August 2015

Importance of Medical Informatics in Medical Students' Curricula in Saudi Arabia

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IMPORTANCE OF MEDICAL INFORMATICS IN MEDICAL STUDENTS' CURRICULA IN SAUDI ARABIA

by

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A Thesis Submitted in

Partial Fulfillment of the

Requirements for the Degree of

Master of Science

in Health Care Informatics

at

The University of Wisconsin- Milwaukee

August 2014

ABSTRACT

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by

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The University of Wisconsin-Milwaukee, 2014
Under the Supervision of Professor Timothy B. Patrick

The main purpose of this research project is to determine the importance of Medical Informatics (MI) course inclusion in the curriculum studied by medical students in Saudi Arabia. The healthcare environment has changed dramatically since last few decades. It has become an information- intensive environment and has shifted its focus on technological applications. As a result of such a shift in focus, efforts should be made that future healthcare professionals be prepared for such an environment through MI. This research project aims to determine the acceptance of MI applications by medical students. The study will compare the acceptability of MI applications among medical students who take MI course with medical students who do not have such a MI course in their curriculum. In addition, the research project will assess MI knowledge among all the medical students.

To my husband, Mr. Abdulaziz Aldossari, and my parents, Mr.Abdullah Almulhem and Mrs.Fawziah Almulhem, who always supported me and encouraged me.

A special thanks to my supervising professor, Dr. Timothy B. Patrick

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

MI – Medical Informatics

IT – Information Technology

EMR – Electronic Medical Record

EHR – Electronic Health Record

CDSSs – Clinical Decision Support Systems

CPOE – Computerized Physician Order Entry

KSU – King Saud University

HIT – Health Information Technology

EBM – Evidence Based Medicine

ICT- Information and Communication Technology

IMIA – International Medical Informatics Association

BMHI – Biomedical and Health Informatics

MSOP – Medical School Objectives Project

HIPAA – Health Insurance Portability and Accountability Act

SAHI – Saudi Association for Health Informatics

KSAU- HS - King Saud bin Abdulaziz University for Health Science

UOD – University of Dammam

TAM – Technology Acceptance Model

AAMC - Association of American Medical College

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation and regards to my advisor Professor Timothy Patrick, Ph.D. for giving me the opportunity to work with him. I have greatly benefited from his guidance, encouragement, and optimistic inspiration. He has provided me the generous support to conduct this research.

I am deeply grateful to Hessah Almulhem, Manahel Almulhem, Fahad Almulhem, Samiha Aljetaily, Moataz Alarfaj, Mosad Aldekeal and other medical students in University of Dammam and King Saud University for helping me distribute the survey to medical students. Without their contribution, this study would not have possible.

I would like to offer my special thanks to Dr. Sami Alnssar, Dr. Amr Jmal, Fatima Alalawi, and Prof. Ali Alsultan for facilitating approval procedures of data collection in University of Dammam and King Saud University. I would also thanks Dr. Nasriah Zakaria for her insightful comments and suggestions.

I would like to express my gratitude to my parents, my brothers, and my sisters, who belief in my ability to achieve my dreams. I fall short of words in expressing their endless encouragements, affection, support and love.

Words cannot express how grateful I am to my husband Mr. Abdulaziz Aldossari, who has been a pillar of strength. He has supported me and cheered me up throughout this study. I never would have reached my goal without his assistance, patience and understanding. Special thanks to little kids, Munirah and Salem, for giving me inspiration to achieve my dreams.

Chapter 1: Introduction

Brief Overview of the Research Project

The main purpose of this research project is to determine the importance of Medical Informatics (MI) course inclusion in the curriculum studied by medical students in Saudi Arabia. The healthcare environment has changed dramatically since last few decades. It has become an information- intensive environment and has shifted its focus on technological applications. As a result of such a shift in focus, efforts should be made that future healthcare professionals be prepared for such an environment through MI. This research project aims to determine the acceptance of MI applications by medical students. The study will compare the acceptability of MI applications among medical students who take MI course with medical students who do not have such a MI course in their curriculum. In addition, the research project will assess MI knowledge among all the medical students.

The Nature of Medical Informatics and Modern Healthcare Environment

Every domain has been revolutionized around the central core of information technology (IT). From education to economic policies to politics, and healthcare, all fields have been influenced by advancements in the field of IT. Use of computers in healthcare started with administrative and financial purposes in 1960's. However more recently, many more complex and intertwined fields such as finance and life serious clinical decision support systems have seen its dependency on IT. There have been several innovations of IT help in facilitating

information access, retrievals, and analysis that resulted in improving healthcare provided to patients (Otto & Kushniruk, 2009).

The discipline that combines the use of communication and computer applications and healthcare is known as Medical Informatics (MI). Shortliffe has defined MI as “the rapidly developing scientific field that deals with the storage, retrieval, and optimal use of biomedical information, data, and knowledge for problem solving and decision making” (P 1. 1995). Currently, MI has integrated with every field of medicine. There are several reasons that call for the development of this critical discipline. Reasons include but not restricted to recent developments of computing and IT, failure of managing medical knowledge base using traditional paper-based methods, and the importance of informed decision-making in the modern healthcare environment (Shortliffe, 1995).

It has been found that many opponents have opposed the field name of “Medical Informatics” for the reason that such a name attributes more to physician-oriented environment and does not recognize its association with other para-health services. Its other names include Healthcare Informatics and Health Informatics which restrict its focus towards biological science. MI by convention includes a wide range of applications applied in healthcare environment. However with the name “Healthcare Informatics”, the field might have restricted implication to public and health prevention domain. (Hersh, William, 2002) (Shortliffe, E. & Cimino, J., 2006). Shortliffe has recommended naming it as Biomedical Informatics to expand its applicability, including both biological and medical applications (2006). Indeed,

using Medical Informatics as a name is still heavily used in professional settings (Hersh, 2002) (Shortliffe & Cimino, 2006).

Application areas of MI, or biomedical informatics, are not restricted to a specific level. However it covers all levels starting from cells to macro level population as illustrated in figure 1. It includes four main areas: clinical informatics, public health informatics, imaging informatics, and bioinformatics. All “patient-oriented” applications are involved in clinical informatics, including applications in medicine, nursing, dentistry and other clinical specialties. Public health informatics applies the same methods and techniques into populations instead of a single patient such as the disease survallince systems. Imaging informatics incloses domains related to radiology, imaging management, molecular visualization, and dermatology. Last area is bioinformatics where specialists and super specialists work in molecular and cellular levels niches (Hersh, 2002) (Shortliffe & Cimino, 2006).

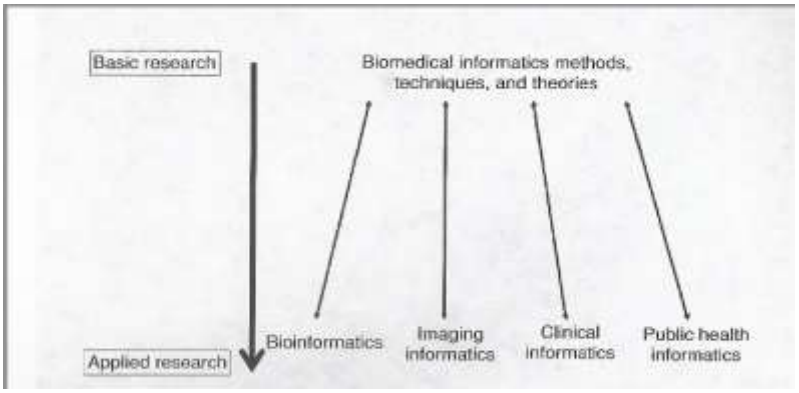

Figure 1.1: Spectrum of medical informatics application areas (Shortliffe & Cimino, 2006).

Applications of Clinical Informatics and their Barriers

Applications of different domain areas are numerous and each application has its own potentials in healthcare. Based on the type of information used, applications of clinical informatics can be classified to patient-specific and knowledge-based applications. Patient-specific information is usually created and utilized for patient care in healthcare facilities while knowledge-based information includes healthcare scientific fundamentals. The essence of patient-specific applications is Electronic Medical Record (EMR) or Electronic Health Record (EHR). It helps to overcome the weakness of the traditional paper record with concerns such as illegibility, incompleteness, accessibility, and security (Hersh, 2002). By upgrading healthcare efficiency and safety, effective employment of EMR is expected to save more than $81 billion each year (Hillestad et al., 2005). According to a systemic review study, the advantages of using EMR in primary healthcare appear obviously in structural and process outcomes, while they still indefinite in clinical aspects (Holroyd-Leduc, Lorenzetti, Straus, Sykes, & Quan, 2011).

Knowledge-based sources include information retrieval domain that has gone through a formidable development process as a result of the Internet and World Wide Web. Accordingly, both healthcare professionals as well as patients make use of the Internet websites to search information about health. (Hersh, 2002). One such websites is MEDLINE, which is a bibliographic database that comprises over 19 million references to journal articles in life science from 1966 (U.S. National Library of Medicine, 2013). Closely tied to MEDLINE is MedlinePlus,

which is the National Institutes of Health's web site for patients that provides reliable, up-to-date health information about diseases, drug, and treatment (U.S. National Library of Medicine, 2013). Furthermore, knowledge- base information involves also medical textbooks and clinical guidelines, which are easily accessible through the Internet (Hersh, 2002).

Another application that has appeared in between knowledge-base and patient- specific information is Clinical Decision Support Systems (CDSSs). This application works by merging the two application systems. This system aims to identify medical errors, alert healthcare professionals, and offer reliable health information to them. In order to accomplish these tasks, it should be connected to EMRs (Hersh, 2002). The impact of CDSSs is well documented in the literature in terms of its positive impact on physicians' performance including diagnostic systems, reminder systems, disease management systems, drug-dosing or prescribing systems (Garg et al., 2005). A recent clinical randomized trial has concluded that EHR-based CDSS significantly improved glucose control and two aspects of blood pressure control in adults with diabetes(O'Connor et al., 2011).

Another application that includes decision support tool is Computerized Physician Order Entry (CPOE). It is defined as "a variety of computer-based systems that share the common features of automating the medication ordering process ensuring standardized, legible, and complete orders" (Kaushal et al., 2003. P 1410). According to a systemic review study, the effectiveness of CPOE systems was positive, especially in the following categories: adherence to

guidelines, alerts and appropriateness of alerts; costs and organizational efficiency; and satisfaction and usability (Eslami et al., 2008).

