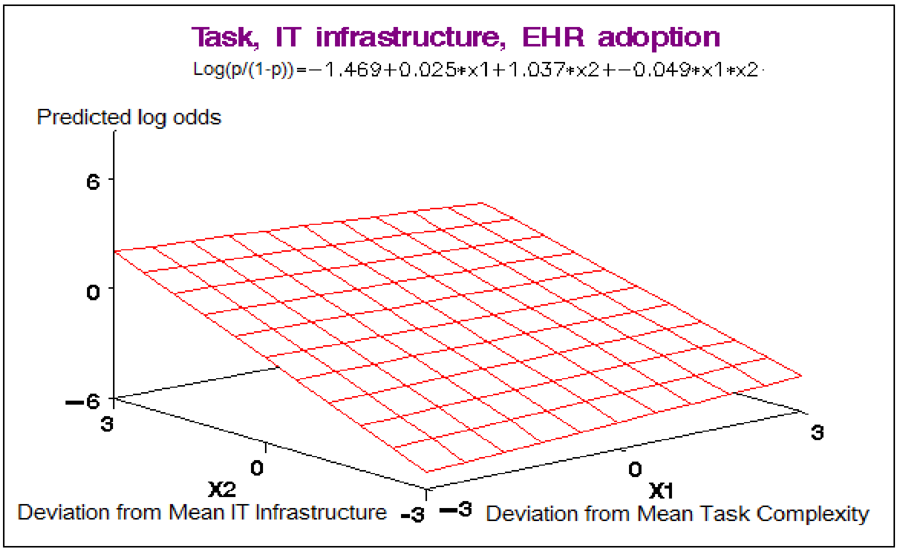

Figure 10. Task complexity, IT infrastructure, EHR adoptions 2

4.3. EHR use

This section investigates the relationships among a hospital's internal characteristics, such as task, structure, and environment, and EHR use using relevant statistical methods.

4.3.1. Hospital characteristics by EHR use

There were 158 hospitals that adopted an EHR system among the 352 hospitals that responded to the survey. Hospitals maintaining multihospital systems and that have a contract with other hospitals were using more EHR functions than single hospitals without any contract (5.69 versus 4.95, p=0.0052; 5.43 versus 4.29, p=0.0162) (Table 21).

Table 21. Characteristics of hospitals adopting an EHR system by EHR use

Basic characteristics		EHR use	p-value[1]
N		158	
Foundation	Private	5.25	0.7754
	Public	5.36	
Multihospital systems	Yes	5.69	0.0052
	No	4.95	
Contract for patient delivery	Yes	5.43	0.0162
	No	4.29	
Location	Urban	5.29	0.7032
	Rural	5.59	

[1] p-value of Wilcoxon's Rank Sum test, but Kruskal-Wallis Test used for bed size

4.3.2. EHR use and task complexity

This study investigated the impacts of task complexity on EHR use before (Model 1) and after (Model 2) controlling for a hospital's general characteristics.

Hypothesis Addressed:
HU1: Hospitals with high task complexity were more likely to use an EHR system.

The result showed that task complexity did not have any significant effect on EHR use (Table 22). Hospitals maintaining a multihospital system had one more EHR function than the single hospital groups.

Table 22. Impact of task complexity on EHR use

Independent variables	Model 1 (Beta[1])	Model 2 (Beta)
Foundation type (private) (ref=public)		0.347
Multi-hospital system (yes) (ref=no)		0.795*
Contracts with other hospitals (group purchasing, etc.)(ref=no)		0.889
Location (urban) (ref=rural)		0.217
Task Complexity (# of specialties)	0.021	0.006

* < 0.05, ** < 0.005, [1] Beta stands for regression coefficient

4.3.3. EHR use and structure

This section investigates the relationship between EHR use and the four factors for hospital structure: (1) de-centralization of decision-making of the IT department on hospital operations such as hiring, promotion, changing programs, and policies, (2) IT staff specialization, (3) IT infrastructure, and (4) organic structural form.

> *Hypothesis Addressed:*
> *HU2: Hospitals with decentralized decision making, high IT staff specialization, high IT infrastructure, and an organic managerial structure were more likely to use an EHR system.*

Table 23 shows the results from this study's investigation of the impact of hospital structure on EHR use before (Model 1) and after (Model 2) controlling for hospital covariates. None of the structural factors was statistically associated with EHR use. Compared to the hospitals without any contracts and not maintaining a multi-hospital system, hospitals with the contract and any affiliation had approximately 1 more EHR functionality, after controlling hospital characteristics.

Table 23. Impact of hospital structure on EHR use

Independent variables		Model 1 (Beta[1])	Model 2 (Beta)
Foundation type (private) (ref=public)			0.338
Multi-hospital system (yes) (ref=no)			0.773*
Contracts with other hospitals (group purchasing, etc.)(ref=no)			0.893†
Location (urban) (ref=rural)			0.235
Structure before EHR adoption	Dec. decision-making	0.011	-0.001
	IT staff specialization	0.066	0.034
	IT infrastructure	0.153	0.115
	Organic structure	-0.182	-0.194

* < 0.05, ** < 0.005, [1] Beta stands for regression coefficient. †: p=0.0502

4.3.4. EHR use and environment

This section describes the impact of environmental complexity on EHR use before (Model 1) and after (Model 2) controlling for hospital covariates.

Hypothesis Addressed:

HU3: Hospitals with high environmental complexity were more likely to use an EHR system.

Table 24 shows that environmental complexity was not related to EHR use as measured by the number of EHR functionalities. Hospitals affiliated or having contracts had more EHR functions than their counter parts.

Table 24. Impact of environmental complexity on EHR use

Independent variables	Model 1 (Beta[1])	Model 2 (Beta)
Foundation type (private) (ref=public)		0.347
Multi-hospital system (yes) (ref=no)		0.811*
Contracts with other hospitals (group purchasing, etc.)(ref=no)		0.939*
Location (urban) (ref=rural)		0.239
Environmental complexity (All hosp. within area)	-0.007	-0.016

* < 0.05, ** < 0.005, [1] Beta stands for regression coefficient. Note: the square root of beds used in this model.

4.3.5. EHR use, task, structure, and environment

Table 25 presents the results of analyses investigating whether hospital structural factors work as moderators between task complexity and EHR use and between environmental complexity and EHR use.

Hypothesis Addressed:

HU4: The relationship between task complexity and the use of EHR would be dependent on hospital structure.

HU5: The relationship between structure and EHR use be dependent on environmental complexity.

There were not any interaction effects between task complexity and hospital structural features or between task complexity and environmental complexity. Affiliation status and contract status were still significant predictors of EHR use.

Table 25. Impact of a hospital's internal features on EHR use

Independent variables		Beta
Intercept		3.644
Foundation type (private) (ref=public)		0.411
Multi-hospital system (yes) (ref=no)		0.829*
Contracts with other hospitals (group purchasing, etc.)(ref=no)		0.897†
Location (urban) (ref=rural)		0.320
Task complexity	# of specialties	0.011
Structure before EHR adoption	Decentralization	-0.021
	IT staff Specialization	-0.006
	IT infrastructure	-0.203
	Organic structure	0.224
Envir. Complexity	All hosp. within area	-0.025
Task complexity*Structure		
Task*Decentralization		-0.009
Task*Specialization		-0.013
Task*IT infrastructure		0.015
Task*Organic structure		0.055
Environmental complexity*Structure		
All hosp. within area*Decentralization		0.024
All hosp. within area*Specialization		-0.001
All hosp. within area*IT infrastructure		0.029
All hosp. within area*Organic structure		0.032

* < 0.05, ** < 0.005, [1] Beta stands for regression coefficient. †: p=0.063

Note: all numeric values were analyzed using mean centered predictors. The square root of beds used in this model.

4.4. Interoperability

This section reports the investigation of the relationships among hospitals' internal features and EHR interoperability using relevant statistical methods described in the research methods section.

4.4.1. Hospital characteristics by EHR interoperability

Among 158 hospitals adopting an EHR system, thirty-two percent of hospitals (51/158) reported that they have any kind of EHR interoperability, partially or fully implemented, on 8 items on patients' clinical information. Those hospitals reported that they had used the following tools for patients' clinical information exchange: e-mail with attached document, internet access to patient records, patient card system such as IC card, health information technology system to system, and others.

Table 26. Characteristics of hospitals adopting an EHR system by interoperability

Basic characteristics		Hospitals having EHR interoperability	Hospitals not having EHR interoperability	N	p-value [1]
% by interoperability status		32.3	67.7	158 (100.0)	-
Foundation	Private	26.1	73.9	69 (100.0)	0.1427
	Public	37.1	62.9	89 (100.0)	
Multihospital systems	Yes	36.4	63.6	77 (100.0)	0.2842
	No	28.4	71.6	81 (100.0)	
Contracts for patient delivery	Yes	35.5	64.5	141 (100.0)	0.0128
	No	5.9	94.1	17 (100.0)	
Location	Urban	32.0	68.0	147 (100.0)	0.7475
	Rural	36.4	63.6	11 (100.0)	

[1] Chi-square test, but Fisher's Exact Test is applied for contracts for patient delivery and location

Table 26 shows the relationship between EHR interoperability and a hospital's general characteristics. While thirty-five percent of hospitals with contracts for patient delivery and group purchasing reported having EHR interoperability, only 5.9% of hospitals not having the contract reported having EHR interoperability (p=0.0128).

Table 27 presents the results on hospital's internal features by EHR interoperability status. The number of medical specialties measuring task complexity was significantly higher in hospitals with EHR interoperability than hospitals without EHR interoperability (p=0.0006).

Table 27. Hospital's internal features by EHR interoperability status

Basic characteristics		Having Interoperability	Not having Interoperability	N (%)	p-value[2]
N		51	107	158	-
Task	# of medical specialties	15.59	11.94	158	0.0006
Structure	Decision making (average)	3.32	3.14	158	0.4298
	Hiring	3.04	2.97	158	0.7818
	Promotion	2.90	2.63	158	0.2790
	Program	4.10	3.85	158	0.3018
	Policy	3.25	3.09	158	0.5116
	IT staff specialization[1]	1.62	1.73	158	0.0960
	IT infrastructure	7.80	7.90	158	0.8879
	Organic structure	2.80	2.71	158	0.6263
Environment	HHI score	0.32	0.29	158	0.4581
	# of hospitals within the area	8.92	8.65	158	0.7723

[1] Standardized using bed size: the number of IT staff/bed*100
[2] p-value of Wilcoxon's Rank Sum test or chi-square test

4.4.2. EHR interoperability and task complexity

Table 28 presents the impact of task complexity on EHR interoperability before (Model 1) and after (Model 2) controlling hospital characteristics.

Hypothesis Addressed:
HI1: Hospitals with high task complexity were more likely to have interoperability.

There was significant association between task complexity and the odds of having EHR interoperability. The odds of having EHR interoperability increase by 8.8% for a 1-unit increase in the number of medical specialties, after controlling for hospital covariates.

Table 28. Impact of task complexity on EHR interoperability

Independent variables	Model 1 (Odds ratio)	Model 2 (Odds ratio)
Foundation type (private) (ref=public)		1.033
Multi-hospital system (yes) (ref=no)		0.854
Contracts with other hospitals (group purchasing, etc.)(ref=no)		7.223
Location (urban) (ref=rural)		1.210
Task Complexity (# of specialties)	1.092*	1.088*

* < 0.05, ** < 0.005

4.4.3. EHR interoperability and structure

Table 29 presents the impact of hospital structure on EHR interoperability before (Model 1) and after (Model 2) controlling for a hospital's general characteristics.

Hypothesis Addressed:
HI2: Hospitals with decentralized decision making, high IT specialization, high IT infrastructure, and an organic managerial structure were more likely to have interoperability.

After adjusting for hospital covariates, the odds of reporting EHR interoperability were estimated to be increased by 48.4% for a 1-unit increase in the score representing organic structural form though the increase was marginally significant.

