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Information Mapping: A Case of Operating Theatre List Management Process

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ABSTRACT

This paper considers an important dimension of information quality that is information flow and proposes a procedure for mapping the operating theatre waiting list (OTWL) process. The paper discusses the issues that make information mapping of the OTWL a challenging task and explains the difficulties associated with traditional process mapping techniques in determining the interdependencies of various elements of the OTWL process activities. The proposed procedure integrates a structured process mapping technique known as IDEF0 with another structured technique referred to as dependency structured matrix (DSM) to map the OTWL process. The paper indicates that it is possible to reduce feedbacks from other activities that affect the stability of the waiting list by administratively controlling the information flow through certain activities of OTWL process.

INTRODUCTION

Information becomes a critical component of business operations (Sen, 2001). Today's technology allows business to collect and analyse "enormous volumes of information and manipulate it in different way to bring out otherwise unforseen areas of knowledge" (Abbott, 2001). Managers make decisions based on information available to them, and misinformed people tend to make poor decisions (Fisher and Kingma, 2001). Type and timing of information flow plays a major role in decision-making process. Information mapping depicts information flow between various entities of a process. Several studies (Bosset, 1991; Evans and Lindsay, 2002; Fadlalla and Wickramasinghe, 4004) stress the importance of process mapping and emphasise the role information flow in improving the decision-making process. This paper deals with information mapping of the waiting list process in hospitals. It considers information flow as a component of two dimensions of information quality; contextual dimension and accessibility dimension.

Information Quality and Information Mapping

Customers view quality in relation to differing criteria based on their individual roles in the production-marketing chain (Evans and Lindsay, 2002). Thus it is important to understand the various perspectives from which information quality (IQ) is viewed. Wang (1998) finds an analogy between quality issues in product manufacturing and those in information, and further asserts that information manufacturing can be viewed as processing system acting on raw data to produce information products. Wang urges organisations to manage information as they manage products if they want to increase productivity. Based on the analogy of Wang, information quality can be viewed by information consumers from various perspectives: as "fitness for intended use," or as "meeting or exceeding customer expectations".

Just like quality management of physical products, IQ has multiple dimensions. IQ dimensions refer to issues that are important to information consumers. However, there are no uniform lists for the IQ dimensions as illustrated in Table 1. The choice of these dimensions is primarily based on intuitive understanding, industrial experience, or literature review (Hung et. al, 2001) and depends on the actual use of information. Good information for a specific user in one case may not be sufficient in another case. Strong et al. (1997) group the IQ dimensions into four categories. These categories are contextual, intrinsic, accessibility and representation. These categories are widely acceptable in the literature (Li et. al (2003) and can implies others dimensions as shown in Table 1.

Good information mapping allows information system's users to receive correct amount of information (completeness), only relevant information (relevancy), updated information (timeliness) at the required time (currency) and with adequate level of accessibility (accessibility). Accordingly, information mapping is directly related to two categories of IQ dimensions; contextual and accessibility.

Operating Theatre Waiting List

There are commonly two kinds of waiting lists in hospitals: outpatients and surgery (Gonzalez-Busto and Garcia, 1999). The first type of waiting list includes patients waiting for consultation in certain sections, including the Accident and Emergency Departments. The second type of waiting list is a reference to the operating theatre schedule. Patients on this list are awaiting a surgical intervention to be conducted in an operating theatre of the hospital. This research deals with the operating theatre waiting list "OTWL" and concentrates on the information mapping of the OTWL process. OTWLs are critical for many reasons: their societal and political impact, their potential link to the patients' life; their relationship to the economic management of operating theatres and the allocation of scarce resources such as surgeons, specialists, nurses and equipment (Al-Hakim, 2006).

Consulting surgeons historically determine the urgency of patients' conditions, the nature of the required surgery and the timing of the operation. They make clinical decisions based on their opinion of the physical status and medical needs of their patients (McAleer, et al., 1995). Decisions regarding the physical status of a patient include assigning the patient to a certain category of emergency. Once drawn up, the composition of a waiting list is unprotected in that it is subject to multiple alterations and modifications, without prior notice or agreement with patients already in the list. Unanticipated changes affect the quality of patient care and may escalate costs considerably. Patients who have their consultation or procedure time altered can suffer prolonged anxiety, pain and discomfort, frustration, anger and stress (Buchanan and Wilson, 1996). For the organisation, delayed or cancelled procedures usually result in activity targets not being achieved.

