Building a Knowledge Management System for the E-Health Knowledge Society

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ABSTRACT

Background & Purpose – Healthcare (HC) is an expensive investment facing challenge to design, develop and implement a cost-effective knowledge management system (KMS) that meets HC professionals' expectations. Concepts like knowledge management (KM) technical perspective, supply network framework, e-business infrastructure and KM architecture are integrated to propose a quantifiable transnational HC-KMS Model that can play a critical role to improve global patient-care quality in a Transcultural society.
Design/methodology/approach –This theoretical research examines relevant theories and reviews literature on HC KM, its frameworks and its infrastructures.
Findings – This paper develops a pragmatic, integrative, strategically viable and an implementable transnational HC KM Model for a global HC Initiatives.
Research limitations/implications – This research provides an integrative, conceptual transnational model grounded in theory and preliminary primary research that needs to be tested further in real/simulated global transnational and transcultural HC environments.
Practical implications – Global KM initiative is currently a main driving point to launch a global HC industry. Hence, this research is a credible framework for a pragmatic and successfully implementable HC KM model.
Originality/Value – This paper contributes a new transnational HC KM model subsequent to pilot testing, within IT infrastructure and cultural aspect of global HC The global HC KM model is an integration of models being: (1) HC KMS technical perspective model, (2) knowledge intensive supply network framework model, (3) e-business infrastructure and capabilities model, (4) knowledge-based decision support (DS) architecture model and (5) e-business KM architecture model.

Keywords: Healthcare, Architecture, Knowledge Management, Infrastructure

INTRODUCTION

HC is knowledge rich yet knowledge is underutilized especially in point-of-care and point-of-need. HC knowledge is spread across medium and new knowledge is generated at a rapid rate and its utilization can impact positively HC outcomes. Since knowledge is dispersed in different mediums it is difficult for HC professionals to be aware of it and hence apply it (Abidi, 2008). KM is "generation, representation, storage, transfer and transformation of knowledge" where knowledge exists in 2 aspects: (1) objective - process based where knowledge is of two types, being: (a) explicit (tangible in documents and expressible) and (b) tacit (know-how experience not expressible) and (2) subjective - evolving phenomenon shaped by a community of social practice (Wickramasinghe et al., 2009).

KM is a long-term project and a facilitator of a KM strategy. Businesses have shifted from

manufacturing (physical organizational assets value) to service oriented (knowledge based organizational assets value), making KM an important HC project. It is easy to capture explicit knowledge but not tacit knowledge as such knowledge is trapped in form of experience in an expert' minds. Various qualitative and quantities research methods can be used (e.g.: questioners, interviewing, observing) to improve tacit knowledge capture. Captured knowledge can be organized by six ways being: (1), know-how, (2) know-who, (3) know-when, (4) know-where, (5) know-why and (6) know-that. Knowledge sharing - intelligence gathering when applying KMSs. KM technology, derived from computer science, is a domain composed of related and categorized classes to help users navigate, e.g.: web pages (Wickramasinghe et al., 2009).

LITERATURE REVIEW

Even though KM is a business administrative concept, it is applicable in HC with an aim to create, share and apply knowledge to influence medical and clinical procedures like diagnoses, therapeutics and prognosis. An example of knowledge - a patient with blood pressure greater than 140 mmHg is going through hypertension. Knowledge is processed from information. Information is contextually sensitive as well as meaningful interpretable data. An example of information – patient's blood pressure being 140mmHg. Information is processed data that by itself has no meaning. An example of data in the above context is the number 140. KM is classified between: (1) know-what – declarative knowledge that provides answers to questions, (2) know-how – procedural knowledge answering the 'how' questions and (3) know-why – evidence-based explanatory knowledge that is neglected in many applications and answer to 'why' questions (Riano, 2010).

HC Data, Information and Knowledge

Data is context relative raw facts/observations with no direct meaning. Information is replaces data within a meaningful content. Knowledge is close to action i.e.: organized and transformed information produced within set of rules, procedures and operations, learnt through experience and practice. When knowledge interacts with information, it increases in content. There is a difference and relevance between data, information and knowledge. Data is numbers and facts. Information is processed and organized data. Knowledge is authenticated and meaningful information. Knowledge is explicit knowledge (easy to articulate, capture and distribute) and tacit knowledge (hidden and difficult to adapt, codify distribute/capture because it is know-how captured through personal experience) (Kalkan, 2008). HC data and information are codifiable standardized concepts combined in differing medical circumstances like patient state, medical condition/therapies to form a more complex information structure (Riano, 2010).

HC KM

KM - an interdisciplinary business model manages knowledge through processes for enterprise information assets Wickramasingha, Gupta & Sharma (ed. 2005, p 2). The KM processes are (figure 1).

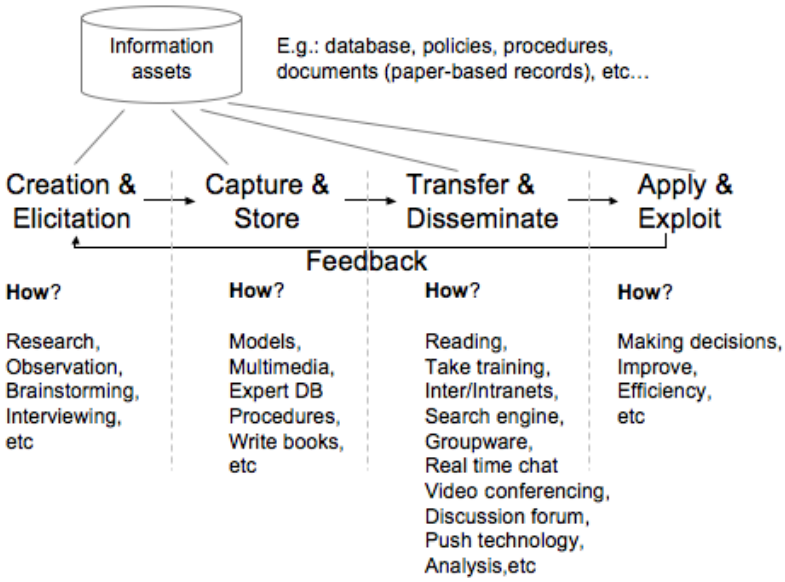

Figure 1. KM Environment.
Adopted from - Wickramasingha, Gupta & Sharma (ed. 2005, p 15)
and (Bose 2002).