Table 29. Impact of hospital structure on EHR interoperability

Independent variables		Model 1 (Odds ratio)	Model 2 (Odds ratio)
Foundation type (private) (ref=public)			0.481
Multi-hospital system (yes) (ref=no)			0.879
Contracts with other hospitals (group purchasing, etc.)(ref=no)			10.57*
Location (urban) (ref=rural)			1.252
Structure before EHR adoption	Dec. decision-making	1.136	1.098
	IT staff specialization	0.968	0.967
	IT infrastructure	0.846	0.799
	Organic structure	1.295	1.484†

* < 0.05, ** < 0.005, † p=0.0557

4.4.4. EHR interoperability and environment

This section investigates the relationship between EHR interoperability and environmental complexity represented by two variables: existence of true competitors and the number of hospitals within the local area (county district). Due to the high correlation issue between HHI and the number of hospitals within a local area, this study only used the latter variable in the model.

Hypothesis Addressed:
HI3: Hospitals with high environmental complexity were more likely to have interoperability.

The study result demonstrates that environmental complexity has no significant impact on EHR interoperability, either before or after controlling for hospital covariates (Table 30).

Table 30. Impact of environmental complexity on EHR interoperability

Independent variables	Model 1 (Odds ratio)	Model 2 (Odds ratio)
Foundation type (private) (ref=public)		0.653
Multi-hospital system (yes) (ref=no)		0.891
Contracts with other hospitals (group purchasing, etc.)(ref=no)		9.460*
Location (urban) (ref=rural)		1.270
True competitor	0.491	0.603
Environment complexity (All hosp. within area)	1.008	1.002

* < 0.05, ** < 0.005

4.4.5. EHR interoperability, task, structure, and environment

This section reports the investigation of whether or not hospital structural factors work as moderators between task complexity and EHR interoperability and between environmental complexity and EHR interoperability.

Hypothesis Addressed:
HI4: The relationship between task complexity and interoperability would be dependent on hospital structure.
HI5: The relationship between structure and interoperability would be dependent on environmental complexity.

Table 31 presents the results of the regression analysis evaluating outcome variable as the odds of having EHR interoperability in hospitals. Among the hospital structural variables, task complexity, IT staff specialization, organic structural factors, and environmental factors had direct or indirect effects on EHR interoperability.

Table 31. Impact of a hospital's internal features on EHR interoperability

Independent variables		Odds ratio
Intercept		0.053
Foundation type (private) (ref=public)		0.959
Multi-hospital system (yes) (ref=no)		0.681
Contracts with other hospitals (group purchasing, etc.)(ref=no)		9.346
Location (urban) (ref=rural)		1.099
Task complexity	# of specialties	1.116*
Structure before EHR adoption	Decentralization	0.951
	IT Staff Specialization	1.003
	IT infrastructure	1.580
	Organic structure	1.049*
Envir. Complexity	All hosp. within area	1.009
Task complexity*Structure		
Task*Decentralization		0.982
Task*Specialization		1.103*
Task*IT infrastructure		1.096
Task*Organic structure		0.947
Environmental complexity*Structure		
All hosp. within area*Decentralization		0.986
All hosp. within area*Specialization		1.037*
All hosp. within area*IT infrastructure		1.041
All hosp. within area*Organic structure		1.023

* < 0.05, ** < 0.005
Note: all numeric values were analyzed using mean centered predictors

For the interaction effect between task complexity and IT staff specialization, the impact of task complexity on the log odds of having EHR interoperability depends on IT staff specialization. The log odds of having EHR interoperability increases as task complexity increases at a high level of IT staff specialization which is above the average of the group (Figure 11). However, the log odds of having EHR interoperability decrease when task complexity increases at a lower level of IT staff specialization which is below the average of the group (Figure 12).

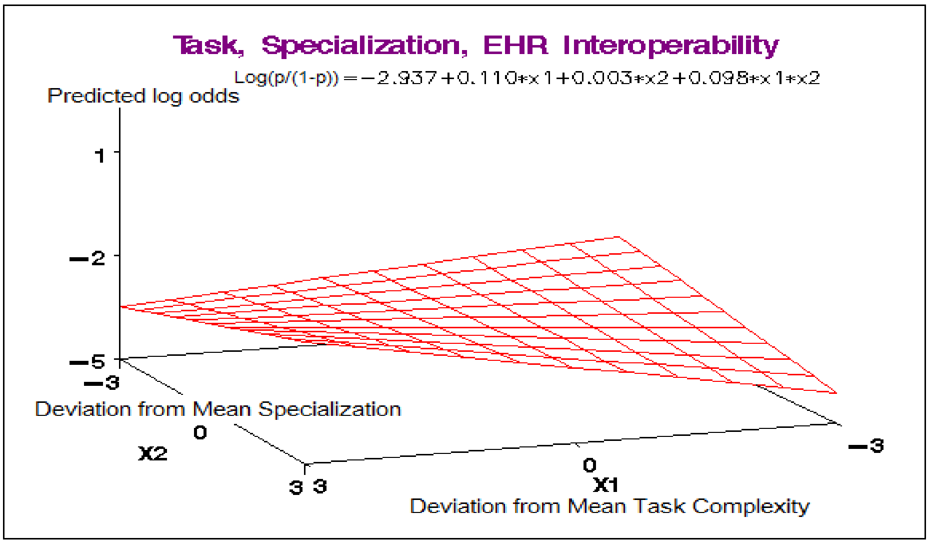

Figure 11. Task complexity, IT staff specialization, EHR interoperability 1

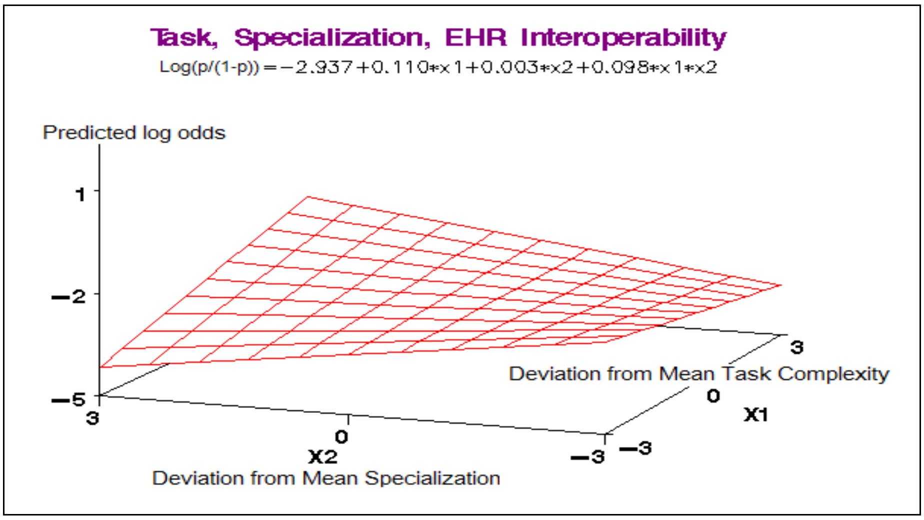

Figure 12. Task complexity, IT staff specialization, EHR interoperability 2

For the interaction effect between environmental complexity and IT staff specialization, the impact of IT staff specialization measured by IT staff per 100 beds on the log odds of having EHR interoperability was heavily influenced by environmental complexity. Assuming that the distinction point of environmental complexity on whether it is high or low complexity is based on above or below the average number of hospitals within the local areas, the log odds of having EHR interoperability increases as IT staff specialization increases at a high level of environmental complexity (Figure 13). In contrast, the log odds of having EHR interoperability decrease as IT staff specialization increases at a lower level of environmental complexity (Figure 14).

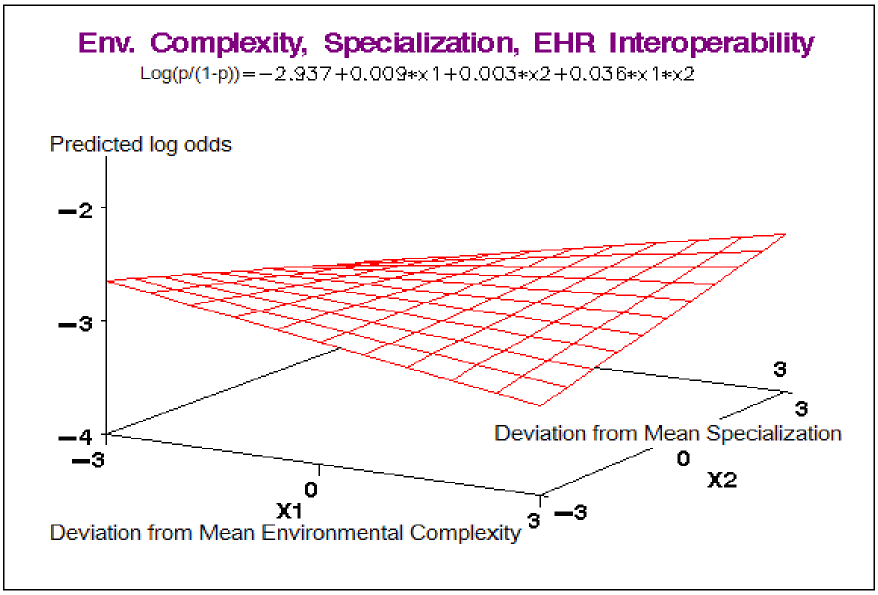

Figure 13. Environmental complexity, IT staff specialization, EHR interoperability1

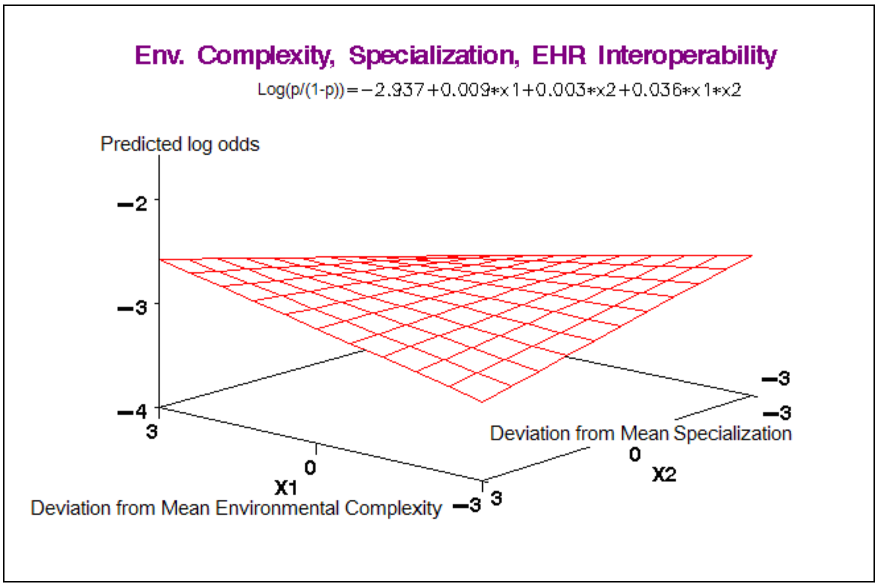

Figure 14. Environmental complexity, IT staff specialization, EHR interoperability2

CHAPTER V DISCUSSION

5.1. Study methods and related issues

This section will review the research methods of this study, focusing on the study design and study population.

5.1.1. Study design

The purpose of this study is to investigate the impacts of hospitals' internal features including task complexity, structure, and environmental factors on hospitals' EHR adoption, use, and interoperability. This study design is similar to a case-control study design comparing two groups in which one has a specific outcome variable and the other is without that outcome variable. The factors suspected to be related to the outcome variables are usually compared with each other in a case-control study design.[129]

Table 32. Comparison of study designs

Group	Study design in this study			Case-Control study design		Static-Group Comparison design	
Time	Past		Current	Past	Current	Past	Current
Study	O	X	O†	O	X	X	O
Control			O	O			O

†: # of specialty, # of hospitals within local area, hospital's organic features were measured at the time of survey
* O: observation, X: exposure to an event or having an event

Campbell and Stanley (1966) proposed 16 types of experimental and quasi-experimental study designs for researchers.[130] Among them, the Static-Group Comparison design is similar to the design of this study in that it has two groups. However, our study's purpose is to measure which factors affected an event which has already happened. Thus, this study slightly modified the Static-Group comparison model (Table 32). There are several reasons that this study did not exactly follow the case-control or Static-Group Comparison study designs. First, this study did not know when the hospitals in the study group adopted an EHR system. Thus, this study compared several factors from the past of hospitals that currently have an EHR system with the same characteristics of hospitals that do not currently have an EHR system measured at the time of the survey. Second, the purpose of this study is not to investigate the impact of an event on the hospital structure, but to find out which factors affect a certain event. Thus, observation before an event occurred was necessary. Third, unlike a study on individual patients or animals, the unit of analysis of this study is hospitals, which are difficult to randomize. Although these features differ from traditional study design, this study contends that they would be sufficient to address the hypotheses of this study.

