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# Overview: Theoretical Perspectives and Methodologies for the Evaluation of Healthcare Information Systems

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## Introduction

Evaluating the impact of computer-based medical information systems requires not only an understanding of computer technology but also an understanding of complex social and behavioral processes. Different theories about the impacts of information systems on organizations guide research and evaluation. This chapter discusses three different theoretical perspectives. The first perspective views the computer information system as an *external force* that affects individuals and the organization. The second perspective assumes that *managers and clinicians can control* the design, implementation, and impact of information systems. A third perspective holds that *complex social interactions* within the organization determine the use and impact of information systems. The discussion of these perspectives is followed by suggested evaluation questions and an overview of appropriate research methods.

In addition to this theoretical framework and the perspectives detailed below, the reader may wish to review Lorenzi et al.'s [1] comprehensive review of the behavioral and business disciplines that offer data and information potentially valuable to evaluating the introduction of new information technologies in healthcare. Related references include Lorenzi and Riley [2] on change management, Snyder-Halpern's [3] organizational readiness approach, Southon, Sauer, and Dampney's [4] articles on a failed information systems initiative in large complex distributed organizations, Lauer et al.'s [5] use of an equity implementation model, Kaplan's [6] 4Cs of evaluation, Berg's [7] myths that hamper implementation, Aarts and Peel's [8,9] articles using a descriptive model of the stages of change, Doolan et al.'s [10] case series on computers in clinical care, and Ash et al.'s [11] qualitative study on physician order entry. Since the first edition of this book was published in 1994, increased recognition of the organizational issues involved in technology implementation has also resulted in the cre-

ation of active working groups in both the International Medical Informatics Association (IMIA) in 1993 and the American Medical Informatics Association (AMIA) in 1996 [12].

## The Need for Evaluation

Since 1994, the pace of computerization in healthcare has accelerated [13–17], while reports of system failures have continued [4,18–20]. Healthcare organizations are considering many new information technology applications in the hope of increasing efficiency, reducing costs, and improving patient care and safety [21]. These products include a growing number of medical computer applications in which healthcare providers interact directly with the computer. These applications are referred to generally as medical or clinical information systems or electronic medical records (EMRs). Medical information systems involve computer-stored databases containing patient information to support medical order entry, results reporting, decision support systems, clinical reminders, and other healthcare applications [22,23]. In some healthcare organizations, a comprehensive system coordinates patient care activities by linking computer terminals in patient care areas to all departments through a central or integrated information system. Other organizations use smaller separate systems that link patient care areas to only one department such as the laboratory, radiology, or the pharmacy. These systems provide communication networks between departments as well as storage and retrieval of medical information. Other computerized databases or expert systems may serve a single department or group of practitioners.

Concerns about patient safety have also accelerated the implementation of computerized physician order entry (CPOE). In California, for example, Senate Bill 1875 requires as a condition of licensure that all hospitals adopt a formal plan to reduce medication-related errors. With the exception of small rural hospitals, this plan "shall include technology implementation, such as, but not limited to, computerized physician order entry . . ." [24]. The Institute of Medicine's 2003 report entitled "Patient Safety: Achieving a New Standard for Care" [25] states that only a fraction of hospitals have implemented a comprehensive electronic health record, but views the necessary technology information infrastructure as a critical component of safe care.

A recent survey of 626 hospitals in the United States found that computerized physician order entry was not available to physicians in 84% of the hospitals [26]. Moreover, these systems often fail because developers frequently emphasize the technological and economic aspects of the systems and neglect social and political considerations such as the organizational environment, social interactions, political issues, and hidden costs such as interruptions of established organizational routines [27–32]. Dowling [33] found in a survey of 40 randomly selected hospitals that 45%

of the information systems failed due to user resistance and staff interference despite the fact that they were technologically sound. Lyytinen [34] and Lyytinen and Hirschheim [35] also report a 50% failure rate for information systems. The authors suggest that failure may be due to technical problems; problems with the format and content of the data; user problems related to skills, competence, and motivations; and organizational problems.

There are few published studies about the reasons for failure and their relative importance. In the March/April 2004 issue of the *Journal of the American Medical Informatics Association* focusing on "perspectives on CPOE and patient care information systems," Berger and Kichak [36], Ash et al. [37], and McDonald et al. [38] address different aspects of computerized physician order entry and its possible unintended consequences. Winkelman and Leonard [39] move further by providing an evaluation framework for considering adaptation of electronic patient records systems for use by patients. In addition, organizations such as the California Healthcare Foundation, VHA, and Alberta Heritage Foundation for Medical Research have conducted recent studies on topics such as the diffusion of innovation in healthcare, use of computer-based patient records, computerized physician order entry, and health technology assessment [13,40–43].