KMSs utilize tacit and explicit knowledge (Bose 2002). KM needs KM technologies like infrastructure, Internet, intranet and extranet as a pre-requisite for the KM environment (Bali & Dwievedi (ed. 2007, p 6). This too is an important strategy when designing a fully functional KMS for the e-health sector. Figure 2 below proposes the HC KM model with common goals (KM theme) through alternating routes (Figure 3).

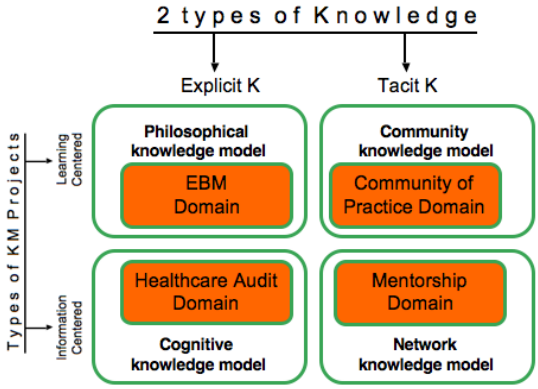

Figure 2. Clinical HC KM model.
Adapted from: Kakabadse, Kakabadse, &
Kouzmin (2003); Lusignan & Robinson (2007)

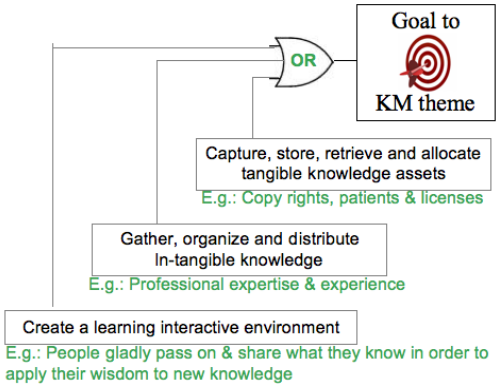

Figure 3. Alternative routes to a common goal (KM theme).

HC KM & Knowledge Services

Medical errors are a major problem when evaluating HC quality and a threat because patients die. Errors are preventable if the right person utilizes right knowledge at the right time. Medical errors result from underutilization of HC knowledge central to clinician's decision making. Clinical decisions are made in a cyclical manner where in each cycle the HC professional applies his knowledge in order to verify prior hypothesis and satisfy constraints to get closer to the final decision, showing that HC knowledge is not a resource but a service. We improve HC quality by utilizing a patient-centered and team-care based KMS.

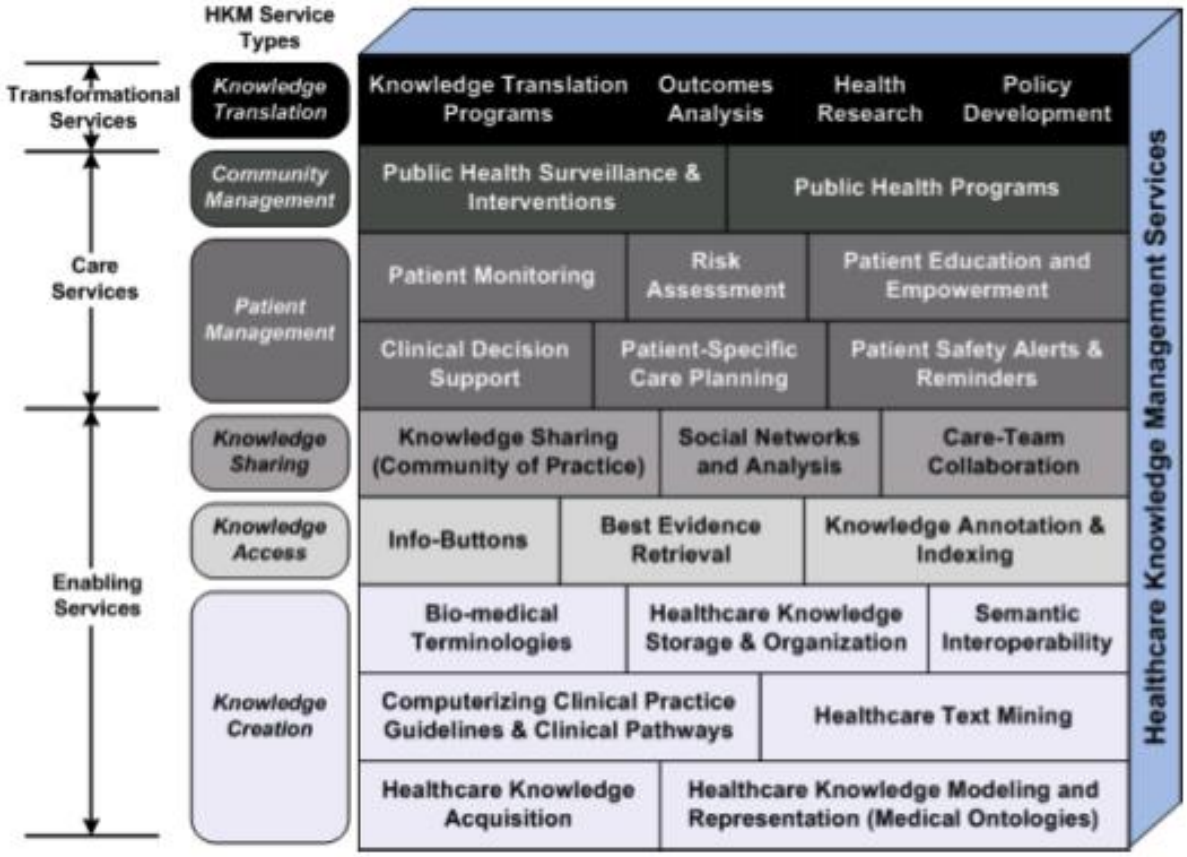

Figure 4. Hierarchical organization of a spectrum of HC KM services
Source: (Abidi, 2008)

Figure 4 - the spectrum of HC KM services from knowledge creation to knowledge translation. Service hierarchies are set along the lines of enabling services, care services and transformational services. The enabling services identify, collaborate, organize and model knowledge to access knowledge. Care services allow the utilization of HC knowledge. The transformational service serves as change agents to promote the culture of knowledge in HC practices (Abidi, 2008).