The outcomes of MI applications are not only restricted on financial advantages, but are also involve limitless of benefits for patients, healthcare professionals, and the entire population per se. In order to maximize these benefits, attempts need to be made to overcome the barriers that prevent full implementation of MI applications. Different barriers of various application types are well documented in the literature. Generally, these barriers can be classified to encompass financial and technical aspects, physicians' perception, privacy, and security concerns (Boonstra, 2010). One of the critical factors that help eliminate some burdens of these barriers is health professional attitude (Castillo, 2010). Consequently, the existence of appropriate MI knowledge among future health professionals may improve their attitudes that would subsequently help to reduce resistance of MI applications.

Changes in Medical Education

The overall goals of medical education can be summarized as:

- To offer scientific medical knowledge to medical students and healthcare professionals.
- To teach them how to apply this knowledge in real medical practice.
- To motivate the development of skills that requires gaining new knowledge during lifetime (Shortliffe& Cimino, 2006).

In order to achieve these goals, medical education should be lined with the ever-changing environment. The significant changes that have been occurring during the past few years are the direct results of advancements in communication and IT and expansion of the World Wide Web. Recently, most medical colleges have incorporated IT as a new tool for learning. Because of the growing number of medical literature available on the Internet and dependency of the medical practice on evidence- base medicine (EBM) , effective management of information should be taught not only to faculty but also to the students (Ward, 2001).

To add, medical science has been rapidly changing. Accordingly, current medical students are expected to face new and unique challenges in the medical practice. There are various sources of medical alerts that arise every day. New biological discoveries, especially at molecular and cellular levels also lead to unfolding the hidden nature of human biology and its many diseases. Technology also plays an important role in the discovery of new therapeutic and diagnostic instruments, which necessitates healthcare professionals to acquire more skills and knowledge (Tosteson, 1990) (Stead, Searle, Fessler, Smith, & Shortliffe, 2011). Stead et al. has stated that “the explosive growth of biomedical complexity calls for a shift in the paradigm of medical decision making—from a focus on the power of an individual brain to the collective power of systems of brains” (2011, P. 429). Such a constant learning atmosphere makes the world more optimistic about the treatment of various diseases that have not been unfolded till date. It also leads to a constant rise in the expectation of superior healthcare services by healthcare professionals (Tosteson, 1990).

Consequently, new opportunities and challenges emerge in medical education with high impact on methods of teaching, process of learning, and design of the medical curriculum. All these factors change medical practice and require modifications in medical education in terms of form and content. Also, medical colleges should create new approaches to handle such issues (Tosteson, 1990) (Ward, 2001).

Significance of the Research Project

Currently, most medical schools in Saudi Arabia, except King Saud University (KSU), do not include a MI course as a part of the medical student's curricula. KSU however teaches a MI course for its third year medical students. As a result, this research project demonstrates the benefits of teaching a MI course and the relationship between MI knowledge and adapting its applications in the future medical practice. Based on our knowledge, this is the first research project that illustrates the importance of teaching MI course in Saudi Arabia. Also, it encourages other medical schools to take KSU as a pilot model and include a MI course in medical students' curricula.

Chapter 2: Background/Literature Review

In this chapter, the author will discuss the adoption rate of MI applications and physicians' acceptance. Also, the author will discuss the urgent need of teaching MI course for undergraduate medical students. The current progress of teaching MI and barriers of teaching MI are also discussed at length. Current status of teaching MI in Saudi Arabia and MI course structure and delivery in KSU are discussed in detail in the later parts of the chapter.

Medical Informatics Applications' Adoption Rate

The adoption rate of MI applications differs on the type of application. Jha, A. and colleagues have published a study in 2008 that examines rates of EHRs use in ambulatory care and hospital settings in seven different nations. The result of the study showed that the UK, Netherlands, Australia, and New Zealand have a universal use of EHRs among general practitioners (each >90%). Germany on the other hand was far away from the general adoption rate of 90% (40–80%). The U.S. and Canada have very few ambulatory care physicians who are adept to constant EHR usage. (10–30%). It is also interesting to note that EHR adoption dropped when hospitals and big healthcare service organizations are considered. Evidence suggested that only a small fraction of hospitals (<10%) in any single country have key components for a fully functional EHR adoption (Jha, Doolan, Grandt, Scott, & Bates, 2008). Despite the financial incentives through Health Information Technology for Economic and Clinical Health (HITECH) Act, more than

45% of the US physicians in office-based practices did not adopt EHR systems by 2011 (Blumenthal & Tavenner, 2010; Jamoom et al., 2012). A 2011 study conducted in Saudi Arabia has found that only three out of 19 government related hospitals (15.8 percent) use EHRs in the Eastern Province, Saudi Arabia (Bah et al., 2011).

The low adoption rate is not only associated with EHR, but is also has found in CPOE adoption as well. Ford, E. et al. have projected that CPOE adoption in urban hospitals will not reach 80% penetration until almost 2029 in the US hospitals (Ford, McAlearney, Phillips, Menachemi, & Rudolph, 2008). A study comparison of seven western nations' implementation levels of CPOE found that the United States and Netherland have the highest use rates (still 20 percent or less). On the other hand, Germany, the United Kingdom, and France have few, if any hospital wide CPOE systems (Aarts & Koppel, 2009).

There are several barriers responsible for such slow adoption of health information technology (HIT) among physicians. High infrastructure cost and physician resistance are some of the major reasons for the slow adoption of EMR. Poon et al. interviewed senior managers at 26 U.S. hospitals to identify the barriers of CPOE implementation. Costs and physician resistance were cited as the top barriers (Poon et al., 2003). Another study aimed to understand the common barriers to a functional and meaningful EMR adoption has found that the expense of implementation (78.4%), increase in physician workload (76.3%), and physician resistance (73.7%) were the most reported concerns for the EHR implementation (Kemper, Uren, & Clark, 2006).

Bhattacherjee and Hikmet have presented a theoretical model of physician resistance of HIT usage by integrating the technology acceptance and resistance to change literatures. This model has developed some deep insights on the perceived indicators for the continued use and common barriers in healthcare adoption. Perceived threat as a predictor of resistance, perceived compatibility as a predictor of perceived usefulness, and related knowledge as a predictor of perceived ease of use were illustrated by the study as depicted in Figure 1.2 (note: They have found that six of the eight hypothesized paths in the research model were significant at P<0.05, with one path (from resistance to change to perceived ease of use) being marginally significant (P<0.10) and one path from perceived ease of use to intention being non-significant (Bhattacherjee & Hikmet, 2007).

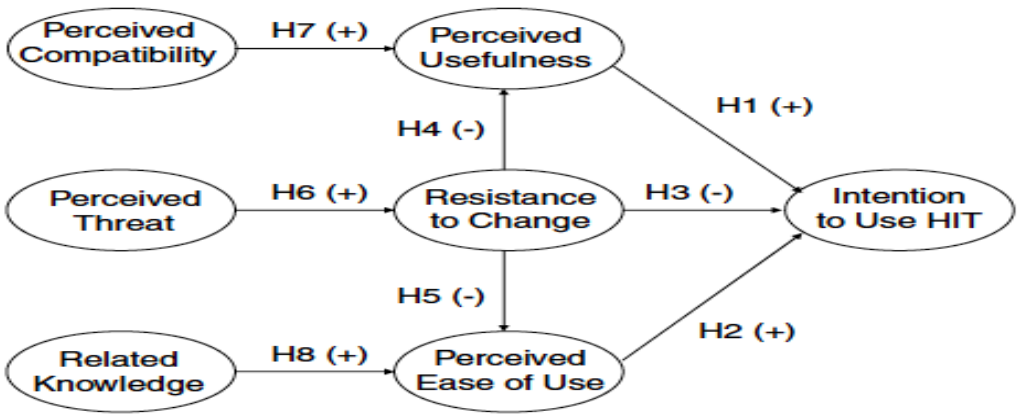

Figure 2.1: A theoretical model of physician resistance of healthcare information technology (HIT) (Bhattacherjee & Hikmet, 2007).

Physicians Acceptance of Medical Informatics Applications

User acceptance is considered as one of the critical factors for successful IT adoption (Walter & Lopez, 2008). Over the past few decades, user acceptance has received significant attention from researchers all over the world. (Hu, Chau, Sheng, & Tam, 1999), (Venkatesh, Morris, Davis, & Davis, 2003), (Davis, 1989). User acceptance or user compliance as it is commonly known, can be clarified, controlled and expected mainly by three dimensions. Users' characteristics, technology characteristics, and organizational context are the three major categorical divisions within user acceptance. Several models of IT adoption have been proposed based on these dimensions (Hu et al., 1999). These models include but are not limited to the diffusion of innovations model (Rogers, 2010), technology acceptance model (TAM) (Davis, 1989) and diffusion/implementation model (Kwon & Zmud R, 1987). These models are considered as general models and are not designed for specific type of users. (Walter & Lopez, 2008).

Adoption of IT by physicians has been studied in depth by many investigators. Hu and colleagues have investigated IT adoption in the context of telemedicine. One of the well renowned papers examined physicians' decisions to accept telemedicine technology. The paper has concluded that physicians differ in decision making using telemedicine technology. This was in contrary to other verticals where the end users were in confirmation. Chau & Hu have explained that this difference comes from physicians' "specialized training, autonomous practices, and professional work arrangements" all of which are individualized and specific for every physician. Adoption of telemedicine as other technology adoption

is primarily restricted through perceived usefulness of the technology and individual attitude of the physicians using the technology (Chau & Hu, 2002a). An exploratory study has confirmed this result and considered the collective attitude of medical staff as an essential factor of technology adoption (Hu, Chau, & Sheng, 2002). Furthermore, Walter, Z., & Lopez, M. have found that perceived threat to professional autonomy has a significant, negative and direct influence on the perceived usefulness of technology adoption. Professional autonomy is considered as a "salient outcome believe affecting physician acceptance of information technology". Moreover, the influence of perceived threat to professional autonomy is larger for CDS systems than for any EMR systems (2008. P.207).

Aldosari B. assessed the factors affecting physicians' attitudes about medical information system usage and its acceptance at the Saudi Arabia National Guard Health System. The results of the study have identified organizational support, professional values, perceived ease of use, and perceived usefulness to be the major and common issues revolving around physicians' attitudes (Aldosari, 2003). Moreover, Chau & Hu have suggested that TAM is more appropriate than the general accepted theory of planned behavior (TPB) to explain the individual physician's technology acceptance decisions (Chau & Hu, 2002b).