Several studies (District Commission, 2002; New Health, 2002; Schofield, 2005) stress the importance of process mapping and emphasise the role of information flow in improving or redesigning the OTWL process. This paper deals with process mapping of OTWL and provides a conceptual procedure for mapping the information flow throughout the activities of the OTWL process.

The procedure is applied for mapping the OTWL process within an Australian Hospital. Information presented is only at a macro level and

Table 1. Categories and dimensions of IQ

Category	Implication / Definition#	IQ Dimensions from Selected Literature				
		Delone and McLean (1992)*	Goodhue (1995)	Wang and Strong (1996)	Strong et al (1997)	Jarke and Vassiliou (1997)*
Intrinsic	Information has quality in its own right.	Accuracy, precision, reliability, freedom from bias.	Accuracy, reliability.	Accuracy, believability, reputation, objectivity.	Accuracy, objectivity, believability, reputation.	Believability, accuracy, credibility, consistency, completeness.
Contextual	IQ must be considered within the context of the task.	Importance, relevance, usefulness, content, completeness, currency, sufficiency.	Currency, level of detail.	Value-added, relevance, completeness, timeliness, appropriate amount.	Relevancy, value added, timeliness, completeness, and amount of data.	Relevance, usage, timeliness, source, currency, data warehouse currency, non-volatility.
Accessibility	Information is interpretable, easy to understand and manipulate.	Useableness, quantitativeness, convenience of access.	Accessibility, assistance, ease of use, location.	Accessibility, ease of operations, security.	Accuracy and access security.	Accessibility, system availability, transaction availability, privileges .
Representation	Information is represented concisely and consistently.	Understandability, readability, clarity, format, appearance, conciseness, uniqueness, comparability.	Compatibility, meaning, presentation, lack of confusion	Understandability, interpretability, concise representation, consistent representation, arrangement, readable, reasonable.	Interpretability, ease of understanding, concise representation, consistent representation.	Interpretability, syntax, version control, semantics, aliases, origin.

* Adopted from Lee et al (2002)
\# Adopted from Turban and Aronson (2001).

more detailed information at the micro level may be required for justification of the results.

The next section of the paper explains issues that make information mapping OTWL a challenging task. The paper explains the difficulties associated with current process mapping techniques and proposes a procedure to overcome these difficulties. The procedure integrates a structural process mapping technique known as IDEF0 with a process design mapping technique referred to as dependency structured matrix (DSM).

CHALLENGES FACING OTWL

The OTWL process has a multiple-criteria objective of:

1. compliance with all due dates and times of the scheduled consultations and operations; and
2. ensuring a quick and convincing response to unanticipated changes to the waiting list.

These criteria may conflict with each other in that the waiting list requires changes in response to unanticipated clinical needs rather than order of arrivals, as well as logistical factors, such as readily available resources (Al-Hakim, 2006). The difficulty of compromising the two conflicting criteria of OTWL objective arises mainly from the process complexity.

Process Complexity

Giddens (Giddens, 1984) - in Biazzo, 2002) describes a process as a series of interdependent actions or activities embedded in a structure. Giddens views a structure as a set of rules and resources which can both constrain and enable social actions. OTWL process is a constructive example that fits Giddens' concept and, accordingly, the OTWL process can be considered as not just a group of activities. Rather, it is a 'sociotechnical' system (Keating, et al., 2001) in which each activity has additional elements other than that activity's input and output. These additional elements are the resources including information necessary to perform the activities and the rules that govern the activity's implementation. The complexity of the OTWL process arises from two aspects:

a. the process mapping aspect which relates to the interdependencies between the elements of various activities of the OTWL process and;
b. the sociotechnical aspect which requires designing work such that a balance can be struck between the technology and the people using the technology. This is known as joint optimisation.

