7 Healthcare Knowledge Management: Incorporating the Tools, Technologies, Strategies, and Process of Knowledge Management to Effect Superior Healthcare Delivery

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Abstract

As medical science advances and the applications of information and communications technologies to healthcare operations diffuse, more and more data and information begin to permeate healthcare databases and repositories. However, given the voluminous nature of these disparate data assets, it is no longer possible for healthcare providers to process these data without the aid of sophisticated tools and technologies. The goal of knowledge management is to provide the decision maker with appropriate tools, technologies, strategies, and processes to turn data and information into valuable knowledge assets. This chapter discusses the benefits to the healthcare arena of incorporating these tools and techniques in order to make healthcare delivery more effective and efficient, and thereby maximize the full potential of all healthcare knowledge assets. To ensure a successful knowledge management initiative in a healthcare setting, the chapter proffers the knowledge management infrastructure framework and intelligence continuum model.

The benefits of these techniques lie not only in the ability to make explicit the elements of these knowledge assets, and in so doing enable their full potential to be realized, but also to provide a systematic and robust approach to structuring the conceptualization of knowledge assets across a range of healthcare environments, as the case study data presented demonstrate.

7.1 Introduction

Knowledge management (KM) is an emerging management technique that is aimed at solving the current business challenges to increase efficiency and efficacy of core business processes and simultaneously incorporating continuous innovation. The premise for the need for KM is based on a paradigm shift in the business environment where knowledge is central to organizational performance [1,2].

KM offers organizations many tools, techniques, and strategies to apply to their existing business processes. Healthcare is an information-rich industry that offers a unique opportunity to analyze extremely large and complex data sets. The collection of data permeates all areas of the healthcare industry and, when coupled with the new trends in evidence-based medicine and electronic medical record systems, it is imperative that the healthcare industry embraces the tools, technologies, strategies, and processes of KM if it is to realize the benefits from all these data assets fully.

The successful application KM hinges on the development of a sound KM infrastructure (KMI) and the systematic and continuous application of specific steps supported by various technologies. This serves to underscore the dynamic nature of KM where the extant knowledge base is always being updated. The KMI framework not only helps organizations to structure their knowledge assets, but also makes explicit the numerous implicit knowledge assets currently evident in healthcare [3], while the intelligence continuum (IC) provides the key tools and technologies to facilitate superior healthcare delivery [4]. Taken together, the KMI and IC can enable healthcare to realize its value proposition of delivering effective and efficient value-added healthcare services.

7.2 Knowledge Management

"Land, labor, and capital now pale in comparison to knowledge as the critical asset to be managed in today's knowledge economy." Peter F. Drucker [2, p. 47].

The nations that lead the world in this century will be those who can shift from being industrial economies, based upon the production of manufactured goods, to those that possess the capacity to produce and utilize knowledge successfully. The focus of the many nations' economies has shifted first to information-intensive industries, such as financial services and logistics, and now toward innovation-driven industries, such as computer software and biotechnology, where competitive advantage lies mostly in the innovative use of human resources. This represents a move from an era of standardization to an era of innovation where knowledge, its creation, and management hold the key to success [1,2,5].

KM is a key approach to helping solve current business problems that are faced by organizations today, such as competitiveness and the need to innovate. The premise for KM is based on a paradigm shift in the business environment where knowledge is central to organizational performance [6,7]. In essence, KM not only involves the production of information, but also the capture of data at the source, the transmission and analysis of this data, and the communication of information based on or derived from the data to those who can act on it [8]. Thus, data and information represent critical raw assets in the generation of knowledge, whereas successful KM initiatives require a tripartite view, namely the incorporation of people, processes, and technologies [9].

Broadly speaking, KM involves four key steps of creating/generating knowledge, representing/storing knowledge, accessing/using/reusing knowledge, and disseminating/transferring knowledge [8,10–12]. Knowledge creation, generally accepted as the first step for any KM endeavor, requires an understanding of the knowledge construct as well as its people and technology dimensions. Given that knowledge creation is the first step in any KM initiative, it naturally has a significant impact on the other consequent KM steps, thus making the identification of and facilitating of knowledge creation a key focal point for any organization wanting to leverage its knowledge potential fully.