One of the most prominent IT adoption models has been the famous "TAM" model developed by Davis. The model answers the fundamental question of acceptance or rejection of information technology (Davis, 1989). The Theory of

reasoned action (TRA) proposed by Fishbein, M., & Ajzen forms the theoretical basis of the TAM model. According to this theory, believes effect attitudes which in turn guide the intentions. Intentions are the final predecessors and a direct attributing factor to behavior (Fishbein, M., & Ajzen, I., 1975). Based on the model, TAM interprets “perceived ease of use” and “perceived usefulness” as the key determinants that affect the user’s acceptance. Perceived usefulness is defined as "the relative degree to which a person believes that using a particular system would enhance a person’s job performance." Perceived ease of use on the other hand is defined as "the degree to which a person believes that using a particular system would be free of effort." (Davis, 1989). Ketikidis, P. et al. assessed a modified version of the TAM and acceptance of HIT systems in a sample of health professionals. They have concluded that perceived ease of use, relevance and subjective norms directly predicted HIT usage intentions (2012).

Due to the existence of several models, Venkatesh, and colleagues have reviewed eight different models and formulated a unified model that integrates all such elements. This model called Unified Theory of Acceptance and Use of Technology (UTAUT) proposed in 2003. They identified direct determinants of user acceptance and usage behavior which include performance expectancy, effort expectancy, social influence, and facilitating conditions, as well as a few moderating variables such as voluntariness, and experience (Venkatesh et al., 2003).

Urgent Need for Medical Informatics in the Medical School Curriculum

"The practice of medicine is inextricably entwined with management of information" (Shortliffe & Cimino, 2006. P. Xiv). In other words, healthcare environment heavily depends on information. It would seem natural to integrate a MI course into medical students' curriculum, which will enable them to effectively manage health information in their future practice. Also, technology has become an integral part in healthcare environment during patient care. If medical colleges do not incorporate a MI course, it will affect not only the quality of medical education but also would reduce the abilities of future healthcare professionals to deliver healthcare (Chen, 2011) (Stead et al., 2011). Stead et al. has epitomized the importance of MI by the following "An understanding of biomedical informatics will assist future physicians as they decide not only what they need to know but also how to find what they need to know in the information infrastructure" (2011, P. 432)

Furthermore, delivering healthcare significantly depends on EBM, which relies on peer-reviewed literature. The volume of medical literature has rapidly grown since last few decades. According to Druss., around 8.1 million journal articles were published in MEDLINE between 1978 and 2001. Between 1978 to 1985 and 1994 to 2001, the yearly number of MEDLINE articles increased to 46%, from an average of 272,344 to 442,756 per year. The growth in the literature was particularly concentrated in clinical research (2005).

The current technological advancements give an impression that most of students demonstrate strong IT skills because they have the ability to use emails,

use word processing and Internet search. However, managing information in a healthcare environment necessitates a higher level of skills (McGlade, 2001). Swanson (1993) in the ACME-TRI Report has suggested that medical students must be taught necessary computer skills that help them to manage health information, support making informed decisions, and improve their capabilities to become lifelong learners. Furthermore, many observers have suggested incorporating MI with medical students' curricula (Mantas, 2011) (Triola, 2010) (Krause, 2006) (Stead et al., 2011). However, there is a lack of appropriate MI education for medical students, especially undergraduate medical students (Otto, 2009).

The need for greater competence is not only asked by medical educators, but is also requested from current medical students. A 2006 web-based survey has indicated that 81% of students and residents agree or strongly agree with "Teaching about technology skills should be included in their medical curriculum". Respondents also have suggested that it is very important to learn about EMR and accessing scientific information on the Internet (Briscoe, 2006). Another web-based survey of 1st and 2nd year medical students has showed that students lack confidence in exposure and the ability to use clinical information systems, competency in accessing databases of clinical information, and knowledgeable about advocacy resources. The author recommends including formal MI training in the students' curriculum in order to improve their MI skills (Krause, 2006).

Moreover, there is a meaningful association between medical students' self-perceived computer knowledge and their attitude toward information and

communication technology (ICT). This has been indicated in a recent study, where it has concluded that students with positive attitudes toward ICT and students who knew the importance of computer technologies in medical education and practice had a higher mean of self-perceived computer knowledge score (Houshyari, 2012).

Current Situation of Teaching Medical Informatics

Several attempts have been made to incorporate MI course in the medical student's curriculum (Chen, 2011). In 2000, the International Medical Informatics Association (IMIA) has published its first version of Recommendations of the International Medical Informatics Association on education in health and medical informatics. The IMIA has revised these recommendations and published the second version in 2011. The IMIA recommendations should be applied as a framework on both levels nationally and internationally. The educational needs are described as a three dimensional framework. The dimensions are professionals in health care (e.g. physicians, nurses), type of specialization in biomedical and health informatics (BMHI) (IT users, BMHI specialists), and finally the stage of career progression (bachelor, master, doctorate). Learning outcomes have been defined in terms of knowledge and practical skills for health care professionals in their role as an IT user and as a BMHI specialist, which is illustrated in figure 2.1. As pointed in this figure, if a student studies medicine to receive a bachelor degree, the student is required to get a minimum of education in BMHI. The student will then be efficiently able to use ICT and become an IT user. Learning outcomes are divided into two types: Learning outcomes for all health care professionals in their

role as IT users and Learning outcomes for BMHI specialists. IMIA recommendations could be applied in BMHI course as a part of medicine, nursing, health care management, dentistry, pharmacy, public health, health record administration, and informatics/computer science curriculum. Additionally, it could also be used for specialized BMHI program irrespective of its position as bachelors, masters or a doctor degree (Mantas, 2011).

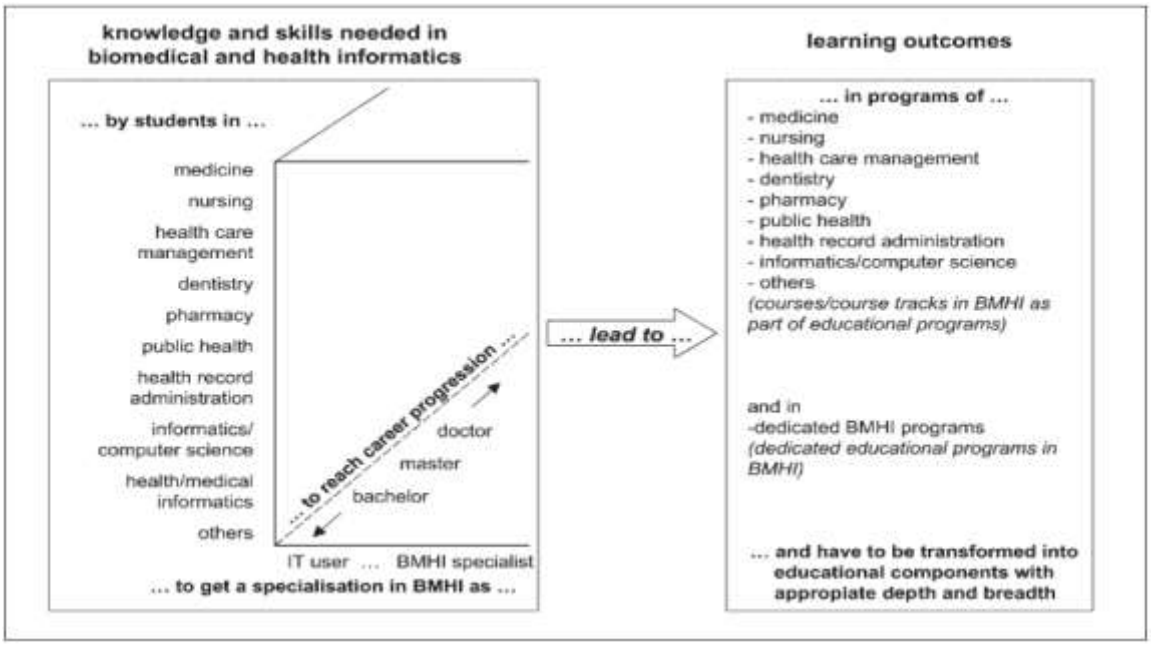

Figure 2.2: Structural outline of the IMIA recommendations on education in biomedical and health informatics (Mantas, 2011).

In 1998, the Association of American Medical Colleges (AAMC) has published Report II of the Medical School Objectives Project (MSOP II) entitled Contemporary Issues In Medicine: Medical Informatics and Population Health. In this report, the Medical Informatics Advisory Panel has classified following five physicians' roles with relevance to MI: Life-long Learner, Clinician, Educator/Communicator, Researcher, and Manager. The learning objectives are outlined within the framework of these five roles (Friedman, 1999). McGowan et

al., have determined the degree to which the MSOP medical informatics competencies have been incorporated into medical school curricula in the United States and Canada. It appears that only a few schools have clear-cut stated objectives and fewer assessed the competencies. The study has concluded that "Some progress has been made but much more needs to be accomplished to insure that physicians will be able to efficiently and effectively use health information technology installed in hospitals and health centers" (2007. P.1418). A recent study aimed to determine medical students' perceptions regarding the importance of the MSOP informatics learning objectives to their future careers. The study has found that the learning objectives for the physician roles of Clinician, Life-long Learner, and Manager received higher ratings than the Educator/Communicator and Researcher roles in terms of both perceived importance as well as amount of emphasis these content areas should receive in the curriculum (Beaudoin, 2013).

In order to support MI education, many formal certifications have been formulated and drafted. Since 1970s, MI courses are compulsory for medical students in Germany (Klar, 1995). Certification of nursing informatics has been made over a decade in the US (American Nurses Association, 2008). Recently, IMIA has offered a certificate for high-quality BMHI education which mandates that IMIA recommendations be satisfied and organizational integration and resources be assessed as well (Mantas, 2011).

