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IMPROVING DATA QUALITY OF HEALTH INFORMATION SYSTEMS – A HOLISTIC DESIGN-ORIENTED APPROACH

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Abstract

Structural changes and increasing market dynamics in the healthcare sector intensify the health providers' need for cost-savings and process optimisation. To address actual drawbacks the adoption of eHealth is currently seen as opportunity to improve not only effectiveness and efficiency but also quality of health services. Data quality aspects will therefore gain in importance. As the actual use of the data is outside of the systems designers' control and in contrast to empirical- and practitioner-based research approaches it is the goal of this contribution to present a first design-oriented approach that helps systems designers to understand the reality of the different stakeholders of healthcare. For this purpose a conceptual model with 44 design elements is presented. For the analysis of the domain two different perspectives are identified. An inter-organisational view defines all elements needed to depict the boundaries of healthcare organisations in order to enable exchange, sharing and integration of data, while the intra-organisational view helps to analyse the inner organisational reality. As not only technical but mainly inter- and intra-organisational issues are actually restricting data exchange, the proposed conceptual model provides a holistic framework for the improvement of data quality which is the prerequisite of high quality health services.

Keywords: eHealth, Health Information Systems, Data Quality in Healthcare, Business Engineering in Healthcare.

1 INTRODUCTION

In basically all industrialized countries the healthcare sector has registered unsatisfactory performance in both costs and quality over many years (Porter & Olmsted Teisberg 2004). The fact that healthcare differs in structure from most other industries is attributable to the high level of regulation, the high proportion of governmental investment, the associated low pressure in respect of effectiveness and efficiency of state-subsidised health providers and the lack of orientation towards patient benefits (Mettler et al. 2007). As a consequence of that, the healthcare sector shows a relatively underdeveloped information system structure (Herzlinger 2006, O'Riain & Helfert 2005, Parente 2000).

Nevertheless, since the emergence of *eHealth* many efforts have been made to eliminate the actual drawbacks. Thus, the adoption of information and communication technology in healthcare is currently seen as opportunity to improve not only effectiveness and efficiency but also quality of health services. As stated by the World Health Organization (2005) cost-savings are expected by reducing redundancy and duplication of examinations and enabling economies of scale. As data quality currently suffers from a fragmented patient process with a high number of heterogeneous health information systems (HIS), the improvement of the actual situation is not an easy task. In the United States, approximately 98.000 people die because of medical malpractice during hospitalisation (Institute of Medicine 2000). Studies in England and Australia revealed that between 12% and 16% of all inpatients are exposed to an "adverse event" (Stoellger 2005). Poor data quality is believed to be one of the origins for this condition. Thus, focussing on data quality will certainly gain in importance when implementing eHealth.

Due to the fact that the term and concept of eHealth is quite new there is, however, a significant variability in the scope and focus of existing definitions. "In terms of its functional scope, most definitions conceptualize eHealth as a broad range of medical informatics applications for facilitating the management and delivery of healthcare. Purported applications include dissemination of health-related information, storage and exchange of clinical data, inter-professional communication, computer-based support, patient-provider interaction and service delivery, education, health service management, health communities, and telemedicine, among others" (Pagliari et al. 2005).

In the majority of cases eHealth-projects not only focus on the advancement of a single healthcare organisation but on the improvement of parts or complete healthcare networks composed of a multiplicity of different stakeholders such as customers, governmental authorities, suppliers and sometimes even competitors. This makes high demands on the development of HIS. As the quality of data generated by such information systems first and foremost depends on its design, it is crucial for system designers to understand the perceived reality of the different stakeholders in healthcare in order to be able to address all information consumers' needs (O'Riain and Helfert 2005).

For this purpose, the conceptual foundations of data quality are first discussed in section 2. Section 3 and 4 provide an overview of the used research methodology, and the results gained from the construction process. Finally in the fifth section, an outlook for continued research in the area is given.