For these reasons, decentralization of decision-making, IT staff specialization, and IT infrastructure of hospitals before EHR adoption were compared with hospitals that do not currently have an EHR system. However, task complexity, organic management structure, and environmental complexity were measured for all hospitals at the time of survey. Although one may question whether it is reasonable to compare some hypothesized factors from past observations of hospitals which have adopted an EHR system with the same factors from current observations of different hospitals, it can shed some light on possible causality because it does observe hypothesized factors before an occurrence of EHR adoption. However, this study does make the assumption that these factors do not change significantly over time and that what characterizes non-adopters now would also characterize them in earlier time periods when adopters were making their decision. One alternative that could avoid the issue of comparing observations from different times would be collecting time-stamped data and conducting a survival analysis. However, this method would be particularly difficult to implement for hospitals who had not adopted an EHR system. For these reasons, this study asserts that its design provides reasonable information about the factors that could play a causal role in EHR adoption, use, and interoperability in hospitals.

5.1.2. Study population

The survey results showed that general hospitals were over-represented in the study population compared to small hospitals. Approximately 73.0 percent of general hospitals responded to this study and, in contrast, only 19 percent of small hospitals participated in this study although small hospitals constitute 73.2 percent of the total hospital population in Korea. The reason for this difference may be mainly due to lack of IT departments in small hospitals. Many general hospitals have used various IT technologies both clinically and administratively, such as electronic billing and healthcare expense reimbursement. In these cases there was a director or manager in charge of the daily activities in the IT department. When the primary investigator requested a hospital's participation in the survey, they might have been more likely to participate because they were in charge of IT. In contrast, small hospitals were less likely to have an IT department and someone who would be interested in responding to the survey. This would lead to a lower response rate from small hospitals.

Although this study did not consider the existence of an IT department or types of hospitals (such as general hospital or small hospital) in the study model, this study argues that there are several reasons that these facts did not critically affect the study results. First, most of the hospitals that participated in the survey were general hospitals. Thus, current study results may best be generalized to the general hospitals and less so for small hospitals. Second, inclusion of type of hospital might produce more distorted study results because the types of hospital are highly correlated with the number of medical specialties (or task complexity measure) which was already included in this study. Third, even though some small hospitals did not have IT departments, most small hospitals had at least one staff member who worked with IT for the purposes of claiming process or reimbursement management, and they participated in this study.

5.2. Research results

This section will discuss the research results of this study, focusing on EHR adoption, use, and interoperability.

5.2.1. Hospital's internal features affecting EHR adoption

General characteristics: The reported EHR adoption rate was 45% of all responding hospitals. This is slightly higher than Park's (2005) study result conducted in 2004 which showed that 38% of non-teaching general hospitals had adopted an EHR system. However, according to Chae's (2005) study conducted in 2005, the EHR adoption rate was approximately 20% of hospitals in a nationwide survey.[4] Considering a 4-year time interval between this study and Chae's (2005) study, the number of Korean hospitals that have adopted an EHR system seems to have more than doubled from 2005 to 2009. The difference from Chae also could be due to the over-representation of general hospitals because 73 percent of the general hospitals in Korea responded to this study and, in contrast, only 19 percent of small hospitals. The size of a hospital generally affects EHR system adoption.[8] In the U.S., depending on the study results, the overall EHR adoption rate in hospitals is 20-40%[7], which is similar to the adoption rate in South Korea.

Hospitals located in an urban area were more likely to adopt an EHR system. This result is similar to studies which focus on U.S. hospitals. According to the AHA (2007) study results, the EHR adoption rate was higher at hospitals located in urban areas than those located in rural areas.[8] Hospitals that had contracts for group purchasing and patient delivery with other hospitals were more likely to adopt an EHR system than hospitals without contracts. Necessity of information exchange with other hospitals might instigate the adoption of an EHR system for those hospitals that had contracts because EHR systems would provide remote access to clinical information that would facilitate patient transfers. Hospitals might be influenced to adopt new technologies through the other contracted networked hospitals, which might affect the adoption of an EHR system for those hospitals.

Hospital's internal features: This study proposed that hospitals with high task complexity, as measured by the number of medical specialties, would be more likely to adopt an EHR system because high task complexity generates a higher work load that could be addressed by IT systems, including EHRs, as a way to more cost effectively handle that workload. There was a demonstrated relationship between EHR adoption and task complexity which would support this hypothesis.

Among a hospital's four measured structural characteristics, IT infrastructure and organic management structure were individually associated with EHR adoption. Hospitals with high IT Infrastructure, as measured by the number of different clinical information systems, were more likely to be adopters of EHR systems. If hospitals are already equipped with various information systems, this suggests that these hospitals maintain a more sophisticated IT infrastructure and have the experience necessary to take on the implementation of an EHR system. This means that they are more ready for the adoption of EHR systems. This result is also in accordance with the results of Anderson (2007) who found a positive relationship between EMR system adoption and IT infrastructure.

This study also found that hospitals with a management structure that is more organic were more likely to be adopters of EHR systems. However, it is not clear whether organic structural factors lead to EHR system adoption or whether adopting an EHR system causes a hospital's structure to be more organic since this study measured organic factors at the time of survey for all hospitals. However this study contends that the former is more likely to occur because organization culture such as organic structure is usually built up over a long period of time and may not be changed easily. The organic structural form has many unique characteristics such as a horizontal rather than a vertical direction of communication, a network rather than hierarchic structure of control and authority,[131] and mutual agreement among co-workers rather than high reliance on rules and standard procedures.[132] These kinds of features usually provide hospitals with an environment in which adoption of innovations including EHR systems can occur more easily. This study result is in accordance with other studies on the relationship organic structural features and organizational innovation described in the literature review sections such as Aiken,[93] Meadows,[94] and Hull.[95] Judging from these study results, this study argues that hospital's organic structural characteristics might critically affect their EHR system adoption.

In terms of measured environmental factors, EHR adoption was related to the number of hospitals within a local area. This result is in accordance with other studies on the relationship between environmental complexity and technology adoption. Abdolrasulnia, et al (2008) found that medical doctors practicing in counties with high concentration of physicians were more likely to adopt an EHR system.[133] A possible interpretation of this study result is that competition forces hospitals to adopt EHR systems because hospitals located in competitive markets might have to use various technologies including EHR systems in order to increase their competitive power through increased managerial efficiency or simply to be viewed favorably and have a better image with respect to their peers.

Interaction effects between task complexity and hospital structure: This study found that the level of task complexity had an impact on how different components of the hospital structure were associated with EHR adoption. While task complexity by itself was positively related to EHR adoption, its association was also moderated by the level of decentralization of the decision-making system and level of IT infrastructure.

The likelihood of EHR adoption increases as task complexity increases when hospitals are under a highly decentralized decision-making system. In contrast, under a highly centralized decision-making system, the likelihood declines as task complexity increases. From this, we can conclude that a hospital's decision-making system plays an important role of a moderator between task complexity and an EHR system adoption. At high levels of decentralization this study is in partial accordance with other research in which adoption of innovations including new technologies occurs more frequently in decentralized-decision making system organizations.[134,135] However the reverse effect occurred when there was centralization of the decision-making system. This is contrary to our initial hypothesis and the explanation for why this might be the case is not evident. A possible explanation would be that hospitals' adoption of EHR might be delayed or lagged because of strong bureaucratic and administrative procedures under the centralized decision-making system. They might want to see other hospitals adopting an EHR system before deciding if an EHR system provides them with clinical and managerial efficiency.

This study also observed that the likelihood of EHR adoption declined as task complexity increased when hospitals reported high levels of IT infrastructure. In contrast, the likelihood increased as task complexity increased when hospitals reported a lower level of IT infrastructure. The latter case can be explained in that hospitals with a lower level of IT infrastructure may adopt EHR systems in order to increase their capacity for dealing with a heavy work load coming from task complexity. However, the former case may need further explanation. Hospitals with high level of IT infrastructure might already hire enough human resources. Current IT infrastructure could also have enough capacity to deal with work load coming from task complexity without EHR systems. Thus, there would be a declining relationship between task complexity and EHR adoption under a high level of IT infrastructure.

Summary: This study found that task complexity, IT infrastructure, organic structure, and environmental competition were associated with EHR adoption. Since it is unlikely that EHR adoption drives the number of specialties in a hospital and that the number is likely to change slowly over time, the most likely explanation is that task complexity is driving EHR adoption. A similar argument can be applied for organic structure and environmental complexity, which are characteristics that are not likely to change within a short period of time. Thus, this study contends that they would be more likely to affect EHR system adoption rather than the reverse although they were measured at the time of survey. Past experience and hospital culture emphasizing flexibility among co-workers might instigate EHR adoption in hospitals with high levels of IT infrastructure and organic management structures. Motivation due to increasing competitive pressure from surrounding peer hospitals might also influence EHR system adoption. With respect to relationship between task complexity and EHR adoption, bureaucratic procedures under high centralization of decision-making and potential slack capacity of IT infrastructure in hospitals with high levels of IT infrastructure appear to differentially affect EHR adoption.

5.2.2. Hospital's internal features affecting EHR use

General characteristics: A multi-hospital system measured by whether a hospital is legally affiliated with other hospitals or not and hospital's contract with other hospitals for patient delivery and group purchasing exhibited a greater degree EHR use as measured by the number of EHR functionalities. Multi-hospital systems might have more resources to invest in sophisticated IT, including EHRs, than single hospitals, which might result in having more EHR functions. However, it is not clear why hospitals with the contracts exhibited higher levels of EHR use, and further research is needed to investigate this issue.

Hospital's internal features: None of the hospital's internal features were related to EHR use. This result suggests several implications for future studies.

First the measure of EHR use might not be properly measuring what this study intended it to measure. The existence of certain subsystems may not be reflective of overall use of the system. Use can be defined as the degree to which an EHR is used in patient care, where the maximum level is when an EHR is used for every patient in every care process. What this study is measuring may be the expanded potential uses of an EHR and not its actual use. Rather than simply counting the number of functions in an EHR system, EHR use may need to be measured more quantitatively. Such measures might be the number of times data retrieval occurred per month, the number of medical professions that used an EHR system, and how many logged on hours an EHR system exhibited. Theoretically, EHR use has a high possibility of correlation with patient care factors such as frequent patient visits that would increase the retrieval of patient charts under the paper-based medical record systems. Similarly, increased information processing demands due to increased admissions or diversity of patients may lead to increased EHR use. EHR use should be an actual use of EHR system and one wholly replacing the paper-based medical record system and reflecting patient treatment process rather than counting the number of functions in an EHR system, which would be a better measurement and provide more meaningful information for users such as hospital managers, health informaticians, and policy makers. However this information is difficult and expensive to collect and has not been done in other studies to date.

Alternatively, the finding that none of the hypothesized internal structural factors were related to EHR use measured by EHR functions may be correct. In this case it might be better to measure performance factors or increasing information processing demands such as patient admissions and bed turnover rates. A recent study reflects this thinking. It investigated the relationship between information processing demand and HIT use in hospitals and found that increased information processing demand, measured by an increase in annual patient admissions, was positively associated with HIT use.[136] It measured HIT use by counting different IT systems and by weighting EHR. A second study looked at the relationship between computerization and quality of care. They found that there was a positive relationship between the two factors.[137] Thus, performance factors such as reducing or increasing information demand and improving quality of care may be more reasonable predictors of EHR use.

Lastly, there have been few previous studies on EHR use as an outcome variable at the organizational level. Most current studies measure EHR use as existence of various functionalities in an EHR system. They do not use those measures as one of the outcome variables. Certainly, it is necessary to develop a more quantitative measure of EHR use mentioned above and to compose hypotheses on how a hospital's task and information process demand are related to EHR use, which will help us to understand the mechanism of variation of actual EHR use.

Summary: Given that EHR use measured by the number of functions in EHR systems was not associated with any of hospital's structural factors, alternative measures of EHR use and internal features selected in different empirical and theoretical standpoints were suggested.

