PART

I

Foundation Concepts of Health Management Information Systems

CHAPTER

1

Health Management Information Systems: A Managerial Perspective

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CHAPTER OUTLINE

Scenario: Key Trends Contributing to the Merging of Enterprise and Health Information Exchange Models[1]

Informatics Corporation of America (ICA), with its website (www.icainformatics.com) offering insightful materials for the interested readers, is a health information technology (HIT) organization whose mission is to provide clinicians and healthcare providers with more or less seamless access to information extracted from various uncoordinated systems for patient diagnosis and evaluation. Recently, ICA sent out a press release to various stakeholders in the healthcare informatics (HI) community outlining five key trends shaping the development of health information exchanges (HIE) among large healthcare organizations:

1. The growing impetus for healthcare provider connectivity.
2. An increasing focus on the need to manage chronic diseases.
3. Increased patient expectation of personal involvement in the care process.
4. Market pressures for improved hospital–physician alignment.
5. Advances in technology facilitating system interoperability.

With an increasing number of baby boomers and the elderly constituting the U.S. population, it is envisaged that these trends will become more prevalent for U.S. healthcare services organizations in the near future.

"These trends highlight the benefits which community-based healthcare models can offer all constituents—physicians, patients, and healthcare providers across the continuum of care," says Gary M. Zegiestowsky, chief executive officer (CEO) of ICA. "The gap between traditional enterprises and HIE is closing, with growing connectivity for physicians and ultimately the entire healthcare community in certain cities or regions. We believe this is signaling a paradigm shift that has both near- and long-term implications for healthcare and HIT."

"In order to keep pace with these trends," Zegiestowsky continues, "physicians in every community first need intuitive, proven technology solutions aligned with clinical workflow to speed the adoption of electronic health records. Moving toward patient-centric care will be possible when all providers across the broad spectrum of care are able to access and utilize a unified patient record in combination with tools that enable better care."

ICA's response to this growing trend is the use of an exchange platform created for both enterprise and HIT systems, such as the A3Align Solution™. For 10 years, practicing physicians and informatics professionals from Vanderbilt Medical Center have developed this technology, which has eventually been installed at Bassett Healthcare's enterprise comprising four hospitals and 27 clinics in Cooperstown, New York. A3Align Solution will also be implemented by both the Montana and Northwest Healthcare for HIE. In addition, Vanderbilt distributed this same technology across its 40 facilities in the Mid-South eHealth Alliance, a successful HIE in western Tennessee.

With these major trends encouraging HIE among healthcare services organizations, what do you believe are the benefits of having all of your health information made freely accessible and interchangeable among all of your caregivers? What would be your worst fear?

I. Introduction

As we enter this world, how did we become aware and conscious of who we are, and of things that surround us? How did we learn about the myriad ideas, sights, sounds, and smells and the many events that we see, hear, feel, and witness in the surrounding space in which we live and breathe for each day of our lives? Aren't "data" and "information" the essential constructing blocks in our lives? Isn't "knowledge" the central intellectual core that links everything else to form meanings, interpretations, and actions? Aren't "information systems" innate in each and every one of us as human beings who find it so very natural to process incoming streams of "stimuli" continuously, seamlessly, and automatically—irrespective of how cognitively complex these stimuli may at first appear to be? Seemingly, all of us have already been introduced somewhat to the subject of health management information systems (HMIS) even from the first day of birth as we "woke up" from our "deep sleep" inside our mother's wombs, most likely, within the confines of a healthcare or maternal health-related facility.

The field of HMIS is inherently complex. Take the myriad terminologies employed in this text as an example. There are subtle differences even with major terminologies used to describe the field. For instance, *health management information systems (HMIS)*, which is the term used liberally throughout the first edition of this text, has, in and of itself, a managerial slant, and whereas *healthcare information technology* (*HCIT* or *health IT–HIT*) has a technology slant, *health information systems (HIS)* or *healthcare information systems (HCIS)* may be interpreted as the umbrella term with a systems or information systems connotation. *Informatics* is another commonly used term among European researchers, and *health informatics* or *clinical informatics* generally refers to the application of data methods in medicine, healthcare services, and clinical practices. For this reason, some authors, as will become apparent in the latter part of the text, use the terms *health informatics (HI)* and *medical informatics (MI)* as well as *e-health (electronic health)*. Thus, in this edition of the HMIS text, for the sake of simplicity and to further reduce complexities for less sophisticated readers, we allow the usage of these several and diverse terminologies to be more or less interchangeable among the works accumulated by the different contributing authors and accompanying editors. Also, to ease the disruption in the readings and simplify the editing process, we have generally dropped the "s" that is typically appended to many of these acronyms to create the plural sense and simply use these acronyms in more or less the plural sense unless it is specifically preceded with an article such as "a" or "the" when attaching a verb to the specific acronyms or using it as a descriptive adjective, as in "the HMIS" field.

More importantly, the HMIS conceptualization we have drawn in this text comes from an eclectic well of traditionally established as well as newer disciplines. Academic researchers, educators, and practitioners from diverse disciplines—including, but not limited to, electrical and computing engineering, industrial engineering, clinical and management engineering, nursing and allied health, health informatics, health management, organizational behavior, computer science, and cognitive science—have all contributed, in one form or another, to the development and accumulation of HMIS knowledge domains.

Indeed, as early as the 1960s, cognitive scientists have modeled the human cognition as an information processing system. Here, the human brain is perceived to act just like the computer, and experiments conducted on the human stimuli-response system inform us of the familiar story of how different external stimuli (information) can exert different patterns of resulting or induced behaviors among the human observers. In other words, the information systems within humans are exemplified by the cognitive activities recurring within the human brain. In the HMIS analogy, the information processors are likened to the eyes and minds of the health organization.