There are four variables that make both defining interdependencies between the elements of the avrious activities of the OTWL process and achieving joint optimisation extremely important:

- Object behaviour. The behaviour of the object (patient) is not predictable and could vary considerably. Significant disruption coudl result from patient behaviour eg cancellation of surgery by a patient. This makes every patient a unique object in the system.
- Surgeon effectiveness. Surgeons differ in skill and expertise. It is hard to measure the effectiveness of a surgeon in dealing with various complexities during surgery.
- Surgery success. Because of the level of complexity and variability it is hard to predict the degree of success of a surgery.
- Surgical time. Though the time required for surgery can be partly predicted, complexities during surgery may considerably affect the surgery time. The high probability of the unpredictability of time required for surgery renders difficult any attempt to precisely schedule OTWL.

While some of the above variables are uncontrollable, their impact on OTWL scheduling can be considerably reduced and effectively managed with (a) correct and real-time flow of information, and (b) coordination of the various interdependencies between elements of the activities involved in the OTWL process. Realising the role of information flow and interdependencies as the main drivers of the OTWL schedule highlights the need for effective process mapping. This is the topic of the next section.

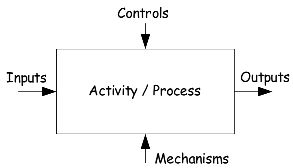
PROCESS MAPPING

Process mapping is a technique used to detail business processes by focusing on the important elements that influence their behaviour (Soliman, 1998). Lin, Yang and Pai (2002) argue that process mapping performs two important functions. The first function is to capture existing processes by structurally representing their activities and elements. The second function is to redesign the processes in order to evaluate their performance.

The value of an activity is derived from the coordination of the process's activities, its rules and resources that make the product or service valuable or satisfactory in terms of its price to the customer. The effectiveness of activity coordination is directly related to process complexity. Browning (1998) stresses that process complexity is a function of at least four factors: (1) the number of activities, (2) the individual complexity of each activity (the number of relationships (or interdependencies) between activities, and (4) the individual complexity of each interdependency. Giddens's seeks additional relationships and interdependencies between resources and rules governing the actions. Three additional important factors can be added here: (5) the relationships or interdependencies between activities and the associated resources and rules, (6) the interdependencies between the resources, (7) the interdependencies between the resources and rules, and (8) the complexity of these interdependencies.

An effective process mapping should therefore consider the interrelationships between activities as well as the object involved, the resources needed to perform the process's activities, the rules and policies that govern the implementation of activities and the flow of information between various elements of the activities. Traditional process mapping such as flow and Gantt charts are not robust enough to handle the process complexity. Traditional process mapping techniques focus only on activities or work flow rather than information flow. They deal with the sequence of activities but do not address the required resources. Accordingly these techniques cannot be used to map the interdependencies between the elements of the activities and hence cannot deal with the complexity factors mentioned above. One structured process mapping technique referred to as IDEF0 can be used to map the various elements of activities. The next section discusses its suitability for mapping process complexity.

Figure 1. IDEF0 elements: inputs, outputs, controls, and mechanisms



IDEF0

The name IDEF originates from the United States Air Force program for Integrated Computer Manufacturing (Mayer, et al., 1995). IDEF0 is one of the IDEF series of techniques that was originally developed in order to describe, specify and model business processes in a structured graphical form (Lin, et al., 2002; Fulscher and Powell, 1999). IDEF0 describes a business process as a series of linked *activities* in which each activity is specified by four elements: inputs, controls, outputs and mechanisms. These elements are referred to as ICOMs (Lin, et al., 2002). Figure 1 illustrates generically how IDEF0 is used to depict activities and their associated elements.

The controls of an activity include actions, policies or regulations that control the activity, while mechanisms refer to the resources required to achieve the activities. We assume that each activity may have several inputs and outputs, may be embraced by a number of controls and may require several resources. An activity may represent a stage, a process, or a certain course of action within the process. The IDEF0 representation fits with the Giddens's concept of a business process as well as the sociotechnical system definition.

IDEF0 allows a hierarchical or top-down decomposition approach to analyse processes at multiple levels of abstraction (Kappes, 1997). The essence of hierarchical decomposition approaches to business process mapping, in which a basic, single-activity description of the process is decomposed step-by-step into its constituent activities to whatever level of detail, is appropriate for the mapping purposes (Fulscher and Powell, 1999). This hierarchical decomposition of activities helps to organize the development of IDEF0 models and proved critical in abstracting the essence of the process itself from the details of current practice. The top level activity which represents the subject of the model is always given the number A0. The next level of activities are numbered A1 to An where n indicates the number of "child" activities that A0 was broken into. Figure 2 illustrates an overview or macro-map of OTWL process mapping (level A_0 detail) for the case hospital using IDEF0.