5.2.3. Hospital's internal features affecting EHR interoperability

General characteristics: A hospital characteristic, contract status with other hospitals for group purchasing and patient delivery, was associated with hospitals' EHR interoperability. Having a relationship with other hospitals that involves movement of patients from one to another might explain an increased level of interoperability to exchange clinical information with other hospitals and could explain this finding.

Hospital's internal features: Task complexity was associated with EHR interoperability as measured by the ability of an EHR system to exchange patient's clinical information electronically with other healthcare organizations. High task complexity means that hospitals provide diverse patients with comprehensive medical care services from primary care to specialty care. They would have many cases being transferred to or being transferred from other clinics or hospitals. All these cases would increase the necessity of healthcare information exchange and EHR interoperability. This could be a possible explanation of this finding.

The degree of organic management structure as measured by questions on a hospital's organic characteristics was marginally associated with the level of EHR interoperability. Such a structure has characteristics that could lead to greater interoperability. As Child described, organic structural form incorporates many flexible features such as lateral communications network, decentralized decision making, and a high reliance on consensus among co-workers.[132] Active collaborations or cooperative, network-based communications among member or networked hospitals may encourage the idea of EHR interoperability. Employees working at those hospitals may place more emphasis on the necessity of patient information. The study result is also in accordance with the other study results that organizational innovation more frequently occurs within organizations with more organic than mechanical managerial structures.[94, 95]

Interaction effects between task complexity and hospital structure: This study found one structural factor that played an important moderating role between task complexity and EHR interoperability and between environmental complexity and EHR interoperability: IT staff specialization as measured by the number of IT staff positions per 100 beds.

The likelihood of EHR interoperability at a high level of IT staff specialization gradually increased as task complexity increased as we hypothesized. At low levels of IT staff specialization the likelihood slightly decreased as task complexity increased. This latter result contradicts our hypothesis that task complexity would increase EHR interoperability. It may be that a competition for resources under high task complexity might cause scarce resources to use for specialty care needs such as hiring more nurses or purchasing medical equipment rather than hiring IT staff for developing interoperability in an EHR system.

This study also found that the likelihood of EHR interoperability at a high level of environmental complexity increased with increasing IT staff specialization. However, the likelihood of EHR interoperability at a lower level of environmental complexity decreased with increasing IT staff specialization. Possible interpretation of the latter result would be that hospitals in a less complex environment might have less motivation to implement EHR interoperability although they had enough IT staff specialization because there are few competitors. Due to lack of similar studies, this study suggests that it is necessary to do further research.

Summary: In summary, this study speculates that high task complexity requiring a comprehensive medical care through patient's referral would lead to increase the likelihood of having EHR interoperability. The study result that hospitals with an organic managerial structure had a higher likelihood of EHR interoperability confirmed other findings in the literature. EHR interoperability can be seen as an innovative event. This study speculates that high competition among medical specialties might force hospitals' resources toward specialty care areas at low levels of IT staff specialization, which might lead to decreased EHR interoperability under high task complexity and a lower level of IT staff specialization. A hospital's weak motivation under a lower level of environmental complexity might lead to decrease the likelihood of EHR interoperability even though there was a high level of IT staff specialization.

5.3. Study limitations

Specific issues regarding research methods and results were partially discussed above. In addition, this study has the following limitations. One involves the generalizability of the study results. This study obtained the data from South Korean hospitals. A study using data from a different country could produce different study results. Thus, the results interpretation may be limited to hospitals in Korea. It may be necessary to further study the proposed hypotheses using data from hospitals in other countries such as the United States.

Another limitation may be a selection bias in study subjects. This study advertised to hospitals' CIOs or IT managers one time through postal mail. In addition, some hospitals were called using a telephone number from the Korea Hospital Association in order to increase the response rate. Due to the limitation of the data collection period, only two hospitals in each local area were selected based on the Korean language's alphabetic order of hospital address. This study also received data collection support from a professional community of hospital IT department managers in Korea. Most association members responded to the survey. One significant characteristic of this association is that most of the members are IT managers of general hospitals, which are larger sized hospitals. This was reflected in the over-representation of general hospitals in the survey responses. Thus there might be some selection bias in which the study results may represent larger Korean hospitals or general hospitals with IT departments.

An informant recollection issue might have affected the quality of survey data. A number of the survey questions were based on recollection of past events and organizational characteristics, such as the year of EHR installation. To respond accurately the informant needed to know the past history of the hospital, at least for the past 6 years. Depending on the informant, a six-year recollection period may be too long a period for accurate recall. However, it is likely that the installation of an EHR system would be a significant event for hospitals, so this study argues that IT managers should be able to remember its introduction year. Thus possibility of incorrect responses in this survey would be reduced.

CHAPTER VI CONCLUSIONS

6.1. Study overview

The objective of this study was to investigate the relationships between EHR adoption, use, and interoperability and hospitals' various contexts such as task complexity, hospital structure, and environment. For this purpose, this study proposed that EHR adoption, use, and interoperability would be positively related to 1) task complexity, 2) structural characteristics such as decentralization of decision-making, IT staff specialization, IT infrastructure, and a hospital's organic structural characteristics, and 3) environmental complexity. This study also proposed that the impacts of task complexity and environmental complexity on EHR adoption, use, and interoperability would depend on hospital's structural characteristics.

This study descriptively defined EHR adoption, use, and interoperability and conducted a nationwide EHR survey of the IT departments in Korean hospitals. The survey was implemented from April 1 to August 3, 2009 through a University of Minnesota internet website. Target survey informants were the chief information officers (CIO) and IT department managers in hospitals in South Korea. Among a hospital population of 1,067, a total of 356 hospitals participated in the survey. The final response rate was 33.5% of the total hospital population.

In the stage of statistical data analysis, this study used Generalized Estimating Equations (GEE), an extension of the Generalized Linear Model, in the case of EHR adoption and interoperability and General Linear Mixed Model with random intercept statement in the case of EHR use.

6.2. Significant findings

The study reveals that the hospital's internal structural features were related to EHR system adoption and EHR interoperability. However, they were not associated with EHR use. The following is a brief summary of significant findings in this study by three parts –one for each outcome.

6.2.1. Findings in EHR adoption

The likelihood of EHR adoption was related to a hospital's internal features and environmental factors. Figure 15 depicts and summarizes the impact of hospital structure and environmental factors on EHR adoption verified by this study.

First, HA1 was supported. The likelihood of EHR adoption increased as hospital's task complexity measured by the number of medical specialties increased.

Second, HA2 was supported by IT infrastructure and organic management structure. The likelihood of EHR adoption increased as hospital's IT infrastructure and organic structural characteristics increased. However, EHR adoption was not individually related to decentralization of decision-making system and IT staff specialization.

Third, HA3 was supported. The likelihood of EHR adoption increased as the number of hospitals within a local area increased.

Fourth, HA4 was supported by two areas. The impact of task complexity on an EHR system adoption was dependent on decentralization of decision-making and IT infrastructure, respectively. Assuming that a hospital adds additional medical specialties or a hospital's task complexity increases, the likelihood of adopting an EHR system of the hospital increases under a decentralized decision-making system, but decreases under a centralized decision-making system. Under the same condition of task complexity, the likelihood of adopting an EHR system of the hospital decreases at a high level of IT infrastructure, but increases at a lower level of IT infrastructure.

Fifth, HA5 was rejected. There was no combined effect of environmental complexity and hospital structure on EHR adoption.

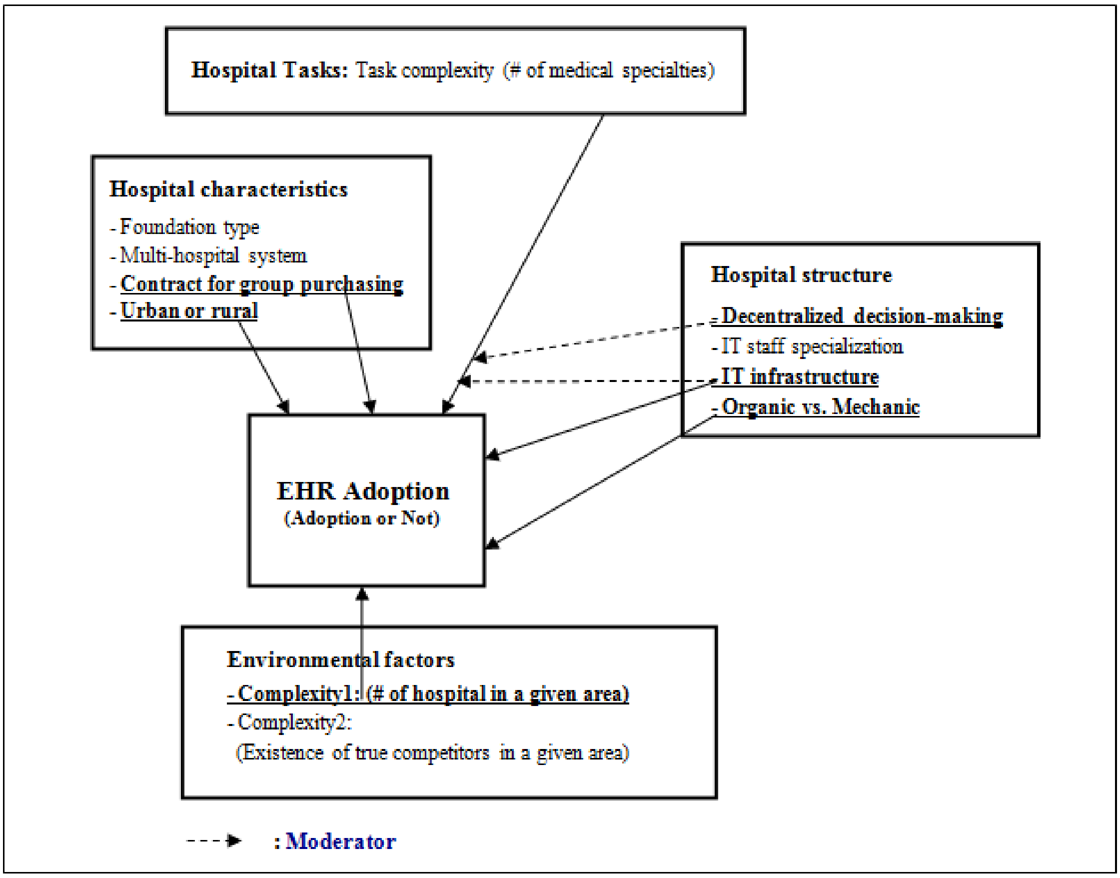

Figure 15. Impacts of hospital structure & environment on EHR adoption

6.2.2. Findings in EHR use

Unlike our expectations, neither a hospital's internal features nor its environmental complexity nor their combination were related to the degree of EHR use. Thus, hypotheses from HU1 to HU5 were rejected. Alternative measures of EHR use and a hospital's internal features were suggested through these findings.

6.2.3. Findings in EHR interoperability

The likelihood of EHR interoperability was related to a hospital's internal features and environmental factors. Figure 16 depicts and summarizes hospital structure and environmental factors affecting EHR interoperability observed by this study.

First, HI1 was supported. The likelihood of EHR interoperability increased as a hospital's task complexity measured by the medical specialty increased.

Second, HI2 was supported with respect to organic management structure though its statistical significance was marginal. Hospitals having greater organic structural characteristics were more likely to have an interoperable EHR system. However, decentralization of decision-making system, IT staff specialization, and IT infrastructure was not individually associated with an interoperable EHR system.

Third, HI3 was rejected. Environmental complexity measured by the number of hospitals within the local area was not related to EHR interoperability.

Fourth, HI4 was supported by the combined effect of task complexity with IT staff specialization on EHR interoperability. Assuming that a hospital adds additional medical specialties, the likelihood of EHR interoperability of the hospital increases at a high level of IT staff specialization, but decreases at a lower level of IT staff specialization. Other than that, none of combined effect of task complexity with a hospital's internal features was reported.

