Improving hospital supply chains by managing risk flows

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Abstract
Supply chain management techniques can help hospitals become more efficient and improve patient care at the same time. However, in order to be effective, we need a comprehensive understanding of both the system idiosyncrasies and the supply chain processes. This paper details a four step framework that is motivated by ideas from the risk management domain. Specifically, we propose to map risk flows throughout a hospital. Its application to the Pharmacy department of a large Italian hospital is also discussed. Uncovering the associated risks in a process allows us a deeper understanding of the system and isolate key activities whose performance should be monitored closely.

Keywords: Supply Chain Management, Risk Management, Hospitals

1. INTRODUCTION
The healthcare expenditure in developed countries has increased dramatically in the last few decades for several reasons. Key among them is the fact that since the 1980's, the need for increasing competitiveness has pushed hospitals to differentiate their services by adding new specialties without dismissing existing ones, and thus making their costs go up. Moreover, the growing trend of supporting healthcare activities by means of technology has also prompted an increase in both investments in new equipment and maintenance costs. No wonder thus the current relevant total national healthcare expenditure as a percentage of GDP, both in the US and Europe, with a large portion being attributed to the hospitals (OECD, 2003-2007; CMS, 2008).

Given this situation, healthcare organizations have recently started looking for ways to improve their efficiency, not only from a clinical point of view but also from as an organization, particularly, supply chain. As a matter of fact, it has been shown that supply chain costs are responsible for about 31% of the total cost for care (Montgomery and Schneller, 2007).

There are two main approaches to rationalize processes and improve the performance of hospital operations namely, process redesign and performance measurement. Process redesign supports efficiency improvement by eliminating unnecessary activities, simplifying material and informational flows, and reducing waste. Performance

measurement, on the other hand, is an effective tool to integrate, align, manage, and sustain hospital processes for superior performance.

However, in order to gain full benefits from methods to increase supply chain efficiency, a deep understanding of processes is essential. In addition, the knowledge of associated risks, which are inherent in both supply chain and clinical processes, is of paramount importance since in business planning terms, cost, quality, risk and quantity are closely interwoven (Wagstaff, 1997).

Let us take a closer look at the impact of risk in the hospital environment. The ultimate goal of managing risks in the healthcare domain is identifying, assessing, reducing, and controlling hazards to patients, staff, and visitors (Harris, 2000), where hazards can be viewed in a broad sense, also including the effects of a scarce level of service induced by an inadequate material management. In fact, the effects of risks may account for a big portion of a hospital budget, and, in this way, risk management becomes a way to reduce expenditure (O'Donovan, 1997). And, supply networks are particularly important functions from the point of view of risk. Given the number of suppliers and customers involved in the system, together with their high degree of interconnectivity, supply chains are constantly under the threat of an imminent disruption and of its domino effects (Singh and Lévy, 2007).

In this paper we explore a risk driven view of supply chains to propose a framework that can help hospitals improve their supply chain performance. Specifically, we offer a four step framework to study hospital supply chain processes along with associated sources of risks and also extend the discussion to include reduction of supply chain waste. We show how this framework can be deployed by discussing its application to one department of a large Italian hospital.

The remainder of the paper is organized as follows. The value of risk management perspective to supply chain management is discussed in section 2. The proposed framework is presented in section 3, followed by section 4 detailing the case study. Finally, conclusions and future research directions are given in section 5.

2. A RISK MANAGEMENT VIEW OF SUPPLY CHAIN

By definition, a supply chain is treated as a set of three separate yet integrated flows: product, information, and money. It is recommended that these three flows be studied to gain a comprehensive understanding of a supply chain. Indeed, depending on the situation, some flows may be more important than others from a practical standpoint. As a result, it is not unusual to see decision makers focus heavily on product flows when studying supply chains in the manufacturing industries in general. This is due to the obvious importance of ensuring product flow through the supply chain to meet specific customer demands. On the other hand, in the Pharmaceutical industry, supply chain design for branded drugs is heavily influenced by the financial flows that gain significant importance due to the presence of tax havens around the globe. Therefore, it is customary for companies in this industry to create a supply chain that is optimized around taxes and monetary flow.

