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Binshan Lin
Louisiana State University

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Health care information systems management: Structure and infrastructure

Binshan Lin
Louisiana State University

ABSTRACT

The practice of medicine is inextricably entwined with the management of health care information system (HCIS). Major problems with HCIS are that it has not evolved from the needs of end users, and lacks of an organizational base to manage the HCIS in the health care environment. The object of this paper is to examine a direction to effectively support and enhance the health care activities through managing HCIS. An integrated focus is provided through a framework for analyzing the structure and infrastructure of HCIS in hospitals.

INTRODUCTION

Information is the life blood of any health care organization attempting to manage problems. Health care professionals recognize that a large percentage of their activities relates to information management. As health care facilities become more information-intensive, more managers find that the practice of medicine is inextricably entwined with the management of health care information system (HCIS) (Association, 1984).

Much progress in information technology has been realized by the application of computers to organizational problems, which lies outside the field of health care (Banta, Cimino & Hupp, 1987; Eckerson, 1991). Earlier fears that computers could replace physicians have not been borne out, and computer-based information systems are likely to remain decision support tools rather than substitute decision makers (Shortliffe, 1989). HCIS not only creates and processes health care services, it also creates and processes information linked through computer systems and available to each workstation. These developments mean that HCIS no longer needs to simply deliver information; it has the potential to take on the driving role and manage various functions in the health care environment.

The HCIS environment can be characterized by distributed processing, heterogeneous networks, and advanced user interface (Livingston, 1991). Major problems with HCIS are that it has not evolved from the needs of end users, and lacks of an organizational base to manage the HCIS in the health care environment. The object of this paper is to provide a direction to effectively support and enhance the health care activities through managing HCIS in a hospital. A primary concern in such efforts is the recognition by managing the structure and infrastructure of HCIS which could help hospital managers appreciate and manage information resources effectively. This paper is organized as follows: Sections 2 and 3 discuss the structure and infrastructure of HCIS in the hospital. Section 4 sttempts to characterize the key applications of HCIS. Section 5 addresses the information policy issues in HCIS.

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THE ORGANIZATION STRUCTURE OF HCIS

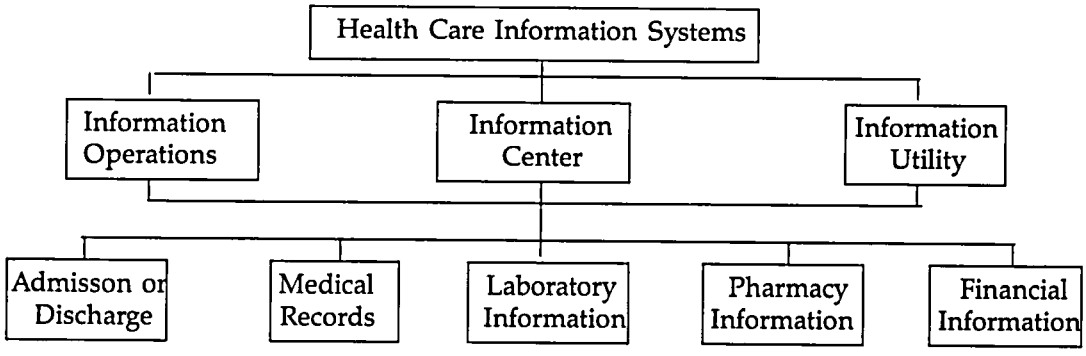
In this seciton, we seek ways of understanding what HCIS is in the organizational context and how HCIS emerged and evolved in the health care environment. To achieve this aim, two major organization structures of HCIS can be identified: (1) information center, and (2) information utility.

Information Center

An information center is defined as an organizational unit that facilitates the transformation of data into information that managerial, professisonal, and support staff can use to solve problems (Christoff, 1990). The concept of the information center was introduced in 1976 by IBM Canada. In its original conception, the information center was a portion of the information system's development resource organized and dedicated to support the users of the information services. Historically, the information center has been demand-driven rather than business-driven. Rapid increases in technology use have caused changes in the information center concept. The information center concept has evolved through two different phases: (1) an effort to deal with mainframe processing bottlenecks, and (2) an effort to demonstrate and train end users in microcomputers (Head, 1985).

