A Model for Achieving Total Quality-Management Information Technology Infrastructure Within an Integrated Delivery System

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The strategic development and deployment of a health management information technology infrastructure is discussed from two perspectives for radiologists and for other medical technologists: the integrated delivery system (IDS) perspective and a total quality-management (TQM) perspective. On the one hand, an IDS perspective is important because of the need to prepare radiologists and other medical practitioners to thrive within rapidly changing health organizational models and evolving health service delivery partnership systems. On the other, a TQM perspective is important due to the need to realize an appropriate, efficient, and cost-effective health information infrastructure for developing seamless, integrated radiological and other medical imaging services. Apart from intelligently pursuing an aligned organizational business strategy with the organizational information system strategy, senior radiological managers and medical technologists of health organizations need to pay particular attention to key quality principles for effecting changes in organizational structures and processes to fit changes in information technological requirements, implementations, and innovations.

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HEALTH CARE INFORMATION technologies (HCITs) have been evolving continually to serve existing and new mechanisms of health service delivery systems more appropriately, efficiently, effectively and strategically.¹⁻³ The need to seek out opportunities for achieving competitive advantage through the application of evolving HCITs is now recognized as a critical success factor for health service organizations needing and wanting to survive or excel in today's rapidly changing health care environments. Many authors⁴⁻⁷ suggest that integrated delivery systems (IDSes) will become the health organizational structure of the future, and that appropriate strategies for HCIT integration must correspondingly evolve to maintain and achieve long-term health organizational service excellence.

As IDSes emerge in the US and Canadian health care scene, health providers and professionals across the continuum of care including radiologists and other medical technologists will be faced with the challenge to harness HCIT intelligently and strategically as a necessary tool, as well as a competitive weapon for providing world-class,

quality health services. In this context, Kim and Michelman⁵ have argued that the potential for achieving competitive advantage with HCIT can be factored according to three fundamental needs: (1) the need for management involvement and support for organization-wide HCIT integration strategy; (2) the need to resolve conflicts surrounding such an integration strategy; and (3) the need to apply evolving HCIT strategically.

More recently, Venkatraman¹ and others have elucidated a five-level organizational transformation framework for enhancing integrated information technology benefits: level 1—information technology for improved efficiency of particular organizational and departmental functions; level 2—information technology for efficiency and effectiveness gains through integrating internal organizational business processes; level 3—information technology for business process redesign to improve overall cost-effectiveness; level 4—information technology for business network redesign to improve networking effectiveness among various health care providers; and level 5—information technology for business scope redefinition for improving total system effectiveness.

The underlying philosophy of this report is to assist senior radiological managers and other medical technologists in applying two generally diffusing concepts for evolving future HCIT applications via a smart and intelligent health information technological platform: the concept of an IDS as the future health organizational model, and the concept of a total quality-management information technology (TQMIT) framework to differentiate among various quality-of-care models in achieving a customer-oriented, service-focused organizational environment to facilitate intelligent informa-

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tion exchange and sharing among multiple health care providers and practitioners within an IDS.

AN IDS'S BUSINESS-HCIT STRATEGIC FIT MODEL

Many well-developed frameworks exist to aid us in the understanding of how the business strategy of an evolving IDS may be aligned with its changing HCIT strategy.^{1,8-11} A common notion threading these various conceptualizations is that both business strategy and HCIT strategy may be considered as operating along a reactive-proactive continuum. Whereas a reactive strategy implies that management of the organization will take a "wait-and-see" posture, a proactive strategy entails management to seek opportunistic behaviors and connotes the idea of being aware of emerging and potentially available options for effecting changes strategically, for example, the management of an organization taking the lead to improve system-wide business process engineering on the one hand, and implementing different levels of HCIT integration applications throughout the organizational system on the other. The planning, design and development of an evolving, integrated HCIT infrastructure from a multiprovider perspective is discussed in Tan.¹²

Historically, independent voluntary hospitals during the early days of health service delivery often adopted a reactive business strategy alongside a reactive HCIT strategy, that is, changes to HCIT applications necessarily followed changes in business strategy that are in response mostly to changes in the environment. In this context, senior management often dictates changes to business strategy only when a change in the environment is perceived as looming without regards to corresponding changes needed for HCIT strategy. This is because HCIT strategy in this setting would often be perceived as the duty and delegated responsibility of lower-level information system managers. This setting is simply depicted by quadrant I of Fig 1.

