The Practice of Informatics

Viewpoint ■

Transforming Information: Data Management Support of Health Care Reorganization

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Abstract Health care delivery systems and organizations around the world are undergoing reorganization and reengineering. Rational decision making about such activities must be based on information. Much of the presently available data is inadequate for this task, and therefore needs to be transformed. One such experience in the province of Alberta, Canada, is discussed. The development of a comprehensive information strategy, the need to apply information management principles, the organizational implications of information management, and a conceptual model for achieving added value from health data are described.

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Health care organizations and health systems internationally are under siege. Many health systems are presently under pressures analogous to that of the room in which Alice in Wonderland found herself when she began to grow larger. Alice grew until the room became too small. One gets the same feeling about health systems internationally: national health systems are under enormous pressure from all sides. There is a decrease in the revenue available to fund health services; the explosion of new treatments, new programs, and new technologies is accompanied by citizens' increasing demands on and expectations of their health systems and is reflected in changing de-

livery modalities, such as managed care; drug costs are rising; population demographics are characterized by the rising average age; health services delivery paradigm is shifting from acute care to community-based care; and employees' expectations for remuneration and compensation are resulting in rising labor costs (Fig. 1).¹ Simultaneously, there are also expectations that the efficiency and effectiveness of health care will improve while the quality of care is maintained or even improved.

For all of these reasons, health systems around the world are under enormous pressure to change. However, decisions about health care organizations and health care delivery systems must not be based on opinion, emotion, historical precedent, or political expediency. Data and information are essential for rational decision making and good management of the health services delivery system in any country. The restructuring of health systems worldwide must be based on data and information.

Historically, the field of medical informatics has had a major focus on physician-delivered patient care in hospitals. Much less attention has been directed toward population-based health care. Increasingly, the field is beginning to emphasize health informatics, which has a broader multidisciplinary focus on health

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Figure 1 Pressures on national health care systems.

services delivery, including community needs assessment, population health status indicators, health promotion, and disease prevention, in addition to the treatment of illness. Health informatics can and should play a major role in the reengineering and restructuring that is occurring in many health care organizations and health services delivery systems.

This article describes selected information management measures used in Alberta, defines the concepts underlying this experience, and extracts principles that may be generalizable to other health care systems and organizations.

The Alberta Experience

To illustrate these objectives, it is necessary to understand the context in which the experience occurred. Seventy-three percent of Canadian health care spending is financed from the public purse.² In other words 27% is privately funded. Canadian health expenditures have risen dramatically over the last ten years while prices and the population have stayed comparatively stable.² In 1980, health represented 20% of governmental spending in Alberta; in 1993 that had risen to approximately 30%.³ In all Canadian provinces, health expenditures have risen slightly while expenditures on all other government programs have declined.² In other words, to maintain expenditures on health care in the absence of new revenue, it has been necessary to reduce expenditures on such items as roads, education, social services, the environment, tourism, law enforcement, and defense.

Approximately four years ago, the Federal and Provincial Ministers of Health in Canada agreed that

health was not underfunded, rather it was under-managed. They concluded that there was a need to contain costs, measure the health status of the population, and measure the performance of the health care delivery system. More recently the Prime Minister has directed the National Forum on Health to look beyond the confines of hospital wards and doctors' lobbies and to look at the social factors that determine people's health.⁴

The ministers identified a lack of information available for use by administrators and policy makers to manage the health care delivery system.⁵ They assigned the challenge of providing this information to the National Health Information Council⁵ and subsequently established the Canadian Institute for Health Information (CIHI) in the spring of 1994. Figure 2 shows the template that the CIHI uses as a model for conceptualizing health information on a national scale.⁵

Among the underlying principles of the template was the assumption that individuals were the source of health information—people and their health needs are the reason that the health system exists. Collectively these individuals, with their personal and unique characteristics, reflect the population for which health services are provided. These individuals exist within an external milieu composed of physiochemical, sociocultural, and economic environments, as well as the health care system. The health care system delivers health-affecting interventions that are directed either at individuals or at populations through collective interventions.

Health is a provincial responsibility in Canada, not a federal one. Consequently, there are ten provincial health care systems in Canada, not just one.⁶ Until

April 1994, the health care system in Alberta was typical of other provincial health care systems in Canada. The provincial Department of Health was responsible for funding and monitoring the provincial health services delivery system. There were five sectors, or "stovepipes," within the Alberta health care delivery system: the practitioner sector (e.g., physicians, dentists, physiotherapists), the acute care sector, the long-term care sector, the public health sector, and the mental health sector. These five sectors existed in solitude. There was little communication among them, they were funded separately, and each was governed by unique legislation. The information systems reflected this separation in that within the five sectors there were multiple users with their own applications, systems, and databases.