Knowledge, however, is not a simple construct. Specifically, knowledge can exist as an object, in essentially two forms: explicit or factual knowledge and tacit or "know-how" [13,14]. It is well established that although both types of knowledge are important, tacit knowledge is more difficult to identify and thus manage [15,16]. Of equal importance, though perhaps less well defined, knowledge also has a subjective component and can be viewed as an ongoing phenomenon, being shaped by social practices of communities [17]. The objective elements of knowledge can be thought of as primarily having an impact on process, whereas the subjective elements typically impact innovation [9]. Enabling and enhancing both effective and efficient processes and the functions of supporting and fostering innovation are key concerns of KM.

Organizational knowledge is not static; rather, it changes and evolves during the lifetime of an organization. What is more, it is possible to transform one form of knowledge into another, i.e. transform tacit knowledge into explicit and vice versa [12]. This process of transforming one form of knowledge into another is known as the knowledge spiral [15]. Naturally, this does not imply that one form of knowledge is necessarily transformed 100% into another form of knowledge. According to Nonaka [15]: (1) Socialization, or tacit to tacit knowledge transformation, usually occurs through apprenticeship-type relations where the teacher or master passes on the skill to the apprentice. (2) Combination, or explicit to explicit knowledge transformation, usually occurs via formal learning of facts. (3) Externalization, or tacit to explicit knowledge transformation, usually occurs when there is an articulation of nuances; e.g. if an expert surgeon is questioned as to why he performs a particular surgical procedure in a certain manner, by his articulation of the steps the tacit knowledge becomes explicit. (4) Internalization, or explicit to tacit knowledge transformation, usually occurs when explicit knowledge is internalized and can then be used to broaden, reframe, and extend one's tacit knowledge. Integral to these transformations of knowledge through the knowledge spiral is that new knowledge is being continuously created [15], and this can potentially bring many benefits to organizations. What becomes important, then, for any organization in today's knowledge economy is to maximize the full potential of all its knowledge assets and successfully make all germane knowledge explicit so that it can be used effectively and efficiently by all people within the organization as required [12].

Healthcare is an industry currently facing major challenges at a global level [4,18]. This industry has yet to embrace KM. Yet, KM appears to provide several viable possibilities to address the current crisis faced by global healthcare in the areas of access, quality, and value [4]. In healthcare, one of the most critical knowledge transformations to effect is that of tacit to explicit, i.e. externalization, so that the healthcare organization can best leverage its knowledge potential to realize the healthcare value proposition [19]. Integral to such a process is the establishment of a robust KMI and the adoption of key tools and techniques. This is achieved by the application of the KMI and IC models.

7.3 Establishing a Knowledge Management Infrastructure

The most valuable resources available to any organization are human skills, expertise, and relationships. KM is about capitalizing on these precious assets [20]. Most companies do not capitalize on the wealth of expertise in the form of knowledge scattered across their levels [21]. Information centers, market intelligence, and learning are converging to form KM functions. KM offers organizations many strategies, techniques, and tools to apply to their existing business processes so that they are able to grow and effectively utilize their knowledge assets. The KMI not only forms the foundation for enabling and fostering KM, continuous learning, and sustaining an organizational memory [2], but also provides the foundations for actualizing the four key steps of KM, namely creating/generating knowledge, representing/storing knowledge, accessing/using/reusing knowledge, and disseminating/transferring knowledge (discussed in Section 7.2). An organization's entire "know-how," including new knowledge, can only be created for optimization if an effective KMI is established. Specifically, the KMI consists of social and technical tools and techniques, including hardware and software, that should be established so that knowledge can be created from any new events or activities on a continual basis. In addition, the KMI will have a repository of knowledge, systems to distribute the knowledge to the members of the organization, and a facilitator system for the creation of new knowledge. Thus, a knowledge-based infrastructure will foster the creation of knowledge and provide an integrated system to share and diffuse the knowledge within the organization [22], as well as support for continual creation and generation of new knowledge [9]. The KMI depicted in Figure 7.1 contains the five essential elements of organizational memory, human asset infrastructure, knowledge transfer network, business intelligence infrastructure, and infrastructure for collaboration that, together, must be present for any KM initiative to succeed.