Strictly speaking, the main challenge faced by supply chains stems from constant struggle to match demand with supply that are inherently uncertain. Constrained by resources and business objectives, supply chains do their best by focusing only on a subset of uncertain events. In an optimization driven regime, the goal of supply chain design and management efforts is often to seek the best solution that will meet profitability goals under given resource constraints. Most big changes in demand and supply are therefore considered outliers and treated as exceptional cases and ignored from the task of managing a normally behaving system. This allows the decision maker

to manage the system effectively as long as no significant disruptions are witnessed by the system. Abnormal changes in demand and supply are studied and managed separately as risk management.

Separating the discussion of abnormal behavior seems logical and an efficient way to manage an already complex supply chain challenge, however, this comes at a price. What often gets overlooked is that many of the risks encountered by the supply chains are the result of the specific design and policy regime proposed by the decision makers at the first place. Due to the artificial separation of process, the cause and effect linkage between supply chain design and risks are clouded and lost. Integrating supply chain design and management with risk management perspective can address this issue by sharpening the focus on disruptions and uncertainty. This will allow decision makers to have a greater awareness of the implications of their choices and allow them to create a more robust supply chain – a critical need for hospitals.

To this end, we propose that decision makers view their supply chains in terms of a fourth flow i.e., *risk flows* (Singh and Lévy, 2007). Since risk in a supply chain can result from the disruption of product, information, or money flows, managing supply chains by focusing on the risk flows will force a disciplined and integrated assessment of various aspects of the supply chain.

In particular, there are for four key reasons to employ a risk flow view for supply chain management:

1. A risk flow view forces a careful mapping and consideration of every step in the supply chain from an external and internal risk perspective;
2. Risk is dynamic in nature. For example, a change in the inventory level changes the risk exposure of the operation on a real time basis. Since risk flows get compounded as it moves through a system - increases or decreases, decision makers are required to balance the local view with the system view;
3. Positioning of resources and the strategies chosen to exploit capabilities are probably the biggest reason for a company inheriting a particular risk profile. This requires a better understanding of tangible, direct and short term benefits with the intangible, indirect, and long term implications of a decision;
4. The tendency to seek minimal cost solutions makes supply chains rigid and slow to react. Even though such solutions may improve efficiency and save cost in the near term, exposing system to greater risks over the long run is likely to negate all such gains. Building a resilient supply chain that is capable of handling disparate risks allows the company to gain a proactive orientation. The result is a stable system that is likely to weather higher uncertainty, due to any reason, quite effectively.

3. A RISK BASED APPROACH TO HOSPITAL SUPPLY CHAINS

The healthcare system is inherently uncertain (Begun and Kaissi, 2004). Products and services from a multitude of organizations have to come together in order to serve the end patient but there is little or no coordination across various sectors engaged in this process. From a practical standpoint, different sectors of healthcare industry operate in a very different manner from each other. They share minimal characteristics in terms of what they produce and how they operate. For example, the supply chain challenges are very different in the pharmaceutical domain than in the hospitals although they affect the service to the end consumer, the patient. But it is almost impossible to think of coordinating these disparate supply chains for better service downstream. In that respect, it is best to study the healthcare supply chain as a set of two separate supply chains namely, a supply chain from suppliers to the hospital dock and from dock to the

bed that takes care of the last '100 yards'. In this paper we will focus on the hospital supply chain that cover the distance from the dock to bed.

Let us take a closer look at hospital operating environment to better under the nuances of its supply chains. First of all, the very nature of clinical work as well as the drivers of demand for hospital services is highly unpredictable. Secondly, the delivery of care at the hospital requires a close coordination of multiple resources i.e., doctors, nursing staff, physical assets, medical suppliers, money, and information to converge when the demand for care arrives, which as mentioned earlier is highly unpredictable. Although many of the hospital visits are scheduled, the unpredictability is driven by the personal nature of care and co-morbidities that make every case unique.