At the same time that organizations move to implement CPOE and other systems, the emphasis on cost effectiveness requires organizations to justify expenditures through detailed evaluations of the impacts of new information systems. Although implementation success depends heavily on the integration of the computer system into a complex organizational setting, professionals who develop, implement, and evaluate healthcare computer systems have few guidelines for designing effective evaluation strategies and selecting appropriate methods to examine the outcomes of system use in healthcare organizations. To ensure that newly adopted systems accomplish their intended purpose, vendors and purchasers alike need to develop detailed plans prior to system implementation for ongoing implementation and postinstallation evaluation to examine the use and long-term impacts of these systems.

Evaluating the impact of computer-based medical information systems requires not only an understanding of computer technology, but also an understanding of the social and behavioral processes that affect and are affected by the introduction of the technology into the practice setting. As technological developments result in the widespread use of computers in healthcare, the social and behavioral sciences can provide an important perspective to guide the establishment of research agendas and the conduct of policy-relevant investigations. According to the conceptual framework developed by Ives, Hamilton, and Davis [44] and Kraemer and Dutton [45], for example, research and evaluation of information systems may involve any or all of the following categories: (1) the external environment of the organization; (2) the internal environment of the organization; (3) the information system users; (4) the systems development environment and staff; (5)

the management and operational environment of the system; (6) the nature of the system including the information processed; (7) patterns of utilization; (8) organizational impacts; (9) and social impacts. These impacts may be direct or indirect, intended or unintended. The following sections outline how different theories about the impacts of information systems influence research and evaluation by suggesting different research questions and demanding different methodological tools for assessing their impacts on organizations and the people in them. Despite 10 years of research since the first edition of this book, the following sections continue to provide a useful framework and examples for the planning and implementation of an effective evaluation of computerization in healthcare organizations.

## Assumptions About Change

Theories about change embody conceptions of the nature and direction of causal influences. Information systems research may be based on a number of different theories or models of change with different or competing assumptions. These models of change influence which research questions will and will not be asked and guide the selection of research methodologies [46].

Three common "storylines" with contrasting assumptions characterize the consequences associated with computer systems: optimist, pessimist, and pluralist [28,47]. The optimist position predicts increased productivity, improved skill requirements, more interdependent jobs, and enhanced communication (i.e., workers share information with workers in other departments by means of common access to a system). The pessimist position, on the other hand, predicts that information technology will rob workers of their expertise and decrease their interactions through job routinization and fragmentation (i.e., workers access information only remotely through computer terminals), and generate conflicts about control over information and other resources [28,47,48]. The present book adopts the third or pluralist position that, while computer systems can have both isolating and integrating capabilities, actual impacts depend on what the organization and its members do with the technology and how the implementation is managed.

According to this position, the introduction of computer systems in healthcare organizations may be accompanied by changes on several different levels. These include changes for: (1) individuals and their jobs, (2) departments as a whole and how each department's work is performed, (3) the structure and functioning of the entire organization, and (4) the quality of both the service patients receive and the medical care that is delivered. Some of these changes may be immediate and evident in the performance of the daily work of healthcare. Other changes may occur slowly and be more difficult to detect. The changes that occur, however, are not simply caused by the computer system. Rather, these changes are viewed as a result of complex interactions between the capabilities of the system itself, administrative decisions on how to use the system in a particular organization,

and actions of individual employees as they adapt to the system in their everyday work [28,49–51].

The pluralist perspective also maintains that research about the effects of computers on managerial decision making, authority and control; the work environment, productivity, and job enhancement; the frequency, nature, and quality of interpersonal relationships among organizational members; and relations between organizations and their environment can enhance our insights into the complex effects of introducing computers into organizational settings [52,53]. To date, however, research findings suggest that these effects are complicated, diverse, and contingent on the specific organizational context. In some instances the availability of the new technology even generates new organizational needs to which it is applied [27]. Understanding the changes that may occur, however, can help analysts predict impacts of individual systems, including both desired and unanticipated effects on the organization in which it is being implemented.

## Evaluation Research and Models of Change

Evaluation research differs from scientific inquiry. While both use the same logic of inquiry and research procedures, scientific studies focus primarily on meeting specific research standards. Although scientific rigor is important in evaluation studies as well, evaluation research must also recognize the interests of organizational stakeholders and be conducted in a way that is most useful to decision makers. While evaluation studies may strive to meet the criteria for scientific rigor, the primary purpose of evaluation research is to provide information to organization stakeholders and decision makers [54].