Determining Interdependency

The elements of an activity do not exist in isolation from elements of other activities in the waiting list management process and the relationships between these elements form the interdependencies between the process's activities. There are six basic forms of interdependencies between elements of activities representing the flow of information mapping; (1) input/input dependency -as between activities A1 and A2, (2) input/output dependency, (3) output/control dependency, (4) input/control dependency, (5) control/control dependency, and (6) resource/resource dependency (Figure 3).

The Activity/Concept (A/C) matrix window of IDEF0 displays in matrix format which concepts (elements) are attached to which activities and how they are attached - as inputs, controls, outputs, or mechanisms (Figure 4). The A/C matrix can be used to depict the six types of interdependencies. Figure 4 illustrates that the advice of an anaesthetist is needed during implementing activities pre-assessment, peri-operations, procedure and discharge and the anaesthetic output from pre-assessment controls the other three activities peri-operations, procedure and discharge. However, IDEF0 is not designed precisely to map information feedback needed from other activities before the start of the current one. Accordingly, IDEF0 cannot be actively used to group activities for the purpose of information flow. This research integrates

Figure 2. Macro-map of OTWL process using IDEF0

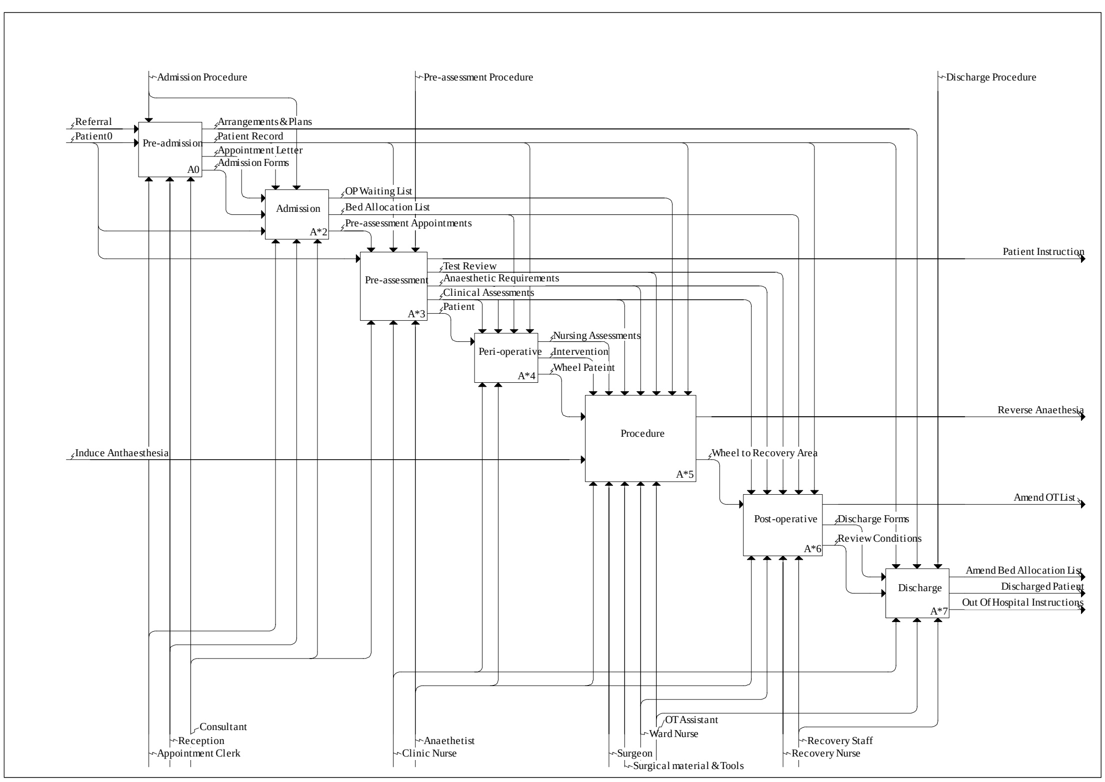


Figure 3. Six basic forms of interdependencies representing the flow of information mapping - (numbered from 1 to 6 - adopted from Al-Hakim, 2006).