2 DEFINING DATA QUALITY IN HEALTHCARE

The term *data quality*, as presented in the constituent IS-literature, is mostly characterised as a multidimensional conception for the properties and conditions of data (Abate et al. 1998, Fox et al. 1994, Huh et al. 1990, Redman 1996, Wand & Wang 1996). Though, there is no general agreement how the dimensions of data quality are defined (Wang et al. 1995). As stated by Price & Shanks (2005) four different research approaches for defining quality criteria are employed: empirical, practitioner, theoretical, or literature-based. Empirical research approaches such as that by Kahn et al.

(2002) or Wang & Strong (1996) rely on information consumer feedback to derive quality criteria and then classify them into categories. Practitioner-based approaches such as that by English (1999) are focussed on ad-hoc observations and (subjective) industry experiences and are therefore in some extent criticised for their lack of rigor (Price & Shanks 2005). On the other hand, theoretical approaches originating e.g. from information economics or communication theory are criticised because of being deficient in relevance. Finally, literature-based approaches use literature review and analysis for deriving data quality criteria. There is, however, a fifth approach. As the actual use of the data is outside of the designer's control, it is crucial to provide a design-oriented definition of data quality that reflects the intended use of the information (Wand & Wang 1996). Thus, in contrast to the other approaches a design-oriented advancement will provide actual guidance to systems designers by helping them to understand the perceived reality of the different stakeholders of the system (Wang et al. 1993), and to identify data deficiencies by mapping the information system state against the real world state (Leitheiser 2001).

As in healthcare the perceptions of the various actors are extremely important to the success of any change effort (Walston & Chadwick 2003), and the boundaries of the organisation where data quality is assessed are hard to define (Lorence & Jameson 2002), the authors believe that a design-oriented approach is required to ensure both relevance and scope. Reviewing the actual literature in the area shows that little has been published so far (cf. Table 1). [1] Therefore it is the aim of this paper to provide a design-oriented artefact in form of a conceptual model for helping systems designers of HIS to comprehend the complex relations and interdependencies between the elements that need to be (re-) engineered both technically and organisationally, in order to improve data quality of healthcare organisations.

	Approach / **Contribution**	**Practicioner-based approach**	**Empirical approach**	**Theoretical approach**	**Design-oriented approach**
With healthcare focus	(Agarwal 2006)	✓			
	(AHIMA 1998)	✓			
	(Alshawi et al. 2003)	✓			
	(Colin et al. 1994)		✓		
	(Davidson et. al 2004)	✓			
	(Gendron & D'Onofrio 2000)		✓		
	(Kelley & Hurst 2006)	✓	✓		
	(Leitheiser 2001)		✓		
With IS focus only	(Ballou & Panzer 1985)	✓			
	(English 1999)	✓			
	(Kahn et al. 2002)		✓		
	(Price & Shanks 2005)			✓	
	(Redman 1997)	✓			
	(Wand & Wang 1996)			✓	✓
	(Wang & Strong 1996)		✓		

Table 1 Research approaches used for deriving data quality criteria of IS.

[1] Since the literature-based approach to quality is generally not used alone but rather as support for one of the other approaches, only the four relevant approaches are shown in the subsequent table.

3 DESIGN-ORIENTED RESEARCH APPROACH

While natural sciences try to explain and predict behavioural aspects of the reality (e.g. of people or organisations) by developing and verifying theories (March & Smith 1995), design-oriented research aims the building and evaluation of innovative artefacts, in order to extend existing capability limitations (Hevner et al. 2004). Artefacts represent the actual results of a design process. They can be characterised as constructs, models, methods or implementations (March & Smith 1995). As the design process is usually initiated by a "need and require intention" (Purao 2002), design science is considered a problem-oriented approach. Depending on the problem area, requirements to the artefact can be specified which influence the construction process and the result itself. In order to ensure the quality of the new artefact, the production process consists of the two iterative steps: *build* – describing the actual construction of the artefact in a transparent and traceable way, and *evaluate* – consisting of activities to prove innovativeness and ability to solve the addressed problem (March & Smith 1995). In this paper the authors focus on the discussion of the construction process (build) and the resulting artefact, keeping in mind that further evaluation activities have to be conducted.