Figure 1 illustrates an organizational placement of HCIS. The information center is typically part of a larger function, such as the information systems division, but interfaces with all other computing resources. It is becoming increasingly common to establish an information center as a separate entity headed by a corporate officer responsible for HCIS at a very high level in a hospital.

Figure 1. Health Care Information Systems Organizational Placement



The main functions of an information center are: (1) to provide assistance to end-users in dealing with computing problems, (2) to provide general technical assistance, and (3) to provide general support services (Jacobson & Cardullo, 1983). Typical services provided by the information center of HCIS include overviews of clinical information enhancements, information requirement analysis for new information service demands, evaluation and selection of microcomputer hardware and software, and installation, training, and maintenance of HCIS.

Information center has applications in geographic locations. The physical structure of the organization plays a key role in enhancing or impeding the informaiton flow between groups both within and across functions (Allen, 1977). Since a HCIS will be used by individuals who have the right to know, close attention must be paid to the actual physical location of the system's users and how these users will be served by the information center. In order to encourage hesitant users to interact with HCIS in a friendly environment, the information center may be positioned as an information resource area of the organization.

Due to their close association with end-user computing, information centers have begun to receive a great deal of attention. Information centers were designed to provide several service functions for end-user computing (Carr, 1987). The crucial characteristics of the information center staff is that they have both hardware and software expertise and are user-oriented. The information center's role in facilitating and managing this burgeoning segment of computing activity has become crucial to the welfare of the entire corporation (Henderson & Treacy, 1986).

In HCIS, information centers are trying to define and justify their role in the area of end user computing. The new missions of information centers in hospitals are: (1) to ensure the competitive use of information technology, (2) to provide cost-effective utilities, and (3) to facilitate organizational flexibility. This suggests a transition from the support role of information center to a more management-oriented role in the health care environment.

Information Utility

The impact of HCIS is already visible in many hospitals where computers are playing an increasingly important *coordinating* and *supporting* role as compared to human elements. The common themes among information utilities are: (1) coordination and (2) support. Coordination can be defined as the additional information processing performed when multiple, connected actors pursue goals that a single actor pursuing the same goals would not perform (Malone, 1988). Coordination is the functionality between the business units and corporate strategy, across the business units, and across functional areas in hospitals.

HCIS needs to seek opportunities to work with task forces and to take accountability for pulling various clinical and management skills together. To provide good health care, physicians must have patient information brought together like it came from one centralized resource. In this context, coordination holds three features: (1) an information utility created a new patient services unit to give its biggest patients a single contact point; (2) an information utility is applying the Just-In-Time strategy to its health care operations; or (3) an information utility may provide services that each business unit reaches entirely different patients, and uses different types of utilities in HCIS.

Two dimensions of support can be identified: quality and variety (Oglesby, 1987). While quality is closely related to support staff, variety is related to the services offered by the HCIS structure. Quality of support can be represented as completeness, availability, cooperativeness, and responsiveness of support staff (Buyukkurt & Vass, 1988). Variety of support implies that the information utility should provide a wide range of services such as on-line training, information project development, assistance with the use of software, health care data extraction, consultation of health care service, and diffusion of public information. The most important identified HCIS benefit could be the quality of care a hospital provides.

Quality service requires closer links among design, operations, and service activities. Information utility is the glue of these integrated business activities in the hospital. Information utility supports the coordination of HCIS information flow and storage. It also helps to process and analyze the control information, the portfolio of decisions made by the organization, and the incoming information. Moreover, information utility serves to integrate all types of health care information into a coherent picture and to manage the decision-making activities over time.

One way to measure the information utility's growth is with a three-stage growth model, which consists of initiation, integration, and maturity stages (Henderson & Treacy, 1986). Emphasis in the initial stage is placed on education and organizational support, whereas the integration stage is concerned with the standardization of information technology and strategic planning activities. The maturity stage focuses on the improvement of the organization's competitive advantage.

HCIS INFRASTRUCTURE

An infrastructure is an underlying base or supporting structure. As this concept applies to HCIS, it means the support personnel and tools which justifies itself only when it remains flexible enough to respond to changes in the health care environment and major shifts in information technology. This issue focuses on the implementation of the diverse computers, operating systems, networks, core databases, and mission critical applications needed by the health care organization.