The result of this complex operating environment is a very challenging supply chain system that is characterized by a highly unpredictable timing and quantity of what is needed to make the system run efficiently. In many ways, managing a hospital supply chain resembles a system that is dealing with disruptions on a constant basis. A critical departure from a traditional supply chain management context is the consequence of supply failure in the hospital environment. Unlike other supply chains, a hospital supply chain performance can have life and death implications. As a result, the goal of product availability tends to override all other supply chain objectives. Consequently, most hospital supply chains suffer from cost issues as efficiency takes a back seat given that just keeping it working is not easy. But now that the cost has become a significant issue, it is difficult to continue to ignore the need for efficiency in hospital supply chains.

Although the hospital environment focuses on risk almost overzealously for obvious reasons, the focus is purely clinical. Significant efforts are made to prevent bad patient outcomes by taking extreme precautions but these are primarily limited to what the medical staff directly controls. In general, hospitals are notorious for neglecting operational risks, risks arising out of poor planning, coordination etc. Incidently, this plays into increasing the clinical risk – non-availability of specific medical products when needed could lead to unfavorable outcomes, even substitution is not a solution in some cases as medical professional have strong preferences for specific products. Clinical and operational risks are in that sense intertwined and should be considered equally important from patient outcome perspective. The intensity of human involvement in care delivery and too many moving parts in the hospital systems necessitate a systematic approach to make the supply chains help meet clinical objectives and perform efficiently. To this end, we take a risk management perspective to study and improve hospital supply chain processes. This approach is detailed in the following sections.

Background

We carried out a two year study aimed at understanding and improving logistics and informational flows at four large and medium-sized regional Italian hospitals in the Torino area. In particular, this project focused on the organizational process starting from physician prescription and ending with drug administration to patients. The objective was the reduction of execution time, material consumption, and the related clinical risks by rationalization of different care delivery phases.

To map risk flows effectively, reflecting the integration between system processes and risks, a structured approach is required that blends expert knowledge of the setting under consideration with a detailed view of the process structure. This is critical since the identification and quantification of a majority of risks is at the heart of this approach. We propose a four-step framework to meet these objectives. These steps are

informed by an extensive literature review and our own research efforts that have yielded key insights into the organizational and clinical practices adopted by most advanced international hospitals.

Step 1: Context analysis
Becoming knowledgeable about the processes and associated actors is of paramount importance for articulating the subsequent steps properly. This is accomplished by means of interviews with management and operational employees, direct observation of activities, and analysis of procedures, organizational charts, and documentation used by hospital departments to trace both clinical and organizational information. Context analysis is strongly supported by the study of similar situations presented in literature as well as hospitals implementing processes comparable with the ones to which the methodology is applied.

Step 2: Process mapping
In this step supply chain processes are broken down in a number of phases and elementary activities, which are hierarchically classified according to an *Activity Breakdown Structure (ABS)* (Figure 1). This tool is derived from Work Breakdown Structure (WBS) (Project Management Institute, 2001); the main difference is that an ABS is process-oriented, whereas a WBS is project or product-oriented.

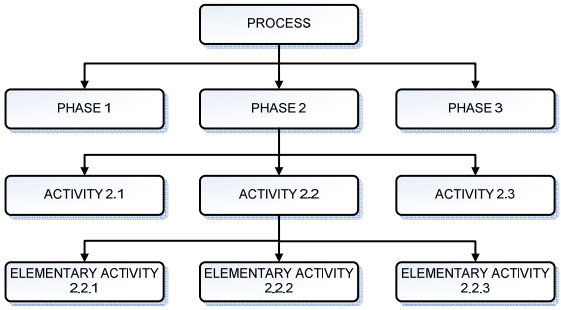

Figure 1 – Activity Breakdown Structure (ABS)

In order to get a comprehensive understanding of how processes work, the Activity Breakdown structure is integrated by two other tools: *process flow charts* and *process sheets.* The aim of process flow charts is to describe activities across time in a logical sequence, as well as specifying people performing them. To this end, cross-functional flow charts are used, which are divided into vertical lanes corresponding to the control of different actors. In addition, in order to obtain a process mapping as more accurate as possible, the proposed approach applies two different flow charts, one describing operational activities (Figure 2), and the other the related exchanged information (Figure 3).