Starting point for the construction of the proposed conceptual model is the so called "Core-Business-Metamodell" presented in Österle et al. (2007) which is considered a general and industry-independent approach to structure the (re-) engineering of businesses on a meta-level. The underlying understanding of business engineering consists of models and methods which enable change processes by combining knowledge e.g. from business studies, change management or systems engineering (Österle & Winter 2003). In contrast to concepts that solely focus on technical, cultural, behavioural, strategic or organisational aspects (e.g. Brunsson & Olsen 1993, Champy 1995, Kotter 1997 or Müller-Stewens & Lechner 2005), business engineering extends those limitations and provides a holistic as well as detailed framework to integrate the various perspectives and activities of analysing, (re-) designing and implementing structural changes in organisations.

As the problem of poor data quality in healthcare is strongly influenced by organisational, behavioural and strategic issues, the business engineering framework provides a comprehensive foundation to address all relevant aspects within the constructed conceptual model. This model representing the designed artefact is based upon the Unified Modelling Language (UML) class diagram concepts (cp. Jacobson et al. 1999) and describes the types of objects in the system and the various kinds of relationships that exist among them. Rectangles build the main building-blocks of the model representing (tangible and intangible) things and persons. A line with a solid arrow head depicts an association relationship between two objects (e.g. uses, conducts), an outline arrow depicts a specialisation relationship (e.g. is-a, has properties-of), a line with a rhombus depicts an aggregation relationship (is-part-of).

4 CONCEPTUAL MODEL OF THE HEALTHCARE DOMAIN

Within healthcare, there is a long-standing practice of including data beyond the traditional boundaries of the organisation (Scott 2002). Furthermore, in order to provide optimal health services the requirements of both, internal and external information consumers must be recognized (O'Riain & Helfert 2005). For systems designers of HIS it is therefore important not only to understand the internals of the own organisation but also the environment in which the organisation is acting. Hence, the authors differentiate two perspectives for analysis: an inter-organisational and an intra-organisational-view (cf. Figure 1). The intra-organisational view provides a set of elements, and the describable relationships among them, which are needed to explain the own organisational reality. On the other hand, the inter-organisational view contains all elements needed to depict the boundaries of the organisation.