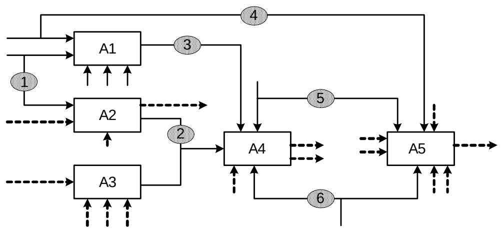
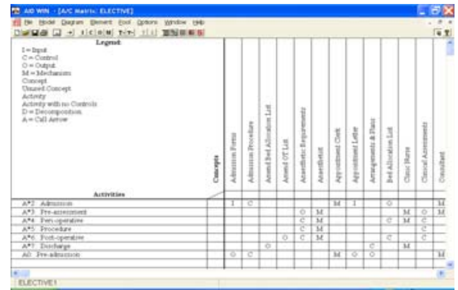


Figure 4. Part of A/C matrix



IDEF0 with another structured technique known as Dependency Structured Matrix.

Dependency Structured Matrix

Steward (1981) described the concept of dependency structure matrix or design structure matrix (DSM) and its application to design process. The actual use of DSM in industry began around 1990 as part of a postgraduate study project conducted at MIT (Browning, 1998). Design process requires complex feedback. One or more prior design activities could be reworked or modified as a result of new information gained from performing another activity at a later stage of the design. Interdependent activities that benefit each other in this way are known as coupled activities (Eppinger, 2001). Coupled activities drive the iterations of the design process. DSM can successfully be used to reduce design project cycle time and control the iterations by grouping design activities into three types of sets: sequential activities, parallel activities and coupled activities. The core concept of DSM is to rely on information flow between activities rather than on work flow. Relying on information flow is what distinguishes DSM from traditional mapping techniques. In traditional mapping techniques, such as flowcharts and Gantt charts, the start of an activity depends on the completion of certain other activities and accordingly these techniques answer the question "what other activities must be completed before the start of the current activity?" DSM answers a very different question (Eppinger, 2001): "What information is needed from other activities before completing the existing one?" Analysing information flow allows re-sequencing of activities such that both cycle time and iterations are reduced.

DSM is a square matrix in which each activity is represented by one row and one column. Initially the activities are listed in the order in which they are presently carried out with upstream or early activities listed in the upper rows (Browning, 1998; Eppinger, 2001). Entries across a row corresponding to an activity represent the other activities that supply information to the current one. Entries below the matrix diagonal signify information received from activities carried before the current one. Entries above the matrix diagonal imply feedback from activities that will implemented at a later stages - the potential for iteration in the process.

In regard to the OTWL process, entries above the matrix diagonal represent potential for editing the waiting list. The entries represent the interdependencies between activities. There are three forms of information dependencies. Where the entries ij and ji are empty, this indicates that activities (i) and (j) have no direct interdependencies. Two activities are coupled when both entries (ij) and (ji) are filled. However, when one only entry (ij) is filled, this means that activity (j) should follow activity (i), that is, activities (i) and (j) are sequential activities.

There are three objectives of using DSM to map OTWL. The first objective is to rearrange the sequence of activities such that the number of entries above the matrix diagonal is minimised. This will reduce the number of times OTWL is revised. The second objective is to identify the parallel activities such that these activities can be implemented concurrently in order to reduce operation cycle time. The third objective is to recognise the coupled activities so that information can smoothly flow between them without any delay. This objective also helps the restructuring of the operating theatre process by ensuring that the activities of each set of coupled activities are managed by the same authority. This kind of reorganisation will reduce the number of decision-making authorities. Figure 5 depicts an initial DSM matrix for the macro-map of the OTWL process.

