Medical Informatics in China: Healthcare IT Trends, Academic and Research Developments

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Summary

Objective: Describing the challenges and advances in medical informatics in China from the perspectives of hospital information systems, workforce, and academic, and research advances.

Methods: The paper summarizes information from the CMIA (China Medical Informatics Association and findings reported by CHIMA (China Hospital Information Management Association), including a White Paper on China Hospital Information Systems.

Results: Biomedical and Health Informatics has grown considerably during the past decade in China, and is an important component of proposed government planning that includes development of healthcare cards, clinical workflow path rules, and rural medicine. CMIA has strengthened as an organization promoting education, research and academic activities, while CHIMA has sponsored many hospital-based activities, including workshops on technical and workforce IT priorities related to proposed reforms of China's healthcare system.

Conclusions: China's challenges and opportunities in biomedical informatics and healthcare IT are considerable, with the former requiring greater promotion of academic research and educational opportunities through CMIA to support the burgeoning development of healthcare IT systems throughout the country. National and international collaboration and exchanges could lead to very useful comparative studies, Recommendations by CHIMA to the national government and academia focus on organizational and workforce standards, roles, and defining career paths for HIT professionals as well as CME education in healthcare informatics at the graduate university.

Keywords

Biomedical informatics education and research, healthcare Iifomation technology, market analysis, professional development

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1. Introduction

One can distinguish three phases in the development of health and medical informatics in China. The first phase was primarily hospital information system focusing on financial and patient management; the second integrated HIS, PACS and telemedicine, while the third phase currently underway involves Electronic Medical Records, Personal health cards and community (regional) healthcare systems. The national government has played an important role in promoting the introduction of information technologies in healthcare, while the professional societies CMIA and CHMIA focus on the needs of their memberships in education, research, and practice.

The Chinese healthcare system is currently experiencing a number of challenges – soaring medical fees, lack of access to affordable medical services, low medical insurance coverage and a lack of penetration in under-developed rural regions. The government has been working on health reforms since 2006, with a new wave of health-care reform in 2009 aimed at establishing a "safe, effective, convenient and affordable" medical system to cover all urban and rural residents by improving four aspects of healthcare by 2020 as indicated in the pathways of Figure 1 [1].

Healthcare IT has become a very important part of the landscape of the whole reform policy. In the "Opinions of the CPC Central Committee and the State Council on Deepening the Health Care System Reform" published by The State Council of China in April, 2009, Information Technology for the first time becomes a part of the reform policy as a separate topic. The goal of Information Technology is to "Establish practical and shared health care information systems. Efforts should be made to energetically promote healthcare informatization. Focusing on promoting the informatization of public health, health care services, medical insurance, drugs, financial regulation, etc., efforts should be made to integrate resources, strengthen the construction of information standardization and public service information platform, and gradually realize unified standards, high efficiency and interrelated communications" [2].

China's hospital information systems over the past twenty years, have evolved from single-computer, single-user to departments and enterprise level management information systems; from silo accounting, drug dispensing and administration to clinical decision support systems and the electronic medical records; from applications within single hospitals to the regional EHR solutions. Compared with hospital information systems in developed countries, Chinese hospitals are progressing well by using state of-the-art technology in their applications but there are still notable short comings.

The China healthcare IT market promises to expand considerably, as hospital computerization is one of the key components of national strategy and planning [3,4,5]. The HIT industry in China is facing unprecedented opportunities and challenges in which human resources play a critical role. The development of modern medical science