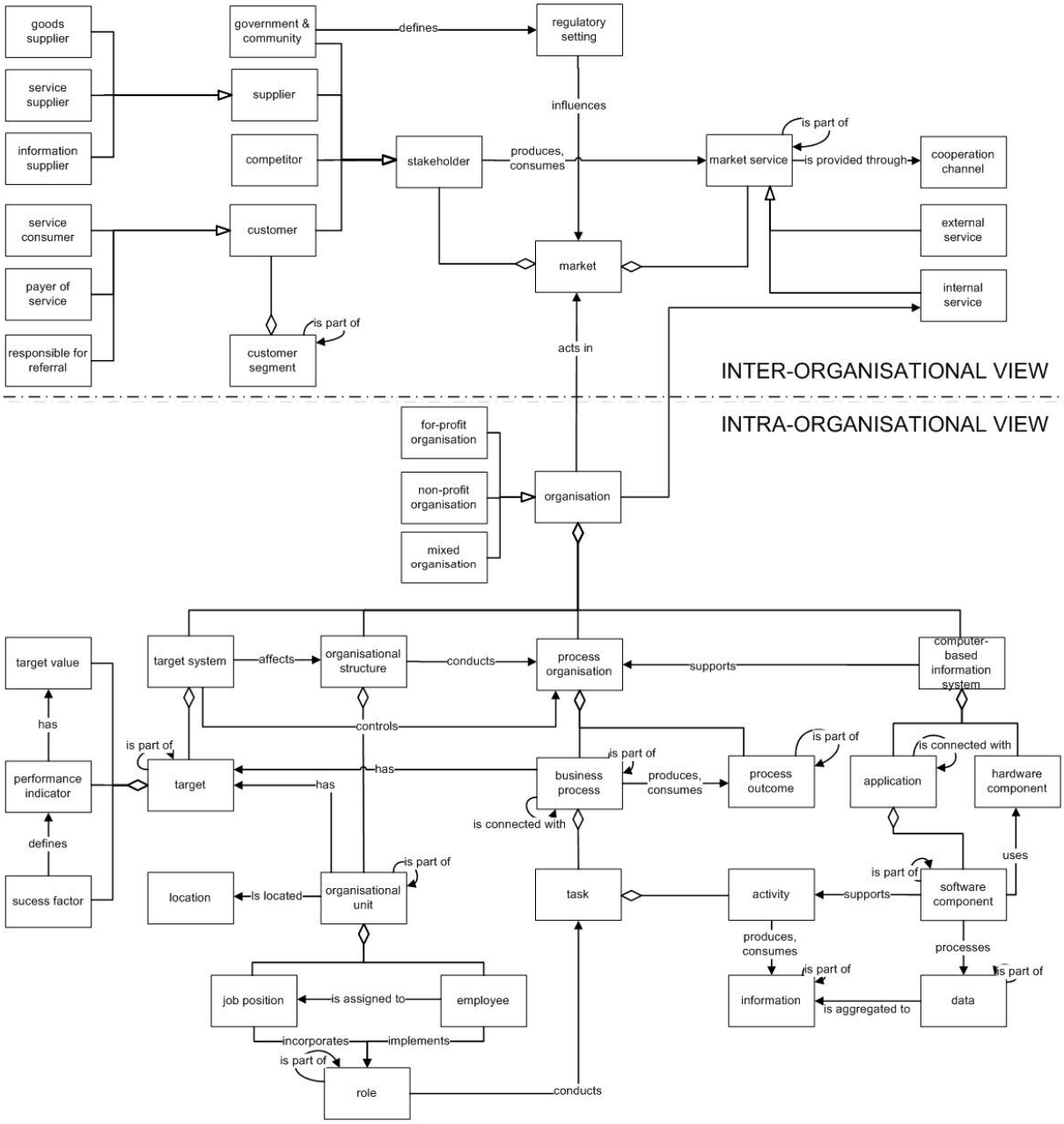

Figure 1 Conceptual model of the healthcare domain on the basis of (Österle et al. 2007)

4.1 Inter-organisational view: Defining boundaries

In healthcare an organisation is engaged in utilising resources in order to create health outcome and other benefits for its multiple constituents. Thus, for delineating the inter-organisational context, stakeholder theory is applied which is based on the obvious fact that the activity of an organisation involves the collaboration, both voluntary and involuntary, active and passive, of numerous and diverse constituents (Post et al. 2002).

Following this understanding, the healthcare market is formed by multiple stakeholders who offer and/or consume different kinds of market services. These services can be composed of internal and external service components and normally are provided through a specific cooperation channel, e.g. physically by a general practitioner, electronically on a health information portal.

The proposed model distinguishes four different types of stakeholders: customers, competitors, suppliers and government/community (cf. Table 2). In healthcare, the same people and organisations often act in many different roles at the same time which can very often change over time (Silverstone 2001). For instance, a general practitioner may be the responsible for a referral (e.g. referral of a patient to a specialised hospital for surgery), the service consumer (e.g. receiving further education at a university hospital), and the payer all at the same time. All these different players of the healthcare sector by definition have multiple goals and priorities. Frequently, these priorities may conflict (Walston & Chadwick 2003). As the same situation can be viewed differently by the different actors (Checkland 1999), it is important to include all their considerations when designing the system. As the focus of the inter-organisational view is on depiction of the interdependencies from a network perception (i.e. the network in which a healthcare organisation is involved), employees are not considered as stakeholders in this perspective. But they play a major role when considering the intra-organisational reality.

Special attention also has to be paid to the regulatory setting of the healthcare market. It is crucial for systems designers to understand the extensive network of regulations that may affect the design and how and by whom those rules are enacted, modified, and applied (Herzlinger 2006).

A good way for simplifying the complex relationships of the inter-organisational context is by extending the model with further helping elements. For example customers with more or less the same needs and interests can be resumed to a costumer segment. This is, however, also possible for the other types of stakeholders.