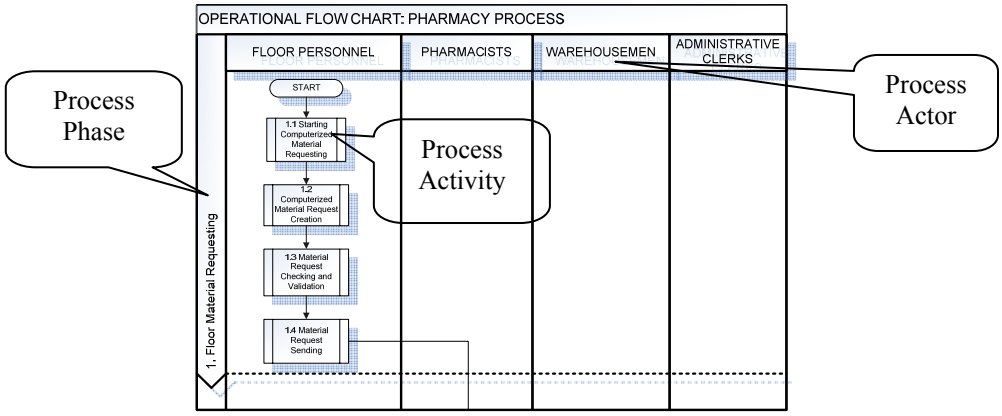

Figure 2 – Operational Flow Chart

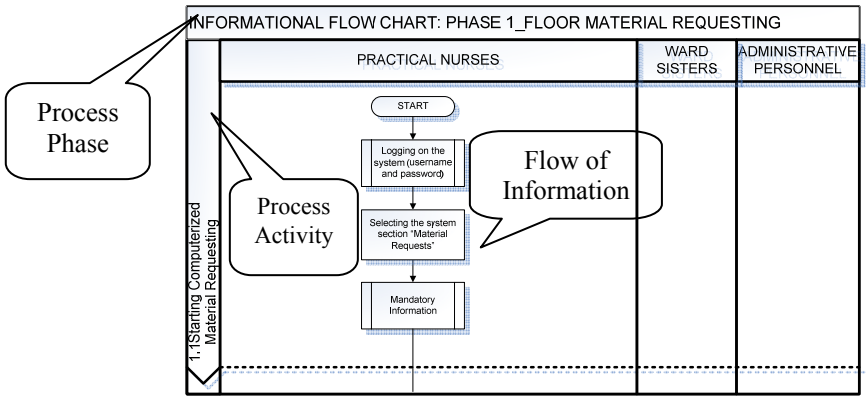

Figure 3 – Informational Flow Chart

Process sheets contain all the information characterizing different process phases, at a level of detail that depends on the complexity of the process under study and on the goals of process mapping. To be more specific, for each activity, its description, actors, inputs, outputs, duration, tools necessary to perform it, and tests to monitor its progress are detailed, together with possible criticalities. These last have been grouped into four categories: organizational criticalities (related to activity management), technical criticalities (related to errors and waste of operators, especially when using technological tools to perform their activities), communication criticalities (errors and waste due to inaccurate information and communication), and structural criticalities (related to structural issues and building layouts).

Step 3: Risk identification

The third step of the approach focuses on process risks, and makes use of two main tools: *Risk Breakdown Structure (RBS)* and *Risk Breakdown Matrix (RBM)*. The RBS is a hierarchical structure very similar to the Activity Breakdown Structure, but devoted to classifying sources of risk (Hillson, 2002) (Figure 4).