7.3.1 Elements of the Knowledge Management Infrastructure

From Figure 7.1 it is possible to identify the five key elements that, together, make up the KMI. It can be seen that these elements support the socio-technical perspective of KM, in that they consist of people, process, and technological aspects [12]. We will now examine each of them in more detail.

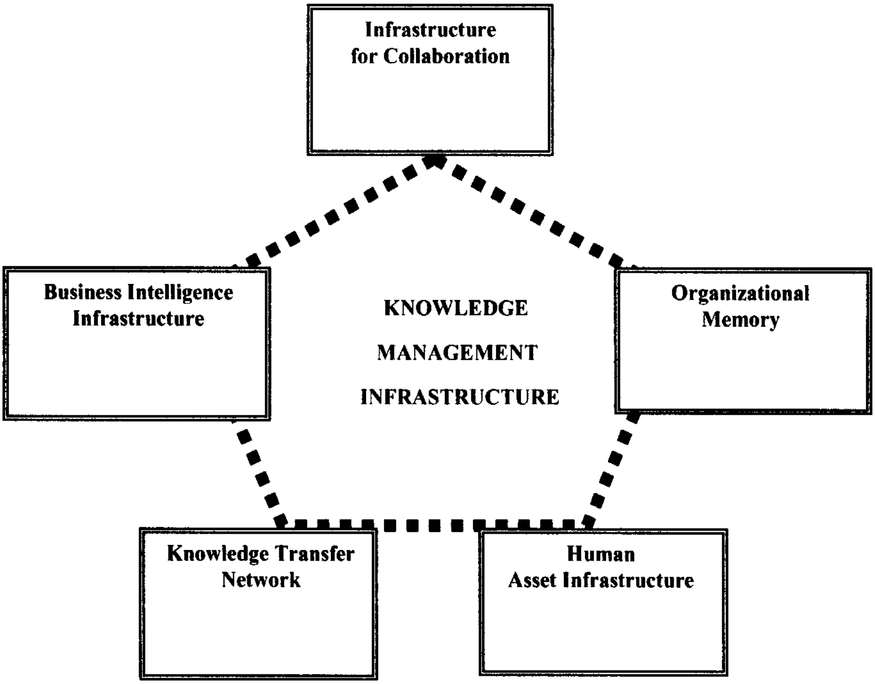

FIGURE 7.1. Key elements that constitute the KMI (adapted from [23]).

7.3.1.1 Infrastructure for Collaboration

The key to competitive advantage and improving customer satisfaction lies in the ability of organizations to form learning alliances; these are strategic partnerships based on a business environment that encourages mutual (and reflective) learning between partners [24]. Organizations can utilize their strategy framework to identify partners and collaborators for enhancing their value chain.

7.3.1.2 Organizational Memory

Organizational memory is concerned with the storing and subsequent accessing and replenishing of an organization's "know-how" that is recorded in documents or in its people [24]. However, a key component of KM not addressed in the construct of organizational memory is the subjective aspect [9]. Knowledge as a subjective component primarily refers to an ongoing phenomenon of exchange where knowledge is being shaped by social practices of communities [18], in the tradition of a Hegelian/Kantian perspective, where the importance of divergence of meaning is essential to support the "sense-making" processes of knowledge creation [25].

Organizational memory keeps a record of knowledge resources and locations. Recorded information, whether in human-readable or electronic form or in the memories of staff, is an important embodiment of an organization's knowledge and intellectual capital. Thus, strong organizational memory systems ensure the access of information or knowledge throughout the company to everyone at any time [26].

7.3.1.3 Human Asset Infrastructure

This deals with the participation and willingness of people. Today, organizations have to attract and motivate the best people: to reward, recognize, train, educate, and improve them [27] so that the highly skilled and more independent workers can exploit technologies to create knowledge in learning organizations [27]. The human asset infrastructure, then, helps to identify and utilize the special skills of people who can create greater business value if they and their inherent skills and experiences are managed to make explicit use of their knowledge.

7.3.1.4 Knowledge Transfer Network

This element is concerned with the dissemination of knowledge and information. Unless there is a strong communication infrastructure in place, people are not able to communicate effectively and thus are unable to transfer knowledge effectively. An appropriate communications infrastructure includes, but is not limited to, the Internet and intranets for creating the knowledge transfer network, as well as discussion rooms and bulletin boards for meetings and for displaying information.