Information and Communication Technology (ICT) involved in KMS

It is very important for a HC organization to develop a KMS where ample information is accessed from repositories so new knowledge can be developed in the community of practice (COP). KMS (figure 5), from a technical perspective, is composed of three components being technology, function and generated knowledge (Abdullah & Salamat, 2005).

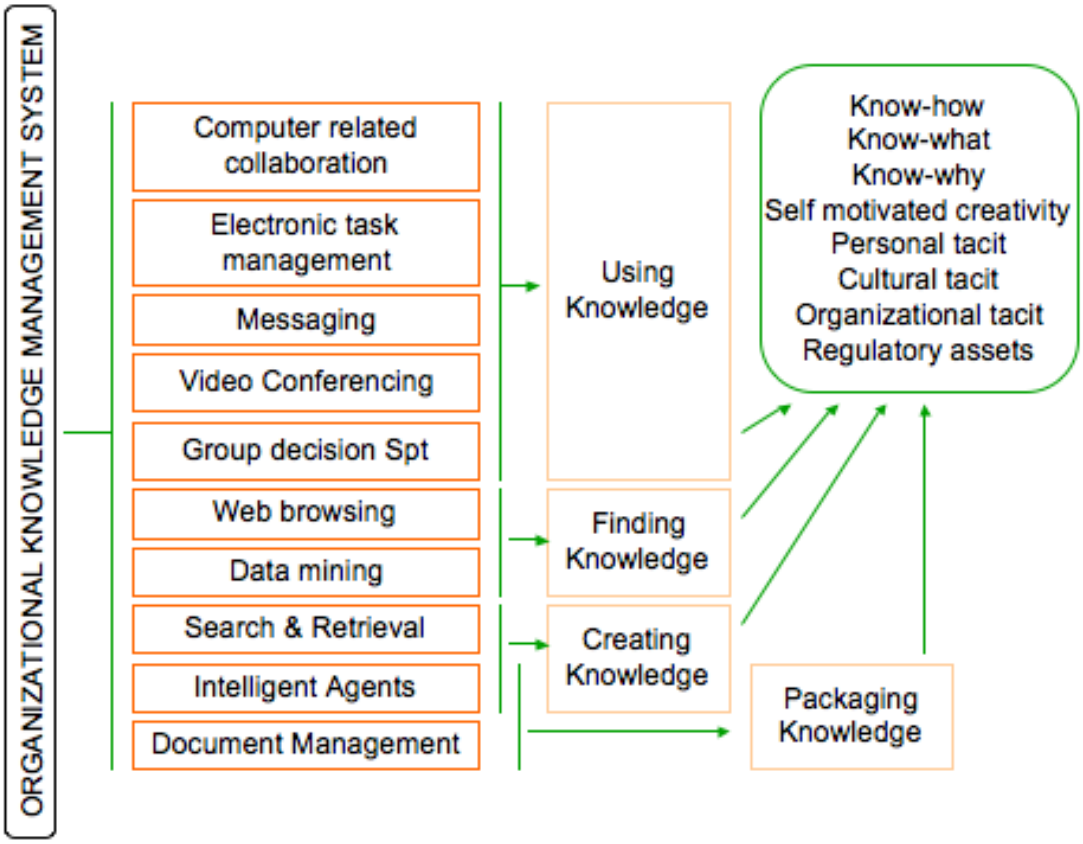

Figure 5. Technical Perspective of a HC KMS Model
Adapted from: (Abdullah & Salamat, 2005)

The goal of ICT goes hand-in-hand with its contribution to decision-making. However it does not lower uncertainty due to the knowledge gap between intelligence and the required knowledge when a HC professional needs to make the right decision. This calls for knowledge assurance due of the tacit knowledge gap. Uncertainty is a cause of incomplete information. The role of ICT is to extract knowledge from information. Also ICT can delude knowledge and make it sticky. Codifying tacit knowledge can solve this gap. This is possible by accessing sources like yellow pages and through proper taxonomy. ICT is needed when decision-making processes are carried out in international organizations (Mohamed,

Stankosky & Mohamed, 2009).

HC KM Framework

HC organization needs KM framework - blue print guideline to implement KMS (Abdullah & Salamat, 2005). Knowledge iterative supply network framework (figure 6) can be applied on a network e.g.: work group, COP, Internet, Intranet, etc and codified using open source programming languages as well as develop a knowledge strategy through six steps being knowledge discovery, knowledge analyses, knowledge classification, knowledge assimilation, knowledge presentation and knowledge operation. The output of one step is an input for the next step. The illustrated loops execute until knowledge is made mature.