Type	**Sub-type**	**Entity**	**Interests**
customer	service consumer	patient, general practitioner…	fast convalescence...
	payer of service	patient, insurance company…	low costs…
	responsible for referral	general practitioner, medical specialist…	integration in treatment…
competitor	-	general practitioner, other hospitals…	reputation…
supplier	supplier of goods	pharmaceutical company…	sell products…
	supplier of services	laboratory, medical specialist…	sell services….
	supplier of information	general practitioner, web portals…	integration in treatment…
government & community	-	ministry of health, patient interest group…	increase quality…

Table 2 Example of a grid pattern for stakeholder analysis

4.2 Intra-organisational view: Understanding internal needs

As the "Core-Business-Metamodell" of Österle et al. (2007) is an industry-independent approach to depict reality, the differentiation of organisation types is a key extension of the presented conceptual model. According to Gendron & D'Onofrio (2000) the healthcare sector consists of three different organisation types: for-profit organisations (e.g. pharmaceutical corporation), mixed organisations (e.g. health maintenance organisation), and non-profit organisations (e.g. public hospital). "While each of the three types participates in the delivery of healthcare services, each is somewhat unique in its orientation" (Gendron & D'Onofrio 2000). Hence, the different types of organisations have dissimilar target systems (cf. Table 3). Based on the work of Kaplan & Norton (1992) a target system of an organisation consists of multiple targets or goals for which success factors can be derived, and which in turn can be measured by performance indicators. For every performance indicator an explicit target value is defined.

Zelman et al. (2003) argued that although health care organisations have faced many of the same implementation issues as organisations in other industries, healthcare organisations also have had to meet some unique challenges in adapting the balanced scorecard approach. For example, "medical staff relations and quality of care are important attributes of hospital performance that can be difficult to measure, interpret, and compare" (Zelman et al. 2003). A clear definition of the target system is therefore one key for success.

Type	**Entity**	**Targets**	**Target systems**
for-profit organisation	pharmaceutical company, private hospital, general practitioner…	produce corporate intelligence and goods for individual consumers	e.g. Consortium Research Indicators of System Performance CRISP (Bergman 1994)
mixed organisation	health maintenance organisation, nursing home…	produce private goods for individual consumers and government programs	e.g. Health plan Employer Data and Information Set HEDIS (Kenkel 1996)
non-profit organisation	university hospital, public health agency…	produce intellectual property and public goods	e.g. patient care reports (Lowe & Baker 1997)

Table 3 Example of a grid pattern for analysis of target systems on the basis of (Gendron & D'Onofrio 2000)

In most cases the target system exerts an influence on the organisational structure of a healthcare organisation. The organisational structure itself consists of organisational units (e.g. departments, clinics, centres), employees with defined job positions (e.g. surgeon, nursing auxiliary, administration) and roles (e.g. surgical first assistant, anaesthesia assistant, radiation therapist) performing specific tasks at different locations (e.g. in-house, off site). These tasks normally can be consolidated to business processes.

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 (Vassilacopoulos & Paraskevopoulou 1997). Business processes can be defined as sets of partially ordered and coordinated tasks (and thereof deduced atomic activities or functions), often cutting across functional boundaries within organisations, by which organisations accomplish their targets (Curtis et al. 1992, Leymann & Altenhuber 1994). The total of all business processes builds the process organisation.

Davenport & Short (1990) define two important characteristics of business processes:

- Business processes have customers; that is, processes have defined (process) outcomes, and there are recipients of these outcomes. Customers may be either internal or external to the organisation.
- Business processes cross organisational boundaries; that is, they normally occur across or between organisational units. Processes are generally independent of formal organisational structure.

An increasing number of processes within and between organisations are supported by computer-based information systems (Riempp & Gieffers-Ankel 2007). Computer-based information systems consist of hard- and software components, using data and procedures to process and disseminate information (Laudon and Laudon 2002). Software components which in total aim at supporting a specific part of a business are called applications. Typical applications in healthcare include business software, medical software, and educational software.[2]

5 CONCLUSIONS AND OUTLOOK

In the recent past, most efforts to improve information and data quality in healthcare are made on a rather technical perspective focussing on the standardisation of the exchanged data of applications (e.g. Health Level 7, DICOM, ICD-10). In healthcare there is, however, a demand for person-to-person interaction for collaborative diagnosis, treatment assessment, planning, and decision making (Avison & Young 2007). Therefore a much higher integration between strategy, processes (especially those which cannot be automated), and the supporting information systems of the different actors is needed.