Although Canada was an early leader to include MI education in undergraduate medical curricula, Canadian medical schools have been slow in the

integration of MI into the medical curriculum (Kaufman, 1997) (McGowan, 2007) (Strauss, 2010). According to a survey that included 16 out of 17 Canada's medical schools, it found that none of these schools have included what is formally known as Health Informatics into their core curriculum. However, only three schools reported that they have offered health informatics as an elective course. The two main reasons behind the slow incorporation of this program are the absence of a clear understanding of what MI means by medical professors and overcrowded curriculum of medical schools. Another related reason is the misconception of MI and belief that MI translates to the use of computers in medical practice. Others however believed that there is no need to incorporate MI to medical curriculum because it could be learned informally during hospital rotations (Strauss, 2010).

In addition to the above mentioned reasons, Triola et al., have suggested other barriers that prevent the widespread of MI inclusion. One of the prime barriers is the shortage of teacher and academic informatics departments. The perception that MI is not related to preclinical courses and there is no place in the clerkships to incorporate it is the second important barrier. Last barrier involves legal and political issues related to modern medical practice, such as the Health Insurance Portability and Accountability Act (HIPAA) concerns and level of access for medical students to EMR systems (2010).

Status of Medical Informatics in Saudi Arabia

In 2000, a health reform committee was formed in Saudi Arabia to review the healthcare services provided to Saudi citizens. The committee has concluded that one of the biggest challenges encountering healthcare system is the absence of health informatics applications. As a result, IT strategic plan was formed by a special taskforce in 2002, which aimed to build a national EHR. The recommendations that were suggested as illustrated in figure 2,2 are to increase the number of health informatics specialist, build a professional association for health informatics, construct specialized excellence center of health informatics, determine EHR specifications, and extend the telemedicine network (Altuwaijri, 2010).

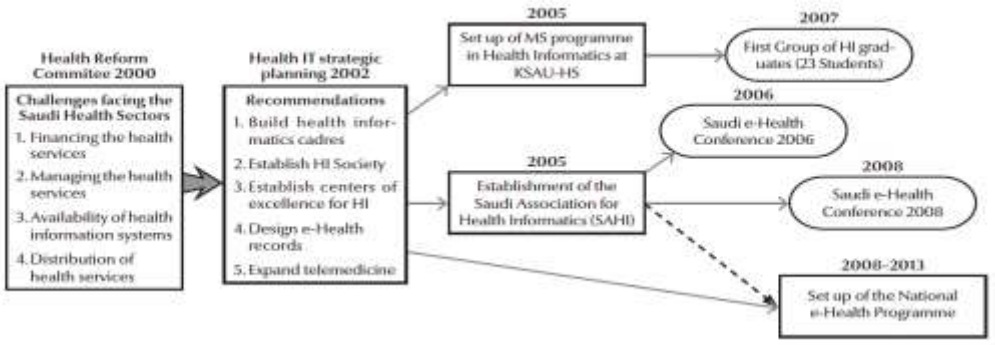

Figure 2.3: e-health initiatives in Saudi Arabia (Altuwaijri, 2010).

Currently, there is a significant demand of MI in Saudi Arabia that resulted from several reasons. Paper medical record is still mainly used in healthcare facilities. Because of a variety of healthcare providers who have been using different healthcare systems with little interoperability between them, patient information have become scattered between different healthcare systems. This

prevents the existence of a complete patient record. Furthermore, these systems are managed in nature rather than patient-care focused which further complicates the problem. Additionally, there is a shortage of MI professionals not only in Saudi Arabia, but also in neighboring countries. On top of that, the population of Saudi Arabia is increasing which necessities effective utilization of healthcare recourses and convenient employment of IT (Altuwaijri, 2010).

Consequently, King Saud bin Abdulaziz University for Health Sciences (KSAU-HS) has launched a Master of Health Informatics degree in 2005 as the first MI program to be taught in Saudi Arabia. The 2-year master program was developed based on the recommendations of IMIA on education in health and MI. The mission of the program is to advance the quality and efficiency of the Saudi health care system through improved information management system. The program structure consists of 14 courses (modules) with a total of 42 semester credit hours. It involves a diversity of graduate level foundation and required health informatics courses, as well as elective health management courses. Appendix A illustrates the structure of the master program in the university. In order to measure the success of the program, an evaluation was conducted by using a questionnaire survey. The students were satisfied with the outcomes of the program in general, and believed that the program was important not only for the government sector but also for the private health sector (Altuwaijri, 2010).

Another response to IT strategic plan is the establishment of Saudi Association for Health Informatics (SAHI). SAHI was developed in 2005 under the direct supervision of KSAU-HS. The two major objectives of SAHI are to develop

and promote health informatics knowledge by organizing scientific and professional conferences, seminars, workshops and exhibitions, and to provide a forum for the exchange of ideas and experience in health informatics among its members. One of the most important events organized every 2 years by SAHI is Saudi e-health conference. Currently, SAHI has participated in developing the King Abdullah Arabic Health Encyclopedia project, which will be the first of its kind within the Arab world (Altuwaijri, 2010) (Saudi Association for Health Informatics).

Medical Informatics Course Structure and Delivery in King Saud University

Before the inclusion of a MI course in the medical college at KSU, Albarrak, who is an Associate Professor in Medical Informatics and e-Learning Unit at KSU, has conducted a study to assess the skills of undergraduate students in different computer fields ranging from data entry to the Internet search. The study was also aimed to assess the readiness of the students or the acceptance of a new MI courses for enhancing their capabilities. The survey was distributed to third year medical students which concluded that medical students had very good basic computer skills. However, they lacked professional MI knowledge and skills. Furthermore, the students have a strong interest in learning and acquiring MI skills and they are aware of their importance. No MI or computer skills courses were provided at the time of this study. However, two computer skills lectures were provided within this research course. This study is considered to be pivotal in determining if the medical students are ready to accept the inclusion of MI course in their curriculum or not (Albarrak, 2010).

Medical college at KSU has introduced a MI course to third year medical students in 2011. The course has the objectives not only to introduce students to MI as a profession but also enable them to understand the current trends in MI as they apply to the healthcare field and the health profession. The course aims to grow student's awareness in different ways, IT is used in health practical and work related situations, explore computer applications in health education, practice, administration and medical search. The students would be encouraged to identify various types of information systems used within healthcare institutions and perform an online search in medical, pharmaceutical and other health literature through the World Wide Web. This course also introduces the students to EHR, CPOE, imaging, and consumer informatics. The MI course will be taught by lecture demonstrations during 17 weeks. Also, it would involve discussions by using Blackboard, which is a learning management system, on several MI topics. In addition, it would include several workshops such as EBM resources on Mobile Platforms, Picture Archiving and Communication System and health information system.

Furthermore, students would conduct clinical information project that requires visiting clinics or hospitals that employ clinical information system. This project aims to allow medical students to study and understand one MI system used in a healthcare organization. After site visits, students are required to write a report and make a presentation to their colleagues. The report would include introduction of the system, background of the system, system benefits, main users of the system, and functionalities of the system, implementation and maintenance

information, challenges during the system's implementation. Appendix B illustrates a sample MI course structure.

Chapter 3: Research Question and Methods

Research Question

The specific research question of the thesis is

Are medical students who take curriculum including a MI course more willing to accept MI applications in their future practice than medical students who do not have a MI course?

Methods

Survey Development

This study is a cross sectional study where data was collected through distribution of the pre formed survey to the third year medical college students. The survey contains questions related to the student's background and questions concerning important concepts in MI. In addition, it also includes questions that would help to assess students' attitude toward adapting MI applications in their future medical practice.

The items in the survey instrument were grouped in the four following sections: Section A – Background information, Section B – Medical Informatics Knowledge, and Section C- Students' Attitudes in Future Medical Practice. In addition to Section D- which asks respondents to add any comments and suggestions. Some of the survey questions would be extracted from a recent study with a focus on evaluation of biomedical informatics curriculum (Silverman, 2012).

Section A contains background questions about students general information such as gender, age, name of the university, whether the medical students took any MI course, and whether students interacted with any clinical informatics application or not. Section B includes questions about students' MI knowledge which includes but not limited to EHR, HIPAA standards, CDSS, EBM, CPOE, telemedicine, and ethical and legal aspect in MI. Above topics may include more than one question. The last three questions in Section B ask the respondents about their opinions regarding the importance of teaching MI and its importance in the healthcare sector. Section C contains students' attitude questions and whether students will accept MI applications in their future practice.

Section A includes both check box type questions as well as write down questions in the answer box. Section B and C would be answered by using a five-point Likert-type scale. The response options ranging from "strongly disagree", which is assigned a numerical value of 1, to "strongly agree", which is assigned a numerical value of 5. In order to avoid acquiescence bias, 5 questions phrased in a reversed manner. For example, question number 7 which asks the respondents the following "Paper medical record protects patients' confidentiality more than Electronic Medical Record". The final survey consists of 33 questions. The survey would need approximately 15 minutes to be completed by the respondent. Appendix C illustrates the distributed survey instrument.

Study Population

In order to determine whether medical students who take curriculum including a MI course are more willing to accept MI applications than medical students who do not have a MI course, the survey has been distributed to two medical schools in Saudi Arabia. The first medical school is the medical college at KSU, which has included the MI in the third year medical students' curriculum. The second medical college is the medical college at the University of Dammam (UOD), which has not taught a MI to medical students before.

In KSU, all third year medical students who have registered in the MI course in the first semester were eligible to participate in the study. Also, all third year medical students of UOD were eligible to participate in the study. In order to differentiate between the two groups, the survey would eliminate medical students if they do not respond affirmatively on the question of attending MI course asked in the beginning of the survey. Respondents have voluntarily participated and responses have been collected anonymously.

Statistical Analysis

Data was analyzed using the predictive analytics software SPSS. In order to assess the internal consistency of the instrument, a Cronbach's alpha has been used. Descriptive statistics, which includes; means, frequencies and proportions, have been calculated to illustrate the study objectives. The reversed questions have been recoded during data analysis. The unpaired t-test has been calculated to compare means and to detect statistically significant differences by the

respondents from two groups. A p value of ≤ 0.05 has been considered statistically significant. The study was reviewed and approved by KSU Institutional Review Board.

Chapter 4: Result

Survey Reliability and Response Rate:

The reliability of this survey has been tested using a Cronbach test. The Cronbach's alpha reliability coefficient for the survey came out as 0.859, which is considered within the reasonable range of internal consistency as suggested by Gliem and Gliem (Gliem & Gliem, 2003). Third year medical students in UOD and KSU have completed and returned a total of 178 questionnaires out of 242 questionnaires provided, leading to a response rate of 73.5%. Response rates have varied in the two universities with a response rate of 89.7% (96 \ 107) in KSU as compared to a 60.7% (82 \135) response rate in UOD.