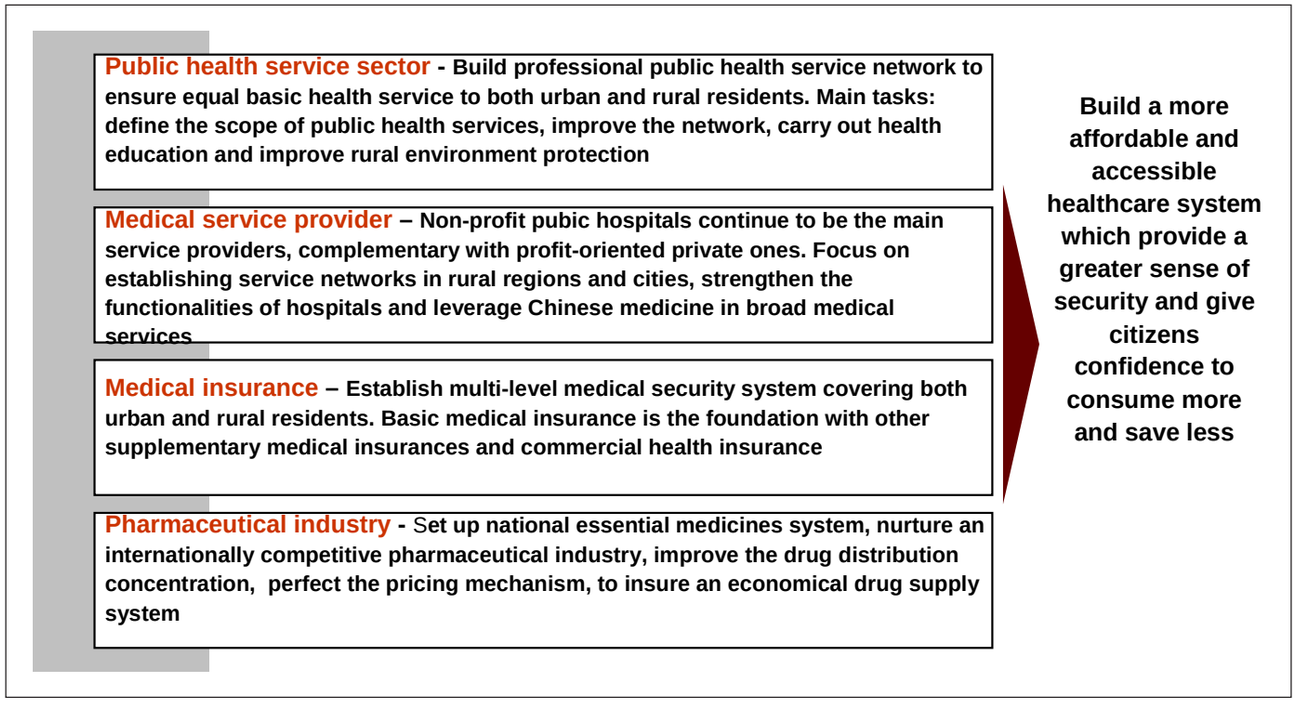

Fig. 1 Perfecting four aspects of healthcare system

requires enhancing the education and training of a clinical workforce that can take advantage of the emerging information society. Yet, at present, healthcare in China lags behind other industries within the country or compared with the international healthcare industry. HIT specialists need to have mastered both healthcare and IT, and health computerization in China requires many more such interdisciplinary people than are available at this time, and the government, educational, and healthcare institutions are beginning to invest resources to solve this gap. According to the China Hospital Information Management Association (CHIMA) survey, 80% of hospitals have established an information or computer center which employ from 5 to 10 professionals. The nation's higher education plan has stipulated a Reference Plan for Computer Curriculum System of Medical Science. Some medical schools are offering health informatics graduate programs. The Talent Center of the Ministry of Health has already added computerization to training courses attended by hospital management (76 credit hours). The approval for a new position - a Health Information Manager - is well under way. Many seminars, training courses and online distance learning programs are available to train more talent related to hospital computerization. On the one hand, a large number of health-care information technology professionals need to be trained; while on the other hand, clinical professionals should receive training in IT. The need for training and maintaining a large pool of high-quality professionals makes human resources and IT-related education the two basic concerns that the health industry must address for a successful migration to modern healthcare information systems.

2. Method

This paper combines a brief overview of research and academic endeavors in China from CMIA with a more detailed overview summarizing results from two CHIMA projects: the HIT market annual survey and its Hospital information systems White paper project.

3. CMIA Overview of Research, Education and Standards

Research

Academic exchanges between international scholars and experts has been very beneficial to medical informatics in China [6]. Besides clinical informatics, bioinformatics, imaging informatics and public health informatics are all included in biomedical informatics more generally. Research ranges from the micro to the macro levels or from the molecular, gene, protein, sub-cellular levels, to the cellular, tissue, organ, organismal and population levels.

