Risk analysis and mitigation strategies for pharmacy supply chain in Qatar

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Abstract

Qatar healthcare services are largely dependent on the state that makes huge investments in purchasing medicines from various parts of the World. This paper investigates into various risks that might impact the pharmacy supply chains and using interpretive structural modeling (ISM) technique models the enablers for effective management of these risks.

Keywords: pharmacy, supply chain, Qatar

Introduction

Today the key issues in supply chain management are the formation of the supply chain and its efficient coordination with objectives of customer satisfaction and sustaining competency. This requires complex flow of information, materials, and funds across multiple functional areas both within and among companies. To achieve this company must identify, evaluate, rank, and manage its supply chain risks. The sources of supply chain risks are many, as different links of a supply chain are exposed to different types of risks. Although it is impossible to completely eliminate risks from a supply chain, it can be reduced or we can say, organizations can better prepare themselves to neutralize them. This can be done if there is a shared understanding among supply chain partners of the variables that could impact the risks and the subsequent development of mitigation strategies.

A significant part of healthcare costs is the pharmaceutical component, which represented approximately $600 billion globally in 2009 (Kelle *et al*., 2012). Despite the size and importance of this industry around the world, especially in developed countries, the area of healthcare Supply Chain Management (SCM) has been given relatively little attention (Kelle *et al*., 2012). One of the recent trend in the pharmaceutical industry has been the global sourcing of both active and inactive ingredients from emerging economies where costs are lower. The long supply chain, with sourcing, manufacturing, packaging and distribution occurring in different locations globally, has increased the risks of contamination or substitution of alternative ingredients, as in

the case of the 2008 heparin accident (Maruchek *et al*., 2011). For a pharmacy supply chain, the interest is not simply the physical processes of conversion and distribution of materials but equally important is the "value-chain" perspective of managing the innovation and development processes through to capacity and production planning (Shah, 2004).

Interpretive Structural Modeling (ISM) can be used for identifying and summarizing relationships among specific variables, which define a problem or an issue (Warfield, 1974; Sage, 1977). In this paper, the enablers of the risk mitigation in pharmacy supply chains have been analyzed using the ISM methodology, which shows the interrelationships of the enablers and their levels. These enablers are also categorized depending on their driving power and dependence.

The main objectives of this paper are:

- to identify specific risks associated with pharmacy supply chains,
- to identify and rank the enablers of risk mitigation in pharmacy supply chains, and
- to find out the interaction among identified enablers using ISM

Risks in a pharmacy supply chain

Pharmacy supply chains can face disruptions due to many types of risks, some of the important risks identified with the help of literature review and discussion with experts are summarized below.

Product perishability: Thus is a critical issue in pharmaceutical/drug supply chains. In a 2003 survey, the estimated incurred cost due to the expiration of branded products in supermarkets and drug stores was over 500 million dollars (Karaesmen *et al*., 2011).

Manufacturers' decisions to cease production: As noted by Shah (2004), pharmaceutical companies secure notable returns solely in the early lifetime of a successful drug, before competition takes place. This competition-free time-span, however, has been observed to be shortening, from 5 years to only 1-2 years. Hence, the low profit margins associated with such drugs may be forcing pharmaceutical companies to stop production affecting the supply and cost.

Shortages: Many times, some of the drugs are manufactured by few companies and so there is no competition. Where competition has been lacking, shortages of some other lifesaving drugs have resulted in huge spikes in prices, ranging from a 100% to a 4500% increase with an average of 650% (Masoumi *et al*., 2012).

Counterfeit: It refers to the intentional and fraudulent production of drugs for economic gain. Sources of the problem are very much related to changes in the supply chain. They include internet pharmacies and sellers, often located in other countries, that distribute and sell counterfeit drug. Group purchasing organizations (GPOs) seeking lower costs for volume purchases may fall prey to counterfeiters and bring them into hospitals and other health care organizations.

Loss of integrity of the cold chain: Majority of the pharmaceutical supply chains can be classified as cold supply chains which requires items to be maintained under a particular temperature so as to avoid degradation in quality of the products. The risk lies in any disorder in time-distance or

temperature in the chain that could hamper the net present value of the activities and their added value in the cold chain (Bogataj *et al*., 2005).

Enablers of risk mitigation in pharmacy supply chain

In this paper 10 variables that can impact risk management in the pharmacy supply chain are selected based on literature review and through discussion with managers responsible for pharmacy supply chains.

Information sharing: Increasing the visibility of demand information across supply chain reduces the risks (Chopra and Sodhi, 2004). In studies by Lee *et al.* (1997a, b) it was concluded that information sharing can significantly minimize the consequences of the bullwhip effect.

Trust among supply chain partners: Lack of trust is one of the major factors that contribute to supply chain risks (Sinha, *et al*., 2004). According to Sahay (2003), in order to consciously reduce mistrust in existing relationships, supply chain managers must continually draw their attention to the benefits, which arise due to a certain degree of trust between both parties.

