© Copyright Massey University 2008

Understanding Business Intelligence in the Context of Health Care

Tobias Mettler[1], Vivian Vimarlund[2]

[1]Institute of Information Management, University of St. Gallen, Müller-Friedberg-Strasse 8, CH-9000 St. Gallen, Switzerland, tobias.mettler@unisg.ch

[2]Department of Computer and Information Science, Linköping University, SE-581 83 Linköping, Sweden, vivvi@ida.liu.se

In today's fast changing health care sector, decision makers are facing a growing demand for both clinical and administrative information in order to comply with legal and customer-specific requirements. The use of Business Intelligence (BI) is seen as possible solution to this actual challenge. As the constituent research about BI is primarily focussed on the industrial sector, it is the aim of this contribution to translate and amend the current findings for the health care context. For this purpose, different definitions of BI are examined and condensed in a framework. Furthermore, the sector-specific preconditions to effectively use and the future role of BI are discussed.

Keywords

Business Intelligence in Health Care, Information Management, Information Technology, Performance Management

1. Introduction

The adoption of information and communication technology (ICT) in health care is currently seen as an opportunity to improve not only effectiveness, efficiency, and quality of health services but also the transparency of the economic activities and the availability of information in real time. Nevertheless the health care sector shows a relatively underdeveloped information system structure [1, 2]. Conversely most studies on Health Information Technology (HIT) discovered a significant relationship between the financial well-being, size, and productivity of a health care organisation and its level of ICT adoption [3]. For example Parente and Dunbar found that especially health care organisations with integrated information systems (IS) have higher total margins and operating margins than those hospitals that do not have them [4]. However, the causality between ICT investment and economic profitability could not be rigorously demonstrated yet. The question whether health care organisations with greater profits from operations and total assets can afford more sophisticated ICT investments or whether ICT itself has a positive effect on the hospital's performance is still unanswered.

Albeit the uncertainty about the business value of ICT investments, the health care organisations will be in need of acquiring expertise and technology for *business intelligence* (BI) in order to comply with new legal requirements of gathering systematic performance information (e.g. in the course of DRG introduction in Switzerland the hospital's are facing an advanced duty to supply information to national and local authorities). Also the increasing competition in the sector will foster the dissemination of a wide array of information including for example the provider's experience in treating particular diseases, availability of beds, pricing of health services etc. [5].

As BI is becoming increasingly relevant for the health care sector, it is the aim of this paper to provide an actual overview of the subject matter. We believe that a better understanding of the meaning and perspectives of BI could improve communication among the many individuals and organisations that use the term and possibly enhance its adoption. For this

reason, we examined a wide range of definitions of the term intelligence. As the great part of the literature about BI is focussed on industrial organisations, we consider it important to put the topic in context of health care, in order to generate a number of ideas about the preconditions to successfully apply BI in a health care organisation. Finally, we discuss the consequences for the future and give an outlook for continued research in the area.

2. Definitions of Business Intelligence

The term *intelligence* has its origins in the field of military science. «On one hand, it [intelligence] refers to an organisation collecting information and on the other to the information that has been gathered» [6]. In the ancient Roman Empire *strategic* intelligence was used for «[…] the analysis of everything that happens before the arrival at the battlefield and this would include any long-term information that would influence the conduct of a whole campaign […]» whereas *tactical* intelligence served for the preparation of «[…] short-term material influencing the choice of the battlefield […]» [7]. In the recent military literature the term intelligence is defined as «the official, secret collection and processing of information on foreign countries to aid in formulating and implementing foreign policy, and the conduct of covert activities abroad to facilitate the implementation of foreign policy» [8].

In information systems research the term *business intelligence* (system) appeared for the first time in the seminal work of Luhn [9]. He defined *business* as «[…] a collection of activities carried on for whatever purpose, be it science, technology, commerce, industry, law, government, defence, et cetera». In a broad sense the *intelligence system* is «the communication facility serving the conduct of a business» [9]. Today two distinct understandings of the term BI (respectively BI system) exist – a data-centric and a process-centric. The data-centric position use BI systems to combine «operational data with analytical tools to present complex and competitive information to planners and decision makers. The objective is to improve the timeliness and quality of inputs to the decision process» [10]. BI is therefore mainly used to *understand* the capabilities available in the firm [11]. The process-centric position notes a major shortcoming in this inherent data-centricity. Because the collection, transformation, and integration of data as well as information supply and analysis are commonly isolated from business process execution, a great part of the information that intrinsically exits within an organisation remains either unused or is at most partially used but deprived of its interpretation context [12]. As they see an organisation as a set of well-integrated processes [13], BI therefore should be used to integrate the information world with the process world in order to *facilitate* decision making with an all-embracing information basis.

