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RESEARCH ARTICLE

Healthcare Informatics Research: From Data to Evidence-Based Management

Thomas T. H. Wan

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Abstract Healthcare informatics research is a scientific endeavor that applies information science, computer technology, and statistical modeling techniques to develop decision support systems for improving both health service organizations' performance and patient care outcomes. The analytical strategies include (1) the formulation of a data warehouse for exploration, (2) data mining, (3) the application of confirmatory statistical analysis, (4) simulation via an interface with computer and information system technologies, and (5) translational research. Healthcare informatics research will help to direct evidence-based strategic management.

Keywords Health care informatics research · Evidence-based management · Analytical strategies · Performance improvement

Introduction

In recent years there has been an explosion of evidence-based medicine (practice), as the direct result of several factors: the aging of the population, rising patient expectations and professional expectations, the proliferation of new information technologies, and the growth of disease management modeling [1]. Massive amounts of clinical and administrative data have been gathered. Little has been done, however, to build the relational databases that can generate information for improving health care processes and outcomes. Such systematic information is needed to build a repertory of knowledge for the use of policy decision makers, providers, administrators, researchers, and patients. Evidence-based knowledge gives users a competitive edge in making policy, clinical, and administrative decisions that improve personal and public health [2]. Furthermore, organizational improvement also will be facilitated by the knowledge gained from best-practice modeling and multivariate modeling of the determinants and the consequences of managerial interventions or strategies.

T. T. H. Wan (✉)
Professor of Public Affairs, Health Services Administration and Nursing, and Director of Doctoral Program in Public Affairs, College of Health and Public Affairs, University of Central Florida, Orlando, FL 32826–0544
e-mail: twan@mail.ucf.edu

Healthcare informatics research

Informatics is a general term that describes the process of data warehousing and data mining [3]. Healthcare informatics research is a scientific endeavor that applies information science, computer technology, and statistical modeling techniques to develop decision support systems for improving both health service organizations' performance and patient care outcomes (see Fig. 1).

The philosophical foundation of informatics is the commitment to knowledge-based or evidence-based decision-making. Decisions that previously had relied on guesswork or instinct now can be aided by data-driven reference points that clarify thoughts and process. That transformation can perhaps best be explained through real life applications of informatics. In health-related sciences, such examples fall into these groups, which are not mutually exclusive: medical events, creation(support of infrastructure), and education.

The health care system is the usual first line of response to medical events, whether of great or less severity. Informatics by identifying sentinel events and leading to analysis can avoid potentially devastating consequences. An example of that potential can be seen in the response to the 2001 bioterrorism attacks. During September 2001, anthrax spores were traced to postal facilities in Trenton, New Jersey and Brentwood, Washington. Epidemiologists faced a daunting task: the New Jersey facility was a facility of 281,387 square feet, staffed by 250 workers per shift and processing over 2 million items of mail per day [4]. Informatics helped to identify the individuals who might have been exposed to anthrax, monitored the screening process, and recorded who received antibiotics and distribution of known cases and known deaths. In addition, informatics guided the recommendations for follow-up procedures