Descriptive Statistics:

The mean age of the participating students was 20.74 years. There were a total of 103 (57.9%) females and 75 (42.1%) male participants who completed the survey. It is very important to note that not all the students in KSU took the MI course and similarly not all the students in UOD did not take a MI course. While 7 students in KSU did not previously take the MI course, 24 students previously took a MI course in UOD. As reported by one of the students, they took this course during their study at different medical college. Table 4.1 shows a descriptive analysis for KSU and UOD respondents. Also majority of the students (73.3%) did not interact with any MI applications in any productive way. Among students who interacted with MI applications, more than 50% of the students

interacted with the E-lab system and all of them came from the group at KSU, as shown in figure 4.1.

Table 4.1: Descriptive data for KSU and UOD respondents.

Variables	King Saud University = 96 cases	University of Dammam = 82 cases	Combined = 178 cases
Gender: • Male • Female	 43 (24.2%) 53 (29.8%)	 32 (18.0%) 50 (28.1%)	 75 (42.1%) 103 (57.9%)
Did you previously take a medical informatics course? • Yes • No	 89 (50 %) 7(3.9%)	 24(13.5%) 58(32.6%)	 113 (63.5%) 65 (36.5%)
Did you previously interact with any computerized clinical system? • Yes • No	 41(23.3%) 54 (30.7%)	 6 (3.4%) 75 (42.6%)	 47 (26.7%) 129(73.3%)

*% of total.

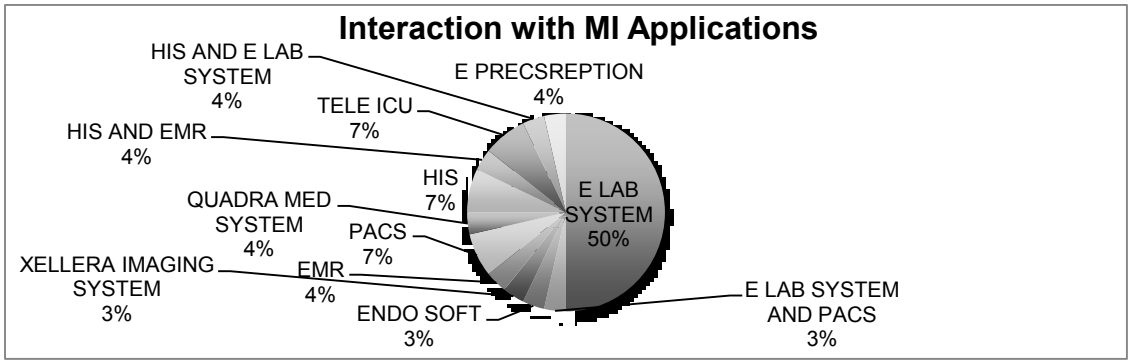

Figure 4.1: Percentage of MI applications that have been used by the respondents.

Assessing Students' Knowledge toward Medical Informatics

The second section of the survey (questions 6 through 19) is drafted to assess students' MI knowledge in their respective universities. The following data analysis has been conducted based on the fact whether medical students previously took a MI course or not. A cross- tabulation analysis has been used to illustrate the level of MI knowledge post a MI course. Table 4.2 illustrates cross-tabulation between taking MI course and EHR knowledge items. It is also important to throw light on EHR knowledge. 39.8% of the respondents who previously took a MI course strongly agreed and 40% of the respondents who did not take a course agreed that the best method to communicate between different healthcare providers is through an EMR. However, 38.9% of the respondents who previously took a MI course agreed and 40% of the respondents who did not take a course were neutral about the confidentiality of EHR. More than 50% of both groups strongly agreed about the benefits of EHR in improving accessibility to patients' data and transmission of patients' information between different healthcare facilities. Also, 50.4% of the respondents who previously took a MI course strongly agreed and 55.4% of the respondents who did not take a course agreed on the ability of EHR in finding specific patient information successfully and diligently.

Table 4.2: Cross tabulation Likert Scale between EHR knowledge and MI course taking.

EHR items	Did you take MI course?		
	Yes = 113 cases	No= 65 cases	Total =178 cases
The best method to communicate between different healthcare providers is through the Electronic Medical Record			
• Strongly disagree	3 (2.7%)*	2(3.1%)**	5 (2.8%)
• Disagree	3(2.7%)*	2(3.1%)**	5 (2,8%)
• Neutral	20(17.7%)*	16(24.6%)**	36 (20.2%)
• Agree	42(37.2%)*	26(40%)**	68(38.2%)
• Strongly agree	45(39.8%)*	19(29.2%)**	64 (36%)
Electronic Medical Record protects patients' confidentiality more than the paper medical records			
• Strongly disagree	4(3.5%)*	2(3.1%)**	6 (3.4)
• Disagree	12(10.6)*	13(20%)**	25(14%)
• Neutral	17(15%)*	26 (40%)**	43 (24.2%)
• Agree	44 (38.9)*	21(32.3%)**	65 (36.5%)
• Strongly agree	36(31.9%)*	3(4.6%)**	39 (21.9%)
The Electronic Medical Record helps to improve access to patient information.			
• Strongly disagree	3 (2.7%)*	0 (0%)**	3 (1.7%)
• Disagree	0 (0%)*	1 (1.5%)**	1(0.6%)
• Neutral	8 (7.1%)*	2 (3.1%)**	10 (5.6)
• Agree	25(22.1%)*	20(30.8%)**	45 (25.3%)
• Strongly agree	77(68.1%)*	42(64.6%)**	119(66.9%)

Table 4.2: Continued

EHR items	Did you take MI course?		
	Yes = 113 cases	No = 65 cases	Total =178 cases
The Electronic Medical Record facilitates transmission of patients' information between different healthcare facilities.			
• Strongly disagree	1 (0.9%)*	0 (0%)**	1 (0.6%)
• Disagree	2 (1.8%)*	0 (0%)**	2 (1.1%)
• Neutral	4 (3.5%)*	2 (3.2%)**	6 (3.4%)
• Agree	33 (29.2%)*	21(33.9%)**	54 (30.9%)
• Strongly agree	73 (64.6%)*	39(62.9%)**	112 (64%)
The easiest method to find specific information within a patient medical record is through the use of an Electronic Medical Record			
• Strongly disagree	6 (5.3%)*	3 (4.6%)**	9 (5.1%)
• Disagree	2 (1.8%)*	2 (3.1%)**	4 (2.2%)
• Neutral	14 (12.4%)*	9 (13.8%)**	23 (12.9%)
• Agree	34 (30.1%)*	36(55.4%)**	70 (39.3%)
• Strongly agree	57 (50.4%)*	15(23.1%)**	72 (40.4%)

* % Within total number of the respondents who took a MI course.
** % Within total number of the respondents who did not take a MI course.

Students' knowledge about various other aspects on MI for both groups is demonstrated in table 4.3. Majority students from both the groups were neutral about the importance of HIPAA compliance standards with 40.7% of the respondents who previously took a MI course and 69.1% of the respondents who did not take the course.

With respect to CDSS, around half of the students who previously took a MI course and more than 50% who did not take a course acknowledge the

importance of CDSS. Also, 43.8% of the students who took a MI course and 53.7% of the respondents who did not take a course also agreed on the ability of telemedicine to overcome the general problems of healthcare system. More than half (54.9%) of the students who took a course and 43.9% of the respondents who did not take a course strongly agreed with the advantages of CPOE. There were 42.3% of the medical students with previous MI knowledge strongly agreed and 46.6% of the group with no previous MI knowledge agreed on the importance of EBM resources.

Both groups agreed with using reliable medical websites for improving their medical knowledge. Irrespective of previous knowledge about MI, 51.3% of the students with a previous MI knowledge and 46% without a previous MI knowledge agreed on using reliable medical websites to be updated with the latest medical literature. 36.3% of students who took a MI agreed and around 46% of the respondents who did not take a MI course were neutral about the role of healthcare providers in directing patients to reliable and sound medical website.

It was also interesting to find that more than half of the respondents who did not take a MI course strongly agreed and around 40% of the students who took a MI course agreed that the healthcare provider should have a reasonably good understanding of the legal and ethical issues involved in using clinical informatics applications. In general, 42.3% of the respondents who took a MI course and 55.2% of the respondents who did not take a MI course agreed about

the ability of clinical informatics applications to overcome the common problems of the healthcare system.

Table 4.3: Cross tabulation between MI other aspect knowledge and taking of MI course.

Other MI aspects items	Did you take MI course?		
	Yes	No	Total
Complying with HIPAA (Health Insurance Portability and Accountability Act) standards is the recommended method to protect the confidentiality of patient medical record			
• Strongly disagree	1 (0.9%)*	2 (3.6%)**	3 (1.8%)
• Disagree	5 (4.6%)*	1(1.8%)**	6 (3.7%)
• Neutral	44(40.7%)*	38(69.1%)**	82 (50.3%)
• Agree	30 (27.8%)*	12 (21.8%)**	42(25.8%)
• Strongly agree	28(25.9%)*	2 (3.6%)**	30 (18.4%)
Using a Clinical Decision Support System helps to reduce the risk of medical errors			
• Strongly disagree	4(3.5%)*	0 (0%)**	4 (2.3%)
• Disagree	2 (1.8%)*	1 (1.7%)**	3 (1.8%)
• Neutral	8 (7.1%)*	12(20.7%)**	20 (11.7%)
• Agree	43 (38.1%)*	30(51.7%)**	73 (42.7%)
• Strongly agree	56 (49.6%)*	15(25.9%)**	71 (41.5%)
Use of telemedicine is very important to overcome problems of the current healthcare system			
• Strongly disagree	2 (1.8%)*	0 (0%)**	2 (1.2%)
• Disagree	5 (4.5%)*	0 (0%)**	5 (3.0%)
• Neutral	25 (22.3%)*	17(31.5%)**	42 (25.3%)
• Agree	49 (43.8%)*	29(53.7%)**	78 (47.0%)
• Strongly agree	31 (27.7%)*	8 (14.8%)**	39 (23.5%)