3. A Framework for Health Care

As mentioned above, the great part of the constituent literature on BI is solely focussed on industrial organisations. When bringing BI in the context of health care, it is therefore important to analyse the differences and similarities compared to other sectors (cp. Table 1):

Table 1 Characteristics of health care and other sectors compared [14].

Differences	Similarities
• *Management* is unified in most sectors, but health care has clinical and administrative reporting.	• All sectors seek improvements in cost, quality and delay through integrated *processes*.
• Most sectors have a clear group of *customers* with typically a few product variants; health care involves a multiplicity of *actors* with distinct needs (e.g. patients, insurance companies, governmental authorities, doctors).	• Following the customer-centred success in other sectors, the *centre of attention* in health care should be primarily the patient but also the mentioned variety of other customer segments.
• Most industrial systems have hard *metrics*, in health care people's feelings and choices matter too.	• As in other sectors, health care will benefit from *system integration*.

© Copyright Massey University 2008

Thus, our understanding of *BI in health care* is that it should help (clinical as well as administrative) *management* in the understanding of the capabilities available in the firm (or the health network) and facilitate *clinical* as well as *administrative* decision making by *integrating* all kind of *hard* as well as *soft metrics* about a variety of internal and external *actors* resulting from a wide spectrum of *processes*.

However, before to introduce or use BI as the link for all internal and external processes and as the intelligence needed to reach affectivity and quality in service production it is necessary to carefully analyse the processes, the actors and information and technology in use (cp. Figure 1).