7.3.1.5 Business Intelligence Infrastructure

In an intelligent enterprise, various information systems are integrated with knowledge-gathering and analyzing tools for data analysis and dynamic end-user querying of a variety of enterprise data sources [28]. Business intelligence infrastructures have customers, suppliers, and other partners embedded into single integrated system. Customers will view their own purchasing habits, and suppliers will see the demand pattern which may help them to offer volume discounts, etc. This information can help all customers, suppliers, and enterprises to analyze data and provide them with the competitive advantage. The intelligence of a company is not only available to internal users, but can also even be leveraged by selling it to others, such as consumers, who may be interested in this type of informational intelligence.

7.3.2 The Intelligence Continuum

The IC consists of a collection of key tools, techniques, and processes of the knowledge economy, i.e. including data mining, business intelligence/analytics, and KM which are applied to a generic system of people, process, and technology in a systematic and ordered fashion [4,18,29,30]. Taken together they represent a very powerful system for refining the data raw material stored in data marts

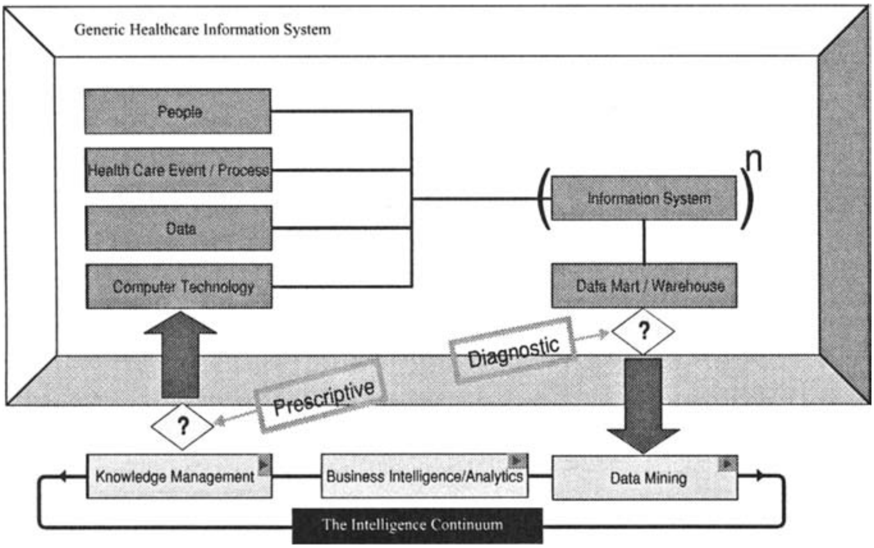

FIGURE 7.2. Application of the IC on the generic healthcare system.

and/or data warehouses, thereby maximizing the value and utility of these data assets for any organization [31–36]. As depicted in Figure 7.2, the IC is applied to the output of the generic healthcare information system. Once applied, the results become part of the data set that are reintroduced into the system and combined with the other inputs of people, processes, and technology to develop an improvement continuum. Thus, the IC includes the generation of data, the analysis of these data to provide a "diagnosis," and the reintroduction into the cycle as a "prescriptive" solution. In this way, the next iteration, or "future state," always represents the enhancement of the extant knowledge base of the previous iteration. For the IC to be truly effective, however, the KMI must already be in place so that all data, information, and knowledge assets are explicit and the technologies of the IC can be applied to them in a systematic and methodical fashion.

7.4 Case Study

This case study focuses on a well-renowned Spine Unit in the Midwest of the US. It is possible to define this environment as a cure environment, since the primary goal of this Spine Unit is to return patients to normal life activities. The following serves to furnish the key elements from this environment as they pertain to KM, its benefits, and applications in this setting. An exploratory case study research was adopted to enable the generation of rich data in a nonrestrictive manner. Information was gathered from several sources, including semi-structured interviews, the collecting of germane documents and memos, numerous site visits, and the direct observation of various procedures, thus enabling triangulation among different data sources [37]. Rigorous coding and extensive thematic analysis was conducted to analyze the qualitative data gathered [38,39]. Each of the points listed was confirmed by multiple interviews, written documentation, and passive observation, thus ensuring the highest level of reliability possible for qualitative research [39].

