Health Care Information Systems: Foundations for Future Research

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Abstract: Historically, health care information systems (HIS) have been designed to satisfy the needs and demands of administrators and clerks: laboratory managers, CFOs, the billing department. They have been purchased by providers as needs arose and linked together one at a time to satisfy specific requirements. These fragmented systems have been crippled by the distrust and parochialism that plague many health care organizations. The future of health care systems is brighter. Change is being brought about as a result of forces in both the health care and the information systems industries. Trends such as the move toward integrated provider networks, managed care, population based care and the computer-based patient record (CPR) are driving and facilitating the development of new HIS models. At the same time, dreams are becoming reality through rapid change in the information systems industry. In response, CIOs, laboratorians, vendors and consultants have sought to create a model for information systems that will preserve existing investments and functionality while at the same time addressing unmet needs and incorporating new capabilities.

The model that has been widely adopted within the HIS community is an architecture that unites disparate systems. It incorporates regional and national networks with local and wide area networks linking the component systems of the health care enterprise, such as the laboratory systems. These are bridged by an interface engine which channels data into a warehouse, or repository. This in turn provides a foundation for enterprise wide information systems as well as simple reporting and query functions. Advanced clinical systems built as enterprise information systems take advantage of emerging technologies to put information in the hands of caregivers at the point of care in ways that support and enhance the care process. This model incorporates all of the technologies identified in the Institute of Medicine's 1991 report on the computer-based patient record. It is, however, unable to resolve all of the shortcomings of information systems. For example, health care data pose significant difficulties. Definitions are not standardized, there are difficulties with coding and taxonomy, outcomes are still poorly defined, and much of the data is textual.

As this model becomes more widely implemented, it begins to make possible new capabilities within laboratory systems. To take advantage of these requires that lab systems development and research focus on issues of integration, intelligence, and imagination. Integration implies a longitudinal laboratory and health care record across time and space as well as the rejection of parochialism. Intelligence implies that our information systems think the way our caregivers think, display information effectively, and that they can understand and take action on the data they contain. Yet imagination may be the most critical focus of all, for it is what keeps us from doing things the way they have always been done when a new perspective would make all the difference in the world.

To properly consider laboratory focused health systems research, it is helpful to place laboratory systems within the context of the current overall health care information systems (HIS) environment. Historically, HIS have been designed and purchased to meet administrative and financial requirements, not those of caregivers. For this reason, they have developed as patchwork systems with a focus on acute care, each component being developed based on pressing business needs. Internal politics combined with weaknesses in system designs have led individual departments or providers to purchase and fiercely defend component systems that may not complement the overall HIS of an organization. Those individual components, each with its own technology, have had to be painstakingly linked together, one by one, into a complex web of interfaces. Caregivers seeking access to the information within these systems have often been daunted by user interfaces that require significant training and that, while useful to those for whom the systems are written, in no way reflect the work flow and thinking of a caregiver.

Change in the HIS industry has been catalyzed by factors in both the health care industry and in the information systems field. Emerging systems are redrawing the discouraging picture above. On the health care side, market-based health care reform such as managed care, and efforts at administrative simplification, are driving demands for comprehensive, standardized systems that effectively integrate administrative and clinical requirements. At the same time, provider consolidation into integrated delivery networks is forcing the creation of health records that span the continuum of care. Managed care strategists now look at health care requirements from the standpoint of populations rather than patients. This opens out the commercial health record into the realms of what have traditionally been the concern of public health planners and epidemiologists: data such as risk factors, immunization rates and the incidence of disease. Payers, including the U.S. Congress, are clamoring for cost savings through quality, efficiency, and "doing the night thing," a demand that has sparked the outcomes movement, the mass production of clinical guidelines, report cards, profiling and a host of other related initiatives all requiring information. Finally, health care information, once a private, written record for use by a caregiver and patient, has become a public utility to be collected by state and federal data commissions, disseminated over community health information networks (CHINs) and analyzed by researchers, planners, marketers and consumer interest groups. All of these trends demand true, comprehensive, integrated clinical information systems. The 1991 Institute of Medicine (IOM) report describing the requirements of the computer-based patient record (CPR) represents perhaps the clearest synthesis of these needs.

On the information systems side, the real catalyst of change is opportunity. This includes:

- Standard health care data definitions and interchange mechanisms
- Open systems, communications, security and data base standards
- Local and wide area networking
- Graphical user interfaces
- Text processing
- High powered, commodity hardware

All of these developments make it possible to

remove communication barriers between systems and providers, increase the distribution of information systems, and move data collection closer to the point of care, thus improving the quality of information.