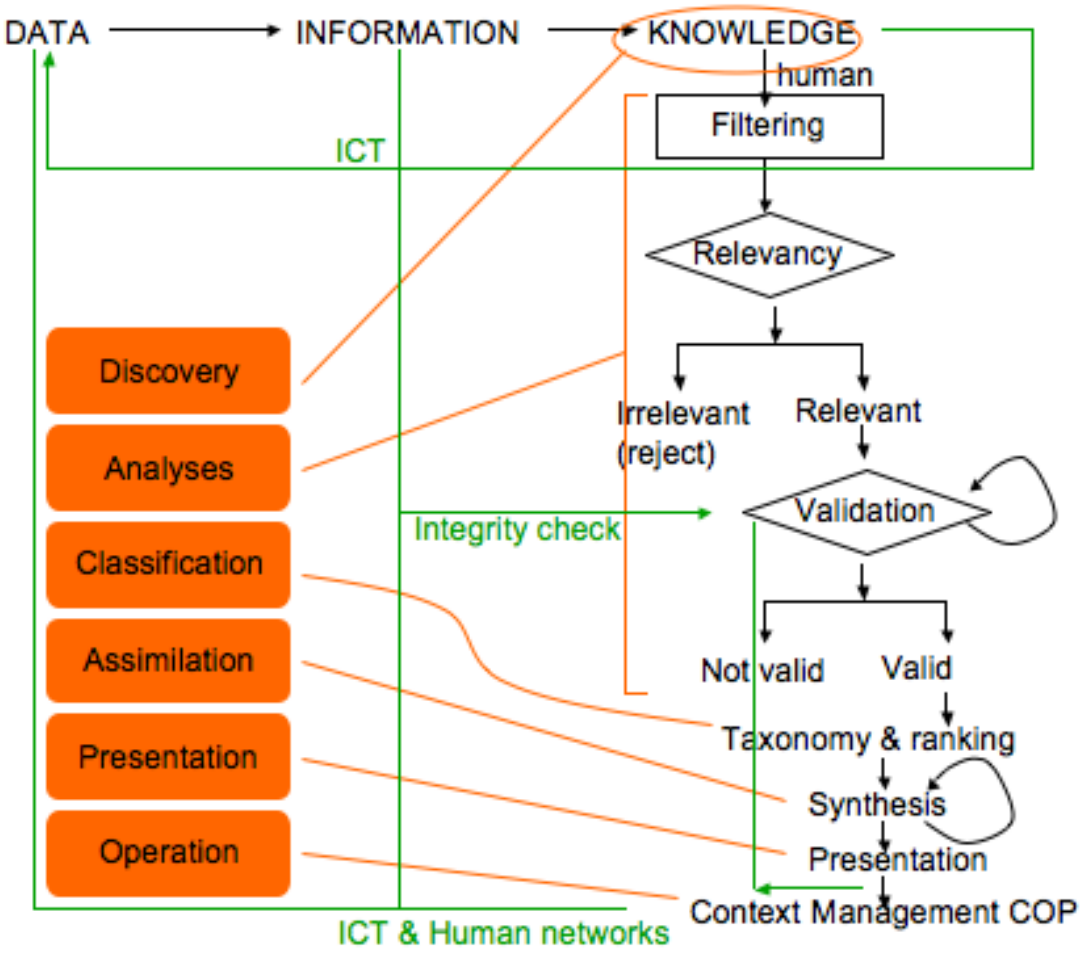

Figure 6. Knowledge Iterative Supply Network Framework
Adapted from: (Mohamed, Stankosky & Mohamed, 2009)

Knowledge discovery is knowledge transforming in phases (data-information-knowledge) using sources like: DSS – decision support system, data warehousing, data mining and statistical systems. Knowledge analysis is the difference between needed knowledge and available knowledge. Knowledge classification is categorizing, ranking and prioritizing valid knowledge in basic parent-child classes. Knowledge presentation is a step to put knowledge together for end-user using technologies like portals, Internet, etc. Knowledge propagation and operation are final steps where knowledge gains its vales when distributed (Mohamed, Stankosky & Mohamed, 2009).

Organizations need to deploy technology using the model in figure 6 to set up knowledge environment, in different KM capabilities (Figure 7).

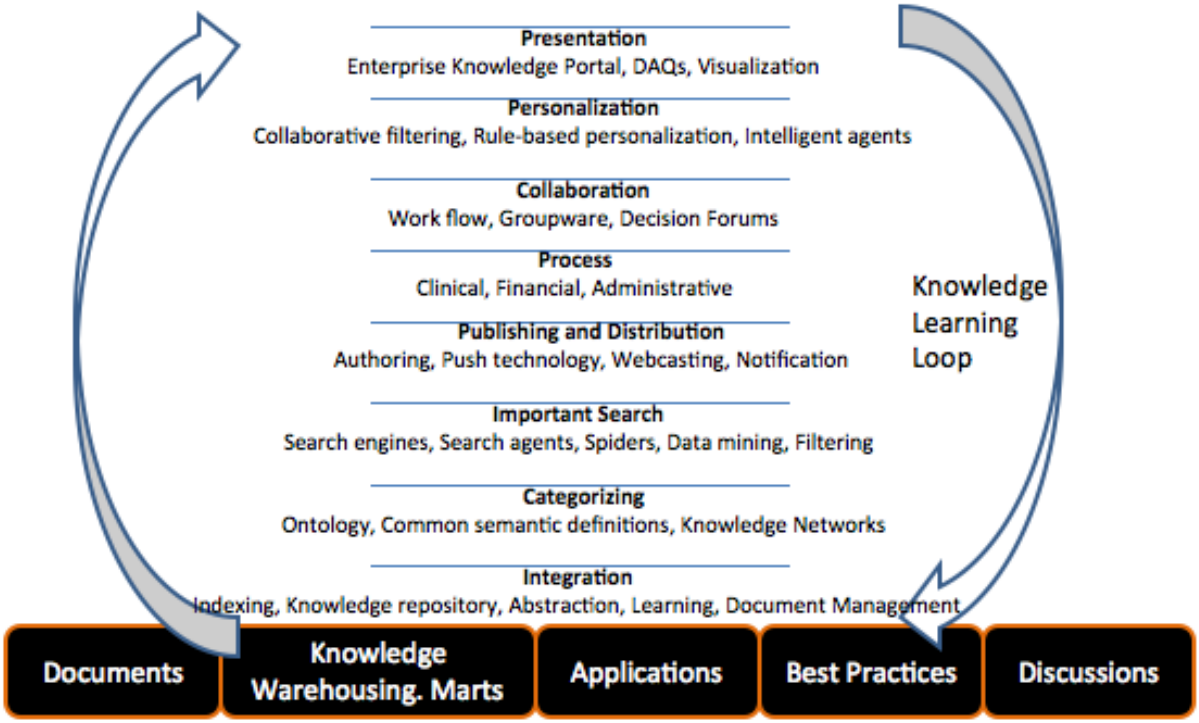

Figure 7. KM Capabilities in HC management systems
Adapted form: *(Bose, 2003).*

The above framework uses existing knowledge and creates new knowledge through a learning process tool, whose capabilities are shown in rectangular boxes, that passes through learning loops. Personalization tool allows end-users to customize a web browser depending upon their required knowledge. The personalization tool promotes customization. Collaboration tool uses applications to connect people through COP and integrate knowledge repositories. The process tool enhances users' ability to participate in relevant business processes and gain access to knowledge, KM applications and DS applications. The publishing and distribution tool facilitates users to setup their applications as to how they want to gain, publish and share knowledge using software agents. The integrated search tool uses indexing tools that are pre-set/set by users to maintain information overload. The categorization tools allow users to search, create and manage knowledge categories. The integration tool integrates all of the above tools for individuals to participate and combine organizational knowledge (Bose, 2002).