Over the last two years, the Alberta health care delivery system has undergone a transformation. Initially, the values of the citizens were considered; existing legislation and policy regarding the delivery of health services were reviewed; programs delivered by service providers were studied; and the resources available to the government to address the health status of the population were assessed. Based on analysis and interpretation of the extensive public input, the Minister has redesigned the health care system in Alberta. Now, rather than a health system comprised of five separate province-wide sectors (practitioner, acute care, long-term care, public health, and mental health), there are 17 health regions. Within each of these geographic areas is a Regional Health Authority that is initially responsible for acute care, long-term care, and public health services for all residents. Eventually, Regional Health Authorities are

expected to be responsible for all health services within their respective boundaries. Citizens are entitled to health care by virtue of residence.⁷

Information Requirements for Restructuring Health Systems

The kinds of decisions that are facing health system managers today are more complex than were decisions in the past.⁸ For example:

- Patient-focused rather than discipline-focused decisions. The concept of multidisciplinary teams is increasingly being used within health care delivery, resulting in a focus on the recipient of care rather than on the provider of care.
- Previously, decisions within the health system were focused within service sectors (acute care, public health, mental health, long-term care, insured services), but now they are becoming focused on regional geographic areas, which require a cross-sectorial perspective.
- Decisions affecting the entire health system require information about the entire health system, e.g., early discharge programs in the acute care sector have a major impact on the home care delivery sector.
- Decisions affecting even a part of the health system still require information about other parts of the health system because of the impact of interdependencies among the sectors.
- Deciding to reduce expenditures on health services while maintaining the quality and maximizing the benefits of health services for citizens will require information about the outcomes of health services. We need to know whether what we are doing makes any difference.⁸

As reengineering or restructuring proceeds, information products of interest to health system decision makers⁸ will include:

- Residents—Information about the health needs and health status of citizens, their families, and their communities
- Recipients—Information about residents who are receiving services from the health system
- Providers—information about available persons and organizations with health service skills (health workforce)
- Services—Information about the range of health-

Figure 2 The template that the Canadian Institute for Health Information (CIHI) uses as a model for conceptualizing health information on a national scale. Reproduced with permission of the Canadian Institute for Health Information.⁵

affecting interventions and activities available in the health system

- **Programs**—information about health program objectives, target populations, resource allocation, and service packages
- **Resources**—distribution of dollars, capital investments, human resources, and information
- **Utilization**—use of resources by service provider, by service recipient, by program, and by type of service. (Service events are the basic information building blocks that enable the measurement of cross-sector, cross-time, cross-region utilization.)

Health Information Processing Strategy

In anticipation of the need to support the reorganization of the health care delivery system in Alberta, a project was begun to develop a Health Information Processing Strategy (HIPS) for Alberta. This project used information engineering principles and enterprise computing concepts to undertake a detailed business process analysis and redesign. This culminated in a detailed functional model of the health system in Alberta. From this model, three architectures were developed: a data/information architecture, an application architecture, and a technical architecture.^{9,10} The information architecture uses as its fundamental unit the construct of a service event.¹¹ A service event is comprised of the services delivered by a service provider to a service recipient at a particular location at a specific time with an associated cost. The primary key for organizing health data is the service recipient. The application architecture is the intersection of the data with the business processes. It is comprised of an infrastructure base, a set of repository databases, operational applications, evaluation applications, and a set of executive corporate applications. The technical architecture is based on principles of interoperability, portability, and scalability, expansibility, and connectivity. In the technical architecture, the applications and databases are available through a communication network to a variety of delivery hardware components. Each hardware component has a communication function, a processing function, and data storage capability. The capacity for each activity varies depending on whether the hardware component is a personal workstation, a work group server, a central facility, or an external resource.⁹

Alberta does not have the resources to discard its legacy systems. It was not possible to throw out either the existing systems or the data that they contained. Rather, HIPS principles were applied to all new sys-

tems development and acquisition. However, in the interim, a data warehouse concept was developed to link administrative records. It used a metadata repository to map data from legacy systems.⁸ This approach enabled the use of existing administrative data from legacy systems. The process differed from that reported by Williams et al.¹² only in the volume of records linked; the Alberta experience required the linkage of approximately 2.5 million individual records from six different legacy systems. Like other jurisdictions, Alberta had a great deal of data and very little information. Managing a health care delivery system in these times of transition requires tough decisions by all stakeholders—the citizens who are the recipients of care, the care providers, the bureaucracy, and the politicians. Fundamental to these decisions are the means by which existing data and information could be managed to provide the greatest benefit to the management of the health system at the least cost.