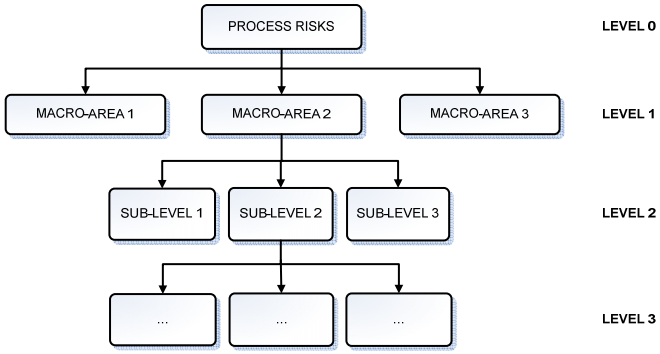

Figure 4 – Risk Breakdown Structure (RBS)

The RBS is created based on the knowledge acquired during the previous phases of the approach. Its first level usually defines macro-areas representing different competence sectors, such as management, technology, patients, and environment. Each macro-area may be broken down into multiple sub-levels, until a proper level of detail has been reached.

The RBS is connected to process activities in the ABS by the Risk Breakdown Matrix, which allows us to go from risk identification to risk quantification. The RBM rows represent the elementary activities constituting the lower level of the ABS, whereas its columns detail the sources of risk forming the lower level of the RBS (Figure 5).

SOURCES OF RISK/OPPORTUNITY / ACTIVITIES	SUB-LEVEL 1		SUB-LEVEL 2		
	RBS 1.1	RBS 1.2	RBS 2.1	RBS 2.2	RBS 2.3
ABS 1.1					
ABS 1.2					
ABS 2.1					
ABS 2.2					

Figure 5 –Risk Breakdown Matrix (RBM)

RBM cells can contain different information according to the kind of analysis that is undertaken (Hillson, 2003; Rafele, *et al.*, 2005). For instance, a cross may show a correlation between an activity and a source of risk. Alternatively, either qualitative information about errors causing risky events or quantitative, or semi-quantitative, evaluations of risk impact can be reported.

Step 4: Waste analysis-FMEA

The identification and, at least partial, quantification of process risks are completed by a waste analysis integrated by a Failure Mode and Effect Analysis (FMEA).

FMEA allows a deep understanding of the failure (or error) modes of a process, product, or system by establishing their causes and effects (Stamatis, 1995). In the presented approach, a particular kind of FMEA, developed by the Department of Veterans Affairs (VA) National Center for Patient Safety in order to address the unique characteristics of the hospital environment, is applied. Health Failure Mode and Effect Analysis (HFMEA) is a five-step methodology to describe processes, identify causes and effects of errors, methods to detect them, and possible improvement measures (DeRosier, *et al.*, 2002).

The effectiveness of HFMEA has been enhanced by considering the typical sources of waste identified by the Toyota Production System principles (Taiichi, 1988). By adapting them to a hospital setting, the following six sources of waste have been

defined: operational activities (all those activities not adding value neither to the process at issue nor to patients); overproduction (performing not necessary activities leading to a not efficient use of resources); waiting time (every period of time when no activity is performed, waiting for the next event happening); transportation (moving materials and patients without adding value to the process); stock (everything waiting for an event, thus increasing costs and taking up room); movements (it regards physical motions of personnel when performing working activities. It is related to useless motions that may also hurt people).

Waste analysis-FMEA has been applied in practice through specific sheets developed from previously detailed process sheets. As far as errors are concerned, these sheets contain a description of failure modes, a classification of risk sources (organizational, technological, communicational, related to structures, and external), causes and effects of errors, methods to detect them, together with improvement actions and corrective measures already taken. On the other hand, similar information is reported for process waste. It is important to notice that FMEA, as well as waste analysis, should be carried out on a regular basis, with the aim of a continuous improvement.