The ability to support a decision is highly dependant on evidence-based medical knowledge. This knowledge is derived from the point of need and is integrated in the process of patient care. Even though there are ample clinical systems platforms and architecture, how knowledge integrates with them varies. For knowledge to well integrate, a clinical system needs to fit well with a clinical setting. In order to build a successful KM framework one has to consider that many clinical information systems (ISs) come in varying platforms. These traditional ISs are not geared to KM/DS. In addition the KM process requires a convergence of forces, political, financial, technical and cultural, to make this initiative successfully possible. This is essential for the improvement of HC quality (Greenes, 2003).

HC KM Infrastructure

When knowledge is not only managed but also integrated with the HC e-business systems, it is referred as e-health as (figure 8). E-health is customer oriented and business oriented. E-Health is customer oriented via connecting Extranets and Intranets for data interoperability within and between organizations. It is business oriented via interoperating core clinical, financial and administrative services across business processes. E-Health requires the right capabilities and infrastructure so the right knowledge will be available to the right people at the right time (Bose, 2003).

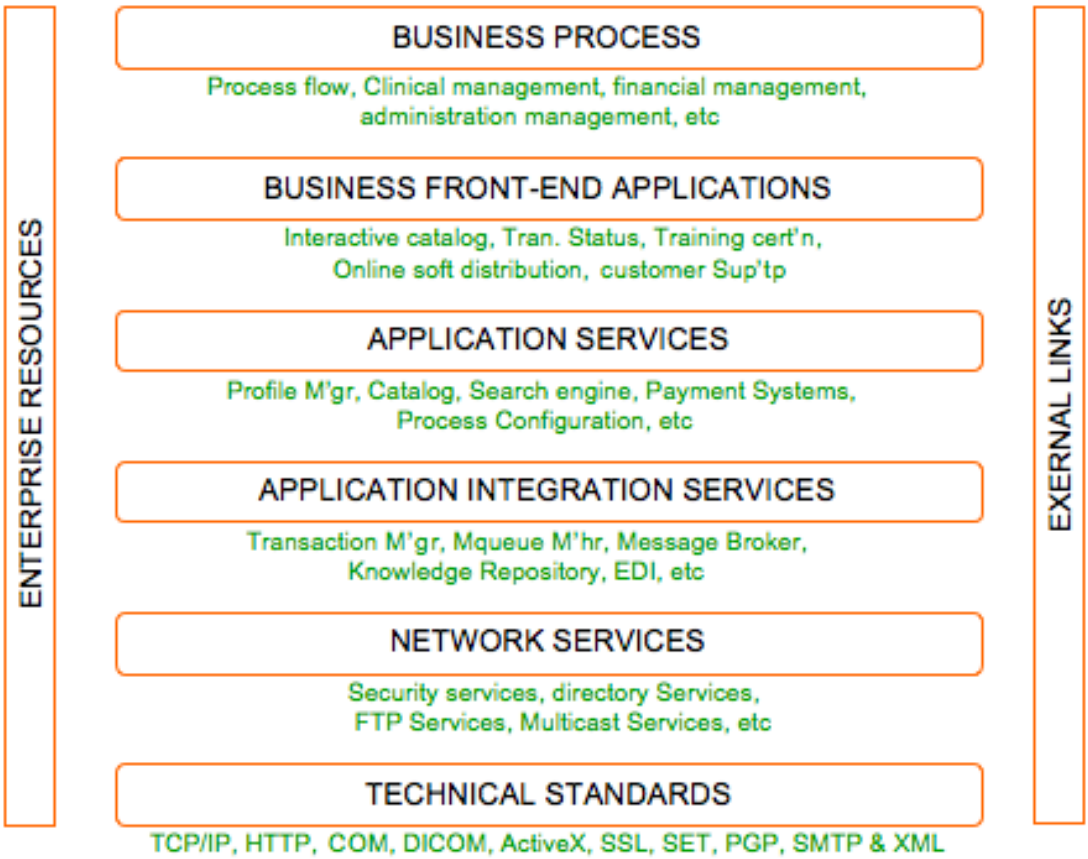

Figure 8. HC Management System's E-Business Infrastructure & Capabilities Model
Source: (Bose, 2003)

HC KM Architecture

HC suffers because their different ISs are not connected together. This makes knowledge sharing complex and hence developing a DSS and integrating knowledge a challenge. Knowledge integration is fragmented and therefore not shared. The solution is to design EKW - enterprise knowledge warehouse that uses common knowledge architecture to peace knowledge together in order to manage a knowledge -base from various systems as a repository to facilitate a DSS application. Hence EKW architecture and its HC DS are (figure 9).

The OKS – operation knowledge store cleans knowledge for other knowledge containers. Its dependent knowledge marts hold subsets of enterprise knowledge that match requirements of users with access tools to provide business intelligence via ad hoc and querying environment,

OLAP – online analytical processing support, knowledge mining, DSS applications and statistical analyses. Knowledge mining tools assist in building knowledge models to aid decision-making by providing, storing and updating new knowledge for evidence-based medicine. The mined knowledge is associations, classes, clusters, exceptions, forecasts, text and web documents, etc. DSS is facilitates to enhance medical and disease management (Bose, 2003).