Next Generation Systems

Given such complex new demands and the opportunities afforded by technological advances, providers have created quite a laundry list of requirements for the information systems they are looking to purchase and implement. Among them:

- Safeguard existing investments - Few providers are in a position to simply throw out their installed information systems base. Especially as integrated provider networks form, the disparate systems already in place must continue to do their jobs, at least for the short term.

- Preserve functionality - Likewise, the administrative needs already being met are not going away, though they are evolving. The addition of clinical functionality assumes the continued support of nonclinical functionality.

- Provide a foundation for expansion - Both of the information system and of the provider network.

- Support the continuum of care - Through required functionality, through a longitudinal patient record, and through access to information systems at the point of care.

- Incorporate a universal person index - Is John Jones also J. Jones also John J. Jones? A universal person index unites the records from disparate systems, both inside and outside the individual health care enterprise. Only with such an identifier can a longitudinal record be developed.

- Integrate - This requires moving beyond simple interfaces to create systems that truly span the health care enterprise. A classic example is health care scheduling where a patient may need a series of services in sequence. Interfaced systems make such scheduling a nightmare; integrated systems treat the challenge as a single whole.

- Supply new applications - New or redefined functionality demands new systems entirely. These may replace existing components, complement them, or use them as a foundation.

- Add intelligence - Human information process capabilities are finite. To extend productivity and reduce errors, the HIS needs to assume responsibility for routine processing and interpretation.

In response to this set of baseline requirements, HIS designers and developers are beginning to standardize on a generalized architectural model. While specifics of the model vary by implementation, the overall outline is as shown in Figure 1.

The boxes around the circle represent the components of the health care enterprise with their individual information systems. These are often referred to as legacy

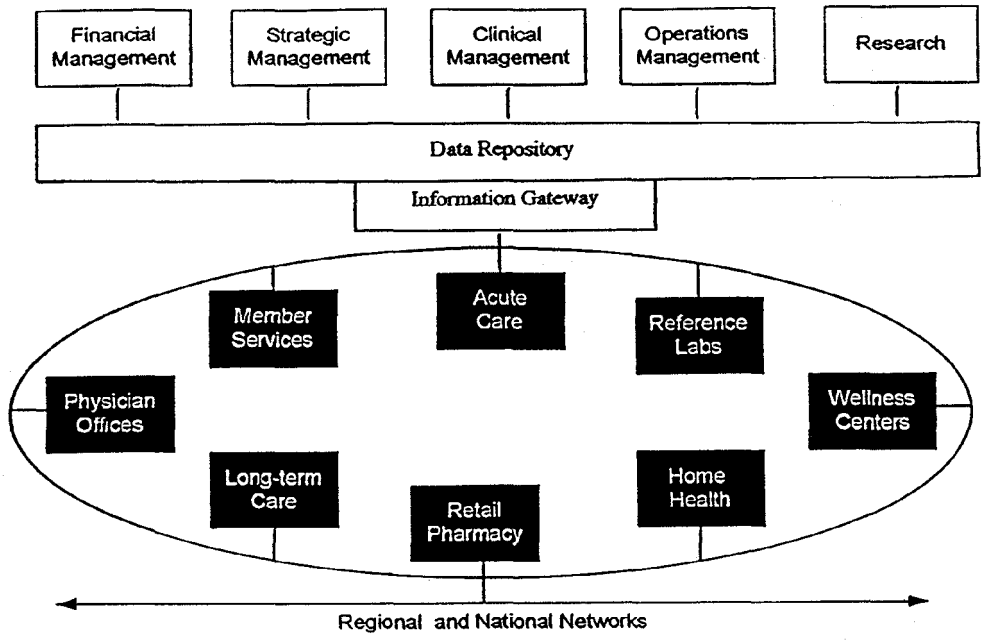

Figure 1. Generalized Architecture

systems, although in fact they may also be new systems that are specialized for a particular application. Each of these systems must meet operational needs and be able to collect component level data applicable to its functions. The circle itself is a local network around which these systems can pass information common to them, e.g., patient name and address or clinical condition. This local network is connected to regional and national networks (the "information superhighway") to which it can pass information and from which information can be obtained. For the care of an individual patient, the network might be used to gather the records of previous care by another provider. For outcomes management, it might be used to gather together a case sample of similar patients for analysis and comparison.

The information gateway might also be shown as part of the local network. It is a combination of traffic cop, facilitator, universal translator and general guide for all the bits and pieces of information flowing into and around the network. It knows which systems need what and can properly format and broadcast that information. It also knows what to extract for the repository. Finally, it includes a component to map everything together using a common person identifier. This makes possible the linking of disparate components of care into a single, logical, longitudinal record. The clinical repository provides a unified data base on which can be built enterprise-wide applications as the newly integrated health care organization determines its requirements. While it need not be a single, physical data base, it does need to be a rationally designed clinical record, providing caregivers with access to immediate,

accurate, and comprehensive information. It represents a data set that is both deep and wide. Deep in that it includes very detailed clinical data such as all of the tests and treatments received by a patient, their results, dosages, specific brand names, etc. Wide in that it includes not only a large sample of patients but care provided across the full provider spectrum. Across the top are shown broad categories of new applications. These can be developed and implemented efficiently when the clinical repository is in place. They, in turn, will enable its expansion by gathering and processing additional information.