The virtual Chinese human female number 1 (VCH-F1) is a high resolu-

tion dataset of a standard Chinese female [7,8,9]. The VCH cadaver was frozen at -70°C, then cryomacrotomed into 8556 slices. The thickness of each slice is 0.2mm. The VCH data set consists of 150 GB of digital anatomic images, MR, and CT images.. The post-processing of the images involved image registration, background removal, image segmentation and ROI extraction, and the 3D reconstruction of tissues and organs. The reconstruction of VCH-F1 three dimensional model and ensuing projects are displayed for health science and anatomy education in the China Science and Technology Museum. With a flying-thru browser, one can observe minute anatomic structures from any angle of view, including from inside the body. Image-guided surgery planning and navigation also involve medical informatics [10]. In living donor liver transplantation, the volume of the potential graft must be measured to ensure sufficient liver function after surgery. A fast method has been proposed to segment the liver based on the hepatic vessel tree. By carefully selecting a projection plane, a 3D point can be fixed in the projection plane. This greatly helps in rapid classification and is used in living donor liver transplantation [11,12].

Tele-surgery is an interdisciplinary field involving tele-operate robotics and robot-assisted minimally invasive surgery, and has a very promising future. Key technologies include newly developed surgical robots, methodologies for localizing marks without physical contact for registration, video overlay and surgical simulation, video transmission and network communication. Stereotactic operations were performed with the frameless stereotactic instrument (named as CAS-R-2) manufactured in-house rather than traditional stereotactic frame, and 2011 patients aged between 0.2 to 89 years (with mean of 30.7 years) were retrospectively studied with CT/MRI image-guided frameless stereotactic surgery between January 1997 to April 2007. The accuracy of position and improvement of findings were observed and related to success in surgery. Compared with the traditional frame stereotactic operations, this method has advantages, such as releasing the patient's pain, is convenient for physicians, extending the range of indicators and increasing the safety and effectiveness of the operations [13,14].

The development of an updated, or modern Traditional Chinese Medicine (TCM) has resulted in a new subject called TCM Informatics, which combines TCM and information science. Its definition, kernel and extension have been explored considerably in China [15]. In addition, while some theoretical research on medical informatics from China has been published in international journals [16,17,18,19] more such fundamental research is needed.

Education

In many universities and colleges of China, medical informatics courses are taken by both undergraduate and graduate students who major in computer science, information science, biomedical engineering, and medicine. At several universities, master degrees and Ph.Ds are awarded in medical informatics, which has led to many textbooks published [20,21,22,23,24], as well as the translation of well-known international texts in the field [25,26]. CMIA has plans for certification and training for medical informatics. The program is expected to involve cooperation with The University of Texas Health Science Center in Houston. Three levels of certification are envisioned: primary, middle and senior level engineers, with both teachers and teaching materials to be made available. So far, however, the training plan is awaiting a more detailed study which would determine the actual demand expected from the job market in China – part of which can be seen from the CHIMA studies reported in the latter part of this paper.

Health Informatics Standards

Referring to ISO documents, standardization of information sharing in China is progressing steadily. It covers the fields of cross-industry and cross-region population and health information, healthcare card data, E-case history, long-distance diagnosis, medical image exchange and sharing, interface of medical treatment equipment, HIS/CIS, and medication E-business. It also involves liaison with ISO/TC215 (Health Informatics) so that the practice of healthcare and medical information systems follows the guidelines of health and medical informatics standards. The China National Institute of Standardization is in charge of the work. Mainly identical or modified ISO Health informatics standards are established as the China national standards, such as Health informatics - Public key infrastructure (PKI) - Part 1: Overview of digital certificate services, - Part 2: Certificate profile, - Part 3: Policy management of certification authority, and Health informatics - Patient health card data - Part 1: General structure, - Part 2: Common objects, Part 3: Limited clinical data, Health informatics - HL7 version 3 - Reference information model - release 1, etc. [27,28,29]. To date 15 national standards for Health Informatics have been released in China.