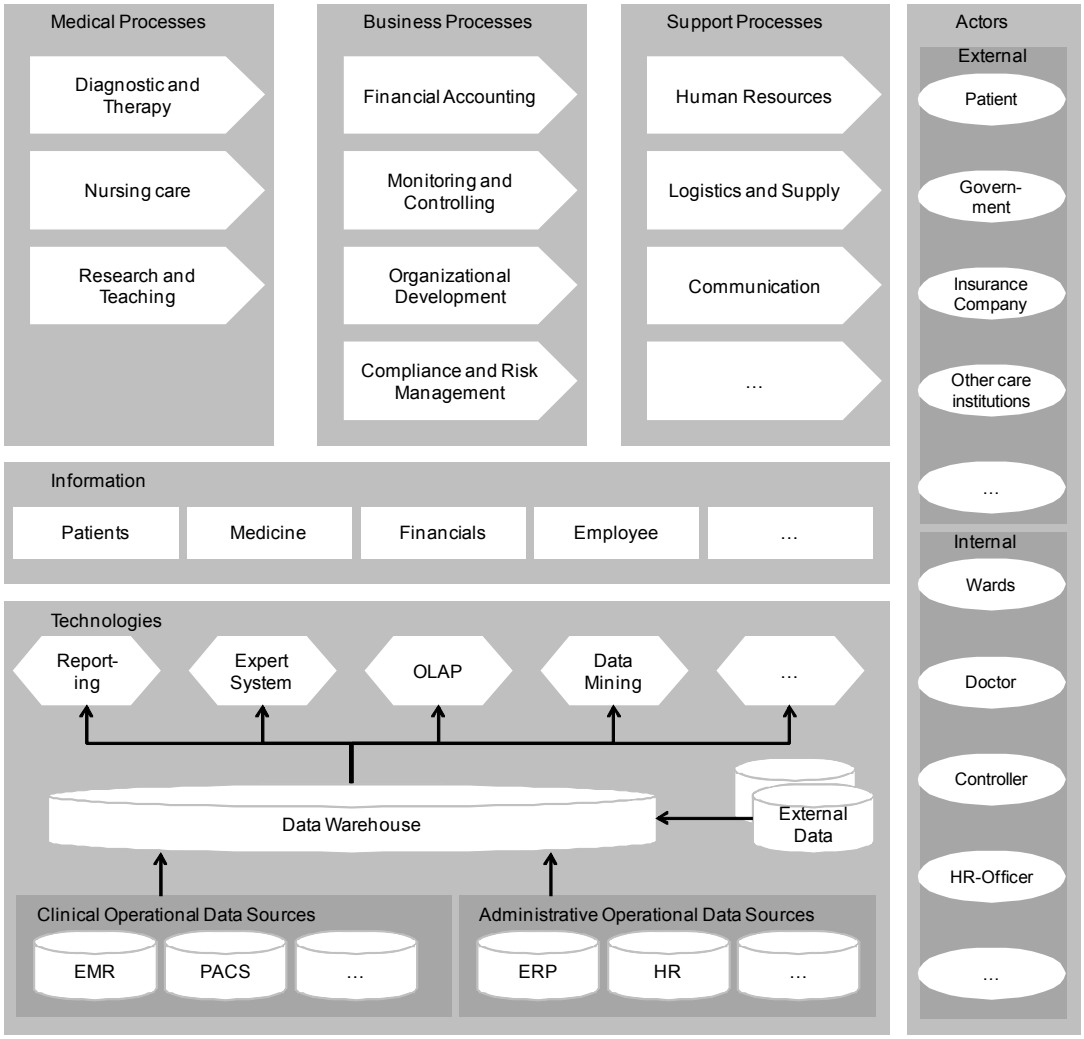

Figure 1 Framework for BI in Health Care.

3.1 Processes

Processes can be defined as sets of partially ordered and coordinated tasks [15, 16]. Health care organisations typically prescribe how their processes have to be performed; especially those processes that represent complex routine work, that involve many persons and organisational units and that are in general frequently performed [17]. In the context of BI, processes can be seen as primary *trigger* for information and data collection, processing and distribution and are therefore very important. A differentation in medical, business and support processes can be seen as logical aid. We define *medical processes* as those activities and work practices within a health care organisation which mainly are focussed on the *health services delivery* (e.g. nursing, medical treatment). On the other hand, *business processes*

comprise activities that are needed to effecively *run* the health care organisation and may not be, or only partially sector specific (e.g. financial accounting). Finally, support processes are used from both kind of processes but only have an indirect impact on medical and business activities (e.g. supply of materials). However, two important characteristics constitute the nature of all types of processes [18]:

- Processes have customers; that is, processes have defined outcomes, and respective recipients. Customers may be either internal or external actors to the health care organisation.
- Processes cross organisational boundaries; that is, they normally occur across or between organisational units, enterprises and sometimes even countries.

3.2 Actors

Within health care, there is a long-standing practice of including information and data beyond the traditional boundaries of a single organisation for the realisation of medical, business and support processes [19]. To provide optimal health services the requirements of both, *internal* and *external* actors must be recognised [1]. Internal actors normally represent the personnel of the health care organisation (e.g. doctors, controllers) to who personalized services and access to up-to-date information is given by the BI system. Whereas external actors correspond to those stakeholders who have a strong influence on the health care organisation (e.g. insurance companies, suppliers, governmental authorities, other health care organisations) but are only punctually incorporated in its processes and information flows. They sometimes have a restricted access to the BI system.

When developing and using a BI system, this heterogeneity of actors may cause problems, since the same information can be viewed differently by the diverse actors [20]. Therefore it is a crucial to involve as much actors as possible when designing or reappraising a BI system.

3.3 Information and Technology

In literature the distinction between information and data often is omitted. In the context of BI, however, it is very important to make this distinction. According to [21], information is the representation of facts, concepts, or instructions in a formalised manner suitable for communication, interpretation, or processing by humans or by automatic means. In contrast, data is only a subset containing exclusively machine-readable information. In a health care organisation three different types of data sources can be found:

- *Clinical data sources* include all kind of medical data (e.g. patient records, laboratory results) which is needed for health service delivery to the patients.
- *Administrative data sources* contain the entire business data (e.g. personnel data, financial data) which is required for running the health care organisation.
- And finally, *external data sources* which either can be clinical or business data from an external provider (e.g. statistical data, medical reports, insurance forms).