7.4.1 Background for Case

In the US, the healthcare industry is in a state of flux [40–43].

> The rate of the rise in healthcare costs has been variable. The shocking increases experienced in the early 1990s, has slowed in the mid- and late 1990s, but there is no guarantee that they will continue to do so [44, pp. xvii].

In other market places, buyers are sensitive to the price of the product and undertake cost–benefit analysis.

> In the medical market place, however, the buyers and users of medical services and technologies have been relatively insensitive to the cost of these services ... The traditional financing and reimbursement policies of the healthcare industry are felt to be largely responsible for this price insensitivity, inhibiting the forces of competitive supply and demand economics [40, pp. 80].

As a result, there is increased pressure on providers of medical care to develop ways to control and mange costs, as well as to increase productivity without compromising quality. In an attempt to stem the escalating costs of healthcare, managed care has emerged. It is aimed at creating value through competition in order to combat "... an extremely wasteful and inefficient system that has been bathed in cost-increasing incentives for over 50 years" [45, p. 40]. The intended result is to provide adequate quality healthcare and yet minimize, or at least reduce, costs.

Managed care organizations (MCOs) contract with individuals, employers, and other purchasers to provide comprehensive healthcare services to people who enroll in their health plans. The essential difference between MCOs and more traditional types of medical care is connected with the distribution of financial risk among the purchaser of healthcare, the provider of the care, and the insurer [46].

> MCOs typically reduce this financial risk for the purchaser of healthcare insurance by guaranteeing a comprehensive range of services at a fixed price to them. To do this of course, the MCO must keep the use of healthcare resources within a budget; thus making critical a focus on managing medical care [18].

This then represents a radical change to the traditional healthcare environment, where quality irrespective of cost was the goal. The new goal is cost-effective quality care, and thus also demands a more competitive healthcare environment.

7.4.2 Spine Care

Nearly everyone experiences back or neck pain at some time during their life. Pain or disability can be caused by injuries sustained at home or work, while involved in sports or recreation, during accidents or falls, or from medical conditions, such as arthritis, osteoarthritis, or osteoporosis. The Spine Unit is part of a large multispecialty group practice and academic medical center located in the Midwest of the US. This center is actually made up of surgeons and medical staff from the Department of Neurology and Neurosurgery and the Department of Orthopedics. A cooperation of the surgeons of these two departments has led to the Spine Unit, where more than 9000 patients with spinal problems are treated annually. The multidisciplinary team in this setting consists of experienced spine surgeons, well-trained psychologists, physical therapists, operating room personnel, and laboratory pathology experts. The multidisciplinary team works with well-established proven protocols. Naturally, with back and neck complaints the process cannot be the same for every patient; rather, it is dependent on the specific complaint the patient has.

7.4.3 Technologies

In order for the Spine Unit to achieve its goal of providing high-quality treatment to patients suffering from various back and neck complaints, many key factors must be addressed concerning both the clinical and practice management issues. Technologies of various types play a key role in enabling effective and efficient high-quality treatments at the center. The clinical technologies include the laboratory and radiology facilities to enable the best possible detection of the specific complaint, as well as the technologies to support the treating of this complaint, especially if surgery is the course of action, e.g. the use of image-guided spinal navigation to facilitate the accuracy, precision, and safety of spinal instrumentation and reduction in operative time, or laparoscopic or endoscopic procedures to minimize invasive spinal surgery. On the practice management side, the technologies include the hospital management information system (HMIS) in place. Table 7.1 describes the systems that comprise the HMIS.

7.4.4 Structure

The spine is a very complex part of the human anatomy. Bones and nerves play a central role in the well-functioning back and neck. Given the inherent complexity with the spine, it is understandable that, for high-class spine care, a multidisciplinary team made up of neurology, neurosurgery, and orthopedics is central to the care of spine patients. In addition to these disciplines, it is also important to incorporate other disciplines, such as physical therapy, pain management, and psychiatry. Thus, what we can see is that, in spine care, the use of multidisciplinary teams is critical to the cure process.

7.4.5 Knowledge Management in the Spine Unit

Modern medicine generates huge amounts of heterogeneous data on a daily basis. For example, medical data may contain SPECT images, signals like EKG, clinical

Table 7.1. Systems comprising HMIS.