Although evaluation studies may not specify an explicit paradigm or theoretical framework, underlying and often unconscious assumptions about models of change may influence both the questions selected for study and the accompanying research strategies [55]. Different assumptions will lead researchers to ask different questions and focus on different outcomes to the computer implementation process. Thus it is important that evaluation researchers also recognize the influence of their own and the organization stakeholders' underlying assumptions about change in selecting specific questions for investigation.

The following sections detail three different models of change prevalent in information systems research, including: (1) the computer system as an external force, (2) system design determined by user information needs, and (3) complex social interactions as determinants of system use. Examples are also included to illustrate the different theoretical perspectives. Many of these examples, as well as those cited in subsequent chapters, both meet the rigorous requirements of scientific investigation and provide evaluation information to stakeholders in the organization under study as well [56].

## *The Computer System as an External Force*

Theories about how information systems affect organizations imply quite different conceptions of what causes change to occur [28,50,55,57–59]. The simplest approach views the computer system as an exogenous or external force that brings about change in the behavior of individuals and organizational units. Information systems are developed and implemented to support management goals. Participants who are expected to use the new technology are viewed as passive or as resistant or dysfunctional if they fail to use the system. Evaluation in this instance usually focuses on technical performance (e.g., cost, speed, accuracy, etc.). Studies are frequently undertaken in the laboratory using controlled clinical trials and there may be little or no investigation of how systems fit into the daily work of the organization into which they will be introduced [60].

In general, studies based on this theoretical perspective treat organizational and technological characteristics as invariant rather than as changing over time. They also fail to include characteristics of the organizational environment and social interaction that may have important effects on outcomes [31]. A variant of this theoretical approach, however, does include the examination of the impact of the computer on specific characteristics of the organization. Leifer and McDonough [61], for example, found that departments that used a computer system were more centralized, less complex, and less uncertain about their environment to begin with than departments that didn't use the system, even when task routineness was controlled.

## *System Design Determined by User Information Needs*

A second theoretical perspective views the design of information systems as determined by the information needs of managers and clinicians [55,57]. In this view, the information system is considered to be endogenous to the organization with organization members having control over the technical aspects of the system and the consequence of its implementation. According to this theory, change occurs in a rational fashion as needs are identified and problems solved. Much of the literature from this perspective is optimistic about the amount of influence that designers and implementers have over system capabilities and characteristics [62,63].

## *Complex Social Interactions Determine System Use*

A third theoretical perspective holds that complex social interations within the organization determine the use and impact of medical computer systems [29,55,57,64,65]. This theoretical perspective is more complex than the

two perspectives outlined above. According to this view, the way technology is ultimately implemented and utilized in a particular organizational setting depends on conflicting objectives, preferences, and work demands. From this viewpoint, predicting organizational change resulting from information systems requires a understanding of the dynamic social and political processes that occur within organizations as well as the characteristics of individuals and the information system. The prediction of outcomes requires knowledge of the processes that occur during system planning, implementation, and use rather than simply the levels of independent variables hypothesized to predict change [57,66].

Barley [67], for example, focused on social interactions in his study of the introduction of computerized tomography scanners in two community hospitals. Results showed that the new technology challenged traditional role relations and patterns of interaction among radiologists and radiological technologists in both settings. Only one of the departments, however, became more decentralized as a result. Moreover, professionals who adopt an innovation may adapt it to their own specific needs and organizational contexts, in a sense "reinventing" the innovation [55,64,68,69].

In another example, Lundsgaarde, Fischer, and Steele [70] studied the reactions of physicians, nurses, and ancillary personnel to the implementation of the PROMIS medical information system. Physicians resisted using the system due to fears that it would disrupt traditional staff relations. Nurses and other staff readily accepted the system, however, because it allowed them to utilize their professional expertise more fully. Aydin [71] also addressed social interactions in her study of the effects of a computerized medical information system on the pharmacy and nursing departments in two hospitals. The results indicated changes in tasks and greater interdependence between the two departments.

Awareness of these different models of change can help system evaluators recognize their own implicit assumptions and consider additional areas of study and the research strategies that accompany them. The next section outlines 12 general research questions suggested by these and other theoretical perspectives. The questions are followed by a discussion of the research methodologies appropriate to each of the different perspectives.

## Evaluation Questions and Research Methods

In evaluating the impacts of a new computer system, an essential step is to determine what questions to ask. This section suggests a number of potential questions for evaluation studies. The selection of appropriate questions will be determined by both implicit assumptions about change and the explicit purpose of the evaluation for the organization itself.