In the context of BI, technology can be seen as *enabler* for storing, analysing, visualising, and giving access to a great amount of data. For this purpose, a wide range of expert systems, OLAP and data mining tools are used coevally in a BI system. On the other hand, technology is required to provide an integrated view of both, internal and external data (for example by means of a data warehouse). It is therefore the base for BI.

Figure 2 clarifies again the relationships of processes, actors, information and technology for the BI context.

© Copyright Massey University 2008

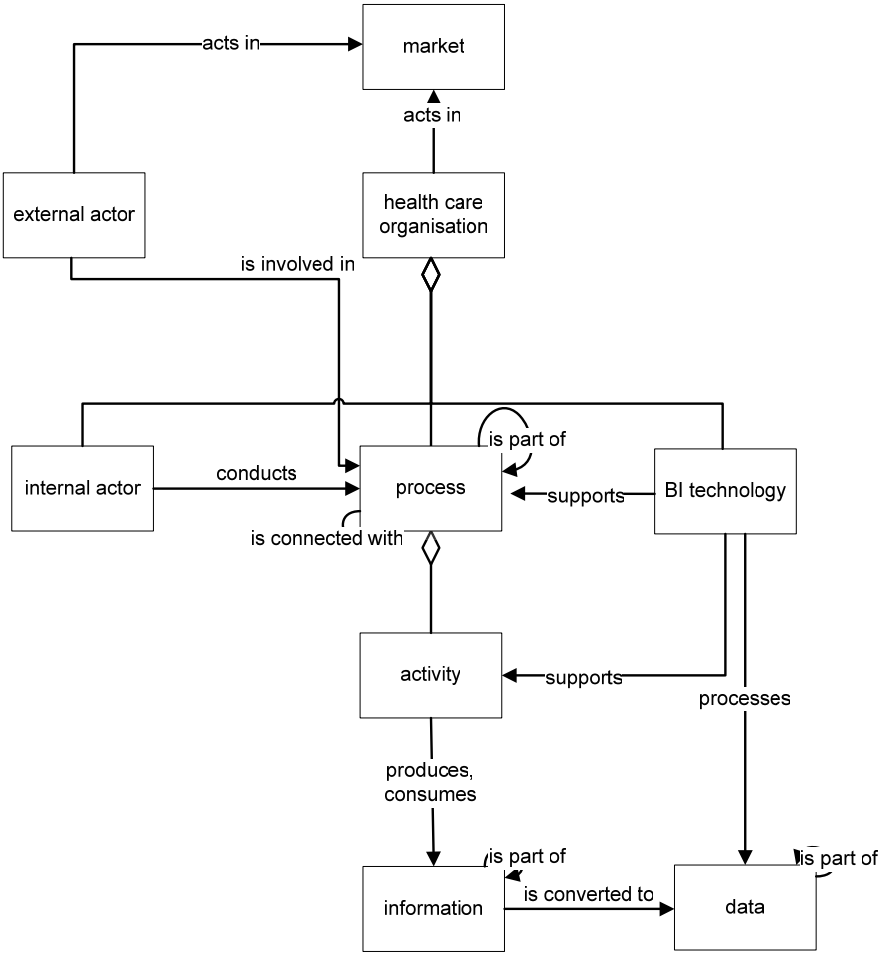

Figure 2 Meta-model of described framework based on [22].

4. Preconditions to Effective Use of BI

We learnt from the past that the introduction and use of ICT in healthcare organisations produce organisational changes in work and interaction routines. Several studies have shown that ICT is a source of concern and that an effective use of technology presupposes investments in organisational, technological and human capital. To effective use BI at an inter-organisational level it is therefore necessary to first establish clear and define ideas about the following issues:

4.1 Collaboration

It is evident that collaboration, both between different types of health care (hospitals and primary care) and between health care and social care, is an indispensable factor to use BI in an effective manner specially because the need of inter-organisational collaboration required produce effective health care services Long-term institutional arrangements and investments in technology and capacity are needed, and everyday works practices have to be developed that are compatible and include functioning interfaces with other actors. To do this involves a mixture of *planned economy* and *market* measures, all the time making sure that there are incentives for all important actors to collaborate. However, in addition to collaboration, it is necessary to have good knowledge about the organisations, to trust in each other, to have clearly established the institutions that will administrate the BI and to have an effective governance of the BI.