Today, evolving IDSes will most likely have to operate proactively for both business and HCIT strategies, that is, opportunistic changes in business strategy are made hand-in-hand with strategic considerations for changes in HCIT. In this context, HCIT strategy changes can sometimes drive business strategy changes and vice versa. For example, if a health science center operates a number of

Integrated Delivery System (IDS)	Business Strategy	
	Reactive	Proactive
Health Care Information Technology (HCIT) Strategy	Reactive Traditional Hospitals Islands of Automation Quality Assurance (QA) The "Classical" Setting	Proactive Evolving IDSes Focus on Shared Goals Total Quality Management (TQM)/Continuous Quality Improvement (CQI) Programs
	Proactive Evolving IDSes Focus on Data Integration Evolve HCIT Infrastructure Utilization Review (UR)/ Utilization Management (UM) Programs	Future IDSes Integrated HCIT infrastructure Total Quality Management Information Technology (TQM/IT) Model The "Ideal" Setting

Fig 1. IDS business-HCIT strategic fit model.

satellites across a certain region, redesigning and implementing a real-time, online teleradiological network may significantly affect the existing health science centers business strategy. This "ideal" health organizational business-HCIT strategic fit is depicted by quadrant IV in Fig 1.

Accordingly, in this setting, management of an IDS taking a proactive business strategy will often need to address questions such as the following:

- What business are we in?
- Why do we want to be in the business we are in?
- Do we operate as one large organization or as many separate units under one legal entity?
- What form of reporting structure should we adopt—hierarchical, matrix or a distributed one?
- How do we go about improving the business we are in?

Similarly, HCIT questions that management must ask in an "ideal" setting, that is, taking a proactive stand may include the following:

- Who are the stakeholders?
- Who should and will be the gatekeeper of the organizational database(s)?
- What capabilities of HCIT connectivity is acceptable (response times) to the organization?
- What technological options and expertise do the organization have?
- What components of HCIT should be integrated first, next, and last?
- What in-house capabilities should the organization build and what aspects of the developmental effort should be outsourced?

- How does the organization involve the different stakeholders in the HCIT integration process?

Evidently, significant knowledge on both the evolving health care environment and the state-of-the-art technology will be needed to answer many of such questions. For example, there is the need of knowledge about changing health care environments, governmental policies, information privacy and security issues, technological breakthroughs, and many other considerations. This knowledge and its accompanying know-hows will be needed, some more or less critically, if questions about response times, database infrastructure design, shifts in organizational structures and processes, information and decisional requirements, and client or server limitations are to be responsively and appropriately addressed.

However, the degree of HCIT integration and the types of radiological applications implemented in anyone health organization today must necessarily reflect the many different stages of organizational evolution from that of the "classical" fit depicted in quadrant I of Fig 1 to that of an "ideal" fit depicted in quadrant IV. In this sense, between quadrant I, where both business and HCIT strategies are reactive, and quadrant IV, where both business and HCIT strategies are seen to be proactive, lie all of the different organizational settings that would be attempting to somehow align their business and their HCIT strategies to some extent, some more proactively in one area and reactively in another or vice versa.