Academic Activities of the China Medical Informatics Association (CMIA):

CMIA has organized many academic activities since its establishment, and held eleven National Medical Informatics Conferences (every three years) from 1981 to 2008. In October 1989, CMIA successfully sponsored the sixth World Congress on Medical and Health Informatics (MEDINFO-89) in Beijing. In the cities of Suzhou (1999), Beijing (2002), Shenzhen (2005),and Zhuhai (2008). CMIA sponsored the 1st, 4th, 7th, 10th China-Japan-Korea Joint

Symposium on Medical Informatics and held the 1st, 2nd Asian-Pacific Medical Informatics Summit in Beijing. In the year 2005, CMIA gave a reception for an American Medical Informatics Association delegation consisting of more than 20 people. This considerably enhanced knowledge exchange and cooperation between US and Chinese professionals in medical informatics.

Currently, CMIA has 5800 members and 31 specialized committees, most of which have similar activities to those of IMIA WG and SIGs [30], such as , for example the, Health and Medical Informatics Education committee, the Electronic Medical Records committee, and Medical Imaging committee, etc..

Given the fast development of the domestic health care industry in China, high level scientific research needs to be promoted, and international information exchange and cooperation need to be strengthened. As a member of IMIA, CIMIA intends to participate fully in its international activities.

4. CHIMA Summary of Survey and Hospital Information Systems

CHIMA has carried out a survey of the HIT market in China for the past three years based on a questionnaire of principal healthcare IT applications. Topics covered include hopstial personnel and department information, formalization and standarization, integration, safety and infrastructure usage and applications.

In the 2008 annual survey, CHIMA received answers from participants representing 1300 independent hospitals, covering 30 administrative regions. Participants are mostly CIOs responsible for the IT department of hospitals. The survey is similar in content to those conducted in other countries, such as the annual survey and report of HIMSS Analytics from the USA. Besides the survey, we have also leveraged the CHIMA 2008 research project "The White Paper on China's Hospital Information Systems", which is commissioned by the Informationization Leading Group Office of the Ministry of Health. CHIMA spent over a year researching and writing this Report, organized more than 10 workshops to capture the thinking of healthcare IT professionals—both positive and negative —to the top 10 topics of concern to the healthcare IT industry. In this project, Accenture provided input from their healthcare experts. This Report provides a thorough review of the current hospital computer environment and comments on the overall health information technology trends in China.

As in other countries, the typical hospital IT lifecycle falls into four stages: system planning & design, development & deployment, operation and maintenance, updates and upgrades. Continuous development and effective results of hospital information systems development require a strong organization and IT professionals, but the organizational setup and demand for talent vary greatly with different implementation models (especially for software implementation). In China, most hospitals purchase information systems from the market and outsource the implementation to the system provider, but then maintains it by itself. The scale of the information center is small, and while the scope of work is usually similar, the difference is that some hospitals also include responsibilities for the library, medical record management and statistics functions under the information centers. Based on the tasks of Information Centers, the HIT professionals need to be involved in the implementation and administration of the hospital information system (HIS).

Estimated Demand for IT Professionals and Factors Constraining IT Healthcare in China

Healthcare IT workforce demand can be estimated from the number of China healthcare institutions and the average number of HIT professionals in them. Based on the 2006 Annual Health Statistics of Ministry of Health, the total number of hospitals is 18,703 [30]. This came from polling hospital Information Center directors based on their experience and classified by hospital size, when Grade III hospitals (with 800 beds and higher) needed 10 to 30 HIT professionals, Grade II hospitals (300-800 beds) needed 6 to 15, while Grade I hospitals (100 to 300 beds) needed 3-6 and unclassified hospitals needed 5 to 10 HIT professionals. The HIT professionals are defined as involving full time work, covering hospital IT system implementation, application and maintenance.

Based on this analysis, hospitals in China require a large number of IT professionals. If one includes outsourcing, HIT demand might be closer

Table 1 Estimate of Positions required by hospital computer network centers

Grade	Number of Hospitals	Positions	Demand Range	Average
Grade III	946	10-30	9,460-28,380	18,920
Grade II	5,156	6-15	30,936-77,340	54,138
Grade I	2,714	3-6	8,142-16,284	12,213
Unclassified	9,887	5-10	49,435-98,870	74,153
Total	18,703		97,973-220,874	159,424