In this contribution it was argued that in order to improve data quality in healthcare a holistic, design-oriented approach is needed. While empirical- and practitioner-based approaches only provide ex post support for deriving quality criteria of information systems, the proposed design-oriented approach gives actual guidance to systems designers by helping them to understand the perceived reality of the different stakeholders of the healthcare sector. The proposed model certainly also can be used as a basis for comprehensively document not only the actual but also the as-is situation. On this foundation, potential weaknesses within and between organisations can be identified. The successional prioritisation of deficiencies provides further potential starting points for innovations and helps to structure complex transformation projects.

However, the approach taken in describing and analysing the healthcare domain depends critically on how and to whom the related questions are being asked. To facilitate the analysis two distinct views are differentiated. Whereas the inter-organisational view contains all elements needed to depict the boundaries of a healthcare organisation, the focus of the intra-organisational perspective is rather on the inner organisational reality. Based upon the work of Österle et al. (2007) a total of 44 design elements were identified to depict both, the inter- and intra-organisational view.

As the conceptual model presented in this paper is still research in progress, future work should be directed at empirically validating the proposed elements and their dependencies. Furthermore, it is certainly helpful to extend the presented insights with other fundamental research such as formal ontologies or systems theory. According to the design-science research guidelines proposed by Hevner et al. (2004) the following activities should be undertaken in the further research (cf. Table 4).

[2] For a systematic overview of medical and health specific applications see (van Bemmel & Musen 1997 or World Health Organization 2006).

Guideline	Proposition of actions
1. Research as an artefact	-
2. Problem relevance	Conduct workshops with selected healthcare professionals in order to investigate the comprehensibility and benefits of the proposed artefact.
3. Design evaluation	Survey a sufficiently large number of healthcare organisations (e.g. insurance companies, hospitals, pharmaceutical companies) with a view to testing the proposed conceptual model regarding to validity, completeness and consistency.
4. Research contributions	Develop feasible methods and tools to help systems designers to adopt the model.
5. Research rigor	Refine the proposed conceptual model based upon a sound theoretical basis.
6. Design as a search process	-
7. Communication of research	Present further insights to health-, management-, and technology-oriented audiences.

Table 4 Proposition of further research activities

To enable developers to use the proposed model, they need advice how the 44 design elements and their relations influence the design of HIS and how the conceptual model can be instantiated for their individual purposes. This is another crucial task for further research in that field, in order to achieve acceptance in practice.

References

Abate, M., Diegert, K. and Allen, H. (1998). A hierarchical approach to improving data quality. Data Quality Journal, 4 (1), 365-369.

Agarwal, S. (2006). Cleaner data, better business. Materials Management in Health Care, 15 (7), 40-44.

Alshawi, S., Missi, F. and Eldabi, T. (2003). Health care information management: The integration of patients' data. Logistics Information, 16 (3/4), 286-295.

American Health Information Management Association (1998). Practice brief: Data quality management model. Journal of AHIMA, 69, (6), 2-7.

Avison, D. and Young, T. (2007). Time to rethink health care and ICT? Communications of the ACM, 50 (6), 69-74.

Ballou, D.P. and Panzer, H.L. (1985). Modelling data and process quality in multi-input multi-output information systems. Management Science, 31 (2), 150-162.

Bergman, R. (1994). Are my outcomes better than yours? Hospitals & Health Networks, 68 (15), 113-116.

Brunsson, N. and Olsen, J. (1993). The reforming organization. Routledge, London.

Champy, J. (1995). Reengineering management: The mandate for new leadership. HarperCollins, London.

Checkland, P. (1999). Soft systems methodology in action. John Wiley and Sons, Chichester.