Table 4.3: Continued

Other MI aspects items	Did you take MI course?		
	Yes	No	Total
Use of Computerized Physician Order Entry (CPOE) helps to reduce errors related to drug names and improve patient safety			
• Strongly disagree	0 (0%)*	1 (1.8%)**	1 (0.6%)
• Disagree	2 (1.8%)*	2 (3.5%)**	4 (2.4%)
• Neutral	7 (6.2%)*	8 (14%)**	15 (8.8%)
• Agree	42 (37.2%)*	21(36.8%)**	63 (37.1%)
• Strongly agree	62 (54.9%)*	25(43.9%)**	87 (51.2%)
Reliance on evidence-based resources is essential to improve quality of healthcare.			
• Strongly disagree	0 (0%)*	0 (0%)**	0 (0%)
• Disagree	3 (2.7%)*	1 (1.7%)**	4 (2.4%)
• Neutral	21 (18.9%)*	15(25.9%)**	36 (21.3%)
• Agree	40 (36%)*	27(46.6%)**	67 (39.6%)
• Strongly agree	47 (42.3%)*	15(25.9%)**	62 (36.7%)
In order to be updated with the latest medical information, a healthcare provider should read the latest medical literature by using reliable medical websites.			
• Strongly disagree	3 (2.7%)*	0 (0%)**	3 (1.7%)
• Disagree	0 (0%)*	2 (3.2%)**	2 (1.1%)
• Neutral	16 (14.2%)*	10 (15.9%)**	26 (14.8%)
• Agree	36 (31.9%)*	22 (34.9%)**	58 (33%)
• Strongly agree	58 (51.3%)*	29 (46%)**	87(49.4%)

Table 4.3: Continued

Other aspects of MI items	Did you take MI course?		
	Yes	No	Total
Directing the patient to reliable medical websites such as MedlinePlus is one of the prime responsibilities of the physician.			
• Strongly disagree	2 (1.8%)*	2 (3.2%)**	4 (2.3%)
• Disagree	23 (20.4%)*	7 (11.1%)**	30 (17%)
• Neutral	39 (34.5%)*	29 (46%)**	68 (38.6%)
• Agree	41 (36.3%)*	21(33.3%)**	62 (35.2%)
• Strongly agree	8 (7.1%)*	4 (6.3%)**	12 (6.8%)
A Healthcare provider should have a reasonably good understanding of the legal and ethical issues involved in using clinical informatics applications.			
• Strongly disagree	1 (0.9%)*	0 (0%)**	1 (0.6%)
• Disagree	5 (4.5%)*	2 (3.2%)**	7(4%)
• Neutral	18 (16.2%)*	9 (14.3%)**	27 (15.5%)
• Agree	44 (39.6%)*	19(30.2%)*	63 (36.2%)
• Strongly agree	43 (38.7%)*	33(52.4%)**	76 (43.7%)
Using clinical informatics applications helps to overcome problems of the current healthcare system.			
• Strongly disagree	1 (0.9%)*	1 (1.7%)**	2 (1.2%)
• Disagree	2 (1.8%)*	2 (3.4%)**	4 (2.4%)
• Neutral	21 (18.9%)*	11 (19%)**	32 (18.9%)
• Agree	47 (42.3%)*	32(55.2%)**	79 (46.7%)
• Strongly agree	40 (36%)*	12(20.7%)**	52 (30.8%)

* % Within total number of the respondents who took a MI course.
** % Within total number of the respondents who did not take a MI course.

In order to detect the difference in MI knowledge between the students who took a MI course and the students who did not take a MI course, a t- test has been conducted as demonstrated in table 4.4. The result shows statistically significant differences between these two groups in 4 of the 14 questions. These items include EHR confidentiality, compliance with HIPPA standards, benefit of CDSS, and CPOE advantages. The other MI knowledge items did not show statistically significant differences between the two groups.

Table 4.4: Comparison of MI knowledge between the medical students who took the MI course and the students who did not take such a course

MI knowledge Item*	**Did you take medical informatics previously?**		***P* value†**
	Yes	**No**	
The best method to communicate between different healthcare providers is through the Electronic Medical Records.	4.09	3.89	.193
Electronic medical record protects patients' confidentiality more than the paper Medical Records	3.85	3.15	.000
The Electronic Medical Records helps to improve access to patient information.	4.53	4.58	.657
The Electronic Medical Records facilitates transmission of patients' information between different healthcare facilities.	4.55	4.60	. 653
The easiest method to find specific information within a patient medical record is by the use of an electronic medical record.	4.19	3.89	.069
Complying with HIPAA (Health Insurance Portability and Accountability Act) standards is the recommended method to protect the confidentiality of patient medical record.	3.73	3.20	.000
Use of a Clinical Decision Support System helps to reduce the risk of medical errors	4.28	4.02	.044

Table 4.4: Continued

MI knowledge Item*	Did you take medical informatics previously?		*P* value†
	Yes	No	
Use of telemedicine is very important to overcome problems of the current healthcare system.	3.91	3.83	.580
Use of Computerized Physician Order Entry helps to reduce errors related to drug names and to improve patient safety.	4.45	4.18	.031
Use of clinical informatics applications helps to overcome problems of the current healthcare system.	4.11	3.90	.119
Reliance on evidence-based resources is essential to improve quality of healthcare.	4.18	3.97	.105
In order to be updated with the latest medical information, a healthcare provider should read the latest medical literature by using reliable medical websites.	4.29	4.24	.697
To direct the patient to reliable medical websites such as MedlinePlus is the responsibility of a physician.	3.27	3.29	.887
A Healthcare provider should have a reasonably good understanding of the legal and ethical issues involved in using clinical informatics applications.	4.11	4.32	.132

*Responses were given on a five-point Likert-type scale where 1 represents strongly disagree, 2: Disagree, 3: Neutral, 4: agree and 5 represents strongly agree.

†Calculated using an unpaired t test using the number of responses, standard deviation, and mean.

This section also includes two direct questions (questions 20 and 21) asking the respondents about the importance of MI course taught to the undergraduate medical students. As shown in figure 4.2, both groups agreed that incorporating a MI course in medical college curriculum is very important to improve the future healthcare provider's acceptance of computerized clinical systems. The acceptance rate was found to be 36.3% and 42.9% by the group that was previously taught a MI and the group which did not study a MI respectively. Moreover, 34.5% of the medical students who previously took a MI course agreed and 36.5% of the respondents who did not take a MI strongly

agreed that teaching MI to undergraduate medical students is important to the healthcare sector, as demonstrated in figure 4.3.

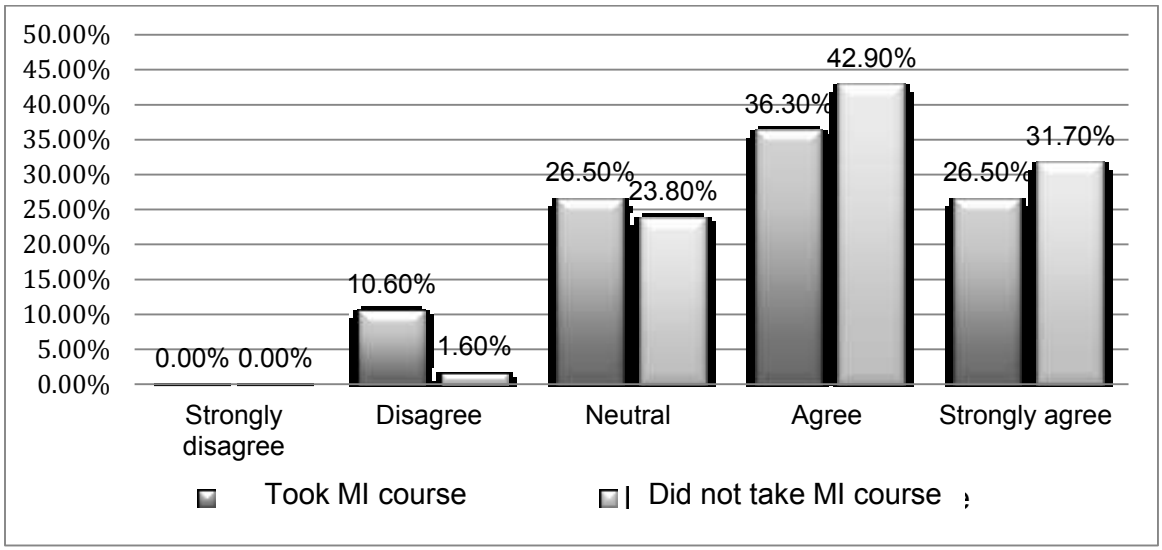

Figure 4.2: The respondents' percentages about incorporating a medical informatics course in medical college curriculum is very important to improve future healthcare providers' acceptance of computerized clinical systems

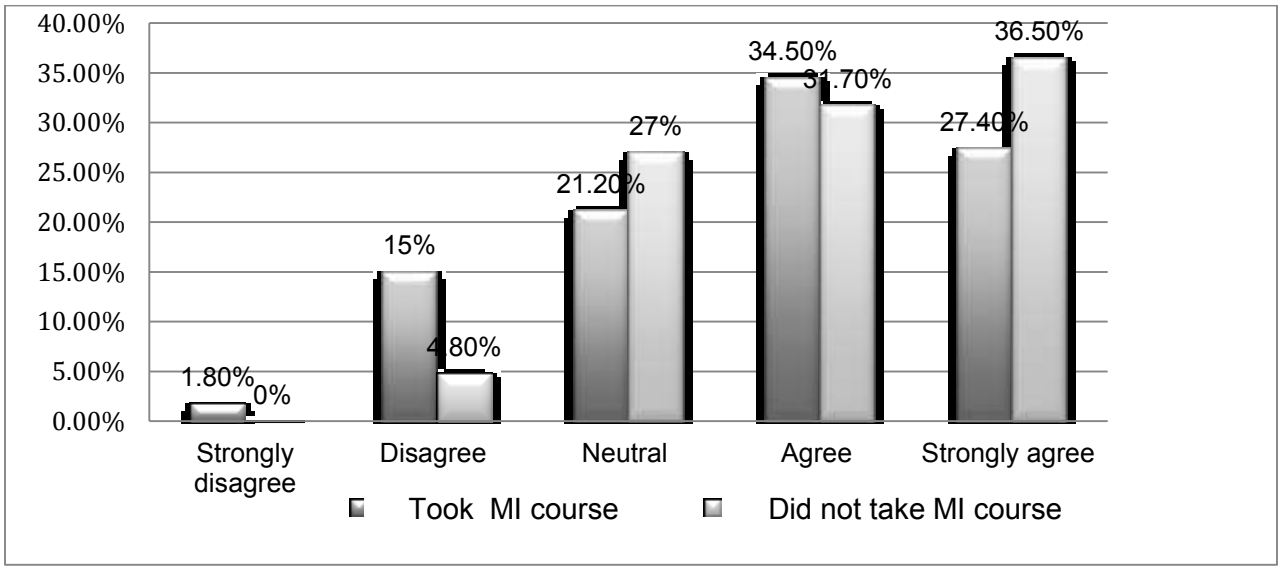

Figure 4.3: The respondents' percentages regarding teaching medical informatics to undergraduate medical students is important to the healthcare sector

Assessing Students' Attitudes in Future Medical Practice

The third section in the survey measures students' attitudes in relation to the use of clinical informatics applications in the future (questions 22 through question 33). The relationship between the medical students taking a MI course and their attitude in the future is tested by a t- test, as showed in table 4.5. The result reveals that EHR attitude items show no statistical difference between the medical students who took a MI course and students who did not take it.