HCIS infrastructure serves as a kind of blueprint for specific implementations of HCIS in the hospital, offering a whole picture perspective on the implications of a system. Baxter's ASAP infrastructure to provide stockless-inventory to hospitals realizes its ability to exploit the information processing capabilities relating to its understanding of the stock-levels in different locations within a given hospital (Vitale, 1986).

The domain of information infrastructure can be defined in terms of two dimensions: (1) architecture — choices pertaining to applications, data, and technology configurations (Parker, Benson & Trainor, 1988); (2) process — concerned with the work processes central to the operations of information systems, including processes for systems development, maintenance, and control systems (Rockart & Short, 1989). In the dimension of architecture, an infrastructure provides a proactive basis for HCIS development as opposed to the reactive backlog approach common in many organizations. Thus, information about existing applications must be mapped to business functions. This involves gathering information about the functions provided by existing systems and how well they meet the organization's information needs.

In the second dimension, the infrastructure relates the health care processes that must be performed to data classes that are required by those processes. It also represents the information flow requirements of the entire health care organization. By establishing infrastructures the organization can reduce burdens of information processing because search procedures are automated to some extent in the standard operating procedures (March & Simon, 1958).

As the infrastructure becomes more highly developed, nontechnological aspects of strategy become more critical in overall hospital effectiveness. Ultimately, the effectiveness of HCIS will depend on its consistency with other aspects of hospital strategy. Most hospital managers appreciate the logic of having a HCIS infrastructure that supports corporate goals. However, many existing HCIS infrastructures reflect the *ad hoc* developments of enthusiastic individuals rather than edicts of a cohesive corporate plan. A shared vision of what is required and how it is to be achieved, along with the commitment from senior management, are crucial factors for success in HCIS. The hospital must maintain continuous communication with other health care organizations involved in the process of HCIS invention. This requires a series of transactions involving information about the state of the art, systems assistance, and transfers of the information system itself.

The evolving process of HCIS is a *learning* process. The challenge of hospital management is not only to learn to live with new technologies, but also to evolve the development of HCIS. The major benefit for information technology lies in its catalytic effect, promoting or indeed forcing changes throughout the rest of the organization (Clegg & Corbett, 1987). It is crucial to mention that HCIS is itself semi-autonomous systems, which have the organization as part of its environment, and so HCIS can evolve a disposition towards the organization, as well as to the rest of the health care environment. For example, many hospitals are recently bringing in information systems managers from outside the health care industry to modernize their HCIS infrastructure.

HCIS APPLICATIONS

HCIS is increasingly intrinsic to the organization's proper functioning, serving a critical mission in hospitals. HCIS becomes providing company-wide computing - which is to say that HCIS lies at the heart of the health care organization - including patient test results, physician management reports to billing, and the major patient care areas, such as radiology, laboratory, pharmacy, medical records, and nursing. HCIS can serve to support the delivery of health care or aid in the analysis or evaluation of health care delivery. The rapid growth in computer technology is related to three trends in health care: the growing appreciation of the wide range of possible uses of this technology, the tremendous growth in information, and the rapidly evolving technologies themselves (Kulikowski, 1983).

Many advances in information technology could become potent forces leading to changes in the future health care environment: (1) networks for communication within the hospital and with the outside world; (2) huge mass memories for the storage of medical records, data, and literature data bases; and (3) powerful microcomputers for automation and personal computing (Van Bemmel, 1985). Many hospital systems take advantages of the computer's data acquisition and interactive multimedia capabilities of graphics, sound, animation, and linking to videodisc images. In general, HCIS includes four major features: (1) network, (2) coordination, (3) decision, and (4) monitoring.

Network. With pervasive, multiplatform networking, HCIS is becoming a store of knowledge and a channel for communication. This change is apparent in the growing concern for sharing data through efficient but secure database management, and in a growing emphasis on interactive queries rather than standard reports. Networks of HCIS between institutions, health care workers, and private individuals will permit a continuous flow of information with feedback (Spyker, Stier & O'Dell, 1984). American Hospital Supply Corporation has developed an information network, called ASAP, that features terminals in customer hospitals (Vitale, 1986). ASAP enables the hospital's staff to order supplies directly and receive an immediate order confirmation and delivery date. Integrated Academic Information System (IAIMS) is another network which has been used to ease the flow of health care information to 5,000 physicians, nurses and academic researchers (Livingston, 1991).