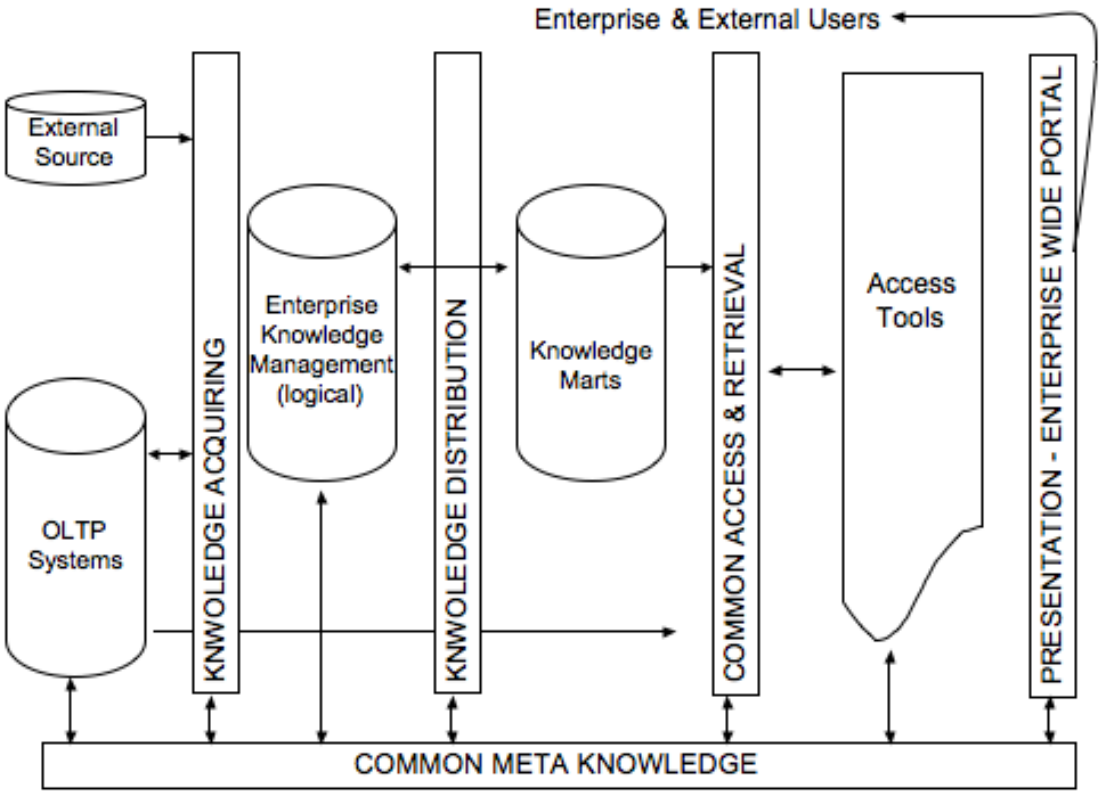

Figure 9. HC KMS Knowledge-Based DS Architecture Model
Adapted from: (Bose, 2003)

While HC professionals generate data and information from EHRs – electronic health records, they also use knowledge during medical and clinical practices like patient diagnoses/screening. AI – artificial intelligence can use machine-learning algorithms to produce knowledge by computing information. Once this knowledge is validated it can be applied to: verify newly arriving information and support decision-making.

The KMA - KM Architecture, (figure 10), incorporates data, information and knowledge via the content management layer. The knowledge map layer integrates and shares these elements from the content management layer. The service layer implements services e.g.: knowledge discovery, explanation seeking, personalization, collaboration and knowledge sharing. The application layer allows integration of this architecture with other systems like: e-learning, RCT - randomized clinical trial tolls, web-based ISs, networking systems, quality checking systems, etc.

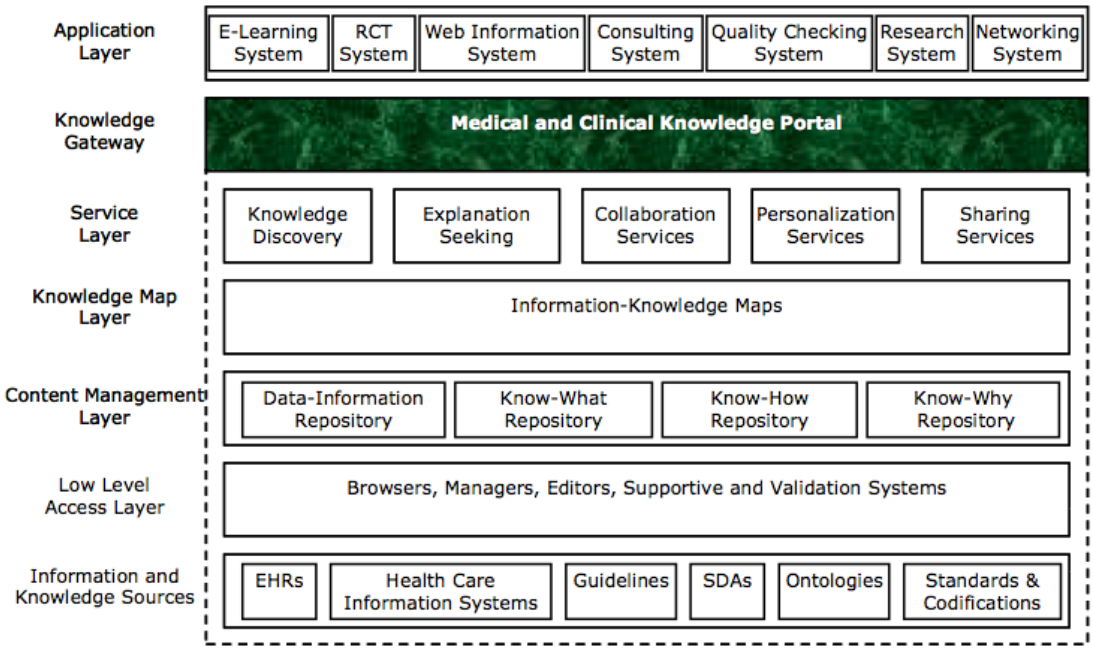

Figure 10. E-Business KM Architecture Model
Source: (Riano, 2010).

The low-level access layer is composed of tools to access information and knowledge from its sources – the information and knowledge layer. The user can import, browse and edit: (1) data and information in EHR/HC ISs and (2) know-what knowledge (e.g.: ontologies, standards and codifications), know-how (e.g.: SDA* structures) and know-why knowledge (e.g.: textual CPGs) (Riano, 2010).

Global HC KM

Knowledge societies are part of knowledge dependant operations-based advanced economies, transitioned into strategies and policies-based learning societies. Every society holds diversity of peoples' skills and experiences where knowledge is a commodity that is subsidized. One barrier is that there are no strategies and policies that can assist a society to become knowledge intensive. Knowledge increases as societies globalize. Knowledge assets become weightless goods increasing with time and use as opposite when compared to tangible goods. A knowledge society is constructed upon four pillars being infrastructure, governance, human capital and culture (Sharma, Samuel & Ng, 2009). For the past decade KM, intellectual capital with people management has attained a lot of attention. People management has concentrated on human behavior, which is a key to the success of a KMS. KM emphasizes on organizational culture and teamwork to share knowledge. Hence leadership style for setting up a mentoring system plays a major role when creating knowledge (Yang, 2007).