The suggested questions cover a variety of theoretical frameworks, including those detailed above. Research on the relationship between

acceptance of a computer system and individual variables such as personality style or resistance to change, for example, treats the computer as an exogenous force and adds a psychological framework in which the investigator assumes that individual differences will influence actions in the work place [72]. In contrast, investigators who look for differences between professions or departments in acceptance of medical systems focus on social interactions and the political nature of information systems, making the assumption that professional or departmental issues will be important in determining individual reactions to new computer systems [49,73,74]. The use of network methods (see Chapter 8) in investigating computer impacts, on the other hand, implies a diffusion model in which acceptance of the innovation is transmitted through channels of communication, over time, among members of a social system.

The 12 questions detailed below, while not exhaustive, provide a beginning framework for addressing system impacts. Additional questions and approaches are suggested in later chapters in the book. Recognizing the purpose of a specific system evaluation will also help determine the focus of the investigation. If, for example, the organization is committed to maintaining the system, evaluators will most likely focus on issues such as how to encourage more individuals to use the system, ensure adequate training, enhance satisfaction with improved system support, encourage the formation of user groups, and so on. If, on the other hand, discontinuing the system is an option, the focus may be on determining how well the system is functioning, the level of system use, and its cost-efficacy. The evaluator who is knowledgeable about different models of change may also be able to suggest additional questions that may provide important information for the decisions to be made for the organization.

The suggested areas for evaluation are organized around the following 12 questions. These questions and the detailed issues they encompass are meant to encourage system evaluators to go beyond obvious questions of user attitudes and system acceptance and attempt to address some of the more difficult issues that will, in the long run, prove important in the implementation of successful, cost effective systems. Table 1.1 links each question with the models of change detailed above and includes suggested evaluation methods. The final section in the chapter provides an overview of the evaluation methods, which are described in detail in subsequent chapters of the book.

## *Evaluation Questions*

1. Does the system work technically as designed?

The first step is usually to determine whether the system actually works. For an order entry system, for example, does the computer actually transmit the needed information about physician orders between nursing stations and the appropriate ancillary department? Does a physician expert system provide the physician with the necessary information to arrive at a

**Table 1.1.** Evaluation questions, models of change, and suggested research methods.

| Evaluation question | Models of change | Suggested methods | Further description |
|---|---|---|---|
| 1. Does the system work as designed? | External force | Qualitative (interviews, observation, documents) | Chapters 2, 3 |
| | User needs | | |
| | Interactions | Survey | Chapter 4 |
| | | Cognitive approaches | Chapter 6 |
| | | Work sampling | Chapter 7 |
| 2. Is the system used as anticipated? | External force | Qualitative (interviews, observation, documents) | Chapters 2, 3 |
| | User needs | | |
| | Interactions | Survey | Chapter 4 |
| | | Internet survey | Chapter 5 |
| | | Cognitive approaches | Chapter 6 |
| | | Work sampling | Chapter 7 |
| 3. Does the system produce the desired results? | External forces | Qualitative (interviews observation, documents) | Chapters 2, 3 |
| | User needs | | |
| | Interactions | Survey | Chapter 4 |
| | | Work sampling | Chapter 7 |
| 4. Does the system work better than the procedures it replaced? | External force | Qualitative (interviews observation, documents) | Chapters 2, 3 |
| | User needs | | |
| | | Survey | Chapter 4 |
| | | Cognitive approaches | Chapter 6 |
| | | Work sampling | Chapter 7 |
| | | Simulation | Chapter 9 |
| 5. Is the system cost effective? | External force | Work sampling | Chapter 7 |
| | User needs | Simulation | Chapter 9 |
| 6. How well have individuals been trained to use the system? | External force | Qualitative (interviews, observation, documents) | Chapters 2, 3 |
| | User needs | | |
| | | Survey | Chapter 4 |
| | | Cognitive approaches | Chapter 6 |
| 7. What are the anticipated long-term impacts on how departments interact? | Interactions | Qualitative (interviews, observation) | Chapters 2, 3 |
| | | Survey | Chapter 4 |
| | | Network analysis | Chapter 8 |
| 8. What are the long-term effects on the delivery of medical care? | User needs | Qualitative (interviews, observation, documents) | Chapters 2, 3 |
| | Interactions | | |
| | | Survey | Chapter 4 |
| | | Work sampling | Chapter 7 |
| 9. Will the system have an impact on control in the organization? | Interactions | Qualitative (interviews, documents) | Chapters 2, 3 |
| | | Survey | Chapter 4 |
| | | Network analysis | Chapter 8 |
| 10. To what extent do impacts depend on practice setting? | Interactions | Qualitative (interviews, observation, documents) | Chapters 2, 3 |
| | | Survey | Chapter 4 |
| 11. What are the impacts on the healthcare system at large? | Interactions | Qualitative (interviews, observations, documents) | Chapters 2, 3 |
| | | Survey | Chapter 4 |
| | | Internet survey | Chapter 5 |
| 12. How will the system affect patient safety | Interactions | Qualitative (interviews, observations, documents) | Chapters 2, 3 |
| | | Survey | Chapter 4 |
| | | Cognitive approaches | Chapter 6 |