However, there is a statistically significant difference in the attitude between the two groups in the use of CPOE in the future with a *P* value at 0.021. Regarding future use of CDSS, the *P* value is 0.003 which indicates a significant relationship between taking a MI course and the positive future attitude of CDSS use. Future use of telemedicine also shows a statistically significant difference between the two groups with *P* value at 0.007.

The remaining attitudes' items do not show any statistically significant difference between students who took a MI course and students who did not take a MI course. These include use of reliable medical websites and attitudes items with respect to the use of clinical informatics applications in general.

Table 4.5 Comparison mean students' attitudes in future medical practice between medical students who took MI course and students who did not take MI course

Attitudes Item*	Did you take medical informatics previously?		*P* value†
	Yes	No	
I will use an Electronic Medical Record in my future medical practice.	4.42	4.31	.399
I prefer to spend my internship and residency in hospitals that use an Electronic Medical Record rather than hospitals that rely on a paper medical record.	4.24	4.23	.972
I will ask healthcare facilities to rely on an Electronic Medical Record instead of a paper medical record.	4.08	3.94	.268
I will use Computerized Physician Order Entry in my future medical practice.	4.35	4.06	. 021
I will use a Clinical Decision Support System in my future medical practice.	4.26	3.87	.003
I will use telemedicine in my future medical practice.	3.86	3.47	.007
Reading medical textbooks is not the only method to keep me updated with required medical knowledge.	3.64	3.64	.984
As a physician in future, I will not resist using clinical informatics applications.	3.74	3.56	.324
If I am not sure about diagnosis or treatment of a patient during delivery of care, I will use reliable medical websites.	3.84	3.89	.755
In order to be a life-long learner, I will use reliable medical websites such as MEDLINE to find up to date medical information.	4.22	4.06	.199
I do have confidence in the use of clinical informatics applications in my future medical practice.(	3.06	3.52	.647
In general, I am enthusiastic about the use of health information technology in patient care in my future medical practice.	3.95	3.85	.445

*Responses were given on a five-point Likert-type scale: 1 _ strongly disagree, 2 _ disagree, 3 _ neutral, 4 _ agree, 5_strongly agree.

†Calculated using an unpaired t test using the number of responses, standard deviation, and mean.

The last section in the survey is an open section with a provision to provide suggestions and feedbacks. Results reveal that 31 respondents provide comments about the importance of MI course inclusion in the medical student's curriculum in Saudi Arabia. Moreover, 21 comments out of the total 31 comments, were provided by the medical students who previously took a MI course. These comments indicate the importance of teaching the MI course. In addition, the participants also made suggestions with respect to inclusion of proper teaching methodology in MI. Methods such as incorporating practical sessions in different MI applications was one of the common suggestions that can be incorporated for a better and effective program. The survey also revealed various criticisms to the teaching methodology in MI curriculum. Other criticism is MI applications were not considered as a reflection of the real healthcare system in Saudi Arabia. Several comments suggest teaching MI course during the first and second year instead of third year and making MI as an elective course. Some also viewed this course, as a better fit for physicians who can be taught the course as a continuing education in a hospital setting.

One of the students wrote: "The course is important, but I prefer to get MI training in a sub intern year. This would help me grasp the practical importance of MI in a real world scenario. The 3rd year is the first clinical exposed year and providing a heavy clinical focused real application based curriculum does not seem appropriate. MI is a novice concept like many other clinical subjects, requiring dedicated learning and assiduous work which require ample time. With

a short third year and the introduction of many heavy focused clinical subjects, such a proper training may not be possible".

On the other hand, comments from the medical students who did not take a MI course stated that the course is of paramount importance and should be included within their curriculum. One of the students even went far to state that "it is sad and unfortunate that the course is not included as a part of the curriculum. However the questionnaire sounds interesting and shows a lot of promise in the immediate future for the course. It could potentially improve the performance of our medical care once the course is implemented in our health care system"

Chapter 5: Discussion and Conclusion

Discussion

Our findings suggest that those undergraduate medical students irrespective of the fact whether they took a MI course or not have good MI knowledge. However the students do not have strong knowledge in the domains of EHR confidentiality, compliance with HIPPA standards, benefit of CDSS, and CPOE advantages. Theses aspects show statistically significant differences between these two groups. The results also reveal that there are statistically significant differences in their acceptance attitudes in the future medical practice between students who took a MI and students who did not take a course in several MI applications such as CPOE, CDSS and telemedicine.

Although the respondents who did not take a MI course also reported good MI knowledge, this cannot undermine the importance of MI inclusion with undergraduate medical students' curriculum for several reasons. Widespread adoption of technological applications between young generations constructs good impression about using technology, which facilitating work in many fields. Furthermore, items in the survey contain general information about MI applications and their benefits in medical practice that make it easy for the medical students without MI knowledge to answer them positively.

Currently, undergraduate medical students are well acquainted with several MI applications such as EHR. Our result shows that there are no

statistically significant in EHR knowledge differences between the two groups except for EHR confidentiality. Also, EHR attitudes items show no significant differences between the two groups.

Moreover, respondents who did not take a MI state that it is very important to include this course in their curriculum. More importantly, direct survey items, which outline the importance of teaching MI course, indicate students' demand to incorporate this course within their curriculum.

Compliance with HIPAA standards is the only knowledge item that has been reported to be neutral from over forty percent of the students who took a MI course. In fact, this topic may not be included within their MI course. In fact, HIPAA standards usually used as an example of patients' health information protection standards in Saudi Arabia even though they are only applied in the United States.

It is important to notice that there are statistically significant differences between the students who took a MI and the students who did not take it in CDSS and CPOE knowledge items. Furthermore, there is a significant relationship between taking a MI course and positive attitudes of using CDSS and CPOE in the future medical practice. The result clarifies the benefits of incorporating MI course in the undergraduate medical student curriculum by improving future healthcare providers' attitudes. In other words, medical students may develop a positive attitude in using MI applications if they get deeper knowledge about the course.

Several comments from medical students who previously took a MI course recommend not teaching MI in the third year and rather introduce it in the first or second year. In fact, the Association of American Medical Colleges has proposed an ideal state of teaching a MI course to undergraduate medical students. It involves teaching MI during all four years and it should be included within all the possible courses. The implementation requires considering informatics as a theme of medical school curriculum (Friedman et al., 1999). Furthermore, students' comments also emphasized a need for practical sessions to be included as a part of the course. As a point of fact, using EHR as an educational tool has been recommended by Otto A and Sliverman H. Such suggestions will help medical students to recognize the significant benefits of EHR and improve familiarity of the application among future healthcare providers (Otto & Kushniruk, 2009; Silverman, Cohen, & Fridsma, 2012). By introducing educational MI applications, medical students will be able to understand the actual advantages of these applications even if using them is not prevalent in the current healthcare system, as pointed by one of the students.

The result of the study shows good MI knowledge, even among the undergraduate medical students who did not have a MI in their curriculum. The students, however lacked knowledge in HIPPA standards and CDSS advantages. These findings were quite different from the findings conducted by Albrrak A. According to Albrrak A., third year medical students in KSU did not have professional MI knowledge and skills that necessitates integration of MI in their curriculum (Albarrak, 2010). Certainly, the difference in time of conducting

Albarrak's study and our study and rapid widespread of technology would have played essential roles to expand undergraduate medical students' knowledge about MI.

The comments section of the current study indicates that the students who did not previously take a MI course were aware about its importance and enthusiastic to take the course. Another study conducted by Albarrak found that the majority of the dental college students in KSU were interested to have a dental informatics course and training as part of their curriculum (Al Barrak, Al Yami, & Bamajboor, 2011).

The result also reveals that 34.5% and 36.5 of the respondents from students who took a MI course and those without MI course agreed and strongly agreed respectively about the importance of MI in the healthcare sector. A similar opinion has been supported by the health informatics master students in KASU-HS during evaluation of the healthcare informatics master program (Altuwaijri, 2010)

As with other studies, the present study also falls on many of its limitations. Firstly, the result of the study cannot be generalized to various medical colleges in the world because it only compared the two individual medical colleges in Saudi Arabia. Second, the distributed survey instrument has not been validated by other researchers or has been published by any major scientific journals. Thirdly, as with other studies, our survey would have been a part of one of more bias. It is probable that the medical students would have

taken a good impression about the potentials of MI applications through the knowledge section. Accordingly, it would lead to have an impact on the future attitudes responses and would have falsely overestimated the positive attitudes. Certainly, the result of this study cannot guarantee healthcare providers' attitudes in using MI applications in their future medical practice, but at least can depict a hopeful picture for the coming future.

Directions for Further Study

Further research needs to assess the effect of studying a MI course in undergraduate medical schools. It would be beneficial to assess healthcare providers' attitudes in their actual medical practices. Such study can be conducted around four years later by using the same sample questionnaire. It may be more beneficial to explore the relationship between the MI course and adoption of its applications in a longitudinal study.

It would also be interesting to assess the attitudes of healthcare providers and understand their perspective about the importance of a MI course. Such study will help to explore physicians' opinions about this course. Moreover, it could help evaluate physicians' attitude and effect of MI knowledge and technology in improving their acceptance.