Colin, C., Ecochard, R. Delahayes, F., Landrivon, G., Messy, P., Morgon, E. and Matillon, Y. (1994). Data quality in a DRG-based information system. International Journal for Quality in Health Care, 6 (3), 275-280.

Curtis, B., Kellner, M.I. and Over, J. (1992). Process Modeling. Communications of the ACM, 35 (9), 75-90.

Davenport, T. and Short, J. (1990). The new industrial engineering - Information technology and business process redesign. Sloan Management Review, 31 (4), 11-27.
Davidson, B., Lee, Y.W. and Wang, R.Y. (2004). Developing data production maps: meeting patient discharge data submission requirements. International Journal of Healthcare Technology and Management, 6 (2), 223-240.
English, L.P. (1999). Improving data warehouse and business information quality. John Wiley & Sons, New York.
Fox, C., Levitin, A. and Redman, T. (1994). The notion of data and its quality dimensions. Information Processing and Management, 30 (1), 9-19.
Gendron, M. and D'Onofrio, M. (2000). An exploratory study investigating data quality in the healthcare industry: what are the implications for data warehousing? In: Proceedings of the Americas conference on information systems, Long Beach, USA.
Herzlinger, R.E. (2006). Why innovation in health care is so hard. Harvard Business Review, 84(5), 58-66.
Hevner, A.R., March, S.T., Park, J. and Ram, S. (2004). Design science in information system research. MIS Quarterly, 28 (1), 75-101.
Huh, Y.U., Keller, F.R., Redman, T.C. and Watkins A.R. (1990). Data quality. Information and Software Technology, 32 (8), 559-565.
Institute of Medicine (2000). To err is human: Building a safer health system. National Academy Press, Washington.
Jacobson, I., Booch, G. and Rumbaugh, J. (1999). The unified software development process. Addison-Wesley, Boston.
Kahn, B., Strong, D. and Wang, R.Y. (2002). Information quality benchmarks: Product and service performance. Communications of the ACM, 45 (4), 184-192.
Kaplan, R. and Norton, D. (1992). The balanced scorecard: Measures that drive performance. Harvard Business Review, 70 (1), 71-79.
Kelley, E. and Hurst, J. (2006). Health care quality indicators project: Conceptual framework paper, http://www.oecd.org/dataoecd/1/36/36262363.pdf, last accessed: 20.11.2007.
Kenkel, P. (1996). The new HEDIS: boon or burden? Health Systems Review, 29 (6), 17-19.
Kotter, J.P. (1997). Chaos, Wandel, Führung. ECON, Düsseldorf.
Laudon, K.C. and Laudon, J.P. (2002). Management information systems: Managing the digital firm. Prentice Hall, New Jersey.
Leitheiser, R.L. (2001). Data quality in healthcare data warehouse environments. In: Proceedings of the 34th Hawaii International Conference on Systems Science, Hawaii, USA.
Leymann, F. and Altenhuber, W. (1994). Managing business processes as an information resource. IBM Systems Journal, 33 (2), 326-348.
Lorence, D.P. and Jameson, R. (2002). Adoption of information quality management practices in US healthcare organizations: A national assessment. International Journal of Quality and Reliability Management, 19 (6), 737-756.
Lowe, A. and Baker, J.K. (1997). Measuring outcomes. Nursing Management, 28 (11), 38-41.
March, S.T. and Smith, G.G. (1995). Design and natural science research on information technology. Decision Support Systems, 15 (4), 251-266.
Mettler, T., Rohner, P. and Winter, R. (2007). Factors influencing networkability in the health care sector - Derivation and empirical validation. In: Proceedings of the 12th International Symposium on Health Information Management Research – ISHIMR 2007, Sheffield, UK.
Müller-Stewens, G. and Lechner, C. (2005). Strategisches Management: Wie strategische Initiativen zum Wandel führen. 3rd Edition. Schäffer-Poeschel, Stuttgart.
O'Riain, C. and Helfert, M. (2005). Analysing healthcare information system strategies in Europe. In: Proceedings of the 10th UK Academy for Information Systems, Newcastle, UK.
Österle, H. and Winter, R. (2003). Business Engineering: Auf dem Weg zum Unternehmen des Informationszeitalters. 2nd Edition. Springer, Berlin.