System	Description
Hospital information systems (HISs)	Provide integrative medical and clinical information support services using a variety of computer services that are linked with high-speed networks.
Expert systems (ESs)	Provide expert consultation to end user for solving specialized and complex problems.
Case management systems (CMSs)	Evolved recently as a result of a growing trend of integrating health service delivery both vertically (coordinating clinical care across providers, i.e. between surgeons and physical therapy) and horizontally (linking institution providing the same types of treatment). Another feature of these systems is that they enable case mix applications and thus provide the capability and flexibility of integrating financial and clinical data. The benefits of this cannot be understated.
Health database management systems (HDBMSs)	Have been used extensively in some hospital settings. HDBMS refer to a repository of logically organized facts and figures which query facilities. A typical example of such an HDBMS is the automated patient record system. These systems also enable data mining and other data analysis techniques to be used with the help of OLAP (on-line analytic processes) features, so that it will be able to analyze cumulative treatments and thus update, revise, or adjust practice protocols as required. This will, of course, ensure the Spine Unit maintains its high standard of offering best possible services to its patients.
Group decision support systems (GDSSs)	Involve the use of interactive, computer-based systems that facilitate the search for solutions to semi-structured and unstructured problems shared by groups. Once again, these systems will benefit the quality of the patient treatment by supporting decision-making processes regarding patient treatments made within the Spine Unit.

information like temperature, cholesterol levels, etc., as well as the physician's interpretation. Added to all of this are the daily mountains of data accumulated from a healthcare organization's administrative systems. Those who deal with such data understand that there is a widening gap between data collection and data comprehension and analysis. These data represent raw assets that need to be converted into knowledge via information. Technologies play a significant role in facilitating the transformation of raw data assets into knowledge. This is done in many ways, from including application of data-mining tools, to just providing a structure and context for apparently disparate data elements so that they can be viewed as a whole within a specific context, typically a case scenario; this, in turn, then supports critical decision making [47]. Integral to any sound KM strategy within a healthcare organization is the transformation of these data and information assets into germane knowledge [48]. However, in order to do this both effectively and systematically it is necessary to have an organizing structured approach.

The HMIS in place at the Spine Unit helps physicians as well as administrators to address this problem by enabling these raw data assets to be transformed into information and knowledge. At the clinical level, for example, the HMIS helps in early detection of diseases from historical databases of symptoms and diagnosis, thus providing an early warning system that leads to a much more effective quality treatment. At the hospital administration level, for example, the HMIS helps in tracking certain kinds of anomalies, which may reveal areas of improvement and may help the realignment of certain kinds of resources (e.g. equipment, personnel, etc.). The major reason for the specific HMIS in place is to support delivery of quality healthcare in a cost-effective manner. These systems are considered to be very sophisticated systems in the current healthcare market. The systems uses National Committee for Quality Assurance standards and data gathered by the Spine Unit, i.e. findings from key medical journals such as *The New England Journal of Medicine* or *Journal of American Medicine*, as well as data generated and analyzed from the center's own database of patient history. These standards are continually updated and revised as new findings become available.

The systems, therefore, not only enable the physicians to perform their work more effectively and efficiently and render high-quality services to their patients, but also provide them with care parameters. This helps to enforce practice guidelines; in addition, it provides peer data on providers which enables benchmarking for specific treatments in terms of costs, length of stay, and other key variables to be calculated. The systems also enable the center to understand the occurrence of outliers, i.e. physicians' practice patterns can be studied to understand why they are outliers and then, if necessary, to change inappropriate behavior and thereby support effective and efficient delivery of healthcare. Physicians play an active role with defining the criteria and characteristics of the functions of the systems. This is an example of knowledge creating/renewal aspects enabled and supported by the system. In addition, the systems facilitate the sharing of knowledge, enabling discourse and discussion between physicians and other members of the multidisciplinary team. Thus, in an ad hoc fashion, the HMISs are supporting the four key knowledge transformations of combination, internalization, externalization, and socialization. However, without a structured systematic approach, i.e. given the ad hoc nature of these knowledge transformations, it is reasonable to expect that the Spine Unit is not fully maximizing the potential of these knowledge assets. We assert that the full potential of these knowledge assets can be realized through the establishment of a KMI.