Over the years, the diffusion of information technology integration trend in health care organizations has concentrated on many different areas. For example, in the past, a concerted effort has been made in improving efficiency of organizational and departmental functions by integrating and streamlining tasks through automation of programmable functions and elimination of tedious routine data processing. Later, the emphasis shifted to data integration via integrated and distributed information technology applications for effecting better and more intelligent decision-making. In this respect, case-mix information systems (CMISs), where the emphasis is on integrating financial and clinical data sources, have experienced a surge of interest first in the United States, followed by Canada and Britain. As information technology knowledge diffuses among health service providers

and new research on the strategic impact of information technology applications becomes available, the next shift in information technology integration appears to focus on networking, as well as business process integration and innovations. Indeed, if an health organization can create new, more efficient and cost-effective processes for the production of similar or higher quality health services that are currently being produced through traditionally expensive and inefficient processes, there are cost benefits and quality improvements to be gained to move from the old to the new business process and servicing model. Thus, significant innovations in business process reengineering is currently perceived to have the greatest payoffs for organizational change to be impacted by information technology applications within the context of evolving IDSes.

From this analysis, we propose in the next section the various quality-of-care models for evolving an integrated HCIT strategy within an IDS.

QUALITY-OF-CARE MODELS FOR EVOLVING AN INTEGRATED HCIT STRATEGY WITHIN AN IDS

Based on the analysis of the business-HCIT strategy fit framework depicted in Fig 1, there exist different quality-of-care models for evolving a HCIT strategy within an health organization. Conceptually, the traditional quality-assurance (QA) model is most suited to organizations that fall in quadrant I of Fig 1. Briefly, QA activities are oriented toward the individual clinicians, and focused on the clinical and technical activities exclusive of interpersonal and organizational issues. It is a one-time effort, rather than a continuous improvement program. In this instance, both HCIT and business management strategies are reactive and will change only if forced to do so. Hence, the incentive here is for business processes to remain unchanged, and little or no HCIT integration is encouraged, which results in islands of automation. These values are characteristics of hierarchically managed, independent hospitals of the past.

The widespread failures of QA programs later gave rise to new methods of quality control. One such model is the utilization review (UR) and utilization management (UM) program. Here, an integration of management technology with clinical reporting is often achieved, with conflict resolution between clinicians and administrators medi-

ated through reliable data integration and implemented changes in HCIT infrastructure. The new HCIT data architecture will thus be redesigned for documenting and detecting data transcription and transmission errors, supporting statistical benchmarking analysis, and establishing proven clinical protocols and guidelines. Tan et al (1994)¹³ discussed and illustrated the implementation of UR/UM programs in health organizations taking a proactive HCIT strategy, which are characteristics of organizations that fall into quadrant II (Fig 1).

However, many health organizations today embrace the TQM or continuous quality improvement (CQI) model. In these models, administrators and clinicians are often encouraged to work hand-in-hand towards a common goal with total quality of care achieved via changes primarily in specific improved business processes. Since HCIT integration often plays a secondary role in these models, HCIT strategy is therefore considered reactive in these mostly top-down management driven programs. Of 10 hospitals surveyed previously in the Greater Vancouver Regional District (GVRD), six were found to have adopted some form of TQM/CQI models (Tan JKH, unpublished data, 1997). These organizations generally fall into quadrant III (Fig 1).

We have seen that organizations that fall into quadrant IV (Fig 1) are those that most resemble future IDSes. These organizations often have to make radical changes and adopt a TQMIT model, where both HCIT integration strategy and business process strategy may be conceived as being proactive simultaneously. In the next section, we discuss such a model for the ideal setting. As may be seen, this model is needed to guide today's radiologists and medical technologists in evolving information technological designs, implementations, and innovations into the future.

THE TQMIT MODEL

In Fig 2, we present the TQMIT model. This model emphasizes the application of continuous improvement principles throughout both the IDS business and HCIT strategy formulation process. In other words, these principles are continually applied in assessing opportunities, threats, strengths, and weaknesses of business and HCIT strategies in relation to both the external environmental context and the internal organizational context. Moreover, these key principles are also importantly applied to

changes in organizational structures and processes to effect strategic alignment. Briefly stated, TQM principles are crucial to effecting HCIT integration and strategic implementation to be both internally and externally relevant. This is why major TQM principles are upheld throughout the TQMIT model.