To implement this model, developers will take advantage of the 9 technologies identified by the IOM in its model of the CPR.

- Databases and database management systems - For coping with huge volumes of disparate data.
- Workstations - Powerful multi-media hardware appropriate to the point of care/use.
- Data acquisition and retrieval - Implying user-friendly data entry and access at the point of care.
- Text processing - Simplified entry and meaningful retrieval techniques
- Image processing and storage - Both archiving of paper and clinical images
- Data exchange and vocabulary standards - To facilitate communications across components and organizations
- System communications and network infrastructure - To permit the widespread dissemination of systems to all caregivers in all locations.
- System reliability and security - To protect confidential data and ensure that systems are available whenever and wherever required.
- Linkages to secondary databases - To extend the model beyond a single health care enterprise, to incorporate knowledge bases, to provide benchmarks.[1]

Despite the advantages offered by the new model, there are a host of challenges yet ahead. For example, on the data front, the best information systems in the world cannot make up for missing or undefined data. At this point, outcomes data definitions are still loosely defined with little agreement across those doing the measuring. Even seemingly simple measures such as length of stay (LOS) may have different definitions within an organization, and more complex, yet familiar measures such as mortality have very different values depending on when and how measured.

Large components of health care data are not yet universally coded, or are coded using organization-specific schemes suitable for internal purposes but useless for public health purposes. Uncoded health care information is typically stored as text, which poses significant challenges of its own. While exciting work is underway in the area of automated text interpretation and coding, as of now, free text is not available for ready analysis or for operations such as decision support to caregivers. Other challenges have more to do with the structure of the health care system. For example, a true longitudinal medical record is predicated on a population focus for health care that spans proprietary organizations. Yet data are still "owned" by providers, insurers, and patients, and are in many cases a strategic asset. This is proving to be a serious impediment to many of the community health information

networks being formed.

Improving Care Through Laboratory Systems

Within the context of this model, laboratory systems have tremendous potential to improve the overall quality of health care. Without attempting a comprehensive catalog of projects, the three "I" words below summarize areas of focus likely to yield significant benefits to patients, providers and payers.

Integration. We have already discussed the mechanics of systems integration. Integration also implies cultural change and quality improvement to break down the distrust between departments and between clinical users and the information services department. One of the significant barriers to the integration of laboratory systems has been the traditional tension between "best of breed" systems and "house-wide" systems. Within the vendor community two trends are likely to reduce or eliminate this tension: One is the movement of lab systems vendors into the broader HIS market, and the other is the purchase and integration of respected lab systems by HIS vendors. The generalized architecture described above is also designed to minimize the integration "hit" from choosing a best of breed departmental solution.

An integrated systems model should also support the decentralization of functions where appropriate so that they are available at the point of care and/or where the caregiver works. If systems provide this level of integration, organizations are then free to reengineer processes, for example in a patient-focused care model, to improve the quality and efficiency of care. Finally, integration implies a truly comprehensive data model spanning time, location, provider and birth to death events. Only with such a model can we truly evaluate the outcomes of our processes, decisions and actions.

Intelligence. Intelligent systems are designed to think and work the way their intended users do. This means that information is presented in a flow and format that facilitates decision making and that parallels work flow. Intelligent systems also take on routine information processing so that users can focus on what is important and requires their clinical or managerial expertise. Laboratory systems have long flagged out-of-range values and provided basic interpretive information. More sophisticated systems provide for reflex testing, though this raises interesting legal issues. Newer systems will offer access to extensive knowledge bases, user control over the intelligence within the system and rules that examine data from the entire process of care to provide alerts and reminders to caregivers.

Imagination. Imagination implies thinking about how we can do things better, how we can reengineer a process to take advantage of computerization, and going beyond the routine solutions. A little creativity can go a long way in systems design and implementation. That includes looking not just at systems but at how they are used. Even the best system cannot overcome bad policies that defeat the system and jeopardize the quality of care.

After many years of promised advances remaining just out of reach, health care information systems are finally beginning to deliver their hoped for benefits to outcomes, quality and the productivity of caregivers. With proper focus, the combined expertise and attention of system designers and laboratorians applied to the issue of laboratory systems seems likely to yield a

rich harvest of rewards in the very near future.

References

1. Dick RS, Steen EB, editors, The Computer-Based Patient Record, National Academy Press, 1991, pp 56-67.