In this newly revised edition, the term *adaptive HMIS* has been used specifically to emphasize the need for a flexible approach to health information administration and management. HMIS students must learn how to apply information science, information systems, and health informatics concepts from an adaptive but integrated health management perspective. More generally, this text aims to provide the students with a state-of-the-art managerial perspective of health information technological systems in the coming years so that they are well prepared to face the many challenges of acquiring and applying new forms of HCIT for healthcare services management purposes in this century and beyond. In this first chapter, we briefly cover the HMIS evolution, its underlying architecture, and its basic functions. We then close the chapter with a brief survey of the role HMIS technology plays in driving today's healthcare and healthcare-related businesses.

II. Evolution of HMIS

In its broadest sense, HMIS encompasses diverse concepts, methods, and applications from many related fields. Its genesis may be traced to multiple roots, including general systems thinking, information economics, management science, information systems development methodologies, software engineering, computer science and communication theory, medical computing, health organization behavior, health management, policy, and health services research. From a practical viewpoint, the evolution of HMIS over the past several decades has been largely driven by strategic, tactical, and operational applications of various information technology (IT) and advanced systems concepts for healthcare services delivery within an individual, group, and, more appropriately, an organizational perspective. The regional or even national health coalitions are also on the horizon, enabled by the establishment of electronic health information exchange infrastructures.

In a world where growing competition for healthcare services delivery is defined by rapidly changing technology and maturing organizational arrangements, it is critical to understand how evolving HMIS technologies operate and how HMIS interact within all key aspects of an organization. In other words, it is important to know how HMIS are developed or procured; how they are managed and maintained; how their functions are executed to support daily operations and more advanced activities, such as continuous quality improvement programs and medical research; and finally, how to evaluate their performance and cost-effectiveness. More importantly, with globalization and the emergence of large-scale computing systems such as electronic health records (EHR) and innovative business-driven applications such as enterprise resource planning (ERP), customer relationship management (CRM), supply chain management

(SCM) systems, and patient-centric applications such as personal health records (PHR), the resulting landscape for future-oriented HMIS is bound to change quickly.

New advances in HMIS are vital to our society because these technologies guide our everyday lives; without them, life would be rather difficult. Imagine, for example, while visiting with your doctor today, you find him or her searching busily through a mountain of incoherent, unorganized, and piecemeal data about you for all of the different visits that you may have made to the different clinics that may now be part of a merged health maintenance organization (HMO), or, what if your doctor has to spend most of his or her time making clarification phone calls to laboratories and pharmacies to gather information rather than focusing on diagnosing and treating your illnesses? Imagine also that these data were recorded using various data-coding schemes by different clinicians with different recording media (such as paper records, tapes, and film images) and stored in multiple locations. How different would it be for your doctor to manage you and your information if these data had been "digitally" captured in standardized formats on nano-chips and could now be easily recombined, reorganized, and made securely accessible and available to him or her quickly even before meeting with you?

Indeed, past technologies such as file folders, paper-and-pencil entries, tape recordings, and X-ray films are both physically limited and very restrictive in terms of keeping secure, accessible, portable, and available records about you and capturing progressive changes to your health and wellness status each time you visit with one of your care providers, who may be practicing in different hospitals and clinics associated with your HMO. These traditional recording methods are limited because the captured data and information can only be kept largely in a "physical" form and not easily accessible, transportable, or available "virtually" or "digitally" to other expert clinicians or even to you, who may decide to travel to another country seeking a second opinion, or who may have been placed in emergencies outside the state of your residence. New forms and modes of HMIS technology such as wearable devices and embedded chips promise to give you the ability to access such recorded information that has been accumulated over the years both conveniently and securely at any time, anywhere. In the foreseeable future, you will also be able to control and access your own personal health records stored online and contributed by all of your care providers. As amazing as new technologies can be, it is important to first understand the type(s) and basic functions of HMIS technologies that currently exist and how these technologies will likely evolve due to increased globalization, continuous healthcare reforms, the corporatization of medicine, and other major trends such as the formation of new alliances and consolidations among healthcare provider organizations.

Apparently, the emergence of satellite-based, wireless, user-friendly portables; the proliferation of cellular networks; new computing privacy and security technologies; and new implementation of various powerful network-based systems such as sensor networks and Internet-based data warehouses are now in the order of multimillion-dollar projects to serve large populations with massive capabilities of automated collection, manipulation, and analysis of multidimensional data sets. These emerging trends are now pressuring senior healthcare executives and managers to become seriously interested in understanding and endorsing cost-beneficial, integrative, and innovative HMIS solutions.

III. HMIS Components and Basic Functions

Publicly, as health consumers become more aware, more informed, and better trained in accessing electronic and social media and as they become more intelligent in evaluating alternative healthcare services (such as using Leapfrog's hospital ratings), engaging in online forums for health information sharing, and participating in physician/hospital referrals among patients and/or virtual marketing using social network sites, consumers are exerting greater pressures for a revolution in HMIS technological applications. With the expansion of the aging baby boomer generation and the accelerating growth in U.S. healthcare expenditures, we can confidently expect the continuing growth of HMIS applications during the coming decades to have a significant impact on primary healthcare, pharmaceutical, rehabilitative, palliative, and home healthcare services. Therefore, management should not and cannot afford to leave the job of designing, developing, and implementing network-based, integrated HMIS in the hands of IT experts or commercial vendors alone. Instead, they must now take a personal interest in paving the way for new generations of HMIS technology—technology that satisfies both organizational requirements and patient needs. As such, the importance of using an adaptive managerial perspective in HMIS design and development within an organizational context for the coming decades cannot be overly emphasized. Let us now turn to an overview of the basic HMIS components and functions.