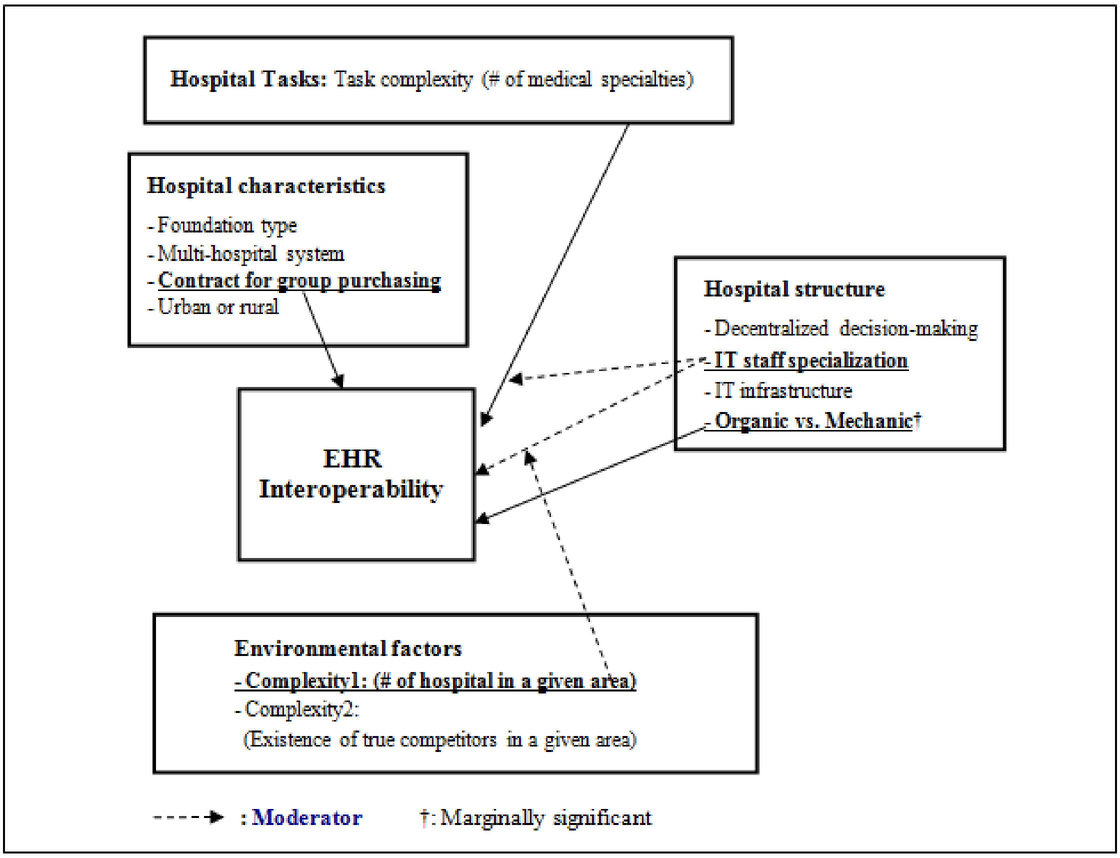

Figure 16. Impacts of hospital structure & environment on EHR interoperability

Fifth, HI5 was supported by the combined effect of environmental complexity with IT staff specialization on EHR interoperability. At a high level of environmental complexity where the number of hospitals within the local area is above the average of the study population, the likelihood of having EHR interoperability increases as IT staff specialization increases. However, the likelihood of having EHR interoperability decreases as IT staff specialization increases at a lower level of environmental complexity where the number of hospitals within the local area is below the average of the study population. Other than that, none of the combined effect of environmental complexity with structural features on EHR interoperability was reported.

6.3. Contributions to the field of health informatics

EHR systems have been rapidly adopted and used in healthcare settings for a relatively short period of time, and they have recently received a nationwide spotlight on EHR adoption, use, and interoperability. This study would be a first study on how various factors surrounding hospitals affect EHR adoption, use, and interoperability. IT managers working in hospitals and students and scholars in academic settings would benefit from this new knowledge about how an overall hospital's structural settings affect EHR system adoption, use, and interoperability.

Another potential contribution would be one of theory application studies using an EHR subject. By introducing an academically well-known organizational theory into the field of informatics, students and informaticians working in empirical fields would get some experience of theory application. According to a recent comprehensive review study,[138] contingency theory has not been used and applied much in the field of health informatics. Researchers and scholars working in the field of health informatics would get an opportunity to see how organizational theory helps to predict EHR adoption, use, and interoperability. Studies based on strong theoretical arguments give us insight on a better logical understanding and prediction of a central phenomenon. This study is one of new approaches to explaining the impact of technology, structure, and environment on EHR system adoption, use, and interoperability based on theoretical arguments.

By introducing the field of health informatics from a foreign country to health informaticians, this study allows them to have a broad viewpoint and picture of the world concerning task and hospital structure. If we study only IT in specific areas and discard the opportunity to obtain knowledge from other countries, then we will have a narrow-minded perspective.

Some research methods and several constructs which were not fully developed in this study can also be used as an arena of criticism through which health informaticians can improve their thoughts and reasoning concerning task complexity and organization structure.

6.4. Future study directions

The following are suggestions for future studies. First, it is definitely necessary for investigators to develop a measure of EHR use that is more quantitatively based rather than measured by counting functionalities in an EHR system. The number of retrievals or total logged-on time per month per medical professional in an EHR system may be some alternatives. This measure should be focused at the organizational level, rather than at individual levels because there have been a paucity of studies focusing on the organizational level.

Second, it is also necessary to choose dynamic categories of predictors such as the number of patient admissions per month, existence of quality assurance, hospital length of stays, and bed turnover rate in terms of EHR use and interoperability because they may be closely related with EHR use judging from the fact that frequent patient's admissions increase paper-chart delivery to the clinical departments. EHR use and interoperability also would be affected by those predictors because an EHR system is quickly replacing a paper-based medical record system.

Thirdly, collecting data that have more hierarchical structures such as individual medical professionals, hospital structures, and environmental factors can be another important study direction. By combining different levels of data structure, we can look at how EHR adoption, use, and interoperability are different or are affected by individual, organizational, and environmental factors.

Fourth, many scholars have argued that hospitals should introduce more information technology to reduce medical errors and to improve the quality of care.[139, 140] From this standpoint, further study is needed to investigate the impact of EHR system adoption, use, and interoperability on clinical outcomes and organizational performance or managerial efficiency.

In conclusion, this study investigated the impact of the hospitals' technology, structure, and environment on EHR adoption, use, and interoperability. By introducing two new concepts, EHR use and interoperability in addition to EHR adoption, this study attempted to see their relationship with other hospital predictors that had not been previously studied. This study anticipates that its results should provide hospital IT managers, health informaticians, and policymakers with new information on the factors related to EHR adoption, use, and interoperability.

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Appendix 1. Hospital Information Technology Survey (English)

Dear Chief Information Officer or Manager,

My name is Young-Taek Park and I am a Ph.D. student in the Division of Health Informatics at the University of Minnesota. Although Health Information Technology (HIT) has been proven to impact decision-making, management processes, quality of care and the bottom line, many hospitals have yet to adopt HIT. To this end, I have been studying the adoption of the Electronic Medical Record (EMR)/Electronic Health Record (EHR) system, use, and interoperability in hospitals. Assuming your participation in this brief survey, upon completion of my study, I can email you the aggregate results of the survey as well as your specific responses.

I believe that the study results will extend the knowledge boundary of EMR/EHR systems. The results will also be used for hospital managers and policymakers to establish good decision making and policy alternatives related to the introduction of the EMR/EHR system.

The data from this survey will only inform research for my doctoral dissertation. It will only be shared in aggregate form, and will not be used for any other reasons. I cordially request your cooperation in acquiring reliable data. If you are interested in receiving a copy of the executive summary, please contact me directly via email.

Your time and participation is truly appreciated.

April 1, 2009

Park, Young-Taek
Ph.D. Student
Division of Health Informatics
University of Minnesota

If you have any questions, please call me: (Cell) 1-612-481-3760, (Home) 612-331-5266, or (Office) 1-612-625-9431 or please send me an e-mail (Email: park0601@umn.edu).
This web-based online survey is available at http://www.tc.umn.edu/~park0601

Release: I understand that my participation in this survey is voluntary and that I may exit or quit the survey at anytime without repercussions.

1. Questions for follow-up this survey:

Respondent's name:	
Respondent's telephone number:	
E-mail address:	

2. Is this hospital part of a multi-hospital system? (1) Yes (2) No

3. If this hospital has any contracts such as group purchasing arrangement with other hospitals, please √ check the first year your hospital started this arrangement.

Before 2003	2003	2004	2005	2006	2007	2008	2009

4. Please check all the following supported by the Hospital Information System in your hospital and please √ check the year it was introduced, if applicable.

Hospital Information System	Introduced?	Year of introduction							
	Yes	Before 2003	2003	2004	2005	2006	2007	2008	2009
Outpatient CPOE*									
Inpatient CPOE									
Drug management/dispensing									
Patient charging processing									
Clinical laboratory work									
Radiology work									
Operating room									
Intensive Care Unit									
ED information system*									
Administrative procedures									

* CPOE: Computerized Physician Order Entry , ** ED: emergency department

5. An *Electronic Health Record (EHR)* system is defined as "a system that integrates electronically originated and maintained patient-level clinical health information, derived from multiple sources, into one point of access" (AHA, 2007). An *Electronic Medical* Record *(EMR) system* is defined as a system that has "the record of patient health information generated by encounters at one particular provider, which is the electronic replacement of paper charts" (Texas Medical Association, 2006).

If your hospital is equipped with either an EMR or an EHR system, please complete the boxes below.

Departments	Implemented			Introduction Year	Type of Installation		
	Fully	Partially	Not		Internal Development	Outsourced	Purchased
Hospital wards							
Outpatient clinics							

6. What are the available functions in your hospital's EMR/EHR system? (**Please check √**)

Functions	**Fully Implemented**	**Partially Implemented**
(1) Access to current medical records (observations, orders)		
(2) Access to medical history		
(3) Access to patient flow sheets		
(4) Access to patient demographics		
(5) Order entry or results review – Lab		
(6) Order entry or results review – Any radiology report		
(7) Order entry - real time drug interaction alerts		
(8) Other clinical alerts		
(9) Clinical guidelines and pathways		
(10) Patient access to electronic records		
(11) Patient support through home-monitoring, self-testing, and interactive patient education		

7. Does your hospital's EMR/EHR system have the ability to transmit and receive these categories of information electronically from other clinics or hospitals (EMR/EHR information exchange)?

Type of information exchanged*	**Fully exchanged**	**Partially exchanged**	**No**
(1) Patient history (family, patient)			
(2) Patient summary (conditions, meds, and allergies)			
(3) Discharge summaries			
(4) Laboratory information			
(5) Imaging information			
(6) Pharmacy information			
(7) Other			

8. How does your hospital transfer medical information to other clinics or hospitals located in different areas? (Multiple choice)
(1) Paper document delivery or receiving (e.g., patient referral form)
(2) Fax
(3) E-mail (with attached documents)
(4) Internet access to patient records
(5) Patient card system such as IC card
(6) Health Information Technology (HIT) system-to-system
(7) Phone call messages
(8) No sharing
(9) Other

9. Frequency of the CIO / IT department manager / IT department director's participation in:

		Always	Often	Sometimes	Seldom	Never
Before EMR/EHR introduction	The decision to hire new staff?					
	The decisions on the promotion of any of the professional staff?					
	Decisions on the adoption of new programs?					
	Decisions on the adoption of new policies?					
Now	The decision to hire new staff?					
	The decisions on the promotion of any of the professional staff?					
	Decisions on the adoption of new programs?					
	Decisions on the adoption of new policies?					

10. What are the specialties of your IT Department employees and how many were there before EMR/EHR adoption?

Specialty or major	Total No. of IT Department Employees	
	Before EMR/EHR introduction	Now
Physician (Medicine major)		
Nurse (nursing major)		
Management/Business/Administration major		
Medical Technology major		
Computer science major		
Etc.		

* Full time equivalent employees, e.g., physician 1, nurse2, medical technician 5, etc.

11. Did your hospital use any of the following standards before EMR/EHR adoption and does your hospital use them now?

Functions	Before EMR/EHR Adoption (Yes)	Now (Yes)
(1) Unified Medical Language System (UMLS)		
(2) Logical Observation Identifiers Names and Codes (LOINC)		
(3) Health Level Seven (HL7)		
(4) Digital Imaging and Communications in Medicine (DICOM)		
(5) SNOMED-CT		
(6) the National Drug Code (NDC)		
(6) the National Drug Code (NDC)		
(7) Nursing Minimum Data Set (NMDS)		
(8) Nursing Management Minimum Data Set (NMMDS)		
(9) Omaha System		
(10) International Classification for Nursing Practice (ICNP)		

* Systematized Nomenclature of Medicine-Clinical Terms

12. If your hospital's structure is most like A, then check (√) 1. If your hospital' structure is most like B, then check (√) 5. Otherwise, check the best one representing how close your hospital is either A or B (3: Middle position between A and B).