Historically, network technology management has moved through three stages: (1) the operations era, (2) the internal utility, and (3) the coordinated business resource (Keen, 1989). Each of these entails various requirements, experience and skill base, technology, and managerial perspective on the use of computer-based networks. Several computer-based networks have developed between the various health care providers, including national or regional systems, not only for epidemiological studies, planning, management, and evaluation, but also for consultation (Mohan & Caley, 1983).

Coordination. One application of HCIS is the systems can provide vehicles through which interested physicians may have input to the health care service coordination process and encourage their involvement. Many hospitals are recently considering emerging HCIS standards, such as Health Level 7 and Medix, to integrate and coordinate disparate systems (Eckerson, 1991). Another example is the drug delivery system, a term that has come to refer to any of several current or potential information technologies for administering drugs, whether implanted or external, continuous or intermittent (Check, 1984). Delivery systems, such as pumps and implantable reservoirs, are already in use for coordination of delivery operations in many hospitals.

Decision. HCIS features, including links to existing hospital databases and on-line literature sources, and automatic report generators, will allow doctors to enter requests for test results and receive readouts in a timely manner. Decision support software will also be available on-line, to aid in diagnosis and determination of appropriate treatment. Some diagnostic assistants (such as DXplain) (Barnett, Cimino & Hupp, 1987) suggest differential diagnoses or indicate additional information that would help to narrow the range of etiologic possibilities. Another system (such as QMR) (Miller, McNeil & Challinor, 1986) suggest a single best explanation for a patient's symptomatology.

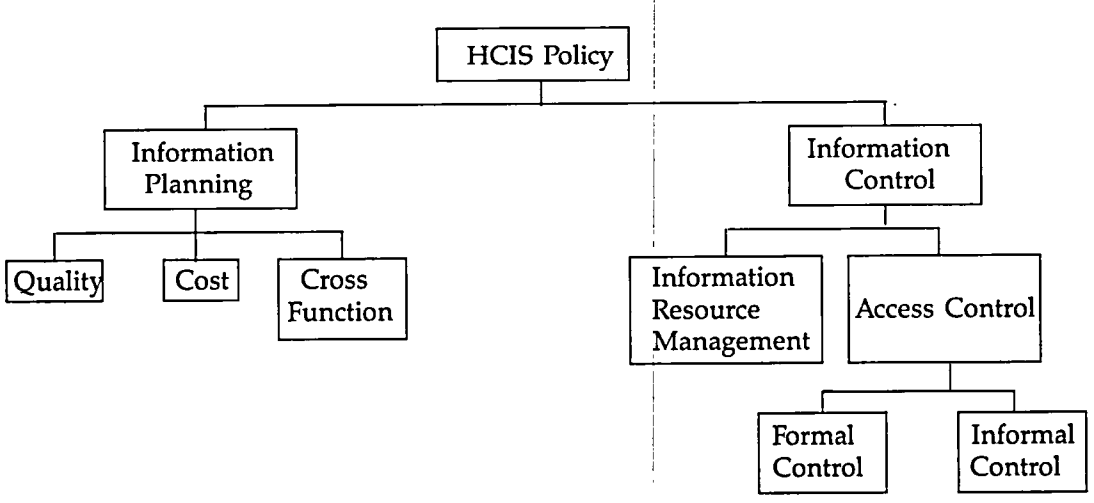
In the HELP system, physiological data, including systemic arterial blood pressure, pulmonary artery pressure, cardiac output, and core temperature, are all recorded automatically (Gardner, West, Pryor, Larsen, Warner, Clemmer & Orme, 1982). The system acts as an adjunct to physicians' own knowledge bases and helps them act in accordance with their decisions. A computerized nursing care plan has been developed utilizing HELP to aid nurses in effectively providing consistent quality care to patients (Johnson, Ranzenberger & Pryor, 1984).

Monitoring. HCIS can be used to monitor the status and quality of health care operations and/or health care industry trends. In hospitals, monitoring and evaluation can be improved through the collection of routine operational data within HCIS. Hospitals can use HCIS to track nurses' performance (Helmer & Suver, 1980). Such a system relies on the integration of two kinds of functions: data base management and statistical analysis of data. Many aspects of medicine could be well served by a simple method to assess the outcome of care in specified groups of patients (Janssen, Viste & Gluck, 1990). The rapid increases of patient monitoring in the home base (Zimmet, Gerstman, Raper, Cohen, Crosbie, Kuykendall, Michaels & Hartmann, 1985) is just another example of HCIS. HCIS that works to provide appropriate service to patients in their home seem good for all parties - patients, those who pay for health care, industry, and government.