to 200,000. Yet, the CHIMA survey of 1300 hospitals shows that that the actual number of healthcare IT professionals is much lower than that which is needed from the above estimates. The average number of the full time employees in IT departments in the surveyed hospitals is 6.7. This comes from 82.1% of the surveyed hospitals, where the number of full time employees in the IT department is below 10, and where in only 3.94% of the surveyed hospitals is the number of full time employees greater than 20 for 2008/2009. The lack of adequate financial support and competent personnel and medical information standardization are currently the major factors inhibiting hospital IT applications in China's hospitals. Among all the surveyed respondents on difficulties in developing hospital IT applications, 65.38% cited lack of adequate financial support as the number one inhibiting factor, while insufficient competent personnel (49.08%), lack of medical information standardization (41.92%), lack of quantification on investment return of IT applications (40.92%), lack of competent suppliers in providing satisfied product and services (35.85%), as figure 2 illustrates.

Comparative Analysis on Healthcare IT Professionals between China and other Developed Countries

Hospital information systems are complicated since the industry itself is very complex. Specially trained professionals are required to implement and operate these systems requiring much more intense knowledge of the domain than do IT professionals in other industries such as banking, taxation and insurance. The CHIMA survey points out that the lack of human resources is seen as the second most important barrier to computerization. Hospitals of Grade III and below agree on the shortage of IT personnel [31].

There is a big gap between the healthcare industry in China and that of other developed countries. According to the 2008 HIMSS Analytics Database, IT departments in hospitals in the United States had an average of 24 IT Full Time Employees (FTEs)[32]. As shown in the HIMSS 2006 survey on full-time employees of hospital IT departments, 80% of hospitals have 10 or more employees, and 31% have over 50, while in China, only 4% employ over 20 and 82% employ fewer than 10 [33]. Among the HIMSS survey questions under the major barriers to Computerization column, "human re-