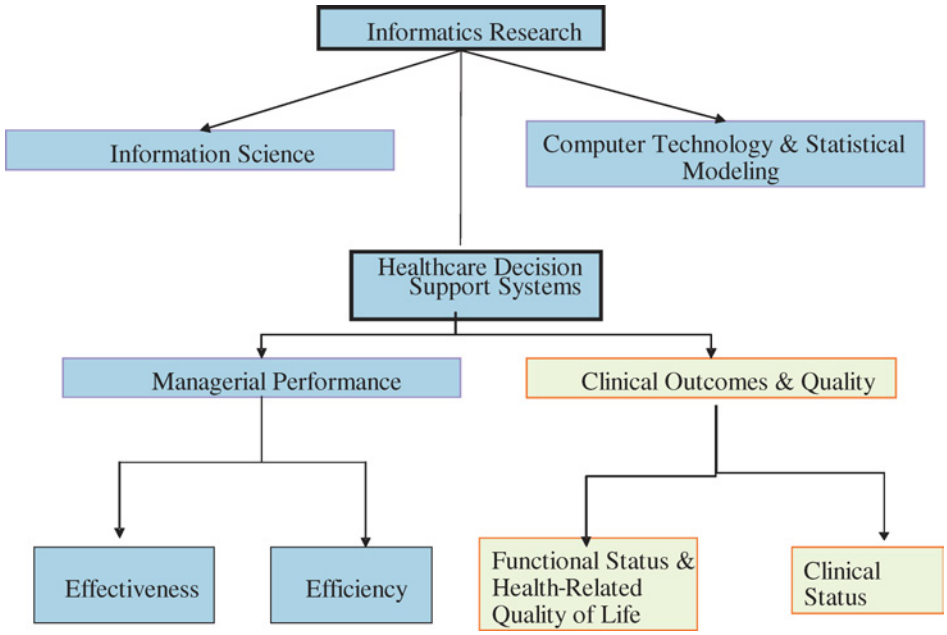

Fig. 1 Healthcare informatics research

[3]. Authorities had available a visual representation of the anthrax threat (using GIS software), which assisted the criminal investigations [4].

In exploring the important role that data can play in responding to a range of sentinel events, one development has been to identify means of recognizing "clusters" of illnesses in the health system. For example, victims of bioterrorism may exhibit short-term, generic symptoms such as respiratory irritations before their condition deteriorates, but such indicators may be ignored by health services. Informatics can provide the ability to recognize a "signal" of impending catastrophe over the "noise" of regular operations [4]. The Department of Defense now relies on automated medical records to detect such threats; its system is called ESSENCE or the Early Notification of Community-based Epidemics [5].

More significant for normal circumstances is informatics' usefulness in identifying and reducing medical errors. In 1999, a report by the Institute of Medicine estimated that between 44,000 and 98,000 people die every year as a result of medical errors [6]. An investigative group, Medstat, reviewed the present error-reporting systems and discovered all to be inadequate due to fragmentation [6]. A key recommendation of the Medstat report was that systems be integrated into one cohesive, manageable system that would enhance error-reporting efforts and provide more accurate data.

Informatics can also be used by the chronically ill via information and communication technology (ICT). Using an ICT system, the chronically ill can monitor their health (blood pressure, sugar levels, etc) at home while participating in a telemedicine videophone consultation with a qualified health professional. The system, which reduces health care costs, is described as "a patient-managed Home Telecare System with integrated clinical signs monitoring, automated scheduling and medication reminders, as well as access to health education and daily logs" [7]. Similar systems exist for the elderly (ARAMIS) and for people with HIV(AIDS (CHESS) [8].

Besides identifying medical events, informatics can now guide the development of infrastructure. The Healthcare Cost and Utilization Project (HCUP), a public–private partnership, is using informatics to assemble a health care data system across the entire United States [9]. Clinical and administrative datasets are being merged into a single HCUP database that is used to assess the quality of care, and to analyze the use and cost of hospital services, medical treatment variations, the diffusion of new medical technology, the consequences of health policy changes, access to care (inference), small-area variations, and the care of special populations [9]. Recently, the HCUP data were merged with the Survey of Integrated Healthcare Systems data, compiled by the Dorenfest Information System, Inc., to analyze the effects of informatic integration on efficiency and on the quality of care [10, 11]. An astonishing result is that informatic integration is associated with better health care outcomes.

The National Health Service (NHS) in Britain recently adopted a policy to improve the data quality of patient electronic records (EPR) [12]. Governing bodies like the British NHS have requirements for accountability in governance; an effective method for organizations to support their decisions is the analysis of good quality clinical information. Informatics has been the tool for transforming pen and paper patient records into a manageable database. In a similar example of its usefulness, although the Hellenic National Health Service in Greece has a treelike managerial structure in which regional areas maintain autonomy, informatics enables effective communication within the system [13]. Confidential health records are securely transmitted from

health care providers to private pharmacies and insurance companies [13]. Nor is informatics unique to economically advanced nations: Papua New Guinea has developed a functional health infrastructure despite the provincial differences due to regulation [14]. In all of these examples, informatics has been used to construct and maintain an infrastructure that preserves the integrity of the health care system.