The objective of information management in the Alberta experience was to facilitate the development of the “feedback loops” necessary to monitor the dynamic interaction of the components comprising a restructured health system. The use of standard data and data standards permits the creation of longitudinal, cross-sectorial, multidisciplinary, person-specific health records. The focus is the recipient of care rather than the organization or health discipline by which the care is delivered. Standardized data captured at the point of service can be used by individual service providers, service delivery organizations, regions, government, and third-party insurers to optimize service delivery.

Data are a collection of facts captured within a specific context, e.g., the policy framework at the time. Information can be defined as relevant knowledge for a specific purpose such as health service administration or clinical judgment and decision making. Data can be transformed into information by selecting, collating, aggregating, and presenting pertinent data. However, when data are taken out of context, misinformation rather than useful information is often created. This is a risk that health informaticians cannot afford. Improvements in the quality of data are required to give decision makers, clinicians, and politicians access to more appropriate information. The remainder of this article describes the concepts and principles that were identified and used to enhance the availability of existing information for use by decision makers across the health system in Alberta. The principles that were used can be applied in any health care delivery organization or system regardless of the nationality of the system.

Scope of Information Management

Information systems can be characterized by a number of domains. Originally, data, applications, and technology were all tightly bound together. Data belonged to an application and had no independent existence. An application was the means by which data were created, updated, and used. Similarly, applications were dependent on the technology that ran them and vice versa. Technology was useless without an application (Fig. 3).

The evolution of information systems has led to a more complex model of the domains comprising such systems. The relationships among the various domains constitute the scope of data management (Fig. 4). The link between information and data management reflects the move to break the original strong bond between data and application. Therefore, the modern day application domain is linked to data management in terms of data capture and data use. While the technology domain remains strongly bound to the application software domain, the data management domain also has its own technology implications, e.g., the need to track where data exist in dispersed technical environments. Therefore, the technology domain is also linked to the data management domain. Increasingly, as technology grows to include both hardware and telecommunications, we will extend our understanding of the relationship between data management and technology. These links among application, information, and technology provided the roots of data administration, which was the precursor of data management.

Methodology refers to both the application development methodology and the business methodology. Methodology overlaps data management because data management's requirements change as the methodologies for application development and technology change. Similarly, changes in the business meth-

Figure 3 Initial linkages among the domains of information systems.

Figure 4 The relationships among the various domains of information systems constitute the scope of data management.

odology result in changes to the technology and concomitant changes in data management. The best example of the effect of changes in both application development and business methodologies on data management's requirements is diagnostic imaging's use of image archiving and retrieval systems. The most important linkage is between data management and the business, in our case health services delivery. The business dictates the data requirements, and data management serves the business.

However, data management must consider all of these domains because to focus on one domain to the exclusion of the others or to exclude any domain rapidly creates an imbalance. Data management is central because data provide the binding principle: the applications are processing data, the technology is transferring data, and the methodology is identifying how data are captured and where they are used in order to minimize the cost of data as a resource. The whole purpose is to serve the business that is health services delivery. Data management is, by definition, the intersection of all the intersections among the domains. The evolution of data management is the evolution of the intersections, the recognition of the impact of the intersections, and the recognition that the various domains are interdependent. Each domain is dependent on all of the other domains, and at the intersections between the domains there is interdependency.

Definition of Data Management

Data management is not glamorous or romantic; it is not even tangible in most cases. It cannot compete with the glamor, romance, and concrete nature of technology, particularly hardware. Data manage-

ment must be done in a coordinated way, led by those who are technical specialists in data and information management, in order to maximize the value of the data and minimize the cost of data capture for the entire health care delivery system or organization. Data management is literally the intersection of all the intersections or overlaps among the domains within information systems. It is the last step or the last piece of the puzzle linking together the domains that comprise information systems. Data management is the analysis and definition of the data to be captured to produce the required information and the identification of the processes needed to capture the data most effectively.

Data management includes adopting or adapting national and international data standards. Merely identifying or creating institutional data standards in isolation from national and international data standards does not contribute to the development of standard data! Conformity with national or international data standards¹³⁻²⁰ ensures comparability across many diverse sources and enhances administrative processes, clinical practice, accountability measures, service provider information exchange, and security provisions. A minimum set of standard data also ensures that information providers are not burdened by redundant data requests.

There is an associated need to identify the corresponding data capture processes and to facilitate the more complex information and data management responsibilities. Integrated information systems require new management processes to ensure that data are of sufficient quality, are adequately secure, are used for the purposes agreed to, and are disposed of appropriately when no longer needed. The more data are used for productive purposes, the more their value increases and the more the unit cost of data capture decreases.