HMIS Components

An understanding of the adaptive but integrated HMIS begins with differentiating among its five major components and their interrelationships:

1. Data/information/knowledge component.
2. Hardware/software/network component.
3. Process/task/system component.
4. Integration/interoperability component.
5. User/administration/management component.

The data/information/knowledge component forms the central core, the content, of all HMIS. It encompasses the specification of, organization on, and interrelationship among data, information, and knowledge elements required of integrated HMIS.

Raw data form the basic building blocks for generating useful information that is to be stored in any HMIS; processed data are transformed into information that serves as useful output for HMIS end-users to make informed and intelligent decisions. Some pieces of data about your child may be that of his or her demographics or the medication that he or she is allergic to (e.g., penicillin). Another example would be his or her childhood vaccination records. Here, the data would be immunization dates and type. Putting all these data together to form a view of a child's immunization schedule derives information. Determining whether the child is due for a vaccine requires knowledge, specifically, the captured experience and knowledge of the attending physician, which could further be stored and recorded into existing HMIS and passed on to another care provider for future care delivery.

The combination of effective data, information, and knowledge resource management involves designing the critical databases and instituting various intelligent data-mining algorithms, rule engines, and online analytical processing (OLAP) tools to manage the increasingly complex and information-intensive care decision situations physicians are facing in this day and age. In other words, organized information and captured experience will, in turn, yield the essential knowledge and business intelligence for guiding healthcare services for the individual care provider, a group of care providers managing related health problems, or an entire health provider organization trying to deliver healthcare services. Figure 1.1 shows the conceptual flow of the data/information/knowledge paradigm within the HMIS organizational and healthcare provider decision-making context.

Ultimately, the HMIS used to support key decision-making functions of healthcare providers and administrators within the organization must be reformed to achieve greater integration of data, information, and knowledge across organizational stakeholders. ICA's newly proposed A3Align Solution, discussed in the chapter-opening scenario, is an example of how innovative HMIS applications can better integrate enterprise databases (such as EHR) and other uncoordinated data systems [such as computerized physician order entry (CPOE) and clinical decision support systems (CDSS)] and to support integrated healthcare delivery at a regional level. In an integrated and well-designed HMIS, the goal is to distribute these information-related elements efficiently, effectively, and appropriately throughout the organization for enriching learning among organizational users and for enhancing the delivery of healthcare services among care providers.

The next critical component within "information systems," aside from the "information" core, is the "technology" layer. Here, the hardware/software/network component features prominently as it entails the choice deployment of various information and computing-related technologies to support HMIS applications and use. Briefly, this component involves configuring various hardware, software, user interface, and communication-enabling infrastructures, associated devices, and applications in such a way as to best achieve efficient and effective information services integration throughout while connecting individuals, groups, and organizations.

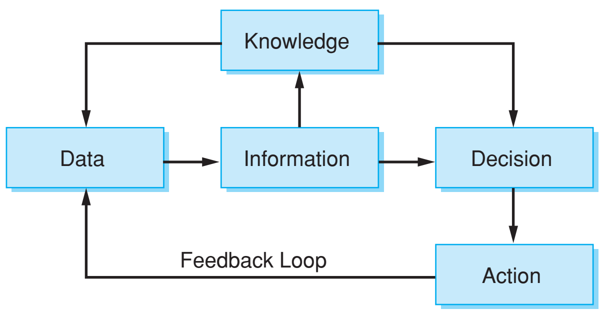

FIGURE 1.1 A Data/Information/Knowledge Decision System.

ICA's A3Align Solution, for example, is an exchange platform created for integrating data and information from both enterprise and HIT systems. It would be important to ensure that all connected devices can access the HMIS applications seamlessly; better yet, these devises can access an adapted version of an application customized to a device platform. In this sense, for any healthcare organization, the technology layer must be supportive of the people (internal users), aiding the performance of tasks to be accomplished by these users and helping them to thrive in the resulting technology-driven environment. Furthermore, new and emerging HMIS technologies and methods play an increasingly significant role in enhancing healthcare organizational delivery of patient care–related services. This brings us to the third basic HMIS component.

The process/task/system component exemplifies the routine and internalized driving engine for HMIS. Here, our focus should be on the cohesion to be achieved within established "local" processes, tasks, and applications. In other words, existing administrative-based HMIS, such as financial information systems, human resources information systems, facility utilization and scheduling systems, materials management systems, facilities management systems, and office automation systems, as well as clinical-based HMIS applications such as EHR, CPOE, and CDSS, must be designed to collect relevant data and accumulate useful information for organizational task-processing and decision-making activities. It is possible, too, that over time organizational structural and procedural changes and/or regulatory changes may require certain different routine processes that have been instituted previously to be changed or completely deleted, yielding room to new processes, tasks, and applications. Therefore, a systems perspective is critical in order to achieve optimal functionality among the different task processes and applications.

Surely, the integration/interoperability component is a key determinant of HMIS success from an enterprise view. Often, the key to positioning today's healthcare services organizations for future success is the interoperability of systems used in managing existing and ongoing healthcare information services vis-à-vis its competitive marketplace environment. The "interoperability" for much of the computerized information processing within the organizational framework must be upheld both internally and externally to achieve efficient, effective, and excellent delivery of healthcare services. This requires not only an elaborate understanding of evolving technological innovations and changing needs in organizational task processes, but also knowledge of the market structure and changing characteristics of the healthcare services industry and how the different current systems should be designed to fit well with every other HMIS application to achieve an integrated, enterprisewide HMIS.