7.5 Discussion

From the data presented on the Spine Unit in Section 7.4, it is possible to observe that the Spine Unit has a significant investment in technology, both at the clinical and practice management levels. On the clinical side there are various technologies that facilitate speedy detection and then enable the subsequent cure to be effective and efficient, thereby ensuring a high standard of quality treatment is experienced by the patient. On the practice management side the HMISs are crucial. When the Spine Unit is analyzed through the lens of KM, the relevant technologies become those on the practice management level, namely the technologies that make up the HMIS. These various technology systems (which make

Table 7.2. Relevant case elements in terms of the KMI model.

KMI element	Case study element
Infrastructure for collaboration	Primarily via the HIS: the system provides the forum for the exchanging of patient data and medical information between members of the multidisciplinary team. Also the GDSS: this provides the opportunity to share and discuss treatment options amongst members of the multidisciplinary team in an efficient and effective fashion. For example, when looking at a patient who had spinal fusion: neurosurgeons and orthopedic surgeons have the infrastructure to exchange key information and data easily in an organized and systematic fashion regarding the best procedure to follow and how to proceed on such a procedure. Such interactions support the knowledge transformations, in particular externalization.
Organizational memory	HDBMS: the database stores large volumes of data pertaining to treatments, key protocols, and statistics regarding cure options, as well as lessons learnt pertaining to various cure strategies.
Human asset infrastructure	Multidisciplinary spine care team: the combination of highly trained specialists from neurology, neurosurgery, and orthopedics, as well as psychologists, physical therapists, operating room personnel, and lab/radiology experts, are all vital to ensuring a proper cure outcome.
Knowledge transfer network	Primarily via the GDSS: the creation of new knowledge, as well as the possibilities to discuss and debate appropriate cure strategies to various cases, is enabled and facilitated. Also via HIS: the ability to access complete medical records and thereby develop a clear understanding of the patients' true history is supported via the HIS; in addition, it is possible to access the latest medical findings via this system. Once again, key knowledge transformations are supported in a systematic and structured fashion, including combination and externalization.
Business intelligence infrastructure	CMS: the case mix data and information stored on this system, as well as the ability of the system to link both vertically and horizontally, enables integration across the Spine Unit, resulting in supporting the business infrastructure.

up the generic healthcare information system of the Spine Unit and are described in Table 7.1) form the collection of key data and information and then, through various interactions of members of the multidisciplinary team with these technologies, protocols, and treatment, patterns are changed or developed; that is, through the interactions of both people and technologies, these raw data and informational assets are transformed into knowledge assets. Table 7.2 identifies each relevant case element in terms of the KMI framework presented earlier.

What can be seen, then, is a very heavy investment in the business intelligence infrastructure, i.e. HMISs which are facilitating the knowledge transfer, maintaining the organizational memory, and enabling the collaboration of the multidisciplinary team in a very effective and efficient fashion. The Spine Unit has highly trained specialists who are encouraged always to keep at the cutting edge of new techniques for achieving better results and higher quality outcomes, with a strong emphasis on continuous improvement, they impart and exchange the knowledge and skills gained via interacting with the GDSS and the HIS components of the HMIS.

One can see from Table 7.2 that, in this cure setting, the KMI is established and sustained through the technologies in place. By explicitly identifying the components of the KMI in the Spine Unit case study, it is possible to make explicit the knowledge assets currently in place, thereby facilitating better management of these knowledge assets, as well as maintaining and updating the KMI itself, as it becomes possible to identify key knowledge transformations in a systematic fashion.

Technologies are continuously changing, and when new technologies are added to the Spine Unit it will then also be possible to evaluate their role in sustaining and supporting the existing KMI. Furthermore, by making explicit the elements within the KMI as they occur in the case study, it is possible to get a feel for the relative complexity of various tasks and processes that are evidenced in the Spine Unit and thus be able to evaluate these to identify whether modifications are required or how best to support them. Therefore, it is not only possible to identify elements of the KMI within the Spine Unit, but by doing so one can ensure that the KM processes that occur are supported and enhanced so that the primary goal of cure for the patient is indeed realized.

In addition, the KMI facilitates the knowledge transformations of the knowledge spiral, which in turn serve to increase the extant knowledge base of the organization, thus enabling the spine unit to maximize the full potential of its knowledge assets. Moreover, once such a KMI is established it is then possible to apply the IC to the data and information stored and generated throughout the healthcare setting so that superior healthcare decisions can be made, as the following example from the orthopedic operating room highlights [4].