4.2 Knowledge

Collaboration requires competence beyond the skills needed for the actual work. In order to collaborate, you need to know about your partners: be aware of what they can do, and how you can help them in doing it; trust their skills, but also know how to call for their help. Several theories on collaboration and social networks in workplaces have emerged. One recent and interesting observation of work is that it is changing its orientation in terms of relationships, both business and social. Dynamic (re)organisations and increasing use of communication technology contributes to new styles of work. One increasingly important part of these new styles is the dynamic personal social networks by which much work is being carried out. Knowledge and responsibilities are distributed over socio-technical networks rather than formalized organisation charts. BI investments are mainly directed towards the knowledge component of collaboration. Access to up-to-date information, regardless of time and place, may allow us to break down barriers between different care providers, improve decisions about what actions are needed, and perform more of them in people's homes. Only when this happens will the potential benefits from BI be realized. However, to redesign processes is not easy [23]. New technology may enable both a more centralized system and a more decentralized one. In inter-organisational cooperation, however, other aspects of knowledge may be quite as important, like the beliefs we form about each other. Trust is one dimension of this. To develop trust between, say, politicians and citizens, their knowledge about each other may need to be analysed, and information exchanged that goes beyond their "rational" needs.

4.3 Trust

Trust is often mentioned as a key concept in collaboration. It is primarily a human and personal phenomenon, but has been used also to describe relations between organisations. Networks, *extended enterprises* and *virtual* or *imaginary* organisations attracted a lot of attention throughout the 1990s. Sako [24] distinguished between three types of trust, depending on the basis for our expectation that the other party will fulfil its promises: contracts, competence, and goodwill. Most long-lasting relationships between organisations involve elements of all three. Hedberg et al. [25] hold that a sense of shared destiny or mission may be essential to make partners use their creativity in developing the potential of their relationship. If trust is just a matter of calculated self-interest, we may get a sequence of shifting market transactions, not a long-term collaboration.

Most of the hopes for improved collaboration between specialists and primary care in health care require a long-term perspective, and a willingness to invest based on expectation that the collaboration will continue. It is rarely possible to specify in advance exactly how. According to Hedberg et al. [25] such investments do not necessarily require formal contracts or absolute certainty. Sometimes special arrangements such as co-owned joint ventures are formed; there may be cross-ownerships of shares etc. Sometimes the investment creates its own lock-in, more or less guaranteeing continued cooperation, as when business partners start building a joint database which is vital to the operations in each company.

Also in health care organisations, organisations – and their employees – need to trust that cooperation will continue. When a county council acquires a new communication tool it must expect that the region's health care institutions will use the same kind of technology long enough for its investment to pay off, and its end users must expect that the BI will be in use long enough to make it worthwhile to learn to use it. Similarly, personal collaboration across organisational boundaries requires time to develop, and stable social relations with your partner on the other side.

Trust in the long-term viability of collaboration can be built in different ways. Sometimes removing obstacles – reasons to doubt that the collaboration will endure – is quite as important as demonstrating long-term intents. It helps if some actor assumes leadership in bringing together the organisations that are to collaborate, and motivate key people in them to do so.

© Copyright Massey University 2008

4.4 Institutions

As we have seen, a partner may be trusted due to a contractual obligation, although trust usually is greater if we also feel s/he has the required knowledge and has good will. A contract is an example of institutions: formalized structures, for instance laws and regulations, which are set up in order to make a society work. Institutions have a complementary and sometimes compensatory relationship to knowledge and trust. Sometimes knowledge and trust may be sufficient for collaboration without any formalization, while a minimum of knowledge and trust seems necessary for anyone to enter into an institutionalised collaboration. Contracts remove some of the uncertainty about one's partners, while sometimes signalling a lack of goodwill-based trust. Networked communities may have various supports for contracts. Many times the 'contracts' of communities are vague and may even constitute the very opposite of a contract. Social structures in communities act as institutions by providing norms and rules that regulate behaviour both internally and externally, thus creating 'socializing policies'.

BI may themselves serve to institutionalise collaboration, through lock-in effects or the conviction that shared information will influence actions. The need to finance BI investments may trigger long-term agreements about partnership, and how future costs shall be divided. Conversely, existing relations between two organisations may determine their ability to work together. Not only may the financing of BI be at stake. It is often claimed that concomitant investments in training and reorganisation are several times larger than the cost of the actual systems, and these also need to be financed.