In fact, as early as 1980, Lincoln and Korpman recognized the difficulties with computer applications in healthcare services delivery.[2] In their classic paper, "Computers, Healthcare, and Medical Information Science," they argued that the goals for medical information science, although easy to state, are difficult to achieve for several reasons. First, adapting well-tested information processing procedures and methods from other fields into medicine is difficult because of the uncertainty and sophistication surrounding the medical context; the wide spectrum of medical data; and the vagueness, disparity, and variation of organizational healthcare objectives. Second, this difficulty is further exacerbated by the apparent dissonance between the often-embedded ambiguity in medical data structure and the rigidity of computer logic structure. Specifically, in medicine, the materials cover the entire range of patient care data and the methods used span a wide range of disciplines, including the management, behavioral, and fundamental sciences, not just information processing and communications.

This brings us to the final but most critical HMIS component, the users. The user/administration/management component brings together and intelligently coordinates all of the other HMIS components. Based on a shared technological infrastructure, for example, various users are, in turn, empowered to perform designated tasks and activities that will support the overall business goals of the organization—that is, to serve their clients both inside and outside the organization in the most efficient, productive, and effective manner. The function of this critical user component, when blended appropriately with all the other HMIS components, is to engender a holistic conceptualization that absorbs the many insights and interactions inherent in any organizational HMIS endeavor.

Altogether, an adaptive, managerial HMIS perspective encompasses a combined interaction of data-related elements, appropriate technologies and methods, designated task processes, and intended users to gather, store, manipulate, and supply the needed information to support key organizational decision-making activities. The HMIS is an integral part of the organizational system, a mechanism that is central to integrating the enterprise and its various components. Every unit of that enterprise, which presumably is interrelated, must necessarily complete its purpose by working in unity. Like a jigsaw puzzle comprising a mass of irregularly shaped pieces that form a picture when fitted together, an adaptive, integrated HMIS emerges when the different components of the enterprise fit together. Still, the HMIS must fit in with the existing culture and organization work environment. An adaptive, integrated HMIS approach therefore exemplifies a holistic conceptualization of the fit among various enterprise components within the context of an adaptive, integrated management perspective. The relationships among these major enterprise components are illustrated in Table 1.1, which may be further used to outline the different parts of this text.

Part I, comprising Chapters 1 through 3, emphasizes HMIS foundational concepts. Chapter 1 provides an overview of HMIS from the health managerial perspective. Chapter 2 highlights the roles and responsibilities of chief executive and chief information officers in healthcare services organizations followed by *Research Brief I*, discussing how a personal digital assistant (PDA) can enhance data collection efficiency for wait-time reductions in emergency departments. Chapter 3 discusses online health information–seeking behavior among Internet users, accompanied by *Technology Brief I*, which focuses on the fundamentals of Internet and associated technologies for healthcare services organizations.

Part II, comprising Chapters 4 through 7, surveys the technology and application layers of HMIS. Chapter 4 focuses on HMIS enterprise software, the new generation of HMIS administrative applications, accompanied by *Technology Brief II*, a refresher overview of basic hardware, software, and interface design concepts. Chapter 5 concentrates on community health information networks (CHIN) to interconnect healthcare provider organizations and build virtual communities. *Technology Brief III*, focusing on HMIS telecommunications and networks, follows this chapter. Chapter 6 familiarizes readers with three key patient-centric management

Table 1.1 HMIS Text: Content and Organization

Part I Foundation Concepts of HMIS	Chapter 1. HMIS: A Managerial Perspective *Joseph Tan* Chapter 2. HMIS Executives: Roles and Responsibilities of Chief Executive Officers and Chief Information Officers in Healthcare Services Organizations *Joseph Tan* *Research Brief I:* Personal Digital Assistants Enhance Data Collection Efficiency during a Study of Waiting Times in an Emergency Department *N. Elkum, W. Greer, and A. Al-Madouj* Chapter 3. Online Health Information Seeking: Access and Digital Equity Considerations *Fay Cobb Payton and Joseph Tan* *Technology Brief I:* Fundamentals of Internet and Associated Technologies for Healthcare Services Organizations *Joshia Tan*
Part II HMIS Technology and Applications	Chapter 4. HMIS Enterprise Software: The New Generation of HMIS Administrative Applications *Joshia Tan with Joseph Tan* *Technology Brief II:* Basic Hardware, Software, and Interface Concepts for Healthcare Services Organizations *Joshia Tan and Joseph Tan* Chapter 5. CHIN: Building Virtual Communities and Networking Health Provider Organizations *Jayfus T. Doswell, SherRhonda R. Gibbs, and Kelley M. Duncanson* *Technology Brief III:* Telecommunications and Network Concepts for Healthcare Services Organizations *Joseph Tan* Chapter 6. Trending toward Patient-Centric Management Systems *Joseph Tan with Joshia Tan* *Technology Brief IV:* Database, Data-Mining, and Data-Warehousing Concepts for Healthcare Services Organizations *Joshia Tan and Joseph Tan* Chapter 7. HMIS Integration: Achieving Systems Interoperability with Web Services *J. K. Zhang and Joseph Tan*
Part III HMIS Planning and Management	Chapter 8. HMSISP/IR: Health Management Strategic IS Planning/ Information Requirements *Jon Blue and Joseph Tan* Chapter 9. HMIS Development: Systems Analysis and Development Methodologies *Joseph Tan* Chapter 10. Data Stewardship: Foundation for HMIS Design, Implementation, and Evaluation *Bryan Bennett*

(continues)