Informatics can also assist with education in health care. Exploring that possibility, a recent medical conference featured delegates from 18 different countries who sought the advice of medical professionals on the role of infomatics in their practices [15]. It was explained that informatics is efficient for rapid retrieval of information, scheduling appointments and monitoring repeat prescriptions [15]. Some members of the panels also utilize informatic technology to develop evidence-based medical care, though the busy practitioner environment often leads to having that development completed outside the office.

The potential for evidence-based medicine is also being developed in the United States. For example, MedReach is described as "an ambitious attempt to provide timely, convenient access to medical information resources for physicians and other health care practitioners in northwest Ohio" [16]. Health professionals who previously have read journal articles or textbooks for information can now find quality data from the Internet without being overwhelmed by superfluous information. Although MedReach is a new project, it has revealed significant potential for efficient transmitting timely, quality medical information to health care professionals.

Analtycial strategies in healthcare informatics research

Healthcare informatics research is a systematic process of compiling, analyzing, and simulating data to produce verified and replicated findings from observed facts or phenomena. The analytical strategies include (1) the formulation of a data warehouse for exploration, (2) data mining, (3) the application of confirmatory statistical analysis, (4) simulation via an interface with computer and information system technologies, and (5) translational research (see Fig. 2).

Data warehousing is the systematic structuring of data within a theoretically informed framework shared by the disciplinary focus, to produce useful information for exploration. Analysts extract from multiple sources, build a relational database that is constantly maintained and updated, and classify and populate the study variables uniformly under a nosological or classification system.

Data mining is the use of a myriad of exploratory and confirmatory statistical techniques to translate masses of raw data into valuable information for decision makers. Benefits of data mining are observed in (1) understanding the patterns of care or services; (2) identifying causal paths or root causes for problems in service delivery; (3) profiling the best practice models, (4) establishing benchmarks for continuous performance enhancement; and (5) differentiating

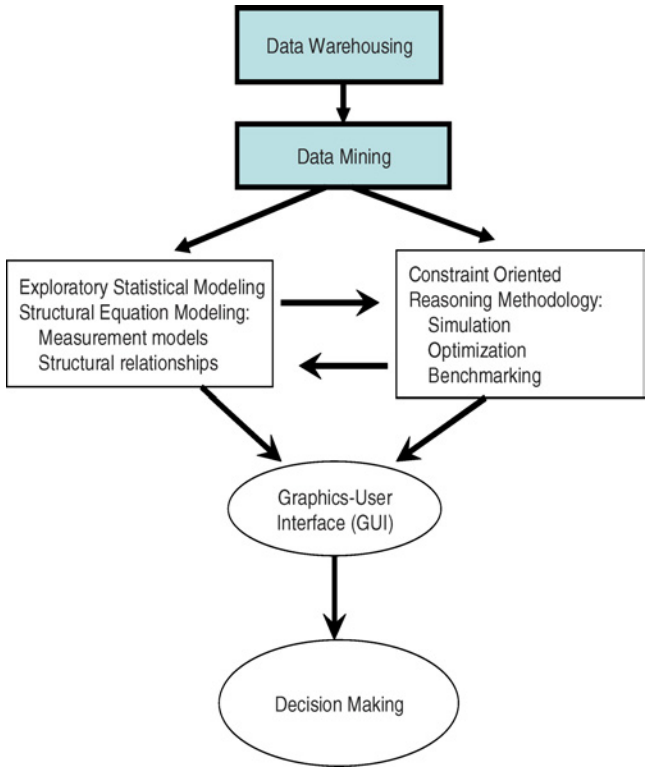

Fig. 2 Analytical strategies of healthcare informatics research

the mechanisms for achieving high performance in a healthcare delivery system.

Simulation and optimization methods should play an important role in research on health services and management. Healthcare informatics researchers build interfaces between analytical modeling and operations research. Graphics–user interface (GUI) presentations should be developed, so that simulated results can guide managerial and clinical decision-making.