4.5 Governance

Governance refers to exercise of power, originally in government. The term has been used increasingly in recent years to refer to measures to safeguard appropriate controls also in corporations. In that context, *BI governance* has mostly referred to decision-making about information systems, and the information which owners and managers have access to as a result of these decisions. This determines, or at least has a heavy influence on, owners' and managers' knowledge about what goes on in their corporation. In many countries, they have a legal responsibility to procure adequate information about business events, something which was demonstrated in a dramatic way in cases like Enron or Worldcom. Similar duties exist in the health care sector.

When BI enables new ways of working, for instance decentralisation and more local decision-making, it also creates new needs for governance. This is particularly true when separate firms or health care sector units collaborate, because they may act on behalf of each other, or the outcomes may be coproduced by actions from several of them. The (legitimate) need to maintain control may halt desirable developments towards more flexible work arrangements.

Developed societies provide frameworks for governance in the form of ready-made institutions. Sometimes these are alternatives to choose from, like the type of corporation that a small business decides to operate as; sometimes they are legally binding. However, in terms of networked health care communities governance is also a tricky topic. Simplified, there's the communitarian view – arguing that resolute community (or other administration) values should govern conduct online – or the libertarian view – which means that individual behaviour and objectives should emerge into norms.

In practice, knowledge, trust and institutions will interact to create the actual governance structure. BI governance will involve rules about who decides what (cf. [26]). Systems will impact knowledge, but work also gives managers and health care givers informal knowledge which influences what information they ask for through formal systems. In designing responsibilities, a high level of trust will mean that less information or institutionalised rules will be required.

5. Consequences for the future

In other industries it now seems rather commonplace to regard BI as an important driver, or at least a trigger, for understanding organisational outputs and to measure them in real time in

order to make changes and improvements. To make responsible decisions about the use of scarce resources of health care it is necessary to identify sources of efficiency or tools that can contribute to improve outcomes. In the health sector, managers and users need real time information to better managing data and to generate information and knowledge needed to improve health care services quality and diminish risks. However, healthcare-specific analytical capabilities have been built until today into other core operational applications as well as embedded in medical equipment and devices. Seldom have they been successfully put forth as stand-alone intelligence applications. For example, significant intelligence is built into CPOE (computerized provider order entry) systems, CDS (clinical decision support) applications, telemedicine devices (e.g., remote vitals sensing appliances) and handheld computing tablets seen everywhere in hospitals, clinics and health care centres. While the central function of these technologies is not analysis, they all employ analysis to make them more valuable.

The future of healthcare business intelligence will play out at the intersection of issues in business and policy, and the use of emerging analytical capabilities to create applications to meet these challenges. Providing real time information would seem to be crucial for this. A pragmatic conclusion therefore is that in the near future BI should be brought into closer contact with the health system if managers will to effective support evidence-based practice, data management and to understand the correlations among them. Quality and safety can only be measured and improved when outcomes are measured, when variation in local or regional differences is eliminated and when multidisciplinary teams sing from the same song sheet. BI's value for health care will therefore not primarily be in simplifying communication and information provision. Rather, its contribution is in *enabling* new ways of working, allowing to integrating information, organizations and to measure outputs in real time.

However, to understand the future direction of BI in health care needs to look three important issues, namely a) Today's pressing healthcare business and healthcare policy issues, b) Emerging trends in business intelligence capabilities, and c) Potential healthcare analytical applications that are currently being overlooked and in parallel with this the use of use of emerging analytical capabilities to create applications to meet these challenges specially in areas such as:

- **Patient Service and Satisfaction Measurement.** Including patient experience, engagement, delight, loyalty and relationship measurement, as well as the most important of all – measuring and tracking the voice of the patient.

- **Healthcare Marketing Management.** Measuring and developing the growing importance of healthcare branding, reputation and trust management, patient/customer segmentation, patient profitability and patient lifetime value.

- **Healthcare Financial Strength.** Revenue optimization, productivity improvement, streamlining claims processing, waste and cost control, activity-based costing.