4. CASE STUDY: APPLYING THE APPROACH TO A PHARMACY SERVICE

Case presentation

The present case study focuses on a 1,372 bed teaching hospital located in Torino (Italy). This is the oldest operating hospital in town, and the largest in Piedmont region of Italy, spread over 142,000 square meters, 14 clinical departments, and 5,822 employees, with 1,030 physicians and 2,063 nurses among them.

The proposed methodology to analyze supply chain processes and risks was applied to the Central Pharmacy of this hospital. Risk analysis was made easier by the presence of an active risk management system in the organization.

Application of the methodology

During *Context Analysis*, floor material request issuing to pharmacy, material request receiving and management, pharmacy inventory management, and material request fulfilling were analyzed. In addition, the study of the related documents helped understand information, qualitative and quantitative data characterizing the process.

Pharmacy *process mapping* by means of ABS, flow charts and process sheets brought attention to three macro-activities: Material Request Management at Floors; Pharmacy Order Management (including both floor material requests to be fulfilled and orders issued to suppliers); and Floor Material Request Fulfillment. Each of them was in turn split into a number of detailed activities (e.g. computerized material request creation, picking materials, and delivering products). Again the second step of the methodology, process sheets, allowed to uncover the main criticalities which were extended in the Risk Identification and Waste Analysis – FMEA phases.

Process knowledge acquired during Context Analysis and Process Mapping, together with the experience of hospital personnel and authors' competencies in both healthcare supply chain and risk management, led to a classification of sources of risks by means of a RBS (*Risk Identification*). These include product identification, quantity evaluation, delivery lead times, and quality of delivered products. The risky events have been correlated with activities detailed by ABS by using a RBM structure. This kind of analysis, as well as discussions with pharmacy management, brought to the

identification of a set of most critical activities to whom Waste Analysis – FMEA was applied.

To be more precise, *Waste analysis-FMEA* was performed on the following tasks: computerized material request creation, material request checking and validation, material picking, material packing, material storing, outgoing package sample quality inspection, material delivery to floors, and product transaction registration. In this section, the results of the application of the fourth step of the proposed methodology to material picking are discussed. Several failure modes could be identified for this activity. For instance, the picking of the wrong items may be caused by both technological and organizational issues, and have both immediate and long term effects on operations. This could be reduced by simple visual identification of items. Another failure mode occurs when picked quantities are different from requested ones, and the informative system is not updated accordingly. This is due to communication problems, but it does not have any relevant effects on patients. As far as waste analysis is concerned, two aspects can be highlighted for material picking. First, useless motions of warehouse operators are due to both organizational issues (e.g. poor coordination among workers) and technological ones (e.g. wrong picking lists). The effect is the same in both the cases: operators do not follow optimized paths, thus taking longer to pick items, with the risk of getting in one another's way. As a solution, it is suggested to have a pharmacist, or another professional figure, monitor picking paths. Second, errors and omissions related to products to be picked and their quantities are all caused by warehouse operator distraction, and bring as a consequence material re-processing, such as repositioning products in the warehouse and picking the right ones. In the investigated context, the best method to avoid distraction errors is introducing an incentive system for operators.

Discussion

The case study revealed an advanced logistics process at the studied hospital, together with a high level of floor computerization, and the adoption of sophisticated technological tools. However, the application of the proposed methodology to the pharmacy service, and in particular FMEA and waste analyses, allowed identification of criticalities and suggested possible actions to deal with them.

Some suggestions are particularly key as they can be applied to multiple phases of the pharmacy's internal supply chain process and have significant margins for improvement. First of all, training courses on how to use information systems and computers, as well as warehouse equipment for storing and handling materials, should be conducted in order to make personnel familiar with these tools and get full benefits from them. Furthermore, teaching the basics of logistics management is highly recommended. This will allow people working in the pharmacy to self identify and correct problems and improve operational efficiency. Finally, one crucial improvement is the systematic adoption of floor pharmacists. These professional serve as a link between pharmacy and medical departments to support physicians in the choice of the drugs that are most appropriate for individual patients. In addition, they take part in logistics activities such as inventory management and order issuing to pharmacy.