Table 1.1 *(Continued)*

	Chapter 11. Managing HMIS Projects: HMIS Implementation and IT Services Management *Joseph Tan*
Part IV **HMIS** **Standards, Policy, Governance, and Future**	Chapter 12. HMIS Standards: Standards Adoption in Healthcare IT *Sanjay P. Sood, Sandhya Keeroo, Victor W. A. Mbarika, Nupur Prakash, and Joseph Tan* *Policy Brief I:* HIPAA, Privacy, and Security Issues for Healthcare Services Organizations *Joseph Tan and Fay Cob Payton* Chapter 13. HMIS Governance, Policy, and International Perspectives: HMIS Globalization through E-Health *Anantachai Panjamapirom and Philip F. Musa* Chapter 14. HMIS Innovation: HMIS Innovation Diffusion in Healthcare Services Organizations *Tugrul U. Daim, Nuri Basoglu, and Joseph Tan*
Part V **HMIS Practices and Cases**	Case 1. Emergency Medical Transportation Resource Deployment *Homer H. Schmitz* Case 2. The Clinical Reminder System (CRS) *Kai Zheng* Case 3. Integrating Electronic Medical Records and Disease Management at Dryden Family Medicine *Liam O'Neill and William Klepack* Case 4. Delivering Enterprisewide Decision Support through E-Business Applications *Rajiv Kohli and Henry J. Groot* Case 5. Mapping the Road to the Fountain of Youth *Joshia Tan*

systems, namely, EHR, CPOE, and CDSS. *Technology Brief IV*, focusing on the fundamentals of HMIS database, data warehousing, and data-mining concepts, accompanies this chapter. Lastly, Chapter 7, which centers on the idea of achieving HMIS integration with systems-interoperable Web services, provides closure to Part II.

Part III, which encompasses Chapters 8 through 11, concentrates on HMIS planning, design, and management issues. Chapter 8 covers HMIS strategic planning and methods to elicit organizational information requirements. Chapter 9 presents HMIS analysis and development methodologies, whereas Chapter 10 offers practical advice on HMIS design, implementation, and evaluation from a data stewardship perspective. Chapter 11 then closes Part III by reinforcing the concepts of HMIS implementation from the perspective of IT project management as well as IT service management concepts.

Part IV, which covers Chapters 12 through 14, acquaints the readers with HMIS standards, policy, governance, and the future. Chapter 12 presents HMIS standards and is augmented with *Policy Brief I*, focusing on the Health Information Portability and Accountability Act

(HIPAA), privacy, and security issues that govern HMIS design, deployment, and use; Chapter 13 opens up the scope of earlier discussions by transitioning into HMIS governance, policy, and international perspectives based on emerging trends of globalization and the e-healthcare paradigm; and Chapter 14 jumps forward with a look at the future of HMIS by dwelling on innovation diffusion.

This ushers us into the final part of the text, Part V, which is devoted completely to selective cases intended to pull together parts and pieces of HMIS concepts, methods, and applications as presented throughout the different parts of this text. Briefly, five selective contributions of HMIS applications cases are covered in Part V. Case 1, which focuses on strategic planning for HMIS in the context of an emergency medical transportation (EMT) setting, opens the case discussions for examining the applications of HMIS solutions to real-world problems. Case 2, "The Clinical Reminder System," offers insights into the development, utilization, and acceptance of a patient-oriented system to aid clinical workflow activities and routine decision making. Interestingly, Case 3, "Integrating Electronic Medical Records and Disease Management at Dryden Family Medicine," zooms in on HMIS implementation within a small physician group practice, while Case 4, "Delivering Enterprisewide Decision Support through E-Business Applications," shows how different generations of decision support evolved for a large-scale healthcare services delivery system. Case 5, "Mapping the Road to the Fountain of Youth," is an accumulation of the concepts covered in the cases in Part V and brings a closure to the entire text. With this overview, it is important to get back to the fundamental conceptualization of an HMIS and what are its basic functions.

HMIS Basic Functions

It is critical that beginning HMIS students achieve a good grasp of the basic functions of an information system. Historically, all information systems, including HMIS, are built upon the conceptualization of three fundamental but iterative information-processing phases: data input, data management, and data output. The data input phase includes data acquisition and data verification. The data management or processing phase includes data storage, data classification, data update, and data computation. Finally, the data output phase includes data retrieval and data presentation. Altogether, these eight elements and three phases define a typical information system as represented schematically in Figure 1.2.

Data acquisition involves both the generation and the collection of accurate, timely, and relevant data. Data are the raw materials needing verification, organization, and transformation before they can be useful information. The process of data generation in HMIS is normally achieved through the input of standard coded formats (e.g., the use of bar codes), thereby allowing rapid mechanical reading and capturing of data. The process of data collection differs from that of data generation in that data can be entered directly at the source (e.g., the use of a point-of-care bar code scanner), thereby enhancing data timeliness, validity, and integrity. Data verification involves the authentication and validation of gathered data. It is generally known that the quality of collected data depends largely on the authority, validity, and reliability of the data sources. The garbage in garbage out (GIGO) principle is an important factor to consider in this process; that is, data containing inaccuracies and inconsistencies should be detected as

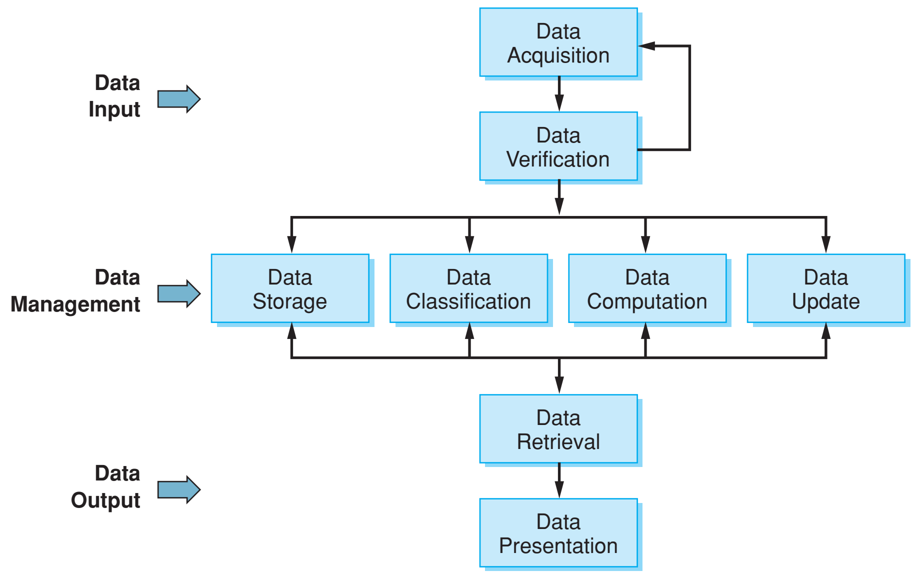

FIGURE 1.2 Basic Functions of a Health Management Information System.

early as possible in the system to allow immediate correction and minimize the eventual costs of system output errors.