INTEGRATING IDEF0 WITH DSM

Despite the strength of IDEF0 specifically in identifying various elements of activities in the form of output, input, control and mechanism and additionally in its ability to graphically map interdependencies between these elements, it still does not expressly or effectively accommodate the full mapping of information. It also does not capture the specific sequencing logic between the process activities and explicitly consider time-order constraints between activities or the parallelism of activities (Plaia and Carrie, 1995). For instance, for a complex process like OTWL process it is difficult to determine activities or sets of activities that may be implemented concurrently or sequentially. DSM can be used to overcome the deficiencies of IDEF0. However, the inability of DSM to identify interdependencies apart from those related to flow of information makes the integration of DSM and IDEF0 very valuable.

At the pre-admission stage, the initial waiting list is formed. All the dot points above the diagonal of the DSM matrix in Figure 5 provide feedback that may require changes in the waiting list. This feedback cannot be easily detected during process mapping using IDEF0. IDEF0 mapping can be amended to accommodate these feedbacks. Analysis of DSM reveals difficulty in rearranging the sequence of activities to reduce feedback. However, from the information flow perspective, some of these activities can be combined. The three activities peri-operative, procedure and post-operative require information from each other and provide feedback to each other. These three activities form a 'coupled' set of activities. From the information flow perspective, the information for these three activities should be between them in-real time and under one authority. The three activities can be merged into one, say Operation. The pre-admission and admission activities can also be administratively combined. The resulting DSM becomes as shown in Figure 6.

Based on the modified DSM, changes in the waiting list will be affected only as a result of a single feedback from the 'Operation' suite.

CONCLUSION

This paper deals with information mapping of the operating theatre waiting list (OTWL) process. It identifies the dynamic variables affecting the process and concludes that the impact of these variables on OTWL scheduling can be considerably reduced by effectively mapping and then managing the flow of information. The paper employs IDEF0 to map the OTWL process and points to the lack of IDEF0 to actively map information feedback. The paper integrates IDEF0 with another structured technique known as Dependency Structured Matrix (DSM) to overcome the pitfalls in IDEF0. The paper relies on information from

Figure 5. An overview mapping of OTWL process with DSM

Activity	Pre-admission	Admission	Pre-assessment	Peri-Operative	Procedure	Post-operative	Discharge
Pre-admission						•	
Admission	•				•	•	
Pre-assessment		•					
Peri-Operative			•		•	•	
Procedure			•	•		•	
Post-operative					•		
Discharge						•	

a case hospital to present the procedure. The results indicate that it is possible to reduce the amount of feedbacks from other activities that affect the stability of the waiting list by administratively controlling the information flow through certain activities of OTWL process.

Figure 6. The modified DSM

Activity	Admission	Pre-assessment	Operation	Discharge
Admission			•	
Pre-assessment	•			
Operation		•		
Discharge			•	

REFERENCES

Abbott, J. (2001). Data data everywhere- and not a byte of use?. *Qualitative Market Research*, Vol. 4, No. 3, pp.182-192.

Al-Hakim, L. (2006). Web-based hospital information system for managing operating theatre waiting list. *International Journal of Healthcare Technology and Management*, Scheduled for Vol. 7, Nos 3/4, pp. 266-282.

Biazzo, S. (2002). Process mapping techniques and organisational analysis: lessons from sociotechnical system theory. *Business Process Management Journal*, Vol. 8, No. 1, pp. 42-52.

Bosset, JL. (1991). *Quality Function Deployment. A Practitioner's Approach*. ASQC Quality Press, Milwaukee, WI.

Browning, T. R. (1998). *Use of Dependency Structure Matrices for Product Development Cycle Time Reduction*. Proceedings, Fifth ISPE International Conference on Concurrent Engineering: Research and Applications, July 15-17, Tokyo.

Buchanan, D., and Wilson, B. (1996). Re-engineering operating theatres: the perspective assessed. *Journal of Management in Medicine*, Vol. 10, No. 4, pp. 57-74.

District Commission (2002). *Operating Theatres: A Bulletin for Health Bodies*. District Audit, www.district-audit.gov.uk. Accessed January 2005.

Eppinger, S. (2001). Innovation at the speed of information. *Harvard Business Review*, January 2001, pp. 149-158.

Evans, JR., and Lindsay, WM. (2002). *The Management and Control of Quality*, (5th edn). South-Western, Thomson Learning, Cincinnati: Ohio.