diagnosis and make treatment decisions? Do the appropriate professionals actually use the system?

A system that seems to work perfectly in tests or simulations may encounter a number of difficulties when actually implemented in a hospital or medical practice. For the purposes of the present volume, we will assume that the technical aspects of the system are operating correctly and focus on evaluating system impacts that stem from determining who actually uses the system, how they use it, and the impacts of its use on individuals, groups, and the delivery of medical care.

2. Is the system being used as anticipated?

Who uses the system, how much, and for what purposes? If system use is optional, is the system used by enough individuals to warrant continuation? Who uses it and who doesn't? What factors influence individual decisions to use the system (e.g., personality styles, professional issues, age, departmental norms for how work should be done, communication networks)? What is its impact on individual jobs (e.g., work overload, job satisfaction, new skills development, new job classifications, etc.)?

Even systems that work are often not used as anticipated. Thus it is important to determine whether the system (1) meets the needs of projected users, (2) is convenient and easy to use, and (3) fits work patterns of the professionals for whom it is intended. These issues are particularly important for computer systems designed for healthcare professionals. In other industries such as banking, insurance, or travel, for example, workers may be required to use a computer system continuously in order to perform their work. Healthcare systems, on the other hand, are frequently an adjunct to enhance or speed medical work performed on and for patients. Using the computer may require changes in daily work patterns that healthcare professionals may be unwilling or unable to make if the system is inconvenient or difficult to use. Other systems may potentially meet user needs, but be too confusing or complicated to encourage use, particularly if individuals only need to use the system on a sporadic basis. For example, a physician with admitting privileges at several different hospitals may be unwilling or unable to learn and remember different computer protocols for each hospital. Furthermore, even when computer use is required, errors are likely when the system is not tailored to the needs of the user. All of these are issues for consideration when evaluating system impacts.

3. Does the system produce the desired results?

Desired by whom? Administrators? Physicians? Other professionals or departments? What competing interests are involved? [75]. Decisions to adopt centralized systems are often made by hospital administrators with varying amounts of consultation with the departments and individuals who will use the system. Ideally, however, system implementation will be preceded by agreement on expected system outcomes for the organization as a whole. Individual departments may actually agree to the adoption of a

system that does not meet their own specific needs, but provides benefits for the institution. Sometimes these agreements involve other negotiated benefits for the department in question.

Aydin [71], for example, found that the pharmacy department in a major medical center agreed to use what it considered to be a "nursing" order entry system. In return for agreeing to the system, the pharmacy negotiated a return to the expanded consultant role that they had been forced to give up under previous budget cuts. In contrast, however, the PROMIS system was discontinued despite its use by radiologists, pharmacists, and nurses because it lacked acceptance by the medical staff, the primary decision-making power in the organization [55,70].

4. Does the system work better than the procedures it replaced?

Computer system implementation requires expenditures for hardware, software, and user training, as well as possible increases in staff for data entry tasks, especially where more information is being gathered and stored than in the past. Thus system evaluators must address system benefits as well as operating efficiency. Has computerization resulted in cost savings in staff time spent in data collection and analysis? If not, are the additional data and analysis made possible by computerization worth the time and money spent (e.g., to meet regulatory requirements, control other costs, increase patient or physician satisfaction, or deliver better healthcare to patients)?

5. Is the system cost effective?

For whom? Individual practitioners? Departments? Patients? The organization as a whole? Medical information systems have the potential to reduce costs by improving information flows between departments as well as by providing information that may not have been readily available before the implementation of the system. On the other hand, costs may increase for employee training and higher salaries when new computer skills are added to job descriptions. Increased personnel expenses in nursing for clerks to enter orders in the computer, for example, may be balanced by cost savings in the pharmacy where the order entry system automatically bills patients for pharmacy charges. On the other hand, direct order entry by physicians may save clerical costs. Order entry may also result in the "capture" of charges that were frequently "lost" with manual systems.