Information Management Processes

The processes that relate to information management in a changing health care system are those that are essential for transforming information; data management or information management is core. Implementing the appropriate information management processes will produce appropriate information for decision makers, from clinicians to politicians, to use when decisions need to be made. The eight information management processes are:

1. Decision analysis—identification of the kinds or types of decisions that need to be made
2. Information requirements analysis—identification

of the kinds of information needed to make the decisions

3. Data planning—analysis and definition of the data to be captured to produce the required information and identification of the processes needed to capture the data most effectively
4. Data capture—the actual processes that gather data throughout the health system (The operative principle is to capture data once and use them many times.)
5. Data quality enhancement—the process required to transform data gathered for a specific purpose into data suitable for other uses (The process simultaneously produces more detailed comparable data and aggregated data.)
6. Information analysis—the analysis of data (both detailed and aggregated) to produce information products for general and specific purposes
7. Information interpretation—the presentation of information and the explanation of the information's relevance or meaning for a particular purpose (Sometimes information is not as "good" as would be desired, but is the "best" that can be produced from the data available.)
8. Decision support—the selection and integration of information (from both formal and informal sources) that pertains to a specific decision (The decision support process includes the identification of information that is "good enough" to use to make a specific decision at a particular time, e.g., the use of operational indicators and health status indicators to determine the effectiveness of a particular health program and to decide whether to continue its funding.)

Organizational Implications

In addition to the implications for information management processes, there are organizational implications of information management. The organizational implications are similar whether the organization is a state or provincial health department, a local hospital, a public health unit, or a home nursing services delivery organization. Previously, information management processes were focused in one organizational unit, frequently known as information services. This is no longer the case. Changing health care and transforming information require re-orientation of the organizational responsibilities necessary for information management. Management of the restructured health system data and resulting information must be a collective responsibility across

the entire organization or health care delivery system.

The eight information management processes described here are carried out across the full spectrum of a reconceptualized health care delivery system or organization. They are carried out across the scope of information and decisions relevant to all of the organizations throughout the entire system and throughout all of the departments within a particular organization. Evaluation of the effectiveness of an entire health system or health organization requires information about the dynamic interaction among all of its interdependent parts. Whether the area of interest is an entire country, a state, a local area, or a health care delivery organization, the management of a health services delivery system dictates that the scope of decisions, and information required to support them, must be oriented around cross-sectorial continuity of care to individual recipients of care, their families, and their communities.

Those responsible for program planning and evaluation within a health services organization or a health care delivery system need to identify what decisions must be made and what information is required to make these decisions. Other levels of management within a health system or organization contribute information requirements to support more localized decision making. The responsibility for decision analysis and information requirements analysis is therefore dispersed among decision makers across departments of the health care organization or in various organizations across the health system, but should be coordinated centrally by program planners and evaluators to optimize alignment of decision criteria and information indicators.

Data planning must be done in a coordinated way, led by those who are technical specialists in data and information management, to maximize the value of the data and minimize the cost of data capture for the entire organization. Data planning includes identifying standard data definitions and the corresponding data capture processes, as well as facilitating the more complex information and data management responsibilities. Integrated information systems require new management processes to ensure that data are of sufficient quality, are adequately secure, are used for the purposes agreed to, and are disposed of appropriately when no longer needed. The more data are used for productive purposes, the more their value increases and the more the unit cost of capture decreases. Data standards are essential to this exercise.

The actual data capture is best located as close to the

source of information as possible. It is equally important to maintain information about the context of data capture to permit appropriate use of the information for multiple purposes, i.e., to achieve value-added use of the information. Data could be used for relevant information purposes within each organizational unit. Standardized data can be abstracted from operational (detailed) data and provided to organizations or organizational units responsible for managing health service delivery across organizations or sectors within the health system. Detailed and specific information is required for service delivery; for management purposes, only those data elements required for decision making would be abstracted and aggregated to predetermined levels. During data planning, the levels of abstraction (extracting only relevant details) and aggregation (counting or summarizing relevant measures) should be agreed to across organizations.

Data quality enhancement occurs at appropriate organizational levels within the health organization or system. Those organizational units receiving detailed abstracted data aggregate the information and send summaries back to the providing organizational units. Data and their context need to be retained to support each organizational unit's interests and decisions. The highest level of data quality enhancement will need to occur at a provincial, state, or federal level to combine data from all service providers and service delivery organizations to produce comprehensive, health-system-wide subject data and to support the information analysis for decision making related to the entire provincial health system.