Since the study highlighted that the hospital undertake organizational changes and innovations, the authors highly recommend the introduction of lean management and six sigma approaches to implement new ideas in an objective manner. These can lead to the reduction of waste, process rigidity, and variability.

5. CONCLUSIONS

The increasing need for improving hospital supply chains highlights the need for a careful investigation of existing processes and mapping of related risk flows. A detailed study will enhance decision makers' knowledge about challenges and suggest ways to meet them.

This paper proposes a four step framework integrating supply chain process analysis with a careful understanding and managing of sources of risks and waste. Following the proposed approach, decision makers can identify, implement, and review strategies driving them towards efficiency. The application of the approach to real setting highlighted that this innovative bottom up approach can uncover critical issues and offer possible solutions that emerged directly from process actors, thus stimulating hospital operators' and managers' commitment towards the methodology and allowing a more accurate and fruitful investigation.

Future research direction could involve integration between the suggested framework and performance management practices. In particular, the proposed approach should drive the identification of activities whose performance should be measured, along with the definition of specific metrics. In addition, the methodology could be used to, over time, know when and how to modify and update a performance evaluation system.

References

Begun, J.W. and Kaissi, A.A. (2004), "Uncertainty in Health Care Environments: Myth or Reality?", *Health Care Management Review*, Vol. 29, No.1, pp. 31-39.

Centers for Medicare & Medicaid Services (CMS) (2008), "National Health Expenditure Projections 2007-2017", available at: http://www.cms.hhs.gov/NationalHealthExpendData/25_NHE_Fact_Sheet.asp#TopOfPage (accessed April 23, 2008).

DeRosier, J., Stalhandske, E., Bagian, J.P. and Nudell, T. (2002), "Using Health Care Failure Mode and Effect Analysis ™: The VA National Center for Patient Safety's Prospective Risk Analysis System", *Journal on Quality Improvement*, Vol. 28, No.5, pp. 248-267.

Harris, A. (2000), "Risk Management in Practice: How Are We Managing?", *Clinical Performance and Quality Health Care*, Vol.8, No.3, pp. 142-149.

Hillson, D. (2002), "The Risk Breakdown Structure (RBS) as an aid to effective Risk Management", Project Management Professional Solutions Limited, presented at the Fifth European Project Management Conference, PMI Europe 2002, Cannes, France, June 19-20, 2002.

Hillson, D. (2003), *Effective Opportunity Management for Projects*, Dekker, New York.

Montgomery, K. and Schneller, E.S. (2007), "Strategies for Orchestrating Selection of Physician Preference Items", *The Milbank Quarterly*, Vol. 85, No.2, pp. 307-335.

O'Donovan, M. (1997), "Risk Management and the Medical Profession", *Journal of Management Development*, Vol. 16, No.2, pp. 125-133.

Organization for Economic Co-Operation and Development (OECD) (2003-2007), "OECD in Figures", available at: www.oecd.org (accessed March 27, 2008).

Project Management Institute (2001), *Practice Standard for Work Breakdown Structures*, PMI, Philadelphia.

Rafele, C., Hillson, D. and Grimaldi, S. (2005), "Understanding Project Risk Exposure Using the Two-Dimensional Risk Breakdown Matrix", 2005 PMI Global Congress Proceedings, Edinburgh, Scotland.

Singh, M. and Lévy, R. (2007), "Supply Network Risk Management Framework. Literature Review", White Paper.

Stamatis, D.H. (1995), *Failure Mode and Effect Analysis*, ASQC Quality Press, Milwaukee, WI.

Taiichi, O. (1988), *Toyota Production System: Beyond Large-Scale Production*, Productivity Press, New York.

Wagstaff, T. (1997), "Productive Use of IT in Support of FM Solutions", *Journal of Management in Medicine*, Vol. 11, No.6, pp. 382-387.