Österle, H., Winter, R., Höning, F., Kurpjuweit, S. and Osl, P. (2007). Der St. Galler Ansatz des Business Engineering: Das Core Business Metamodel. WISU: Das Wirtschaftsstudium, 36 (2), 191-194.
Pagliari, C., Sloan, D., Gregor, P., Sullivan, F., Detmer, D., Kahan, J.P., Oortwijn, W. and MacGillivray, S. (2005). What is eHealth (4): A scoping exercise to map the field. Journal of Medical Internet Research, 7 (1), e9.
Parente, S.T. (2000). Beyond the hype - A taxonomy of e-Health business models. Health Affairs, 19 (6), 89-102.
Porter, M. and Olmsted Teisberg, E. (2004). Redefining competition in health care. Harvard Business Review, 82 (6), 64-76.
Post, J.E., Preston, L.E. and Sachs, S. (2002). Redefining the Corporation: Stakeholder Management and Organizational Wealth. Stanford University Press, Stanford.
Price, R. and Shanks, G. (2005). A semiotic information quality framework: Development and comparative analysis. Journal of Information Technolog, 20 (2), 88-102.
Purao, S. (2002). Design research in the technology of information systems: Truth or dare. Working paper, http://purao.ist.psu.edu/working-papers/dare-purao.pdf, last accessed 20.11.2007.
Redman, T. (1996). Data Quality for the Information Age. Artech House, Norwood, USA.
Riempp, G. and Gieffers-Ankel, S. (2007). Application portfolio management: a decision-oriented view of enterprise architecture. Information Systems and E-Business Management, 5 (4), 359-378.
Scott, W.R. (2002). Organizations: Rational, natural, and open systems. 5th Edition. Prentice Hall, Upper Saddle River, USA.
Silverstone, L. (2001). The data model resource book – Volume 2: A library of data models for specific industries. John Wiley & Sons, New York.
Stoellger, P. (2005) Qualität als das Andere der Quantität: Wie bildet sich «Sinn für Qualität»? PrimaryCare, 5 (47), 979-982.
Van Bemmel, J.H. and Musen, M.A. (1997). Handbook of Medical Informatics. Springer, New York.
Vassilacopoulos, G. and Paraskevopoulou, E. (1997). A process model basis for evolving hospital information systems. Journal of Medical Systems, 21 (3), 141-153.
Walston, S. and Chadwick, C. (2003). Perceptions and misperceptions of major organizational changes in hospitals: Do change efforts fail because of inconsistent organizational perceptions of restructuring and reengineering? International Journal of Public Administration, 26 (14), 1581-1605.
Wand, Y. and Wang, Y.R. (1996). Anchoring data quality dimensions in ontological foundations. Communications of the ACM, 39 (11), 86-95.
Wang, R.Y., Kon, H.B. and Madnick, S.E. (1993). Data quality requirements analysis and modeling. In: Proceedings of the Ninth International Conference on Data Engineering, Vienna, Austria.
Wang, R.Y., Storey, V.C. and Firth, C.P. A framework for analysis of data quality research. IEEE Transactions on Knowledge and Data Engineering, 7 (4), 623-640.
Wang, R.Y. and Strong, D.M. (1996). Beyond accuracy: What data quality means to data consumers. Journal of Management Information Systems, 12 (4), 5-34.
World Health Organization (2005). eHealth: Report by the Secretariat, http://www.who.int/gb/ebwha/pdf_files/WHA58/A58_21-en.pdf, last accessed 20.11.07.
World Health Organization (2006). eHealth tools & services: Report of the WHO Global Observatory for eHealth. http://www.who.int/kms/initiatives/tools_and_services_final.pdf, last accessed 20.11.2007.
Zelman, W.N., Pink, G.H. and Matthias, C.B. (2003). Use of the balanced scorecard in health care. Journal of Health Care Finance, 29 (4), 1-16.