The preserving and archiving of data may be regarded as part of the data storage function. Memory (i.e., a physical storage system) and indexing (i.e., the selection of key words to determine major subject areas) are primary means of amassing data. When accumulated data are no longer actively used in the system, a method to archive the data for a certain period is usually advisable and may sometimes be mandatory, as when it is required by legislation. A closely related element to data storage is data classification (or data organization). It is a critical function for increasing the efficiency of the system when the need arises to conduct a data search. Moreover, imposing a taxonomy on the data that have been collected and stored provides greater understanding of how the data can be reused. Most data classification schemes are based on the use of certain key parameters. For example, data referring to a patient population may be classified and sorted according to various diagnostic classification schemes, such as the widely accepted ICD-9-CM, a clinical modification of the original ICD-10 system developed by the National Center for Health Statistics (NCHS). More recently, the ICD-10-PCS (the International Classification of Diseases, 10th Procedure Coding System) has replaced volume 3 of ICD-9-CM.[3,4] While ICD-10-PCS is yet to be implemented, awaiting propagation from the World Health Organization (WHO), such an organized patient data system is useful for conducting a case-mix analysis because it comprises a set of diagnostic codes of thousands of patient classifications. Each code has seven alphanumeric characters, including section, body system, root operation, body part, approach, device, and qualifier. Indeed, the particular taxonomy employed will have a powerful influence on the way the data can be subsequently used.

This is because a high degree of semantics is implied in any particular data classification. Crowe and Avison noted that if the wrong classification is chosen, a great deal of potentially useful information could be lost.[5] This, however, is not a problem that can be easily resolved due to the lack of standardization among competing taxonomies. System integration and data interoperability have, therefore, been an enduring challenge for HMIS researchers and practitioners.

New and changing information is accounted for through the element of data update. The dynamic nature of such data modification calls for constant monitoring. For HMIS to maintain current data, mechanisms must be put in place for updating changes in the face of any ongoing manual or automated transactions. The concept of processing a transaction (i.e., whenever an event alters the current state of the system) is critical for ensuring data timeliness. Such updates can be either online (real-time) or batch processed sequentially. Due to legal and ethical considerations, archiving and tracking each data update can be a critical requirement in designing and implementing HMIS. Data computation involves various forms of data manipulation and data transformation, such as the use of mathematical models, statistical and probabilistic approaches, linear and nonlinear transformation, and other data analytic processes. Computational tasks allow for further data analysis, synthesis, and evaluation so that data can be used for strategic decision-making purposes other than tactical and/or operational use.

Data retrieval is concerned with the processes of data transfer and data distribution. The data transfer process is constrained by the time it takes to transmit the required data from the source to the appropriate end-user. A key problem in data transmission is the existence of noise (i.e., distortion) that could be both internal and external to HMIS. The data distribution process ensures that data will be accessible when and where needed. There must also be ways to ensure that unauthorized users are denied access to sensitive data in the system. This is normally achieved through the institution of data security and access control mechanisms, such as the use of firewalls, passwords, user authentication, and other forms of user identification. One significant criterion to be considered in the data retrieval function is the economics of producing the needed information. Many early systems (particularly stand-alone hospital information systems) were far too costly to operate, and the costs were simply not justified relative to the value of information that was finally produced. This situation has largely changed with advancing HMIS techniques and technologies available at decreasing costs.

Finally, data presentation has to do with how users interpret the information produced by the system. In situations where only operational or even tactical managerial decision making is expected, summary tables and statistical reports may suffice. However, certain managerial decision making involves strategic thinking and active collaboration. The use of presentation graphics for higher-level managerial decision analysis is particularly encouraged because these appear to provide a better intuitive feel of data trend. Tan and Benbasat[6] and Tan[7] have presented a theory to explain and predict the human processing of graphical information, which is valuable to guide HMIS designers in the matching of presentation graphics to tasks.

To illustrate these various HMIS data phases, we can use the case of a computerized patient health records system for inpatients, which is usually supported with bedside terminals. In this system, data acquisition comprises the generation and gathering of daily notes on symptoms, treatments, diagnoses, progress notes, discharge summaries, registration of orders for laboratory tests, operations, anesthesia, and other sources of information such as patient demographics and physicians' findings. The data may also come from other interconnected HMIS through live or batched data feeds. The data to be coded and automated are usually formatted into specific and normalized elements, fields, and records.