In terms of radiological services, the main premise of the TQMIT model is that an increased focus on the strategy of an IDS through quality initiatives will improve HCIT-based radiological service performance. In this regard, the single biggest challenge in developing an effective, integrated HCIT infrastructure for evolving customer-focused, future-oriented radiological services, such as teleradiology, is first nurturing a clear vision of IDS strategy. The electronic connectivity achieved through an IDS will enable, as an example, various radiological departments of the vertically integrated organizations within the IDS to reengineer business processes and create effective computer-based radiological services. Currently, a client (ie, patient) needing more than one radiological services is repeatedly asked the same questions and each provider agency does their own assessment and creates duplicate imaging files. The information is not shared and the client experiences first hand the disjointedness of the system. An integrated radiological function such as the use of an integrated network of radiological information systems (RISs) connected to an IDS would allow for the reduction in duplicate information. It would command a timely transfer of radiological images between agencies, and achieve a substantial reduction in staff hours of radiologists and associated technologists required to generate, retrieve, analyze, store, and document much of the same information. The next step is to achieve necessarily changes in organizational structures and processes to allow radiologists and medical technologists to have more flexible access and readily usable information systems for performing their routine work. This may include, for example, integrating advanced picture archiving and communication systems (PACS) with the networked RISs. Any changes in the flow of radiological information within the new infrastructure would then be managed appropriately, efficiently, and effectively. Some organizations may see the benefit of a total on-line storage system, while others may still want to maintain a parallel system of both online and offline storage of printed images and films for legal and other regulatory reasons.

Fig 2. The TQMIT model.

Apparently, the establishment of an integrated HCIT infrastructure for evolving future RISs and integrated PACS is not without its peculiar problems. Major challenges to be faced include the need of a common perspective and aligned business-HCIT strategy, the development of standard protocols for the transfer of radiological images among independent systems, and the need for in-house expertise or technological know-hows to be imported probably from outside the health care field. Apart from these challenges, other equally important barriers include the difficulty of cost and revenue projections, the compatibility of purchased

equipment with existing systems, training needs, space and facility design problems, and regulatory and legal issues, as well as general fear experienced by management of implementation failures. Fortunately, many field experimentations of such larger developmental efforts and organizational transforming endeavours have been instituted in recent years and lessons gleaned from these experiences will be most precious for those organizations that would follow suit. For example, the various presentations from other participants in the *RIS, PACS, and Teleradiology* conference held in Lubbock, TX as discussed in this special supplement of the *Journal*

of *Digital Imaging* provided solid examples of these endeavours.

To date, a blueprint for the seamless, integrated application of RISs, PACS, and teleradiology has not been developed.¹⁴ This is because, like other clinicians and technologists, radiologists, for the most part, have little understanding about the detailed business issues and information needs at the strategic management level of the health care organizational system. While many of these clinicians are normally fluent in the developing technology trends, they usually are not as knowledgeable about business and marketing strategies as their counterparts—the health executives and managing directors. In contrast, many of these health executives and managing directors are often not aware of all of the possibilities that RIS and PACS technologies can offer and the strategic use of such technologies as teleradiology and telemedicine within an interorganizational context.

A second dimension to the lack of interaction between the management specialists and radiologists is the relatively different culture, mental models, and training that are inherent to the two disparate groups. For example, users (managers) may falsely assume that as soon as the information is generated on an image, interpretation can be made readily available on-line. However, radiologists know that such interpretive information this soon automatically dictates that only a certain limited degree of analysis can be provided. Whereas management believes that the request will result in reasonably complete data analysis and image interpretation, including links to other databases and reports, the actual radiologists' reports may be a far cry from management's expectation.

A third dimension compounding these problems is the large number of people with whom radiologists must interface (eg, physicians, patients, managers, directors, other experts and colleagues) to achieve any intelligent and meaningful reporting. Interpretation of an image would also be biased from reading a strongly worded report emanating from the referring physician or from a previous interaction with colleagues about a particular patient's conditions. Resolution of images, the quality of computer hardware and software, and the use of different algorithms for image and signal processing may also play a critical part in radiologists' interpretation and other cognitive processing. Finally, there are still a few radiologists who would even resist using online digital images for interpre-

tation for the mere fact that they have never been properly trained to interact with online systems or that, to date, resolution of digital images, no matter how well improved, is still not acceptable to them.