INFORMATION POLICY ISSUES

Some policies may smoothe the path for HCIS adoption and encourages end user computing; others may affect computing costs or bear on fundamental concerns such as information control and security. These policy issues are usually crucial to the hospitals in the long run and they warrant attention by senior managers and others. Information planning and information control are the cornerstones of the HCIS policy. Their outputs align the HCIS strategic direction with the hospital's strategic business direction. Without proper planning and control, end-user computing may reinforce the organizational status of potentially redundant functions or positions. Figure 2 illustrates these two HCIS policies.

Figure 2. Two Major Issues of HCIS Policy



Information Planning in HCIS

The strategic planning in HCIS should focus on an understanding of how an effective planning process is carried out rather than just studying a myriad of issues related to the process. This focus provides a vehicle for evaluating the planning process. This philosophy holds to the viewpoint that HCIS is developed to support management decision making, enhance service differentiation, reduce costs and increase revenues, and enlarge market share. Rackoff (Rackoff, Wiseman & Ullrich, 1985) proposes five basic thrusts of a strategic plan, namely differentiation of service, cost control, innovation, growth control, and creating market alliance.

The investigation of information planning had the crucial effect of creating a vision for managers involved in HCIS: to make more creative use of the information systems, thereby improving their own managerial effectiveness. A HCIS is not just a system, it s a service. Wherever the service is most needed, that is where the HCIS should be. The information planning led managers to develop the skill of deliberately choosing the approaches: *quality, cost, and cross-function.*

HCIS planning should meet customer needs using the principles of total quality management, which encapsulates four elements: setting standards, appraising conformance to these standards, acting to ensure standards are met, and planning for improvement in standards (Feigenbaum, 1983). Total quality management involves a series of steps that ultimately lead to an alignment of management and customers. The challenge for HCIS managers is to combine quality of care with income enhancements.

Successful implementation of HCIS recognizes not only the skillful employment of management but also the adoption of cost management. These management actions are intended to reduce risks and to pave the way for capturing the benefits. Cost reduction due to labor saved in performing clerical tasks often is a primary motivation for implementing a HCIS. The database managed and controlled by IS specialists of various sub-units of an organization constitute the information utility (Madnick, 1977). The end-users, through their desktop terminals, access the information utility for health care service that is either directly usable or indirectly usable.

Most information systems are viewed as being functional as opposed to cross-functional (Weatherbe, 1988). A very crucial concept of HCIS management is that most of the information needed to improve the decision making within a function will come from outside of the function. In such case it is necessary for the department to lead HCIS implementation with full authority and coordinate interdepartmental interests reasonably. To solve part of the problem, top management needs to use its leadership and influence to achieve cross-functional design in HCIS. In addition, a wide range of communication between related departments and efficient education and training may be needed.

Information Control consists of verifying whether everything occurs in conformity with the plan adopted, the instructions issued, and the principles established, and then taking the appropriate corrective actions (Fayol, 1987). Organizations usually adopt a variety of control mechanisms to ensure that process is performed in compliance with established plans, standards, quality criteria, and in conformance with organizational goals and values (Aldrich & Mueller, 1982; Pennings & Woiceshyn, 1987).

HCIS can be treated as an administrative resource having both *allocative* and *authoritative* aspects, and as capable of significantly influencing the manner and form of control employed in hospitals. Allocative resources are used to generate power over objects, and authoritative resources are used to generate power over persons (Giddens, 1979). Information control policy enables the user to plan for and enforce rules and priorities that will govern or restrict the activities of users during the information process. The information control of HCIS involves two elements: information resource management and access control.

Information resource management assumes that the behavior of users and the information utilization by the organization is consistent with organization policies. In control through HCIS, information control is embedded in the *infrastructure* of the health care service process. Information resource management enables a manager to plan for, allocate, and monitor the use of HCIS resources in the organization. The resources include clinical information systems, health-library resources, medical research support, and basic science research support.