A (Hospital Structure)	1	2	3	4	5	B (Hospital Structure)
(1) Hierarchic structure of control, authority, and communication						A network or horizontal structure of control, authority, and communication
(2) Emphasis on formal communication channels (limited access to managerial information)						Emphasis on open communication channels (Not limited access to managerial information)
(3) Strong insistence on a uniform managerial style throughout the business unit						Managers' operating styles allowed to range freely from the very formal to the very informal
(4) A strong emphasis on holding fast to true and tried management principles despite any changes in business conditions						A strong emphasis on adapting freely to changing circumstances without too much concern for past practice
(5) Strong emphasis on always getting personnel to follow the formally defined procedures						Strong emphasis on getting things done even if this means disregarding formal procedures
(6) Tight formal control of most operations by means of sophisticated control and information systems						Loose, informal control; informal relations and norm of co-operation for getting work done
(7) Strong emphasis on getting line and staff personnel to adhere closely to formal job descriptions						Strong tendency to let the requirements of the situation and the individual's personality define proper on-job behavior

Appendix 2. Hospital Information Technology Survey (Korean language)

병원의 정보기술 (Information Technology: IT) 실태조사

전산담당 최고책임자 또는 관리자님께,

저의 이름은 박영택이라고 하며, 미네소타 주립대학교 보건정보관리학과 박사과정에 있는 학생있습니다. 보건정보기술이 의사결정 및 관리지원, 양질의 의료제공 등에 긍정적인 영향을 미침에도 불구하고, 많은 병원들이 보건정보기술의 도입을 주저하고 있는 실정입니다. 이러한 이유로, 저는 전자의무기록(EMR)/전자건강기록(EHR)의 도입, 이용, 그리고 정보교류 현황에 대한 공부를 해오고 있습니다. 현재 병원에 관한 자료를 수집하고 있으며, 자료수집에 참여해주시면 귀병원의 현황과 전체병원의 통계에 대한 자료를 이메일로 송부해 드릴 수 있습니다.

저는 본 연구의 결과가 EMR/EHR 시스템과 관련하여 기존에 우리가 알고 있는 지식영역을 넓히게 될 것이라고 생각합니다. 또한 본 연구결과는 병원의 EMR/EHR 시스템 도입과 관련하여 병원의 관리자와 정부의 정책입안자가 좋은 의사결정과 정책대안을 만드는데 유용하게 쓰이리라 생각합니다.

본 조사로 부터 얻은 자료는 저의 박사학위 논문을 위하여 쓰일 것입니다. 오직 요약된 형태로써 쓰이며, 다른 어떠한 이유로는 쓰이지 않을 예정입니다. 이러한 자료수집에 정중하게 도움을 요청하는 바입니다. 만약 조사결과에 대한 요약된 자료를 받기를 원하시면 저에게 이메을 통하여 연락을 주십시요.

시간을 내여 참여해 주셔서 진심으로 감사드립니다.

2009년 4월 1일

박 영 택
박사과정
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미네소타 주립대학교

질문이 있으시면 미네소타 주립대학교 박영택, 전화: (미국) (핸드폰) 1-612-481-3760, (집) 1-612-331-5266, or (학교) 1-612-625-9431, 이메일: park0601@umn.edu 로연락을 주십시요.
이 자료조사는 웹싸이트를 통하여 온라인으로 (http://www.tc.umn.edu/~park0601) 가능합니다.

안내문: 이 설문에 대한 참여는 자발적인 것이며, 어떠한 것에도 영향을 받지 않고 언제든지 설문지 작성을 그만둘수 있습니다.

1. 설문지 관리를 위한 응답자에 대한 질문:

응답자의 직책 및 이름:	
응답자의 전화번호:	
응답자의 이메일 주소 (설문확인을 위함):	

2. 본 병원은 하나의 재단 또는 법인으로 다병원체계 (a multi-hospital system) 로 운영되고 있습니까?

(1) 예 (2) 아니요

3. 같은 재단이나 법인이 아닌 다른 병원과 협력관계를 맺고 있으면 (예, 협력병원, 자매병원, 모자병원 등), 형태에 관계없이 맨 처음 협력을 시작한 연도를 √ 해 주십시요?

2003 이전	2003	2004	2005	2006	2007	2008	2009

4. 본 병원의 병원정보화시스템에 의해 지원되는 다음의 모든것에 대하여 체크하여 주시고, 가능하면 해당 시스템의 도입년도를√ 해 주십시요.

병원정보시스템	도입되었나요?	도입연도							
	예	2003 이전	2003	2004	2005	2006	2007	2008	2009
외래 처방전달 (OCS)									
입원 처방전달 (OCS)									
약제업무 및 관리									
환자 원무관리									
임상병리 검사업무									
방사선과의 검사업무									
수술실 진료업무									
중환자실 진료업무									
응급실 진료업무									
행정업무									

* OCS: Order Communication System. ** ED: emergency department.

5. 전자건강기록 (Electronic Health Record: EHR) 시스템은 "병원내부 및 외부의 여러 부서에서 전자적으로 생성된 환자에 대한 임상정보를 통합 및 유지하여, 필요시 모든 것에 신속하게 접속할 수 있는 하나의 시스템"으로 (미국병원협회, 2007), 전자의무기록 (Electronic Medical Record: EMR) 시스템은 "하나의 특정 의사에 의하여 생성된 환자의 임상정보기록으로 종이의무기록을 전자적 기록으로 대체하는 것"의 (Texas Medical Association, 2006) 전자적 시스템으로 정의할 수 있습니다.

만약 본 병원에서 EMR 또는 EHR 시스템을 운영하고 있다면, 다음 사항에 대하여 응답하여 주십시요

설치부서	실행형태			도입연도	개발형태		
	완전	부분적	미실행		내부적개발	외주용역	구입
병 동							
외 래							

6. 본 병원의 EMR/EHR시스템에는 어떠한 기능들이 있습니까? (√**표기를 해 주십시요**)

주요기능	완전한 실행	부분적 실행
(1) 현재의 의무기록에 (Medical records) 대한 접근 (관찰, 처방입력)		
(2) 진료기록에 (Medical history) 대한 접근		
(3) 환자의 경과기록지에 (Patient flow sheets) 대한 접근		
(4) 환자의 기초기록에 (Patient demographics) 대한 접근		
(5) 처방입력/결과리뷰 (Order entry/results review):병리실(Labs)		
(6) 처방입력/결과리뷰: 방사선기록* (Any radiology report)		
(7) 처방입력 – 실시간 약품부작용에 대한 경보 (Real time drug interaction alerts)		
(8) 기타 임상적인 기록에 대한 경보 (Other clinical alerts)		
(9) 임상가이드라인 및 치료경로 제공 (Clinical guidelines and pathways)		
(10) 전자기록에 대한 환자의 접근 (Patient access to electronic records)		
(11) 홈모니터링, 자가검진, 대화식 환자교육을 통한 환자지원		

* 또는 영상의학 기록

7. 본 병원의 EMR/EHR 시스템은 다음과 같은 카테고리의 정보를 다른 병원이나 의원과 전자적으로 주고 받을 수 있는 기능이 있습니까 (EMR/EHR 정보교환)?

주고받을 수 있는 정보의 종류*	전체적 교류	부분적 교류	없음
(1) 환자의 히스토리 (Patient history) (가족력, 환자력) (family, patient)			
(2) 환자기록 (Patient summary) 요약지 (현상태, 약품처방 내력, 알러지)			
(3) 퇴원요약지 (Discharge summaries)			
(4) 임상병리정보 (Laboratory information)			
(5) 영상이미지정보 (Imaging information)			
(6) 환자에 대한 처방약품 정보 (Drug information)			
(7) 기타			

8. 본 병원은 어떻게 의료정보를 다른 지역의 의원이나 병원들에 전송을 하고 있습니까 (복수응답 가능)?
(1) 종이차트 전달 및 접수(예. 환자의뢰서)
(2) 팩스밀리머신
(3) 이메일 및 자료첨부 기능
(4) 환자기록에 대한 인터넷 접속
(5) IC card와 같은 환자카드시스템
(6) 의료정보공유(Health Information Technology: HIT) 시스템의 이용
(7) 전화메시지
(8) 정보공유 없음
(9) 기타

9. 본원의 전산담당 최고책임자 (실장, 부장, 또는 과장) 의 병원내의 의사결정에 대한 참여정도:

		항상	종종	때때로	가끔	전혀
EMR/EHR 도입이전	신규직원 채용을 위한 의사결정					
	기존직원의 승진에 대한 의사결정					
	새로운 운영프로그램 도입의 의사결정					
	새로운 규정채택의 의사결정					
현재	신규직원 채용을 위한 의사결정					
	기존직원의 승진에 대한 의사결정					
	새로운 운영프로그램 도입의 의사결정					
	새로운 규정채택의 의사결정					

10. EMR/EHR 도입전의 전산부서의 대략적인 전문인력규모는 어떠했으며, 현재는 어떠합니까 ?

전문인력 (전공)	전산부서의 정규인력 규모	
	EMR/EHR 도입 이전	현재
의사 (의학전공)	명	명
간호사 (간호전공)	명	명
경영/관리/행정	명	명
의학기술 관련 (Medical technologies)	명	명
컴퓨터 관련전공	명	명
기타	명	명

* 예., 의사 1 명, 간호사2 명, 의료기사 5 명, 기타 5명

11. 본 병원의 EMR/EHR 도입전 표준화 시스템은 어떠했으며 현재는 어떤것을 사용하고 있습니까?

기 능	**EMR/ EHR 도입이전 사용 (예)**	**현재 사용 (예)**
(1) Unified Medical Language System (UMLS)		
(2) Logical Observation Identifiers Names and Codes (LOINC)		
(3) Health Level Seven (HL7)		
(4) Digital Imaging and Communications in Medicine (DICOM)		
(5) SNOMED-CT*		
(6) 한국의약품표준코드(KD 코드, Korea Drug Code)		
(7) Nursing Minimum Data Set (NMDS)		
(8) Nursing Management Minimum Data Set (NMMDS)		
(9) Omaha System		
(10) International Classification for Nursing Practice (ICNP)		

* Systematized Nomenclature of Medicine-Clinical Terms

12. 병원 조직 구조가 A 에 가까우면 1 에 √ 체크해 주시고, B 에 가까우면 5 에√ 체크를 해 주십시요. 그렇지 않으면 A 나 B 를 잘 반영하는 것에√ 체크하여 주십시요 (3 은 A 와 B 의 중간 정도에 위치합니다).

A (병원조직 구조)	1	2	3	4	5	B (병원조직 구조)
(1) 권한위임, 교류, 관리체계가 수직적						권한위임, 교류, 관리체계가 수평적 또는 네트웍 중심적
(2) 공식적인 의사소통 채널 (제한적 경영정보 접근)						개방적 의사소통 채널 (자유로운 경영정보 접근 가능)
(3) 조직부서의 동일한 관리스타일 중시						조직부서의 다양한 관리스타일 인정
(4) 상황변화와 상관없이 검증된 관리원칙 고수						과거 원칙에 관계없이 상황변화에 민감하게 대처하는 것 강조
(5) 담당자를 통한 공식적 업무처리절차의 강조						공식적인 절차보다 문제해결의 성과강조
(6) 잘 정립된 통제관리 장치에 의한 엄격한 공식통제						느슨한 비공식적 통제, 규범이나 비공식적 협력 관계에 의한 통제
(7) 직무기술서에 명시된 업무결재라인 강조						상황이나 개인특성에 따른 의사결정인정

- 설문에 참여해 주셔서 감사합니다! -

Appendix 3. IRB Letter

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Research Subjects' Protection Programs
Institutional Review Board: Human Subjects Committee (IRB)
Institutional Animal Care and Use Committee (IACUC)
Institutional Biosafety Committee (IBC)

Mayo Mail Code 820
D-528 Mayo Memorial Building
420 Delaware St. SE
Minneapolis, MN 55455

Phone: 612-626-5654
Fax: 612-626-6061
irb@umn.edu
iacuc@umn.edu
ibc@umn.edu
www.research.umn.edu

Date: February 10, 2009

To: Young-Taek Park

From: Institutional Review Board (IRB)

Subject: IRB Review Not Required

The IRB determined your planned activities which include looking at the impact of hospitals' organizational factors such as hospital structure, technology, and environment on Electronic Health Record adoption, use, and interoperability do not meet the regulatory definition of research with human subjects and do not fall under the IRB's purview for the following reasons:

☒ The proposed activities are a) not a systematic investigation and/or b) not designed to develop or contribute to generalizable knowledge [45CFR46.102(d)].