Figure 1.3 illustrates an abstract of a patient health record that could be implemented as a Web-based system for monitoring patient medical conditions and treatments in a healthcare services organization. As for data verification, the system relies on the ease with which the coded data may be mechanically processed and properly decoded. In many cases, standard forms and standard terms are used in recording patient data to ensure data integrity and consistency. Most computerized patient record systems have built-in capabilities to reject invalid data inputs through the use of range checks (e.g., specifying a patient's age to fall within a verifiable

1. Patient Medical Insurance Number: ____________
2. Patient Name: ____________
3. Date of Admission: / /
4. Date of Discharge: / /
Mo/Day/Yr:

5. Sex:
__ Male
__ Female

6. Birthdate: / /

7. Tel. No.: ____ ____ ____

8. Next of Kin: ____________

9. Address: ____________

10. Admission Source:
__ Admitting
__ Emergency
__ Outpatient

11. Location of Patient: ____________

12. Discharge Status:
Alive:
__ With Approval
__ Against Notice

Death:
__ Autopsy
__ No Autopsy

Transfer to:
__ Other Institution
__ Home

13. Type of Death:
__ Anesthesia
__ In Operating Room
__ Postoperative
__ Other

14. General Remarks:
____

PROCEDURES

15. Principal Procedure:
a. ________ Date: / /

16. Additional Procedures
a. ____________
b. ____________
c. ____________

17. History/Physical:
____

18. Laboratory:
____

19. Radiology:
____

PHYSICIANS

20. Principal Specialist: ____________
Second Specialist: ____________
Family Physician: ____________

DIAGNOSIS

21. Principal Diagnosis: ____________
22. Additional Diagnoses:
a. ____________
b. ____________
c. ____________

FIGURE 1.3 A Sample Abstract for a Computerized Patient Medical Record System.

range of classification) and other means (e.g., using batched totals). After data input, the data are kept securely (data storage) in a database, a central data repository. This is to ensure that the data are accessible to the healthcare services providers on any subsequent visits by the same patient. A unique patient identifier and a master patient index (MPI) are used to identify the exact locations of all related records of a specific patient. This type of data organization also allows for easy processing and regular updating by care provider organizations.

Updating and maintenance of the data (data update) to ensure timeliness and integrity can be carried out either on a daily basis (i.e., routinely) or interactively (real-time). For example, some hospitals collate their daily census through batch processing around midnight. Additional data-processing functions include data analysis and synthesis to transform and combine various elements of the input data into useful and meaningful information (data computation). The data retrieval function ensures that the appropriate end-users (e.g., physicians, nurses, quality improvement managers, and medical researchers) have access to accurate, timely, and relevant information from the system. The distribution of information to end-users typically occurs through Web-based services, where appropriate users can be authenticated whenever they want to abstract certain views of the stored data or perform queries. Ultimately, data presentation in the context of the preceding example is concerned with generating reports that are easy to read and interpret for use in informed patient care or related decision making.

IV. HMIS Cultures

Why do HMIS cultures matter? A health information system exists as part of a larger system to support one or more of a combination of administrative, financial, clinical, research, or managerial activities occurring within a health organization. Yet, it is the culture of the health services organization that largely determines the appropriate product mix, roll out, and use of HMIS solutions within the organization. More likely than not, existing and traditional HMIS applications often tend to be disintegrated so that critical information embedded in the different parts of the organization is not going to be transparent among employees of the organization.

In terms of HMIS cultures, based on what we now know about successful and effective IS/IT (information systems/information technology) leadership, a healthcare services organization may intentionally or unintentionally adopt and nurture one of four types of cultures: an information-functional culture, an information-sharing culture, an information-inquiring culture, and an information-discovery culture.[8] Understanding the different characteristics of each of these cultures is important to guide managers, administrators, and systems analysts in generating appropriate HMIS solutions for the organization.

An information-functional culture essentially takes the traditional view that information is power and that giving up information means giving up the power of controlling others. It also follows that as most organizations are structured functionally, information-functional culture therefore limits the flow of information within a functional area such as human resources, accounting and finance, sales and marketing, and IT. For example, nurses in an emergency department of a healthcare services organization adopting an information-functional culture will attempt to safeguard their own use of patient-gathered information as well as limit the sharing of patient records as a way of exerting power over nurses in other departments. Thus, whenever nurses from the acute care units or other departments need to schedule a care routine of a discharged patient from the emergency department, they would have to involve the emergency department nurses.

In contrast, an information-sharing culture promotes trust among employees of different departments within the same organization. While needing to be sensitive as to the privacy, confidentiality, and security of particular information under his or her safeguard, it is important that nurses, physicians, and others be able to share certain types of information with fellow employees for the benefit of the entire organization. For example, the chief medical officer (CMO) of a hospital who wants to see that his or her direct reports work collaboratively to benefit the efficient and effective running of the entire hospital must not only encourage sharing of information among individual physicians, but he or she should also focus on making information—especially on procedural problems and patient care process failures—transparent among the individual physicians in the hospital.

An information-inquiring culture essentially makes transparent the core values, beliefs, and purpose of the organization and ensures that critical information about the due processes, procedures, and functioning of the organization is easily accessible for all employees throughout the organization. Employees are also encouraged and trained to actively monitor such information and to align their daily actions and behaviors with the trends and new leadership directions of the organization. For instance, all nurses and doctors of a healthcare provider organization could be asked to greet and politely interact with incoming and discharged patients to promote its reputation as an organization focused on patient care and customer satisfaction. All employees are also clear about how conflicts should and can be resolved quickly and the due procedures for attending to patient complaints.

Finally, an information-discovery culture entails that the organization is able to share insights freely and encourages its employees to collaborate in offering new products and/or services that meet the needs of existing and new clients. Employees throughout the organization are also provided with a comprehensive view of how the organization functions and how it will support them in their attempt to deal with crises and radical changes and/or finding ways to achieve competitive advantages against its competitors. For healthcare organizations, it is difficult to imagine the adoption of an information-discovery culture, especially among the physicians, because of these organizations' strong traditional roots in which physicians are accustomed to make their decisions independently about the patients under their care, even though they are affiliated with the organizations in which they practice.

Understanding HMIS applications begins with having an appreciation of how health organizations function and how IT is used in these organizations. The complexity of healthcare organizations and the intricacy of its myriad processes often is the root cause of IT failures in health care. Many health executives thought that slapping a complex HMIS on top of the problems encountered in a healthcare organization would resolve its woes when, in many cases, it not only worsens it, but adds unnecessary expenses when the root causes of these problems are not well understood. It is far more important to map out the processes, simplify the complexity, consolidate the needs, and identify the core IT requirements. From here, management has to nurture, cultivate, and respect the working of the HMIS culture and implement appropriate HMIS solutions accordingly.