The second element, access control, involves configuration control, authorization management, and auditing activities. In control through the structure of HCIS, i.e., information center or information utility, control is embedded in a firm's policies, procedures, and well-defined job descriptions, and incentive schemes.

While one contribution of HCIS is to strengthen control systems in hospitals, HCIS can create a tremendous control problem and challenges. With thousands of transactions being processed in a short period of time, an error can spread through an immense number of transactions in minutes. Integrity should be one component of security and accuracy/validity should be one component of integrity (Sandhu & Jajodia, 1991). In addition, because of the confidentiality of the information contained in the HCIS, security and privacy are major concerns in HCIS. HCIS security is distinguished from conventional computer security in that it involves more than the physical and logical security. Management security, the protection against all risks associated with the organizational, personnel and administrative tasks that are implemented to help secure all the information assets, should be considered as well. The potential risk from end user computing is recognized by the fact that three categories of frequent end user (clerical personnel, functional area personnel, and managers) together account for the majority of computer abuses (Wong, 1985). Hospitals need a HCIS security plan which should take into account the HCIS structure, the HCIS infrastructure, and how resources will be allocated to cover the mix of security precautions that will be used.

Privacy policy must be able to prohibit access to the HCIS by unauthorized people and be able to restrict access. User access to the HCIS and the resources must be controlled, typically by a user code and password. Networks are more difficult to secure because of the need to coordinate security among a number of functions, and also because of the complexity of managing HCIS. Each person's access must be controlled according to their need to know. Access to the HCIS should be restricted according to user identification and working station.

Two alternative policies can be adopted by health care organizations. They are control and slack environment. In the control environment, all financial and managerial activities are controlled to ensure that HCIS activities are effective and efficient. In the slack environment, sophisticated controls are absent, and instead, motivations to use HCIS in an experimental manner could be developed. The choice of appropriate policy concerning development of HCIS depends on goals and objectives of the specific organization.

The management literature distinguishes formal and informal approaches to access control (Child, 1975; Daft & Macintosh, 1984). In formal control, various organizational activities are integrated by using preestablished plans, schedules, formalized rules, and procedures to substitute for direct personal supervision of employees. Under many circumstances, HCIS function requires internal manuals to document such policies, procedures, and standards as: (1) HCIS policies and procedures, (2) programming standards and guidelines, and (3) controls and planning guidelines.

Informal controls, on the other hand, depend on personal control in which human input is required to make task adjustments. The human input may take the form of individual intervention or group meetings. Informal controls tend to be less visible than formal controls and may be erratic in their applications, depending on individual leadership skills and group norms (Kerr & Slocum, 1981).

Although few health care organizations rely only on one or the other of these control approaches, the selection of control mechanisms is related to the complexity of managing HCIS. Three factors are typically associated with the complexities of managing HCIS: (1) diversities among applications, (2) diversities in activities, and (3) diversities among end users.

Information control cannot be only added on to HCIS; the control mechanism must be integral parts of the system. A systematic approach to information control planning may save the hospital time, money, and personnel - it may even save the very life of the hospital. A total organizational contingency planning is suggested for hospitals. Driving the need is the implementation of new systems and the greatly expanded use of microcomputers and minicomputers in almost every department, where it is apparent that HCIS must address the issues for corporate-wide information security policy. HCIS should become an integral part of the ongoing management process and should provide controls and policies throughout the health care organization. This new outlook will lead to more effective solutions in the areas of end-user authenticaiton, encryption, contingency planning, security standards, and corporate-wide security policies.

CONCLUSION

The issue is not whether information systems will play a pervasive role in the health care environment of the future, but rather how we can ensure that HCISs are implemented and managed effectively to optimize information technology's role as a stimulus and support for the health care organization and for individual practitioners. Hospitals are in their infancy in having to struggle with management issues in HCIS. This paper has examined an organizational approach to effectively support and enhance the health care activities through managing HCIS in the health care environment. In developing the perspective, an integrated focus is provided via a framework for analyzing the structure and infrastructure of HCIS in hospitals.

Recognition of the structure and infrastructure of HCIS has significant implications for the management of health care environment, and for further research into HCIS implementation. Until the structure and infrastructure change, hospitals will be slow to adopt the information systems. Future studies aimed at developing on-line medical databases and decision support systems will have the greatest potential for improving hospital services in the future.

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