The orthopedic operating room represents an ideal environment for the application of a continuous improvement cycle that is dependent on the IC. For those patients with advanced degeneration of their hips and knees, arthroplasty of the knee and hip represents an opportunity to regain their function. Before the operation ever begins in the operating room, there are a large number of interdependent individual processes that must be completed. Each process requires data input and produces a data output, such as patient history, diagnostic test, and consultations.

From the surgeon's and hospital's perspective, they are on a continuous cycle. The interaction between these data elements is not always maximized in terms of operating room scheduling and completion of the procedure. Moreover, as the population ages and a patient's functional expectations continue to increase with their advanced knowledge of medical issues, reconstructive orthopedic surgeons are being presented with an increasing patient population requiring hip and knee arthroplasty. Simultaneously, the implants are becoming more sophisticated, and thus more expensive. In turn, the surgeons are experiencing little change in system capacity, but are being told to improve efficiency and output, improve procedure time, and eliminate redundancy. However, the system legacy is for insufficient room designs that have not been updated with the introduction of new equipment, poor integration of the equipment, inefficient scheduling, and time-consuming procedure preparation. Although there are many barriers to re-engineering the operating room, such as the complex choreography of the perioperative processes, a dearth of data, and the difficulty of aligning incentives, it is indeed possible to effect significant improvements through the application of the IC.

The entire process of getting a patient to the operating room for a surgical procedure can be represented by three distinct phases: preoperative, intraopertive, and postoperative. In turn, each of these phases can be further subdivided into the individual, yet interdependent, processes that represent each step on the surgical trajectory. As each of the individual processes is often dependent on a previous event, the capture of event and process data in a data warehouse is necessary. The diagnostic evaluation of these data, and the reengineering of each of the deficient processes, will then lead to increased efficiency. For example, many patients are allergic to the penicillin family of antibiotics that are often administered preoperatively in order to minimize the risk of infection.

For those patients who are allergic, a substitute drug requires a 45 min monitored administration time as opposed to the much shorter administration time of the default agent. Since the antibiotic is only effective when administered prior to starting the procedure, this often means that a delay is experienced. When identified in the preoperative phase, these patients should be prepared earlier on the day of surgery and the medication administered in sufficient time such that the schedule is not delayed. This prescriptive reengineering has directly resulted from mining of the data in the information system in conjunction with an examination of the business processes and their flows. By scrutinizing the delivery of care and each individual process, increased efficiency and improved quality should be realized while maximizing value. For knee and hip arthroplasty, there are over 432 discrete processes that can be evaluated and reengineered as necessary through the application of the IC [49].

7.6 Conclusions

Healthcare globally is facing many challenges, including escalating costs and more pressures to deliver high-quality, effective, and efficient care. By nurturing KM and making the knowledge assets explicit, healthcare organizations will be more suitably equipped to meet these challenges, since knowledge holds the key to developing better practice management techniques, and data and information are so necessary in disease management and evidence-based medicine. The case study data presented depicted the complexity of the service delivery process, driven by the complexity of the issues being dealt with by the teams, which in turn requires that many disciplines create and share knowledge to enable the delivery of a high quality of care. Thus, the need for shared knowledge is a fundamental requirement. The KMI was presented and used to structure these disparate knowledge assets as explicit and integrated within a larger system, i.e. the generic healthcare information system, that allowed analysis of the extent of the KMI for the Spine

Unit. Further, such a framework in particular supports in a systematic and structured fashion all four key knowledge transformations identified by Nonaka [15], in particular that of externalization (tacit to explicit). The application of the IC to this generic healthcare information system ensures that maximization of appropriate and germane knowledge assets occurs and a superior future state will be realized.

On analyzing the case data with the KMI framework and IC model, the benefits to healthcare of embracing KM become clearly apparent. Given the challenges faced by healthcare organizations today, the importance of KM, understanding the means available to support KM, and explicitly developing and designing an appropriate healthcare information system using the KMI framework and then applying to this the IC model is, indeed, of strategic significance, especially as it serves to facilitate the realization of the value proposition for healthcare.

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