6. How well have individuals been trained to use the system?

How many errors occur? Are data entry errors widespread, or limited to a few users? Do individuals communicate with colleagues about new ways to use the computer system? Is system support readily available when problems arise? Are improvements needed in the training provided, user-friendliness of the system, time available for users to practice and become familiar with the system, communication with users, and support in solving system problems?

7. What are the anticipated long-term impacts on how departments linked by computer interact with each other?

Is communication and coordination between departments more or less efficient using the computer system? If departments worked well together before the computer system, has computer implementation created any new problems? Has the computer system resolved ongoing problems such as slow transmission of orders, and so on? Are lab results reported faster with the computer system? Does one department feel they are bearing more than their share of the new job responsibilities related to the computer system (e.g., nurses or clerical staff doing order entry for pharmacy or radiology)? Is another department concerned with errors in order entry (e.g., errors in radiology orders made by clerical staff on nursing units)? Do these issues affect system effectiveness?

8. What are the anticipated long-term effects on the delivery of medical care?

Will lab/radiology results reporting be faster? If so, will the increases in efficiency be evident in decreased lengths of stay? Will computer-based monitoring of physician orders eliminate duplicate and/or unnecessary tests? If so, what will be the impact on the cost or quality of care? On physician satisfaction? If an order entry system, for example, requires nurses, clerks or physicians to enter the reason for requesting a specific radiology test along with the order, will radiologists be able to document that having this information enables them to better meet physicians' diagnostic needs?

9. Will system implementation have an impact on control in the organization?

Will the new system enable administrators to monitor or control physician practice behavior, decrease departmental independence in professional decision making, and so on? If so, what is the impact on physician attitudes, cost of medical care, and so on? Is there a shift in the balance of power between clinical personnel and managers, between departments, between the institution and attending physicians? Is there an impact on the competitive position of the institution? Who determines what information is to be included in new systems and how it is to be collected and used? [76].

10. To what extent do medical information systems have impacts that depend on the practice setting in which they are implemented?

Under what circumstances and in what organizational settings do certain effects occur? How common are these effects? What are the impacts of organization, size, culture, values, and so forth on system outcomes? What evaluation questions are appropriate in different settings?

11. What are the impacts on the healthcare system at large?

A report by the Institute of Medicine identified computer-based patient records (CPRs) as a key infrastructural requirement to support a reformed healthcare system [14]. It has been estimated that these systems when implemented nationwide could save $80 billion per year. However, at present there are few studies that have investigated the financial, organi-

zational, and behavioral changes that will need to be made at the national, state, and institutional levels in order to overcome barriers to this information technology. Questions to be asked include: Will the system better enable patients to manage their own healthcare? Will the system help to control costs? Will the system improve care?

12. How will the medical information system affect patient safety?

A number of reports estimate that as many as 98,000 to 195,000 people in the United States die in hospitals due to potentially preventable errors [71–74,77–80]. Many of these errors could be prevented by implementing information technology that is currently available. Questions that should be raised include: Will the electronic health record system be integrated with other systems such as laboratory, pharmacy, radiology? Will the system provide decision support to physicians when they enter orders? Can the system detect potential adverse events and issue alerts and reminders to providers to avoid harm to patients? What unanticipated impacts on patient safety might occur as a result of the medical information system?

The following section provides a brief overview of some of the research methods appropriate to these evaluation questions and the models of change they represent (see Table 1.1).

## *Research Methods*

Numerous research methods are available to support investigation of the research questions and the underlying models of change described above. This section provides a brief overview of some of these methods with examples of their contributions to research on information systems in healthcare organizations. The discussion includes qualitative methods, multiple research strategies to evaluate information systems in collaborative healthcare environments, survey research methods, cognitive approaches to evaluation, work sampling, social network analysis, computer simulation, and research strategies that combine quantitative and qualitative methodologies. Each of these methods is described in detail in subsequent chapters of the book.

*Qualitative research*, described in detail in Chapter 2, is conducted in natural settings and is characterized by the use of data in the form of words rather than numbers, primarily from observations, interviews, and documents. These methods attempt to understand change from the point of view of the participants and their social and institutional context. Qualitative methods are particularly useful in determining *how* and *why* specific outcomes occur [81]. In instances where the investigator is attempting to build a theory of how a medical information system affects the organization and its members, for example, these methods provide important insights into the reasons for change. While particularly useful when the major purpose of the investigator is theory building, however, qualitative methods are equally important in theory testing [82]. Case studies, which may combine

quantitative and qualitative methods, are used both for theory construction [81,83–84], and for testing theories or hypotheses about causes and effects [85,86]. In theory testing, specific theoretical propositions need to be developed in advance to guide data-collection and hypothesis testing [87].