Fadlalla, A., and Wickramasinghe, N. (2005). An integrative framework for HIPAA-Compliant I*IQ healthcare information systems. *International Journal of Health Care Quality Assurance*, Vol. 17, No. 2, pp.65-74.

Fisher, CW., and Kingma, BR. (2001). Criticality of data quality as exemplified in two disasters. *Information & Management*. Vol. 39, pp.109-116.

Fulscher, J. and Powell S.G. (1999). Anatomy of a process mapping workshop. *Business Process Management Journal*, Vol.5, No.3, pp. 208-237.

Giddens, A. (1984). *The Constitution of Society*. Polity Press, Cambridge.

Gonzalez-Busto, B. and Garcia, R. (1999). Waiting lists in Spanish public hospitals: a system dynamics approach. *System Dynamics Review*, Vol. 15, No. 3, pp. 201-224.

Goodhue, D.L. (1995). Understanding user evaluations of information systems. *Management Science*, Vol. 41, No. 12, pp.1827-1844.

Huang, K-T., Lee, Y.W., & Wang, R.Y. (1999). *Quality information and knowledge*. Prentice-Hall PTR. NJ.

Kappes, S. (1997). Putting your IDEF0 model to work. *Business Process Management Journal*, Vol. 3, No. 2, pp. 151-161.

Keating, CB, Fernandez, AA, Jacobs, DA & Kauffmann, P. (2001). A methodology for analysis of complex sociotechnical processes. *Business Process Management Journal*, vol. 7, no. 1, pp. 33-49.

Lee, W.Y, Strong, D.M., Beverly, K., & Wang, R.Y. (2002). AIMQ: A methodology for information quality assessment. *Information & Management*, Vol. 40, No. 2, pp.133-146.

Li, N.Y., Tan, K.C., and Xie, M. (2003). Factor analysis of service quality dimension shifts in the information age. *Managerial Auditing Journal*, Vol. 18, No. 4, pp.297-302.

Lin, F., Yang, C. and Pai, Y. (2002). A generic structure for business process modelling. *Business Process Management Journal*, Vol. 8, No.1, pp. 19-41.

Mayer, RJ, Menzel, CP, Painter, MK, DeWitte, PS, Blinn, T & Perakath, B. (1995). *Information integration for concurrent engineering (iice) IDEF3 process description capture method report*, Knowledge Based Systems.

McAleer, W. E., Turner, J. A., Lismore, D., and Naqvi, I. A. (1995). Simulation of a Hospital Theatre Suite. *Journal of Management in Medicine*, Vol. 9, No. 3, pp. 14-26.

New Health (2002). *Operating Theatre Management Project- Supplementary Report on Process Mapping*. NSW: NSW Health Department.

Schofield, W., Rubin, G., Piza, M., Lai, Y., Sindhusake, D., Fearnside, M., and Klineberg, P. (2005). Cancellation of operations on the day of intended surgery at a major Australian referral hospital. *Medical Journal of Australia*, Vol. 182, No. 12, pp. 612-615.

Sen, K. (2001) 'Does the measure of information quality influence survival bias?' *International Journal of Quality and Reliability Management*, Vo. 18, No. 9, pp.967-981.

Soliman, F. (1998). Optimum level of process mapping and least cost business process re-engineering. *International Journal of Operations & Production Management*, Vol. 18, No. 9/10, pp. 810-816.

Strong, D.M., Lee, Y.W., and Wang, R.Y. (1997). Data quality on context." *Communication of the ACM*. Vol. 40, No. 5, pp.103-110.

Steward, D. (1981). The design structure system: A method for managing the design of complex systems. *IEEE Transaction on Engineering Management*, Vol. 28, pp.71-74.

Turban, E., & Aronson, J.E. (2001). *Decision support systems and intelligent systems* (3rd ed.). Upper Saddle River, Prentice-Hall, Inc. NJ.

Wang, R.Y. (1998). A product perspective on total data quality management. *Communications of the ACM*, Vol. 41, No. 2, pp.58-65.

Wang, R.Y., and Strong, D.M. (1996). Beyond accuracy: What data quality means to data consumers. *Journal of Management Information Systems*, Vol. 12, No. 4, pp. 5-34.

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