Translational research plays an important role in converting scientific knowledge into routine medical and managerial practices. With the aide of healthcare informatics research, practitioners, healthcare executives, and policy decision makers can rely on evidence-based knowledge to improve the efficacy and effectiveness of health care services.

The most important use of information and communication technology is to enhance the healthcare information infrastructure so that the quality of patient care will be improved and the improvement sustained. The Committee on the Crossing the Quality Chasm, Next Steps toward a New Health Care System strongly advocates that at the point of care, the clinician and the patient review the results from the scorecard together and then use scientific knowledge to decide together on continuing care [17].

Significance of healthcare informatics research

From 1992 to 1996, I had the pleasure of serving on the National Committee on Vital and Health Statistics (NCVHS)

in the United States. This advisory committee, appointed by the Secretary for Health and Human Services, pursues the long-term goal of enhancing the nation's healthcare delivery system through the use of information technology [18]. In one of its recent reports the Committee emphasizes the necessity for a comprehensive National Health Information Infrastructure (NHII) to ensure quality health care for all Americans who access care. The final report of the NCVHS Workgroup is entitled *Information for Health: A Strategy for Building the National Health Information Infrastructure* (November 2001). The report outlines a process for mobilizing institutional and technological factors to support health decision using a comprehensive national health information infrastructure.

Considerable progress has occurred through these initiatives led by the Department of Health and Human Services: the Consolidated Healthcare Informatics Initiative, the licensing agreement with the College of American Pathologists for SNOMED-CT, the recently concluded NHII 2003 Conference, and the appointment of a Senior Advisor on the NHII. Never the less, in the absence of systematic efforts to build interdisciplinary research on healthcare informatics and performance improvement, the quality gap will remain. The Curriculum Development Award in Interdisciplinary Research, initiated by the Department of Health and Human Services, is particularly timely. The award will foster the development of evidence-based health care, in both practice and management.

The health care system is changing to one in which good evidence is both available and actually used to stimulate effective performance by health care providers and organizations. That inevitable transformation is reflected in the institutionalization of healthcare informatics research as a specialization or profession. The health care system's performance can benefit thereby from the best work in integrating multidisciplinary perspectives to generate evidence-based knowledge and decision support modeling. Thus both the quality of patient care and organizational performance can be improved.

There is no formal interdisciplinary training program for healthcare informatics and performance improvement in the United States. Demographic data on healthcare executives from the Health Information Management Systems Society suggest that a significant number of healthcare informatics experts will be needed to build a solid infrastructure of health information systems. Furthermore, a severe shortage of policy analysts in healthcare informatics is well documented in a series of reports from the National Committee on Vital and Health Statistics, USA.

The recommendations to health professions

Health professions should retool their skills and develop a healthcare informatics infrastructure. That will aid the efforts to improve patient safety, reduce costs, and enhance both the effectiveness and the quality of health care. In programs educating health services administrators, establishing an interdisciplinary training and research in informatics and performance improvement should result in a framework at both the predoctoral and postdoctoral levels. The formation of partnerships with leaders in the health care industry who may want to shape the research and educational agendas will yield fruitful results.

To summarize: healthcare informatics is an interdisciplinary field that draws upon knowledge from computer, information, cognitive, management and health care sciences. The field of healthcare informatics is defined as the study of computer and information science applications within the context of health care management to compile, manage, and process data and knowledge for delivering quality health care and improving the performance of health care organizations. Although the establishment of Health Informatics Training Programs at the universities is timely, I believe that the future of healthcare management will rely on healthcare informatics research and development. The important step forward is to promote data warehousing and data mining activities with massive clinical and administrative data, under the auspices of federal agencies such as the Centers for Medicare and Medicaid Services and the Agency for Healthcare Research and Quality. That is the necessity step toward achieving better integrated care [19]. It can also offer practitioners and policy makers evidence-based decision support. The health care system will then deal more effectively with significant medical events, infrastructure support, and the exploration of information technologies [1, 20–23].

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