The growth of a knowledge society takes time and is based on causes, effects, dynamics and consequences. This leads to products of a society that are committed to sustaining development (Chou & Passerini, 2009). When public goods are shared, the level of knowledge creation that contributes to increasing value lowers since there are no incentives in place for such contributions. One solution is to increase incentive with a stringer plan for IPRs – intellectual property rights to foster knowledge creation. Therefore these public goods become private club goods where there is a pay-per-view scheme only for members. An IPR plan, if too stringent, could pose negative effects on knowledge circulation and innovation in

developing countries. The start of the commons/free software movement has improved free access but this too has reduced incentive. Another possible solution is to have a IPR plan that can balance knowledge creation, knowledge acquisition and discrimination of knowledge at the lowest costs so each country will have the most desirable IPR protection to maximize it's knowledge production/welfare.

If a country's GDP per capita is low then so is the IPR standard. An IPR's strength is low due to foreign technologies adapted for local use to produce knowledge. Hence reflecting a weak IPR plan. These plans are strengthened when a country switches from foreign technologies to domestic knowledge creation. This gives birth to high-tech products, e.g.: USA in 19th century and currently Asian nations like Indonesia, Malaysia, Philippines and Thailand as well as Taiwan, South Korea, Singapore and Hong Kong. It does not depend on a country's GDP spending power standing to have a more stringent IPR standard. However the level of standard is dependant on the level followed by other countries this country is interacting with. High-income countries (e.g.: USA, Australia, Germany, Netherlands, Sweden, Italy, South Korea, Japan, Denmark, France, Spain, Switzerland, Singapore, etc) have stronger copy rites protections than low-income countries. This depends on the level of income countries adapting differing levels of IPR protection strategies. Mid-income countries are China and India. There is a possibility to reach equilibrium between high and mid-income countries through a game theory. The trade related aspects of intellectual property rights (TRIPS) was a minimum standard established since 1984 for developing countries to adhere by. Upon experimental analyses most of the developing countries suffer from the TRIPS. Few developed countries are benefiting from TRIPS while most developing countries are not (especially the low income countries). For developing countries foreign development investment (FDI) and technology transfers can improve, if IPRs plan (not IPR standards) is strengthened with an improved economical competitive nature of the country. Knowledge transfer is dependant upon GDP per capital, size of market. Open trade, setting up of insensitive, political stability, etc. This is the reason why countries like China have a high rate of FDI just because they have strong IPR plans but weak IPR standards (Sharma, Samuel & Ng, 2009).

Experience and Knowledge

There is a close relationship between experience and knowledge. Experience is considerable in cases when refining/creating knowledge. Both experience and knowledge are human intellectual assets. While knowledge plays a key role in information management and business management, taking no account for experience when investigating knowledge makes knowledge meaningless. Experience can be defined as perceived knowledge/skill a human attains through experience. As an example, one avoids high traffic accidents by understanding that he/she needs to drive carefully and this knowledge is derived through personal/others experiences. The knowledge from experience is gained when one has met a problem and has successfully solved it via a solution making experience a specialization of knowledge. If experience is considered as a case then all cases are stored in a case base with previous attained experience is referred as previous case, stored case/retained case. The difference in experience and knowledge is derived though communication where one may say that he goes to school to study, not to gain experience but knowledge. The same person goes to a well-experienced doctor to get treated since the doctor's experience is also dependant upon past cases he/she treated and got experience through his/her attained knowledge. Also one draws a lesson from experience but does not say that he/she drew lesson from knowledge. In the field, an expert finds experience more important than

knowledge when dealing with problems making experience to be at a higher level than knowledge. This is also a cycle for while new experience can be gained from past knowledge, new knowledge too can also be gained from past experience (Sun & Finnie, 2005).

METHODOLOGY

We propose a qualitative study. It is an investigative methodology, grounded in theory, relying on literature review. We looked for variables related to KM and KMSs – the case of HC. Our research passed through two phases. In the first phase a general study was conducted on KM. Its objective was to understand an in-depth meaning, purpose and functionality of HC KM pertaining to e-health. Experts who conducted this research aimed to investigate the effects and challenges that the current HC organizations face when implementing KMSs. Literature reviewed was derived primarily from journals and book publications. In the second phase a conceptual and practically viable integrated KMS model-based solution – figure 11 below was proposed to narrow/cement the significant widely mentioned challenges.

SIGNIFIGANT CHALLENGE

HC KM is a service and an expensive initiative. Even though there are overwhelming intellectual contributions expressing KM theory; the authors of this paper have identified that the literature lacks to propose a fully integrated and well functionally viable KMS model for designing, developing and implementing a KMS for a knowledge society.

In addition, many challenges arise during the time of knowledge re-use. This gives rise to some of the common challenges being:

(1) Data accuracy – generated data by a group needs to be validated before use,
(2) Data interpretation – newly formed information needs to be mapped as per standards hence usable by another group,
(3) Data relevancy – knowledge from non-relevant data forms an organization to adhere losses pertaining to cost, risk and complexity,
(4) Data's ability to support/deny hypothesis – does the generated knowledge support decision-making? ,
(5) KMS adoption – does the organizational culture support the use of a KMS?, and
(6) Large knowledge base is complex – leading an organization to a flux (Annely, 2006).

A major problem in many organizations is convincing people within an organization to share knowledge. This shows the importance of an organizational culture to facilitate knowledge creating, learning and sharing. Technology plays a key role, e.g.: Lotus Notes, video-conferencing, multi-media-based mail, document management systems, Intranets, artificial intelligence tools, etc. At this stage once an organization knows who has the right knowledge; knowledge maps can be adapted to share this valuable knowledge. At this stage the organizations lack an effective tool to measure the attained knowledge. This is because intellectual capital is an organizational asset needed for accounting processes to valuing intangible assets (Gupta, Iyer & Aronson, 2000).

It is also important to note that culture plays a great role in knowledge sharing. Societal cultures that respect knowledge, generation and sharing are also open to the KM principles. An organization can better excel in such a culture (Smith, J. G. & Lumba, P. M., 2008). It

was also noted that organizations need a more developed working definition of knowledge to distinguish data information on one hand and knowledge on the other. This is to assure that these three terms and concepts are treated differently. If this is not well understood then organizations will confuse themselves when initiating projects like blindly incorporating data warehousing architecture planning within a KM initiative. Most knowledge is tacit, well embedded within the meaning of its context. It is this type of knowledge that is difficult to articulate. Therefore organizations can sustain competitive advantage/s when using this type of knowledge.