Information analysis and information interpretation occur across all organizational levels. Access to data with standardized definitions and common abstraction and aggregation criteria allows many individuals to use data relevant to their information requirements and decision-making responsibilities. Similarly, decision support should be available to any individual with the appropriate presentation tools. Automated decision support environments and executive information systems are only as useful as the data they contain and their relevance to the decisions that need to be made.

The entire information management process is not conducted only once. The process is dynamic because changes to the health system or within a health organization require different decisions over time. In addition, refined data will become increasingly available as systematic information infrastructures are implemented and extended. Organizations will be able to access data with well-understood definitions and produce information products relevant to their spe-

cific decisions, rather than rely on information analysis services from units specializing in transforming administrative data into information products on an ad hoc basis. The availability of comparable data will improve the productivity of program planning and support areas throughout the health system.

Turning Administrative Data into Value-added Information

The following processes are required in any health care organization or health services delivery system to produce value-added information from currently available administrative data. These value-added processes will supply more comprehensive information in support of decision making.

1. Administrative data capture. Data about various combinations of residents, recipients, providers, services, programs, resources, and utilization subjects are captured by every health program at various levels of aggregation using various working definitions and measurements. The results of these data capture processes are administrative data sources. The policy framework and definitions for each information source need to be captured.
2. Data source evaluation and cleanup. Each data source is analyzed and processed to contribute to value-added information products focused around residents, recipients, providers, services, programs, resources, and utilization subjects. Data cleanup involves converting administrative data, to the extent possible, into common definitions and units of measure. Data files are then developed for each information subject for selected time periods to allow comparability across data sources. The context of all data elements (the program assumptions under which data were captured) must be made available as well. The results of this process are detailed subject data files.
3. Data aggregation. Detailed data are aggregated either to produce predefined summaries for further information analysis or to contribute to specific information products. The results of this process are aggregate subject data files.
4. Information analysis. Information analysts access detailed and aggregate subject files to combine relevant data for general purposes (such as summaries used for the current annual report) or for specific purposes (such as ad hoc information requests). The results of this process are various data views.
5. Interpretation analysis and decision support. In-

formation is presented in the most useful format (such as charts and graphs) for specific decision makers, with relevant explanations and interpretation. The results of this process are actual information products.

The data source evaluation and cleanup and data aggregation are parts of a data quality enhancement process that develops a more comprehensive (and therefore more valuable) information resource. Individuals who are knowledgeable about program and support functions can contribute to the process of identifying what decisions need to be made and what information is required to support them. The data enhancement process needs to be performed by those who are technical specialists in data and information analysis, with input from those who are knowledgeable about each program delivery area. The data enhancement process can contribute to systematic data planning by helping to identify what information is needed to support the new orientation of the health system or health care organization. As the information resource improves and as information analysis and access tools become more available, information analysis, information interpretation, and decision support processes will be able to be conducted across program evaluation, planning, and support units within the health care organization or health services delivery system.

In the short term, many of the information requirements might need to be approximated or estimated from existing data. In the long term, more systematic data capture will yield more refined, consistent data and therefore better quality information. However, there is no need to wait for "perfect" information sources to be in place. The current data and information resources are continually improved by use. The more the data are used, the more they are improved.

Figure 5 shows the data management processes, data

Figure 5 A conceptual model for value-added information made up of data management processes, data requirements, and organization.

requirements, and organization used to create a conceptual model for value-added information to provide a greater return on investment in the resource that is health information. The information resource requires management in the same way that we manage other resources in our health care organizations and health services delivery systems. It must be valued, invested in, and maintained.

Conclusion

The restructuring of health care needs to be supported by reoriented processes for managing data and information to support decision making across the health services delivery system or health care organization. Comprehensive management of a health system requires population-based health information. The goal is to produce comprehensive, comparable, longitudinal, health-system-wide information that focuses on the people who are receiving the care. Such information needs to be used to manage the interdependent changes that occur during reorganization. Significant progress can be made toward the goal of comprehensive health system information by making full use of existing administrative data sources, i.e., the legacy systems. Old systems and data need not necessarily be discarded; ways can be found to use what already exists. Developing enhanced, comprehensive, cross-sectorial data requires careful attention to data management, including data standards, data capture techniques, and data management processes. In addition, organizational implications of data management must be carefully structured to facilitate information analysis and decision support in all program development, support, and evaluation activities. Health informaticians and data managers are uniquely positioned to influence and support the reorganization and restructuring initiatives under way in many national health care systems. These efforts provide health informaticians and data managers with a rare opportunity to contribute along with clinical colleagues to the goal of providing quality health care to all people.

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