Qualitative methods are also particularly useful in collecting and analyzing data pertinent to the design of medical information systems. Fafchamps [88], for example, describes an ethnographic work flow analysis of physician behavior in the clinics of two healthcare institutions. Information about physician needs, practice behavior, and the clinical setting was collected by (1) asking physicians to describe what they were doing and conducting a guided tour of the clinics, (2) structured observations of meetings and interpersonal interactions, (3) focused interviews, and (4) analyzing formal and informal notes and reports. These data were analyzed and used to help design a physician workstation.

*Multiple research techniques* need to be used to evaluate the impact of information systems on different members of the healthcare team (see Chapter 3). For example, a study of an electronic patient record system in a surgical intensive care unit examined the patient care team of residents, fellow, attending physicians, pharmacists, and nurses [89]. Each team member brought different backgrounds, perspectives and skills to the team. These different skills and perspectives had implications for the adoption and use of the patient record system on their unit.

*Survey research methodologies* are also widely used to study the impact of information systems (see Chapter 4). In survey research, responses to predefined questions or items are collected from a sample of individuals, departments, or organizations to produce quantitative descriptions of population characteristics or of relationships between variables. Zmud and Boynton [90] provide summary data and statistical analysis on 119 scales that have been used to study information systems.

In considering attitudes toward computers, for example, a comparative survey of physicians, pharmacists, lawyers, and CPAs by Zoltan-Ford and Chapanis [91] found that physicians and lawyers expressed dissatisfaction with what they perceived to be the depersonalizing nature of computers and with the complexity of computer languages. Surveys by Teach and Shortliffe [92] and Singer et al. [93] concluded that physicians generally accept applications that enhance their patient management capabilities, but tend to oppose applications that automate clinical activities traditionally performed by physicians themselves. Anderson et al.'s [94] survey of medical students, residents, and practicing physicians found that, while physicians recognize the potential of computers to improve patient care, they express concerns about the possibility of increased control over their practices, threats to privacy, and legal and technical problems.

Surveys can also be used to collect descriptive data needed to establish policies or to solve problems. Survey data may indicate the existence of problems, as well as their seriousness and pervasiveness. In this instance the

methodology is problem-driven [45]. Kaiser and King [95], for example, used survey research in their study of the emerging role of information analysts. Kraemer and Dutton [45] provide a useful propositional inventory based on a meta-analysis of the findings from a large number of surveys. In general, studies based on surveys fail to examine the relationships between information systems and their external environments, the dynamics of how change takes place, and societal impacts of the information system.

The *Internet* also provides a new research tool (see Chapter 5). First the Internet is a rich source of qualitative research that can be used to identify research issues, generate hypotheses, or for needs assessment. Second, electronic interviews can be conducted via e-mail or in chat rooms. Also, surveys can be administered by e-mail or posted in newsgroups or discussion forums or on the Web.

*Cognitive approaches* to evaluation focus on understanding the processes involved in decision making and reasoning of healthcare workers as they interact with information systems in carrying out a range of tasks (see Chapter 6). Methods that have been developed in the areas of usability engineering and cognitive task analysis have important implications for the assessment of cognition involved in complex medical tasks and the impact of information systems.

*Work sampling* provides evaluation tools that can be used to assess the effects of clinical computer systems on the work patterns of healthcare workers (see Chapter 7). These techniques permit the investigator to address questions such as (1) How and by whom is the system used? (2) How much time is spent using the system? (3) What effect does the system have on other work-related activities? (4) How long should it take to use the system? (5) How can work patterns be improved so as to use utilize each member of the healthcare team's knowledge and training to the fullest extent?

Another approach to the study of social interactions, frequently termed *social network analysis* or structural analysis, focuses on interactions that occur between individuals and/or departments as a medical information system is adopted and its use diffuses throughout the organization (see Chapter 8). The network or structural approach hypothesizes that individuals' responses to the information system are affected and constrained by their positions and roles in the social system of which they are a part. Individual adoption and use is seen as dependent on group interaction [55,64,96,97]. This perspective differs fundamentally from those that assume that individuals and organizational units are somewhat independent of one another in the ways in which they respond to and use an information system. Instead, this approach attempts to identify the communication structure or the underlying social structure, generally unknown to organizational participants, by collecting and analyzing relational data. Network analysis methods are based on graph theory, clustering methods, and multidimensional scaling, and are described in detail in Chapter 8.