Conclusion

It is high time that future healthcare providers get prepared for high dependency of information technology in the medical practice. The inclusion of a MI course in the undergraduate medical curricula is suggested to provide required IT knowledge and skills. This paper has examined the importance of a MI course in undergraduate medical schools in Saudi Arabia. The purpose of the current study is to assess the MI knowledge among undergraduate medical students and compare individual attitudes in using MI applications in future. The study also reveals that the medical students from both groups are quite familiar with the basic concepts of MI. Also, taking the MI course has had a positive impact on students' attitudes on using MI applications in future. Consequently, integrating a MI course in undergraduate medical curricula is strongly recommended in order to effectively prepare healthcare providers for the future.

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Appendix A: The Structure of Health Informatics Master Program in King Saud Bin Abdulaziz University for Health Sciences (Altuwaijri, 2010).

Study core areas and course titles
Required foundation courses (6 credit hours)
Students are required to complete 2 courses from the following:
Foundation of medicine & medical terminology[a]
Introduction to information technology[b]
Statistical analysis
Health informatics courses (21 credit hours)
Students are required to complete the following 6 courses:
Introduction to health informatics
Health information systems
Electronic health records & standards
Legal, ethical, and social aspects of health informatics
Decision support in health care & knowledge management
Health informatics project
Students are required to select 1 course from the following:
Topics in health informatics
Directed study in health informatics
Health sciences courses (6 credit hours)
Students are required to take research methodologies and select 1 course from the other courses:
Research methodologies in health care
Health services administration
International health systems
Financial management of health organization
Organizational behaviour in health care
Informatics courses (9 credit hours)
Students are required to complete the following 3 courses:
Web technology
Database design & management
Information technology project management in health care

Appendix B: Medical Informatics Course Structure in King Saud University.

Course Outlines

Lecture/Workshop/Discussion hours: 2-4 hours weekly (17 weeks)

Week	Topic	Speaker/Readings
1 1-4 Sep	Course Orientation **Lecture 1**: Introduction to Medical Informatics ***Workshop I: DxR workshop***	Dr. Amr/ Dr. Nasriah *Chapter 1 Shortliffe
2 8-12 Sep	 **Discussion #1**: Introduction to Medical Informatics Discussion_ **Lecture 2**: Medical Search	Dr. Amr/ Dr. Nasriah Dr. Ahmed Albarrak **Supplementary Readings** *Chp 7 Shortliffe
3 15-19 Sep	**Discussion #2:** Medical Search discussion **Lecture 3**: Health Information Systems*	Dr. Amr Jamal / Dr. Nasriah Dr. Ahmed *Guest Speaker- Dr Yasser Sami- Quality Department KKUH
4 22-26 Sep	**Lecture 4**: Bioinformatics*	*Guest Speaker- Dr. Anas Halees, KFSHRC Dr. Amr Jamal Dr.Tameem Alghanam Ms. Ranyah
5 29 Sep-3 Oct	**Lecture 5**: Consumer Health Informatics* **Lecture 6**: Clinical Data **Discussion #3:** HIS discussion	Dr. Amr Jamal / Dr. Nasriah Ms. Ranyah *Guest Speaker, Dr Abdul Karim Muhanna, KFSHRC **Supplementary Readings**

		Chapter 2 &14 Shortliffe
6 6-10 Oct	**Lecture 7**: Electronic Health Record **Discussion #4:** Clinical Data Discussion	Dr. Amr Jamal / Dr. Nasriah **Supplementary Readings** Chp 12- Shortliffe
7 12-16 Oct	Hajj Vacation	
8 20-24 Oct	19 October Hajj Vacation	
9 27-31 Oct	Midterm **Discussion #5:** Electronic Health Record Discussion *Workshop 2: EBM resources on Mobile Platforms*	Dr. Amr Jamal / Dr. Nasriah Dr.Amr Ms Ranyah Dr. Tameem
10 3- 7 Nov	**Lecture 8** : Clinical Informatics as a Career for Physician*	* Guest Speakers- Dr. Osama Swailem
11 10-14 Nov	**Lecture 9**: Medical Error **Lecture 10**: Clinical Decision Support	Dr. Amr /Dr. Nasriah **Supplementary Readings** *Chp 20, Shortliffe
12 17-21 Nov	**Discussion #6:** Medical Error discussion **Lecture 11**: Imaging Systems *	Dr. Amr Jamal /Dr. Nasriah *Guest Speaker Dr. Metab Al-Kubayyer **Supplementary Readings**

		*Chp 9, Shortliffe
13 24-28 Nov	**Discussion #7:** Imaging Systems Discussions	*Guest Speaker Dr. Metab Al-Kubayyer
14 1-5 Dec	**Lecture 12**: Computerized Physician Order Entry **Discussion #8:** Clinical Discussion Support Discussion	Dr. Ahmed Albarrak Ms. Ranyah Dr. Tameem **Supplementary Readings**
15 8-12 Dec	No classes	
16 15-19 Dec	No classes	
17 21-25 Dec	***Workshop #3: PACS/HIS***	
18	Consolidation	
19	Written Exam	
20	Practical Exam	
21	Vacation (18 Jan-22 Jan)	
22	***Workshop #4 : Presentation on CIS report***	

Appendix C: The Distributed Survey Instrument

Dear Participant:

My name is Jwaher Almulhem and I am a graduate student at University of Wisconsin-Milwaukee. For my master thesis, I am examining the importance of Medical Informatics (MI) course inclusion in medical students' curricula in Saudi Arabia.

I kindly request that you complete the following short questionnaire regarding your attitudes towards medical informatics education. It should take no longer than 15 minutes of your time. Your response is of the utmost importance to me. There is no compensation for responding nor is there any known risk.

Please do not enter your name or contact details on the questionnaire. It remains anonymous. This survey is voluntary and you may refuse to participate at any time. If you require additional information or have questions, you are welcome to email me at Almulhem@uwm.edu

Thank you for taking the time to assist me in my educational endeavors.

Sincerely,

Jwaher Almulhem

Almulhem@uwm.edu

Survey Instrument

PLEASE ANSWER THE FOLLOWING QUESTIONS BY CROSSING (**X**) THE RELEVANT BLOCK OR WRITING DOWN YOUR ANSWER IN THE SPACE PROVIDED.

Section A – Background information

This section of the questionnaire refers to background. The information of this section will allow us to compare groups of respondents. Once again, we assure you that your response will remain confidential. Your cooperation is appreciated.

1. Gender

Male	
Female	

2. Age (in complete years)

3. Where do you study?

4. Did you take medical informatics course previously?

Yes	
No	

5. Did you interact with any computerized clinical system previously?

Yes	
No	

If yes, please specify when and what is the system ……

Section B – Medical Informatics Knowledge

This section explores your knowledge regarding Medical Informatics discipline.
To what extent do you agree with each of the following statements. Please indicate your answer using the following 5-point scale where:
1. = Strongly disagree
2. = Disagree
3. = Neutral
4. = Agree
5. = Strongly Agree

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
6. The best method to communicate between different healthcare providers is with the Electronic Medical Record.	1	2	3	4	5
7. Paper medical record protects patients' confidentiality more than the Electronic Medical Record.	1	2	3	4	5
8. The Electronic Medical Record helps to improve access to patient information.	1	2	3	4	5
9. The Electronic Medical Record facilitates transmission of patients' information between different healthcare facilities.	1	2	3	4	5
10. The easiest method to find specific information within a patient medical record is by using a paper medical record.	1	2	3	4	5

11. Complying with HIPAA (Health Insurance Portability and Accountability Act) standards is the recommended method to protect the confidentiality of patient medical record.	1	2	3	4	5
12. Using a Clinical Decision Support System helps to reduce the risk of medical errors.	1	2	3	4	5
13. Using telemedicine is very important to overcome problems of the current healthcare system.	1	2	3	4	5
14. Using Computerized Physician Order Entry helps to reduce errors related to drug names and to improve patient safety.	1	2	3	4	5
15. Using clinical informatics applications helps to overcome problems of the current healthcare system.	1	2	3	4	5
16. Reliance on evidence-based resources is essential to improve quality of healthcare.	1	2	3	4	5
17. In order to be updated with the latest medical information, a healthcare provider should read the latest medical literature by using reliable medical websites.	1	2	3	4	5
18. Directing the patient to reliable medical websites such as MedlinePlus is the responsibility of the physician.	1	2	3	4	5
19. A Healthcare provider should have a reasonably good understanding of the legal and ethical issues involved in using clinical informatics applications.	1	2	3	4	5
20. Incorporating a medical informatics course in medical college curriculum is very important to improving future healthcare providers' acceptance of computerized clinical systems.	1	2	3	4	5
21. Teaching medical informatics to undergraduate medical students is important to the healthcare sector.	1	2	3	4	5

Section C-Students' Attitudes in Future Medical Practice

This section explores your attitude regarding use of medical informatics applications in your future medical practice.

To what extent do you agree with each of the following statements. Please indicate your answer using the following 5-point scale where:

1. = Strongly disagree
2. = Disagree
3. = Neutral
4. = Agree
5. = Strongly Agree

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
22. I will use an Electronic Medical Record in my future medical practice.	1	2	3	4	5
23. I prefer to spend my internship and residency in hospitals that use an Electronic Medical Record rather than hospitals that rely on a paper medical record.	1	2	3	4	5
24. I will ask healthcare facilities to rely on an Electronic Medical Record instead of a paper medical record.	1	2	3	4	5
25. I will use Computerized Physician Order Entry in my future medical practice.	1	2	3	4	5

26. I will use a Clinical Decision Support System in my future medical practice.	1	2	3	4	5
27. I will use telemedicine in my future medical practice.	1	2	3	4	5
28. Reading medical textbooks is the only method to keep me updated with required medical knowledge.	1	2	3	4	5
29. As a physician in future, I will resist using clinical informatics applications.	1	2	3	4	5
30. If I am not sure about diagnosis or treatment of a patient during delivery of care, I will use reliable medical websites.	1	2	3	4	5
31. In order to be a life-long learner, I will use reliable medical websites such as MEDLINE to find up to date medical information.	1	2	3	4	5
32. I do not have confidence in the use of clinical informatics applications in my future medical practice.	1	2	3	4	5
33. In general, I am enthusiastic about the use of health information technology in patient care in my future medical practice.	1	2	3	4	5

Section D- Comments

Please use this space to add any additional comments or suggestions regarding importance of Medical Informatics (MI) course inclusion in medical students' curricula in Saudi Arabia.

……
……
……

Thank you for your co-operation in completing this questionnaire.