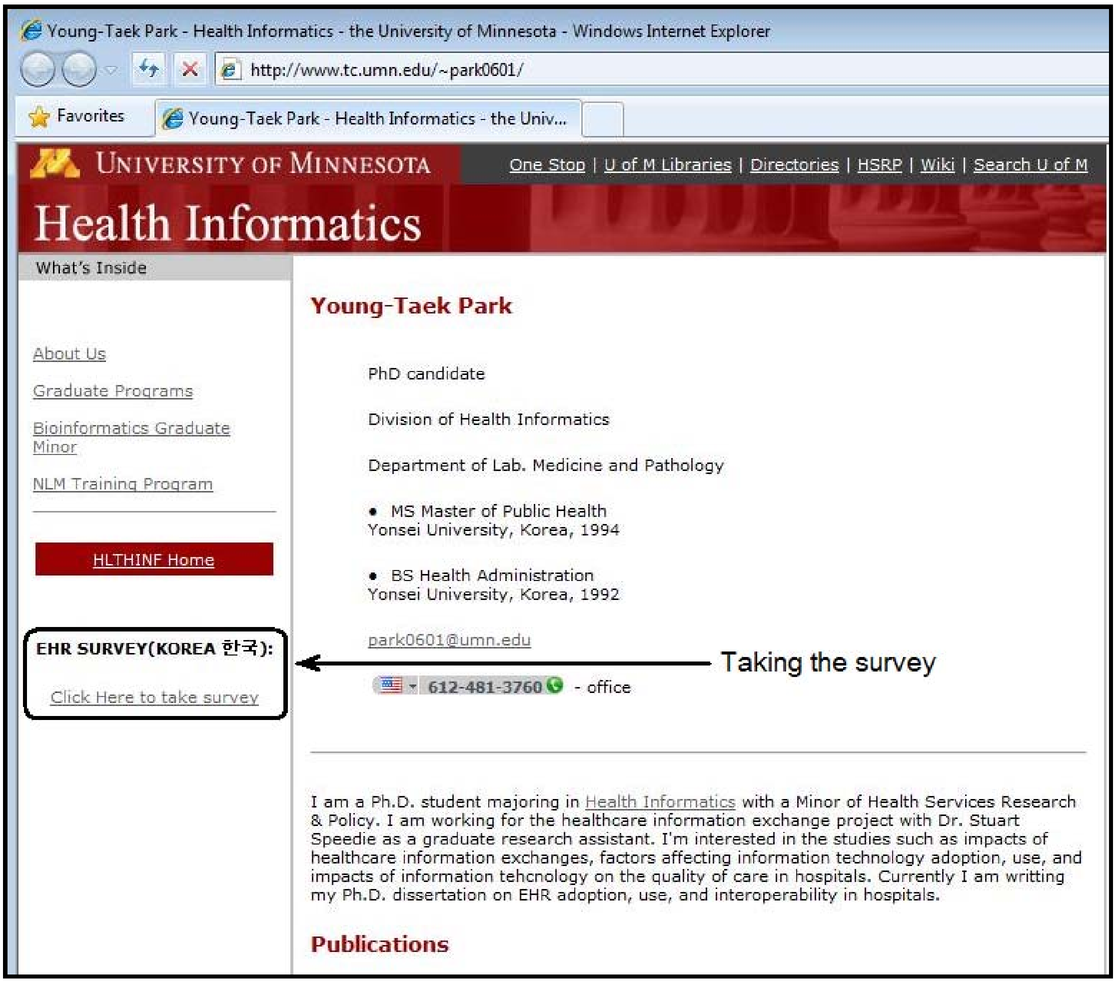
- ☐ Quality assurance activities and evaluation projects designed for self-improvement or program evaluation, not meant to contribute to "generalizable" knowledge, do not meet the threshold of research with human subjects.
- ☐ Retrospective case studies are not a systematic investigation and therefore are not considered research. Although IRB review is not required for the case studies described above, you still may have obligations Please contact the Privacy Office at 612-624-7447 for their requirements under HIPPA privacy laws and state laws. Please contact the Privacy Office at 612-624-7447 for their requirements.

☒ Researchers will not obtain private identifiable information from living individuals [45 CFR 46.102(f)].

- ☒ Interviews of individuals where questions focus on things not people (eg. questions about policies) do not require IRB review.
- ☐ You will be analyzing aggregate data that cannot be linked to a living individual.

Please do not hesitate to contact the IRB office at 612-626-5654 if you have any questions. Thank you for allowing the IRB to make the determination about whether or not review is required.

Appendix 4. University of Minnesota home page for the survey



Appendix 5. Survey introduction and password section

병원의 정보기술 (Information Technology: IT) 실태조사

전산담당 최고책임자 또는 관리자님께,

저의 이름은 박영택이라고 하며, 미네소타 주립대학교 보건정보관리학과 박사과정에 있는 학생입습니다. 보건정보기술이 의사결정 및 관리지원, 양질의 의료제공 등에 긍정적인 영향을 미침에도 불구하고, 많은 병원들이 보건정보기술의 도입을 주저하고 있는 실정입니다. 이러한 이유로, 저는 전자의무기록(EMR) / 전자건강기록(EHR)의 도입, 이용, 그리고 정보교류 현황에 대한 공부를 해오고 있습니다. 현재 병원에 관한 자료를 수집하고 있으며, 자료수집에 참여해주시면 귀병원의 현황과 전체병원의 통계에 대한 자료를 이메일로 송부해 드릴 수 있습니다.

저는 본 연구의 결과가 EMR/EHR 시스템과 관련하여 기존에 우리가 알고 있는 지식영역을 넓히게 될 것이라고 생각합니다. 또한 본 연구결과는 병원의 EMR/EHR 시스템 도입과 관련하여 병원의 관리자와 정부의 정책입안자가 좋은 의사결정과 정책대안을 만드는데 유용하게 쓰이리라 생각합니다.

본 조사로 부터 얻은 자료는 저의 박사학위 논문을 위하여 쓰일 것입니다. 오직 요약된 형태로써 쓰이며, 다른 어떠한 이유로는 쓰이지 않을 예정입니다. 이러한 자료수집에 정중하게 도움을 요청하는 바입니다. 만약 조사결과에 대한 요약된 자료를 받기를 원하시면 저에게 이메일을 통하여 연락을 주십시요.

시간을 내어 참여해 주셔서 진심으로 감사드립니다.

2009년 4월 1일

박 영 택
박사과정
보건정보관리학과
미네소타 주립대학교

질문이 있으시면 미네소타 주립대학교 박영택, 전화: (미국) (핸드폰) 1-612-481-3760,
(집) 1-612-331-5266, or (학교) 1-612-625-9431 이메일: park0601@umn.edu 로 연락을 주십시요.
이 자료조사는 웹싸이트를 통하여 온라인으로 (http://www.tc.umn.edu/~park0601) 가능합니다.

안내사항 : 이 설문에 대한 참여는 자발적인 것이며, 어떠한 것에도 영향을 받지 않고 언제든지 설문지 작성을 그만둘수 있습니다.

병원 검색: 전체 주소 검색 : ::도선택:: ::구선택:: 검색

1 [redacted]
2 [redacted]
3 [redacted]
4 [redacted]
5 [redacted]
6 [redacted]
7 [redacted]

Password: 설문 참여

각주: 본 설문조사는 미네소타 주립대학교 대학원 보건정보관리학과의 학과장인, Stuart M. Speedie 박사(TEL: 미국-612-624-4657)의 승인을 받은 것이며, 본 대학교 보건정보관리연구소의 지원을 받고 있다 (연락처: Ms. Doreen Gruebele, TEL: 미국-612-625-8440).

Appendix 6. Survey main page

EHR SURVEY1

http://[redacted]/survey_kor/survey.php

1. 설문지 관리를 위한 응답자에 대한 질문.

응답자의 직책 및 이름:

응답자의 전화번호:

응답자의 이메일 주소 (설문확인을 위함):

2. 본 병원은 하나의 재단 또는 법인으로 다병원체계 (a multi-hospital system) 로 운영되고 있습니까?

예 　　 아니요

3. 같은 재단이나 법인이 아닌 다른 병원과 협력관계를 맺고 있으면 (예, 협력병원, 자매병원, 모자병원 등), 형태에 관계없이 맨 처음 협력을 시작한 연도를 √ 해 주십시요?

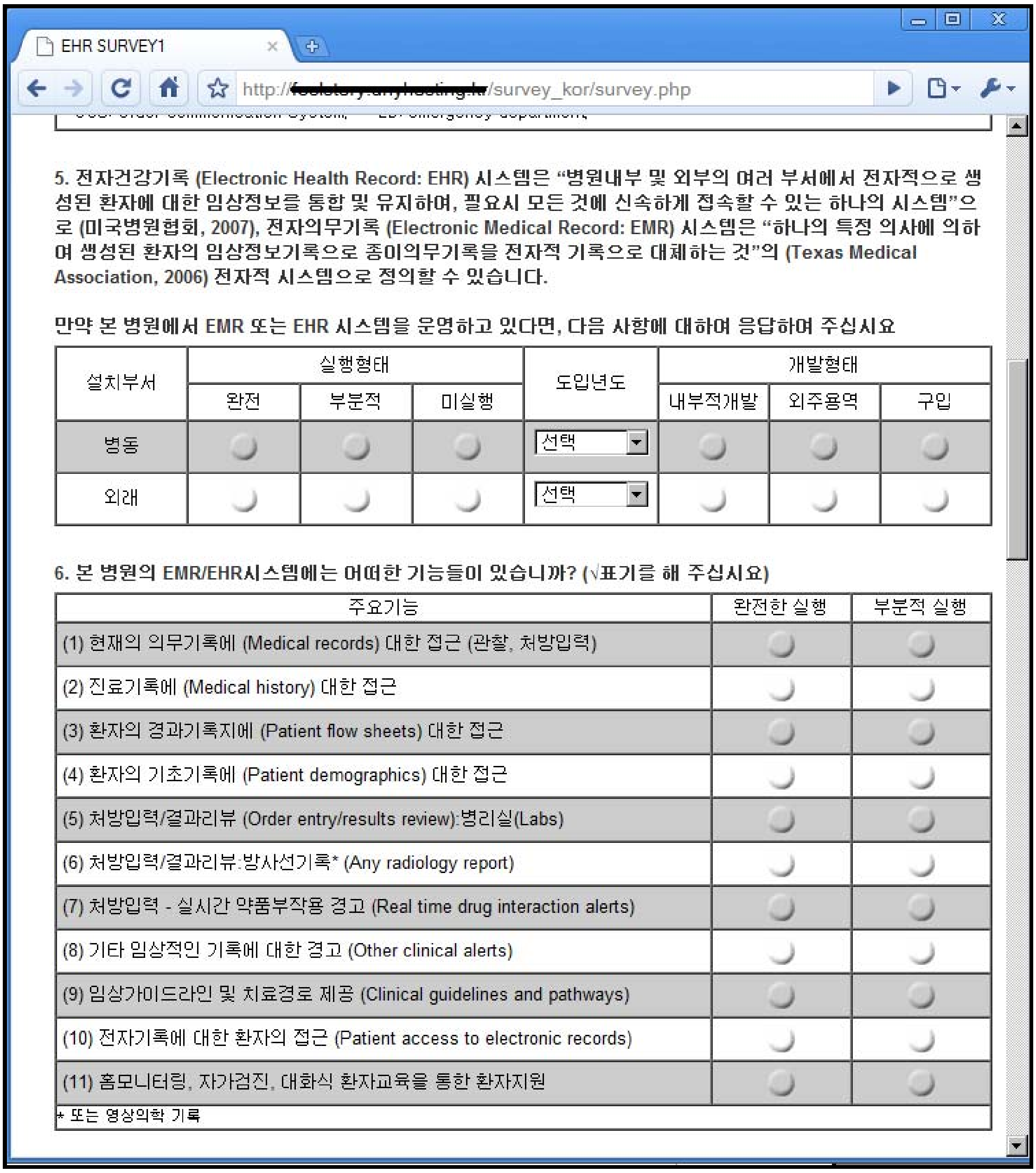
2003년 이전 　 2003 　 2004 　 2005 　 2006 　 2007 　 2008 　 2009

4. 본 병원의 병원정보화시스템에 의해 지원되는 다음의 모든것에 대하여 체크하여 주시고, 가능하면 해당 시스템의 도입년도를√ 해 주십시요.