- **Healthcare Operations Analysis.** Partner management and measurement, collaboration opportunities, agility improvement, working capital and asset management.

- **Healthcare People Development.** Provider experience measurement, provider loyalty and the voice of the provider analysis, learning and growth measures, innovation, knowledge, culture and intangible value analytics.

References

[1] O'Riain C, Helfert M. Analysis healthcare information system strategies in Europe. UKAIS 2005 - 10th Annual Conference; 2005: Newcastle: UK Academy for Information Systems; 2005.

[2] Parente S T. Beyond the hype: A taxonomy of e-health business models. Health Affairs 2000; 19 (6): 89-102.

© Copyright Massey University 2008

[3] Fonkych K, Taylor R. The state and pattern of health information technology adoption. Santa Monica, CA: RAND Corporation; 2005.

[4] Parente S T, Dunbar J L. Is health information technology investment related to the financial performance of US hospitals? An exploratory analysis. International Journal of Healthcare Technology and Management 2001; 3 (1): 48-58.

[5] Porter M E, Olmsted Teisberg E. Redefining competition in health care. Harvard Business Review 2004; 82 (6): 64-76.

[6] Laqueur W Z. A world of secrets: The uses and limits of intelligence. New York: Basic Books; 1985.

[7] Austin N J E, Rankov N B. Exploratio: Military & political intelligence in the roman world from the second punic war to the battle of Adrianople. London: Routledge; 1995.

[8] Random R A. Intelligence as a science. Studies in Intelligence 1958; 2 (2): 75-9.

[9] Luhn H P. A business intelligence system. IBM Journal of Research and Development 1958; 2 (4): 314-9.

[10] Negash S. Business intelligence. Communications of the Association for Information Systems 2004; 13: 177-95.

[11] Gluchowski P. Business Intelligence - Konzepte, Technologien und Einsatzbereiche. HMD - Praxis der Wirtschaftsinformatik 2001; 222: 5-15 (in German).

[12] Bucher T, Dinter B. Process orientation of information logistics - An empirical analysis to assess benefits, design factors, and realization approaches. 41th Annual Hawaii International Conference on System Sciences (HICSS-41); 2008: Waikoloa, Big Island, Hawaii: IEEE Computer Society; 2008.

[13] Hammer M, Champy J. Reengineering the corporation - A manifest for business revolution. New York: Harper Collins Publishers; 1993.

[14] Avison D E, Young T. Time to rethink health care and ICT? Communications of the Association for Computing Machinery 2007; 50 (6): 69-74.

[15] Curtis B, Kellner M I, Over J. Process modeling. Communications of the ACM 1992; 35 (9): 75-90.

[16] Leymann F, Altenhuber W. Managing business processes as an information resource. IBM Systems Journal 1994; 33 (2): 326-48.

[17] Vassilacopoulos G, Paraskevopoulou E. A process model basis for evolving hospital information systems. Journal of Medical Systems 1997; 21 (3): 141-53.

[18] Davenport T H, Short J E. The new industrial engineering - Information technology and business process redesign. Sloan Management Review 1990; 31 (4): 11-27.

[19] Scott W R. Organizations - Rational, natural, and open systems. 5 ed. Upper Saddle River: Prentice Hall; 2002.

[20] Checkland P. Soft systems methodology in action. Chichester: John Wiley & Sons; 1999.

[21] Bode J. Der Informationsbegriff in der Betriebswirtschaftslehre. Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung 1997; 49 (5): 449-68 (in German).

[22] Mettler T, Rohner P, Baacke L. Improving Data Quality in Health Information Systems - A Holistic Design-oriented Approach. European Conference on Information Systems; 2008: Galway: 2008.

[23] Olve N G, Vimarlund V. Locating ICT's benefits in elderly care. Medical Informatics and the Internet in Medicine 2005; 30 (4): 297-308.

[24] Sako, M. Prices, quality and trust. Inter-firm relations in Britain and Japan. Cambridge University Press: Cambridge; 1992.

[25] Hedberg B, Dahlgren G, Hansson J, Olve N G. Virtual organisations and beyond: Discover imaginary systems. Chichester: John Wiley & Sons; 1997.

[26] Weill P, Ross J. IT governance: How top performers manage IT decision rights for superior results. Boston: HBS Press; 2004.