From the TQMIT perspective, the HCIT strategy must first be aligned with the business strategy and longer-term versus shorter-term objectives of the IDS must be clearly stated before true sharing of information between management and radiologists can be achieved. Moreover, existing RIS and PACS capabilities must be integrated within an integrated HCIT infrastructure to capitalize fully on the new IDS structure. As well, one must not only be fluent with the fluid RIS, PACS, and other HCIT technological environments, but must be able to strategically apply evolving HCITs and RIS technology. Hence, the TQMIT model presented here calls for the need to emphasize strategic use of radiological and advanced imaging technologies within the context of an IDS.

As an illustration, consider a network of medical imaging (MI) departments in a large and complex IDS. One way to align business and HCIT strategy is to develop integrated RISs with existing organizational management information systems for comparing performance among various MI departments. However, benchmarking in this case may be extremely difficult because of the diverse data capture techniques and the various data coding options. Leonard et al¹⁴ discussed how the lack of standardized performance indicators for MI departments can lead to inability to compare performance across MI areas or across providers. As well, there may be the lack of an integrated HCIT infrastructure for evolving customer-focused, future-oriented RISs. Finally, management may not be ready to support a system-wide RIS/PACS network infrastructure design and implementation simply because of the enormous costs, and the lack of relevant in-house technological expertise.

IMPLEMENTATION OF RIS/PACS NETWORK FOR AN IDS

Shortell et al⁶ have envisioned an IDS as a network of organizations providing a coordinated continuum of care services to a defined population. These systems are vertically integrated, broad-based, and embrace a full range of clinical, administrative, and ancillary services. Common ownership of the networked institutions and practices is not necessary, but there must be clear agreements

that providers within an IDS share financial risks and benefits.

Attempts to integrate RIS/PACS technology for an IDS are only meaningful if there is a clear vision of the organizational or system strategic goals and objectives. A need assessment exercise should first be performed just to ensure that the time is right for designing, developing, and implementing a system-wide network. The stakeholders should be identified and partners created in jointly funding the project, because failures in such implementation efforts can have significant and unthinkable consequences. The guiding principles of doing it right the first time, as implicated in the TQMIT model discussed here, should be upheld at all times. This entails, at the least, achieving an alignment of strategic business objectives with HCIT strategy. Various quality-of-care models can be used to guide the evolution of HCIT integration and IDS strategy formulation. Only when the strategic objectives for an IDS have been aligned with those of corresponding HCIT/RIS units should management proceed with the design, development, and implementation of new and innovative RIS technologies. The central point in this TQMIT analysis is the need for an effective, well-coordinated quality-initiative program to support all phases of the HCIT integration process.

Apart from visionary and planning support, as well as funding approval from senior management, implementation of new technology requires tremendous support and training for both the people

leading the implementation and those who will be impacted by these new developments. Conferences and tutorials such as those provided through the *RIS, PACS, and Teleradiology* conference can be an important stepping stone to educating radiologists and medical technologists appropriately before any major implementation efforts are taken. Other educational strategies include focus groups, technical support hotlines, training of inexperienced radiologists on the job through peers who have been trained to use the technologies, and sending affected radiologists and technologists to tour sites that have implemented the new technologies. Support from vendors and other technical specialists would also be critical during the initial implementation stages. Altogether, to ensure the success of future RIS and various quality HCIT initiatives, ongoing information management training and technical support must be made available so as to establish an environment for continuous improvement, process reengineering, and quality improvement. Such a change process is not discrete, but rather continuous.

In conclusion, more attention from senior radiological managers and medical technologists to applying key quality principles on changing organizational structure and processes to effect greater alignment in organizational business and HCIT strategies is needed to successfully steer new and innovative developmental efforts in information technology infrastructure for housing advancing RIS, PACS, and teleradiological innovations.

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