V. Conclusion

This chapter started out with a real-world scenario describing the challenge of HMIS integration within a healthcare organization. It briefly highlighted the roots and evolution of HMIS discipline. The basic components and functions of a health management information system were further contemplated. It is clear that in order to understand HMIS, students should appreciate the functioning of a healthcare organization, such as the HMIS cultures, before HMIS solutions can be efficiently and effectively deployed in the organization and used to their full capacity.

In the next chapter, we highlight the roles of the chief information officer/chief executive officer for healthcare services organizations. Understanding these roles is critical for managing and designing future HMIS. Following this, we close Part I of this text with a chapter on how users are individually seeking health information on the Internet, selecting the best healthcare providers, and learning to become better-informed consumers. It is hoped that instructors will find these three foundational chapters in Part I helpful in encouraging students to become excited about the world of HMIS. The scenario at the beginning of each chapter and the minicases, *Research Briefs, Technology Briefs, Policy Briefs*, additional readings, and discussion questions that are offered at the end of the chapters are ways to motivate the students' learning—as well as to help them seek answers to many more new questions about HMIS—as new knowledge and technological breakthroughs in HMIS-related fields continue to emerge in a rapidly changing world.

Notes

1. http://www.digitalhcp.com/2008/05/27/dc-rhio-sets-ambitious-plans.html, accessed May 27, 2008.
2. T. L. Lincoln and R. A. Korpman, "Computers, Healthcare, and Medical Information Science," *Science* 210, no. 4467 (1980): 257–263.
3. ICD-9 is a U.S. Public Health Service official adaptation of a system for the classification of diseases and operations. The original system was developed and updated periodically by the World Health Organization for indexing hospital records. See T. C. Timmreck, *Dictionary of Health Services Management* (Owings Mills, MD: National Health Publishing, 1987): 306.
4. ICD-10-PCS is purported to be a replacement code set for ICD-9-CM. See http://www.inhcc.com/Standardization/coding _systems.htm, accessed June 1, 2008.
5. T. Crowe and D. E. Avison, *Management Information from Data Bases* (New York: Macmillan Press, 1980).
6. J. K. H. Tan and I. Benbasat, "Processing Graphical Information: A Decomposition Taxonomy to Match Data Extraction Tasks and Graphical Representation," *Information Systems Research* 1, no. 4 (1990): 416–439.
7. J. K. H. Tan, "Graphics-Based Health Decision Support Systems: Conjugating Theoretical Perspectives to Guide the Design of Graphics and Redundant Codes in HDSS Interfaces."

In J. K. H. Tan with S. Sheps, *Health Decision Support Systems* (Gaithersburg, MD: Aspen Publishers, 1998): 153–173.
8. Booz Allen Hamilton, *Information Sharing* (New York: HarperCollins, 2006). See also www.boozallen.com.

Chapter Questions

1–1. How does HMIS affect or influence the different departments within a healthcare services organization?
1–2. Why is it difficult to integrate IT and medicine? Discuss the need for an integrated management perspective of HMIS.
1–3. List the five major components of integrated HMIS. Discuss which component deserves the most attention in today's HIT environment and why. Provide specific examples of each component in the context of your work.
1–4. If you were a CIO, which of the four types of IT cultures would you pursue, and why?
1–5. List and illustrate the basic functions of an HMIS. How may these basic functions be extended to accommodate complex health information processing tasks such as medical diagnosis and teleconsultation?

Mini-Case: MinuteClinic

MinuteClinic, owned by pharmacy giant CVS, is a retail healthcare provider with more than 500 locations established throughout the country. The centers are designed to treat patients with minor injuries or sicknesses, and more than 1.8 million patient visits have been documented since the company's inception in 2000. By creating a healthcare delivery model that responds to consumer demand, MinuteClinic makes access to high-quality medical treatment easier for more Americans.

As more patients used MinuteClinic resources, one issue the company faced was how to pass medical information to primary care physicians. As Cris Ross, chief information officer of MinuteClinic, explains, "There are a number of things we do very well with physicians, except connect electronically. We've been looking for a business-to-business exchange."

As a solution to this problem, MinuteClinic recently turned to ePrescribing connectivity network SureScripts to facilitate this exchange. It is the first time the SureScripts network has been used for anything other than pharmacy orders and related transactions.

"The idea is that we already have pharmacies connected," acting SureScripts CEO Rick Ratliff told Digital Healthcare & Productivity by telephone. "We have an ability to identify a physician uniquely on the network."

As part of this connection, MinuteClinic will convert records from its proprietary electronic medical records system into Continuity of Care Record (CCR) standard format. Ratliff adds that this record "can be moved around almost like a piece of mail" from provider to provider, and into personal health records (PHR).

Now with every visit, MinuteClinic practitioners stress the importance of maintaining a medical home for each patient by making information accessible to primary care providers. If a patient doesn't have a primary care provider, MinuteClinic provides a list of physicians in the area who are accepting new patients. Practitioners are then able to use a multipurpose software-based approach at the conclusion of each visit that generates educational material, an invoice, and a prescription (when clinically appropriate) for the patient, as well as a diagnostic record that is automatically sent to the patient's primary care provider's office (with the patient's consent) to facilitate continuity of care.

Mini-Case Questions

1. How might embracing the CCR standard benefit and/or damage MinuteClinic's overall profitability?
2. Why does MinuteClinic choose to promote the patient/primary care provider relationship?
3. What patient issues might MinuteClinic face in implementing an electronic record that can be easily transferred from clinic to physician?