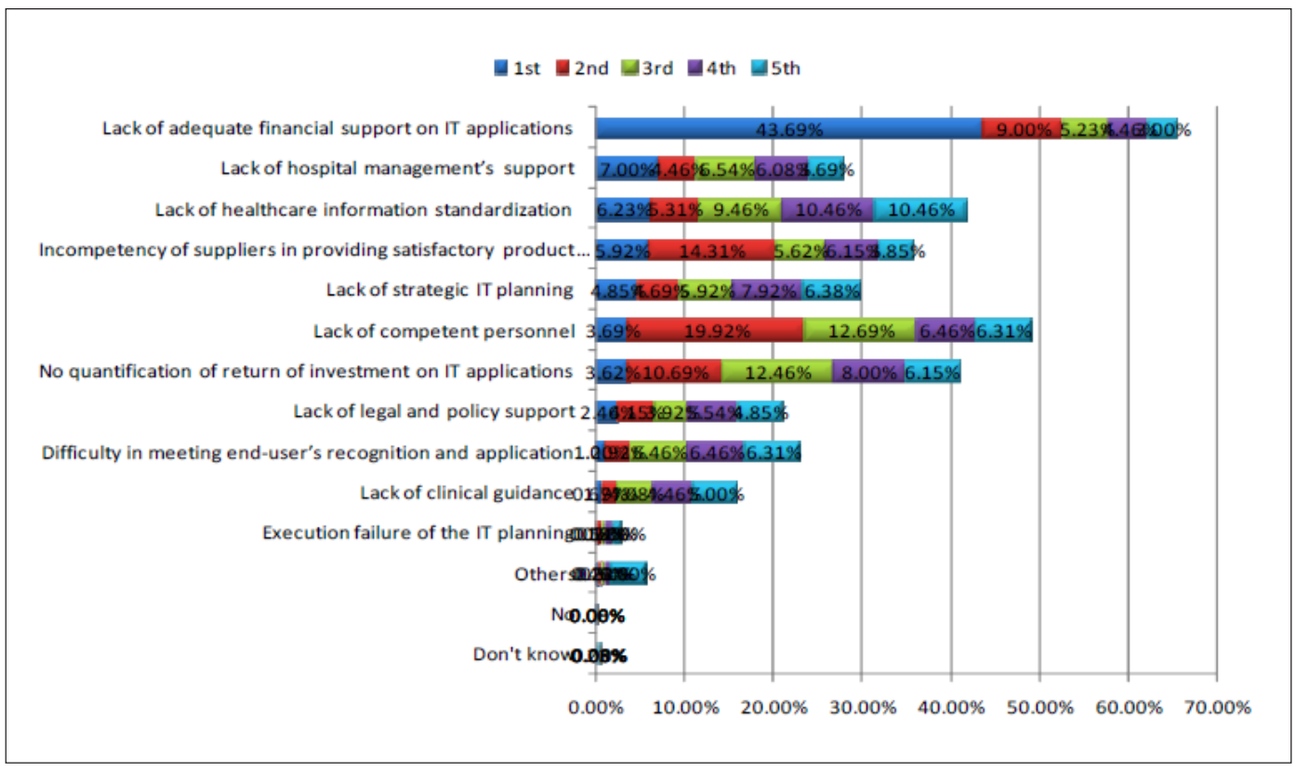

Fig. 2 Rank of main difficulties constraining hospital IT application development

sources shortage" was over the past four years listed as one of the top ten barriers; in 2006 it was also listed as the second highest barrier. However, the degree or seriousness is very different. The shortage of hospital IT professional in China is considerably greater.

In the United Kingdom, there are about 100,000 physicians, 380,000 nurses and 50,000 other medical professionals. According to the National Health Services (NHS) statistics cited in MOH's strategic plan for talent in 2002.[34] HIT professional account for 4% of medical professionals. The MOH also stated in the report that education plans should be prepared to solve this shortage problem. Based on Ministry of Health statistics [35], in China there are 1,938,272 physicians, 1,3495,89 nurses and 1,710,849 other medical professionals including pharmacists, technologist and administrators. The number of HIT professionals should therefore be about 200,000 based on the ratio cited, which also corresponds to the number estimated in Table 1. The survey shows the number of current IT professionals is far from the adequate number of persons required. The composition of the HIT professionals in UK and China is also different. China is especially weak in knowledge management and clinical informatics, since HIS still focuses in China on billing functions, and is just beginning to get into the clinical information stages. Also CIOs in China hospitals often are reported to be short of strategic planning skills, focusing more on software and hardware maintainance.

5. Conclusions and Future Directions

The status of biomedical informatics and Healthcare IT is undergoing rapid change in China. Demand for IT professionals from 18,703 hospitals requires a large increase in current personnel. Compared to other developed countries, China is constrained in what its hospitals can do to improve quality and reduce costs through information technology due to the shortage of trained personnel. The current supply of university trained graduates is unable to meet demand, as their knowledge, education levels and experience are not well matched to real hospital IT tasks.

Based on interviews with stakeholders and workshops with industry thought leaders, this is largely due to the government and academic system not having recognized the importance of informatics and the impact of IT on the healthcare industry in the past. As a result, the career paths for HIT professionals are not well defined, and salaries are uncompetitive. From the CHIMA survey, almost all hospitals claim it's difficult for HIT departments to hire and retain quality personnel.. In addition, there are few formal health informatics programs, available through the higher education system. Only a few universities offer health informatics master programs, but the courses does not align with the health IT market expected skill sets; and many teaching professionals in universities have not had hands-on experience. In summary, in the one hand, the market cannot get qualified professionals, and on the another hand the schools are not educating the students to match the demand. Considerable effort will be needed to change this critical shortage of professionals.

Besides the many practical policy issues that need to be addressed, it is clear that biomedical and health informatics should be added to medical research and education system as soon as possible. Medical universities should offer health informatics majors and degree courses so HIT professionals can be trained more adequately to meet current and future demands, and the Ministry of Health can help select outstanding research and education institutes and allow them to offer master and doctor degrees in health informatics. The experience of industry experts with to train and groom HIT specialists such as CIO, system planer and analyst, health informatics researchers and teachers can also be called on, while incentives to encourage academic societies and HIT professionals to actively participate in writing education materials like textbooks would be a great advantage.

Continuing medical education plans would also benefit from including IT components as more healthcare professionals find this an essential field of knowledge already. Establishing examination standards for different levels and conduct training and subsequent evaluations will aso be critical, while support seminars, training courses, online teaching programs for training staff in information technology applications should become routine.

Promoting the exchange of international biomedical informatics and HIT professionals and sponsoring qualified students and teachers to study abroad to upgrade the workforce in healthcare informatics and IT will be essential for long term progress in the field.

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