병원정보시스템	도입되었나요?	도입연도							
	예	2003이전	2003	2004	2005	2006	2007	2008	2009
외래 처방전달 (OCS)									
입원 처방전달 (OCS)									
약제업무 및 관리									
환자 원무관리									
임상병리 검사업무									
방사선과의 검사업무									
수술실 진료업무									
중환자실 진료업무									
응급실 진료업무									
행정업무									

* OCS: Order Communication System, ** ED: emergency department

Appendix 6. Survey main page (continued)



EHR SURVEY1

http://[redacted]/survey_kor/survey.php

5. 전자건강기록 (Electronic Health Record: EHR) 시스템은 “병원내부 및 외부의 여러 부서에서 전자적으로 생성된 환자에 대한 임상정보를 통합 및 유지하여, 필요시 모든 것에 신속하게 접속할 수 있는 하나의 시스템”으로 (미국병원협회, 2007), 전자의무기록 (Electronic Medical Record: EMR) 시스템은 “하나의 특정 의사에 의하여 생성된 환자의 임상정보기록으로 종이의무기록을 전자적 기록으로 대체하는 것”의 (Texas Medical Association, 2006) 전자적 시스템으로 정의할 수 있습니다.

만약 본 병원에서 EMR 또는 EHR 시스템을 운영하고 있다면, 다음 사항에 대하여 응답하여 주십시요

설치부서	실행형태			도입년도	개발형태		
	완전	부분적	미실행		내부적개발	외주용역	구입
병동				선택			
외래				선택			

6. 본 병원의 EMR/EHR시스템에는 어떠한 기능들이 있습니까? (√표기를 해 주십시요)

주요기능	완전한 실행	부분적 실행
(1) 현재의 의무기록에 (Medical records) 대한 접근 (관찰, 처방입력)		
(2) 진료기록에 (Medical history) 대한 접근		
(3) 환자의 경과기록지에 (Patient flow sheets) 대한 접근		
(4) 환자의 기초기록에 (Patient demographics) 대한 접근		
(5) 처방입력/결과리뷰 (Order entry/results review):병리실(Labs)		
(6) 처방입력/결과리뷰:방사선기록* (Any radiology report)		
(7) 처방입력 - 실시간 약품부작용 경고 (Real time drug interaction alerts)		
(8) 기타 임상적인 기록에 대한 경고 (Other clinical alerts)		
(9) 임상가이드라인 및 치료경로 제공 (Clinical guidelines and pathways)		
(10) 전자기록에 대한 환자의 접근 (Patient access to electronic records)		
(11) 홈모니터링, 자가검진, 대화식 환자교육을 통한 환자지원		

* 또는 영상의학 기록

Appendix 6. Survey main page (continued)

7. 본 병원의 EMR/EHR 시스템은 다음과 같은 카테고리의 정보를 다른 병원이나 의원과 전자적으로 주고 받을 수 있는 기능이 있습니까 (EMR/EHR 정보교환)?

주고받을 수 있는 정보의 종류	전체적 교류	부분적 교류	없음
(1) 환자의 히스토리 (Patient history) (가족력, 환자력)			
(2) 환자기록 (Patient summary) 요약지 (현상태, 약품처방, 알러지)			
(3) 퇴원요약지 (Discharge summaries)			
(4) 임상병리정보 (Laboratory information)			
(5) 영상이미지정보 (Imaging information)			
(6) 환자에 대한 처방약품 정보 (Drug information)			
(7) 기타			

8. 본 병원은 어떻게 의료정보를 다른 지역의 의원이나 병원들에 전송을 하고 있습니까 (복수응답 가능)?

- 종이차트 전달 및 접수(예. 환자의뢰서)
- 팩스밀리머신
- 이메일 및 자료첨부 기능
- 환자기록에 대한 인터넷 접속
- IC card와 같은 환자카드시스템
- 의료정보공유(Health Information Technology: HIT) 시스템의 이용
- 전화메시지
- 정보공유 없음
- 기타

9. 본원의 전산담당 최고책임자 (실장, 부장, 또는 과장) 의 병원내의 의사결정에 대한 참여정도:

		항상	종종	때때로	가끔	전혀
EMR/EHR 도입이전	신규직원 채용을 위한 의사결정					
	기존 전문직 직원의 승진에 대한 의사결정					
	새로운 운영프로그램 도입의 의사결정					
	새로운 규정채택의 의사결정					
		항상	종종	때때로	가끔	전혀
현재	신규직원 채용을 위한 의사결정					
	기존 전문직 직원의 승진에 대한 의사결정					
	새로운 운영프로그램 도입의 의사결정					
	새로운 규정채택의 의사결정					

Appendix 6. Survey main page (continued)

EHR SURVEY1

http://[redacted]/survey_kor/survey.php

	새로운 운영프로그램 도입의 의사결정	○	○	○	○	○
	새로운 규정채택의 의사결정	○	○	○	○	○

10. EMR/EHR 도입전의 전산부서내 전문인력규모는 어떠했으며, 현재는 어떠합니까?

전문인력 (전공)	전산부서내 정규인력 규모	
	EMR/EHR 도입 이전	현재
의사 (의학전공)	명	명
간호사 (간호전공)	명	명
경영/관리/행정	명	명
의학기술 관련 (Medical technologies)	명	명
컴퓨터 관련전공	명	명
기타	명	명

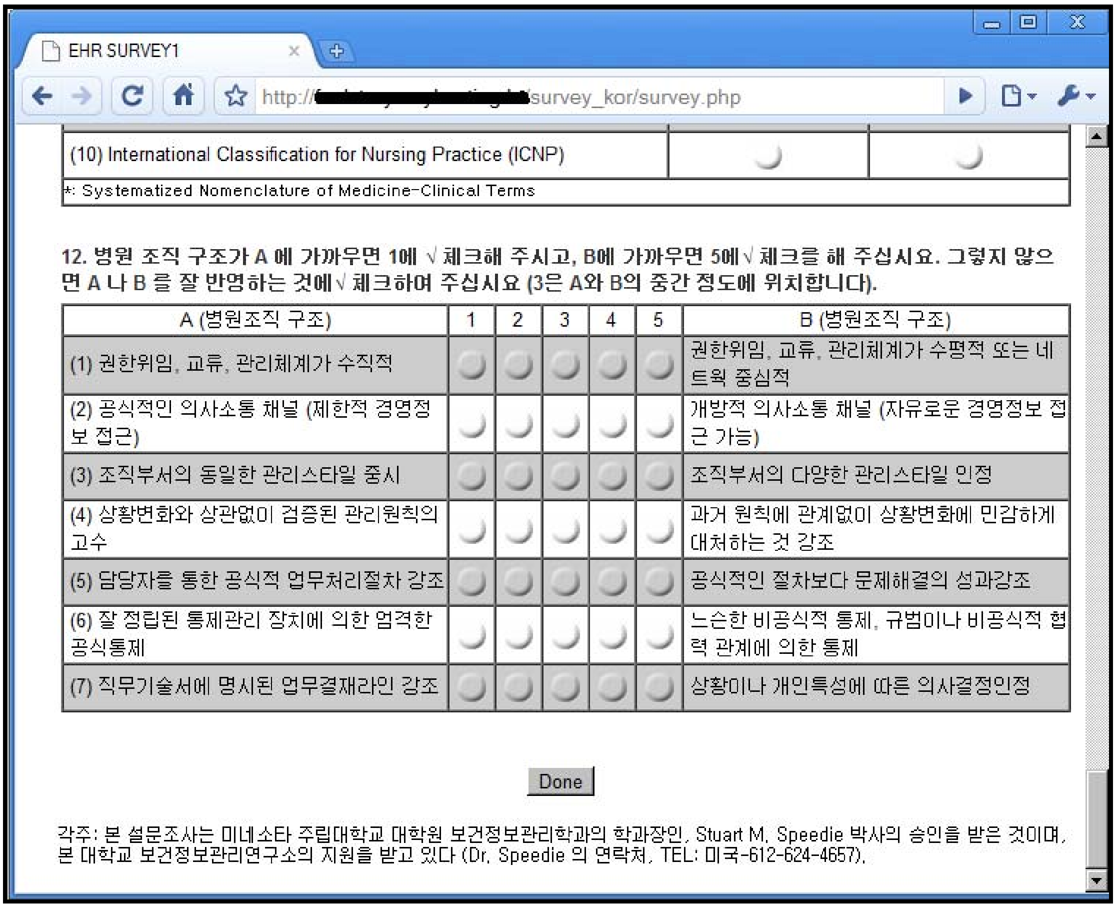
* 예., 의사 1 명, 간호사2 명, 의료기사 5 명, 기타 5명

11. 본 병원의 EMR/EHR 도입전 표준화 시스템은 어떠했으며 현재는 어떤것을 사용하고 있습니까?

기능	EMR/EHR 도입이전 사용(예)	현재 사용(예)
(1) Unified Medical Language System (UMLS)	○	○
(2) Logical Observation Identifiers Names and Codes (LOINC)	○	○
(3) Health Level Seven (HL7)	○	○
(4) Digital Imaging and Communications in Medicine (DICOM)	○	○
(5) SNOMED-CT*	○	○
(6) 한국의약품표준코드(KD코드, Korea Drug Code)	○	○
(7) Nursing Minimum Data Set (NMDS)	○	○
(8) Nursing Management Minimum Data Set (NMMDS)	○	○
(9) Omaha System	○	○
(10) International Classification for Nursing Practice (ICNP)	○	○

*: Systematized Nomenclature of Medicine-Clinical Terms

Appendix 6. Survey main page (continued)



EHR SURVEY1

http://[redacted]survey_kor/survey.php

(10) International Classification for Nursing Practice (ICNP)		

*: Systematized Nomenclature of Medicine-Clinical Terms

12. 병원 조직 구조가 A 에 가까우면 1에 √ 체크해 주시고, B에 가까우면 5에 √ 체크를 해 주십시요. 그렇지 않으면 A 나 B 를 잘 반영하는 것에 √ 체크하여 주십시요 (3은 A와 B의 중간 정도에 위치합니다).

A (병원조직 구조)	1	2	3	4	5	B (병원조직 구조)
(1) 권한위임, 교류, 관리체계가 수직적						권한위임, 교류, 관리체계가 수평적 또는 네트웍 중심적
(2) 공식적인 의사소통 채널 (제한적 경영정보 접근)						개방적 의사소통 채널 (자유로운 경영정보 접근 가능)
(3) 조직부서의 동일한 관리스타일 중시						조직부서의 다양한 관리스타일 인정
(4) 상황변화와 상관없이 검증된 관리원칙의 고수						과거 원칙에 관계없이 상황변화에 민감하게 대처하는 것 강조
(5) 담당자를 통한 공식적 업무처리절차 강조						공식적인 절차보다 문제해결의 성과강조
(6) 잘 정립된 통제관리 장치에 의한 엄격한 공식통제						느슨한 비공식적 통제, 규범이나 비공식적 협력 관계에 의한 통제
(7) 직무기술서에 명시된 업무결재라인 강조						상황이나 개인특성에 따른 의사결정인정

Done

각주: 본 설문조사는 미네소타 주립대학교 대학원 보건정보관리학과의 학과장인, Stuart M. Speedie 박사의 승인을 받은 것이며, 본 대학교 보건정보관리연구소의 지원을 받고 있다 (Dr. Speedie 의 연락처, TEL: 미국-612-624-4657).