Even though this challenge has been expressed widely in literature; institutions still, show reluctance to deal with this challenge because still more emphasis is express on explicit knowledge. Top management must show support in KM initiatives that facilitate tacit knowledge sharing. Organizations need to understand that in a KM initiative, IT works in balance focusing on tacit knowledge. So IT can work as an integral component and not a major component (Kalkan, 2008). Ample research is conducted on KM while little notice is given to experience management. Experience is derived from knowledge. In other cases, knowledge is derived from experience (Sun & Finnie, 2005). Even though there are ample clinical ISs they differ in platforms. Traditionally speaking, such systems are not geared to the problem of KM and decision-support. Thus these systems lack the ability to generate evidence-based medical knowledge, mandatory to improve HC quality (Greenes, 2003). Considering that very little research is conducted towards the above stated challenges, the proposed fully functional integrated KMS model for a knowledge society poses a solution worthy of consideration. We need to apply system thinking and hence look at the picture from a holistic manner (Bali & Dwievedi (ed. 2007, p 42).

PROPOSED SOLUTION

The proposed global KM model (figure 11), below, has integrated all the pre-requisite KM models. To begin with the Technical Perspective of a HC KMS Model fulfills the requirements for the KM environment, HC KM model and the spectrum of HC KM services. This model is a pre-requisite for the Knowledge Iterative Supply Network Framework that fulfills the requirements for the KM Capabilities in HC management systems. This is hence a pre-requisite for the HC Management System E-Business Infrastructure and Capabilities Model. The HC Management System E-Business Infrastructure and Capabilities Model is the pre-requisite for the knowledge-based DS architecture model and the e-business KM Architecture Model.

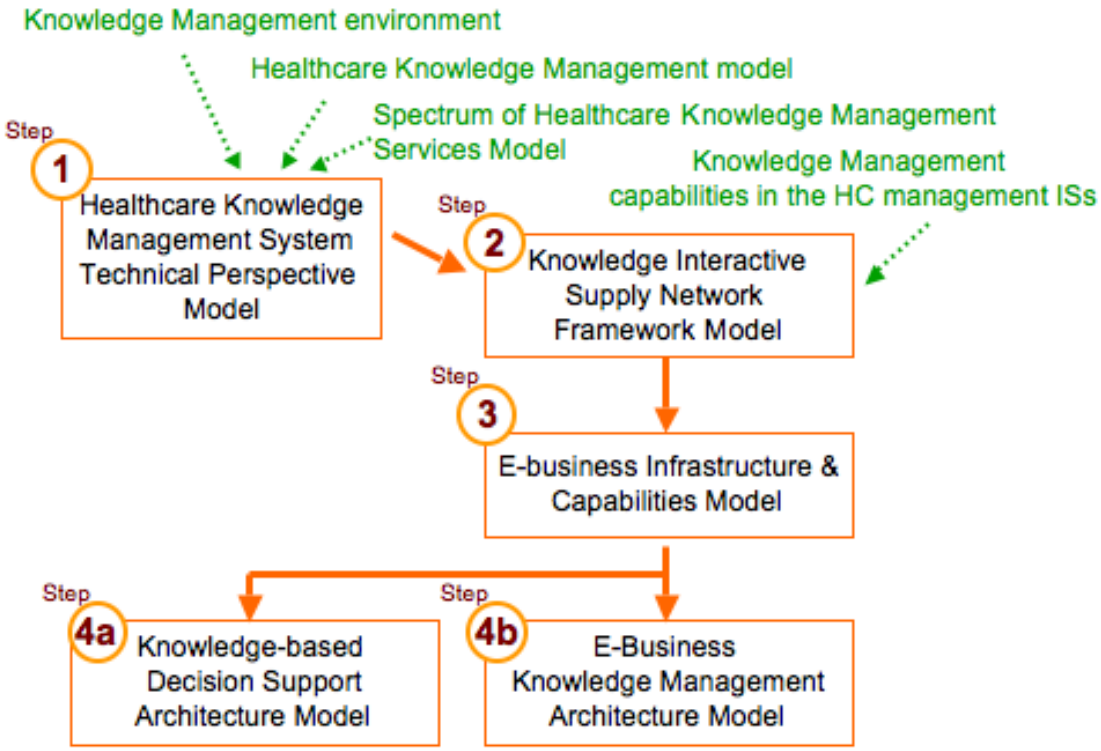

Figure 11. Global HC KMS Model

Considering that this model is implementable within an e-Health environment, there are nine lessons in making e-Health a success being: (1) Be ready for a stickier shock, (2) Get doctors and nurses on board, (3) Getting expert help, (4) Start small, (5) Training is important an (6) Expect productivity hit - after implementation productivity in HC drops by 50% in the first two, tree weeks but re-bounds by 75% (Brooks, Grotz, 2010).

CONCLUSION

In order to facilitate the ease in future design, development and implementation of a KMS for a knowledge society; a conceptually and practically viable four step model is proposed – figure 11 above for future testing in a HC environment. The next step of the authors of this paper is to test the proposed model in a health care case study for its practicality. The proposed global KM model encourages focus on the above-mentioned significant challenges to be considered when applying this model. This model is patient centered and facilitates improving of HC quality.

HC professionals and government leaders need to harness the concepts and practical intelligence to share knowledge to provide better HC service being more decision oriented catering to set standards. This strategy can lead the way to global knowledge sharing for the next generation of e-Health services. The proposed global HC KM model - figure 11 above is an integration of: (1) HC KMS technical perspective model – figure 5. (2) Knowledge Interactive Supply Network Framework Model – figure 6, (3) E-Business Infrastructure and Capabilities Model – figure 8. (4) Knowledge-Based DS Architecture Model - figure 9 and (5) E-Business KM Architecture Model – figure 10. It is up to management to make the whole initiative work out successfully. Management needs to motivate end-user e.g.: doctors, nurses, experts and developers to work together in development, training, testing and

implementation of this system.

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