Anderson and Jay [68], for example, used network analysis in their study of the time-of-adoption of a computer-based hospital information system. Medical doctors adopted the innovation (i.e., began entering their orders) in clusters, with all of the doctors in a clique adopting at about the same time. "Network location was found to have a significant effect on the adoption and utilization of the HIS (the computer-based-innovation) independently of background and practice characteristics of physicians" [68,98,99]. In other words, the network variable increased unexplained variance in innovativeness in addition to that explained by such individual characteristics of the doctors such as age and medical specialty. Furthermore, utilization patterns were similar among physicians belonging to each group.

*Computer simulation models* can also be used to study medical information systems (see Chapter 9). This approach provides researchers with a relatively inexpensive means to study operational effectiveness and predict the effects of changing the operational environment without actually interfering with the ongoing work of the organization. In one study, Anderson, Jay, Schweer, and Anderson [100] developed a mathematical model to characterize the process by which physicians change their use of a medical information system. A structural equation model was constructed using data collected from members of a hospital medical staff. The model indicated that consultation with other physicians on the hospital service led to greater exposure to and a more favorable attitude toward potential computer applications. Physicians who were more knowledgeable about computers were more likely to tailor the system to their individual practices. All of these factors resulted in increased use of the system by physicians. The results of the study led to a number of policy recommendations regarding strategies for introducing computer technology to physicians.

In a second study, a computer simulation model of the order entry process for a hospital information system was developed and used to perform computer simulation experiments to estimate the effects of two methods of order entry on several outcome measures [101–103]. The results indicated that the development and use of personal order sets for order entry could result in a significant reduction in staffpower, salaries, fringe benefits, and errors for the hospital.

## Combining Methods

Studies that attempt to examine complex social interactions as determinants of system use generally require a combination of qualitative and quantitative methods. Qualitative data, for example, can be used to gain critical insights into motivations and interactions within the organization. Detailed observations in the actual organizational setting can also be used to interpret the findings and explain how and why information systems bring about changes. Subsequently, qualitative data, surveys, and experimental methods can all be used for empirical testing of hypotheses. This

combination of qualitative and quantitative methods produces insights that neither method alone can provide. Furthermore, the findings are considered to be more robust and generalizable [104].

In one example, both qualitative and quantitative methods were used to study the impact of a clinical laboratory computer system [104–106]. Quantitative results showed differences between technicians in their reactions to the computer system. Shedding further light on these differences, qualitative data indicated that laboratory employees differed in their orientation to the nature of their work. One group of technicians focused on work load increases, the other emphasized improved results reporting and service. The users' response to the computer system depended on their perception of the extent to which the system supported or interfered with the performance of their job as they defined it.

## Conclusion

Each of the methods described above is explained in detail, with sample evaluation instruments where appropriate, in Chapters 2 through 9. The chapters also include examples of studies that make different theoretical assumptions, address different evaluation questions, and employ different research methodologies. Each study also has important practical policy implications for the organization under study.

## *Additional Readings*

### The Social Impact of Computers

Anderson and Jay [65] and Anderson [22,23] review evaluation studies of the use and impact of healthcare information systems. Dunlop and Kling [107] provide an important collection of readings outlining the different positions in the debates about social issues surrounding computerization.

### Evaluation and Models of Change

Kling [28], Kling and Scacchi [29], Lyytinen [31], and Markus and Robey [57] provide detailed theoretical research frameworks for information systems and research dealing with information systems problems.

Rice's [108] chapter is a detailed review of the different paradigms and theoretical frameworks adopted by information system researchers.

### Research Methods

The three volumes from the Harvard Business School Research Colloquium on research methodologies that can be used to study information systems cover qualitative research methods [109], experimental research methods [110], and survey research methods [111].

Nissen, Klein, and Hirschheim's [112] edited volume provides comprehensive documentation of current research methods and approaches in information systems today.

Rossi and Freeman [54] is an excellent textbook on evaluation research. Patton [113] provides an excellent introduction to qualitative approaches to evaluation. Yin [81] is an excellent monograph on case study research.

Scott [97] provides a good readable introduction to network analysis.

A special issue of *Computers in Biology and Medicine* [114] provides a good review of evaluation methods in health informatics.

Friedman and Wyatt's text on evaluation methods in medical informatics [115] provides a detailed course on the evaluation of informatics in healthcare organizations and is an excellent complement to the present volume.

## *Future Directions in Evaluation*

Kaplan and Shaw [116] provide an up-to-date review of evaluation literature on the people, organizational, and social issues related to the implementation of information technology in health care, including recommendations for future research.

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