Responsive supply chain: Pharmacy supply chains need to be responsive in exigent situations. This might be an outbreak or disaster where the supply chain need to find the sources of supply and efficiently transport the medicines. Further, there is a need for more agile equipment which will shorten process cycle times by an order of magnitude and require minimal time for cleaning and changeover. This will avoid long campaigns and should lead to "pull"-based active ingredient manufacturing, and therefore more responsive supply chains (Shah, 2004).

Collaborative relationships among supply chain partners: In order to manage risk effectively in a supply chain, organizations are moving to adopt closer relationships with key suppliers (Giunipero and Eltantawy, 2004). Shah (2004) has shown that, to achieve the target service level, the finished goods stock can be approximately halved in the collaborative case. Another stream of research addresses how to assure supplier relationships that promote and provide incentives for safety with suppliers, including the implementation of cost-sharing contracts for recalls (Chao *et al*., 2009).

IT enablement of supply chain: Information sharing is facilitated by recent advances in information technology (IT) (Lee and Whang, 2000). Thus today's supply chains are highly dependent on IT enablement for effective and efficient performance.

Strategic risk planning: Formulating an appropriate and effective organizational strategy can to a certain extent mitigate supply chain risks (Finch, 2004). According to Chopra and Sodhi (2004), managers must do two things when they begin to construct a supply-chain risk management strategy. First, they must create a shared, organization wide understanding of supply-chain risk and secondly they must determine how to adapt general risk-mitigation approaches to the circumstances of their particular company.

Aligning incentives and risk sharing in a supply chain: According to Mentzer *et al*. (2001) a key component for supply chain management (SCM) is sharing both risks and rewards between the members of the supply chain A supply chain works well if the incentives of its member

companies are aligned which requires the risks, costs, and rewards of doing business are distributed fairly across the network (Narayanan and Raman, 2004).

Knowledge about risks in pharmacy supply chain: According to Harland *et al.* (2003), there are many different forms of supply chain risks which can be divided into different classes according to how its realization impacts on a business and its environment. By understanding the variety and interconnectedness of supply-chain risks, managers can tailor balanced, effective risk-reduction strategies for their companies (Chopra and Sodhi, 2004).

Continual risk analysis and assessment: To assess supply chain risk exposures, the company must identify not only direct risks to its operations, but also the potential causes or sources of those risks at every significant link along the supply chain (Norrman and Jansson, 2004).

Benchmarking supply chain practices: Benchmarking is a process of comparing performances either internally or externally through standards and indicators (Székely and Knirsch 2005). Pharmacy supply chains need to continuously benchmark their performance on responsiveness, and preparedness for contingencies.

ISM methodology and model development

ISM methodology helps to impose order and direction on the complex relationships among elements of a system (Sage, 1977). ISM falls into the soft operations research (OR) family of approaches. ISM helps to identify structure within a system of related elements. It may represent this information either by a digraph (directed graph) or by a matrix. Using the process view allows the researcher to pay explicit attention to the assumed nature of the causal relationships between the chosen variables (Anantmula and Kanungo, 2008). ISM model also portrays the hierarchy of the variables. The need of hierarchy is pressing as often the enablers considered together may seem equally important and sometimes overriding each other. Such a situation makes it difficult to have a clear mental model. The development of a hierarchy helps in the classification and categorization of the enablers, and thereby formulates their respective strategies and policies while providing clarity of thought. The various steps involved in the ISM methodology are applied in the following paragraphs.

Structural Self-Interaction Matrix (SSIM)

For analyzing the enablers of the risk mitigation, a contextual relationship of "leads to" type is chosen. This means that one variable helps to ameliorate another variable. Based on this, contextual relationship between the variables is developed.

Keeping in mind the contextual relationship for each variable, the existence of a relation between any two enablers (*i* and *j*) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of relationship between the enablers (*i* and *j*):

- V: Enabler *i* will ameliorate Enabler *j*;
- A: Enabler *j* will be ameliorated by Enabler *i*;
- X: Enabler *i* and *j* will ameliorate each other; and
- O: Enablers *i* and *j* are unrelated.

SSIM for enablers of risk management for pharmacy supply chain are presented in Table I.

Table I: Structural Self Interaction Matrix (SSIM)

Enablers	10	9	8	7	6	5	4	3	2
1. Information Sharing	V	V	V	V	V	V	X	X	V
2. Supply Chain Responsiveness	A	A	A	A	O	A	A	A	
3. Trust among SC partners	V	V	V	V	V	V	X		
4.Collaborative Relationships	V	V	V	V	V	V			
5. IT Enablement	A	O	A	A	A				
6. Aligning incentives and risk sharing policies	V	X	V	V					
7. Strategic risk planning	V	A	V						
8. Continual Risk analysis and assessment	V	A							
9. Knowledge about various types of risks in a supply chain	V								
10. Benchmarking									

Reachability matrix

The SSIM is transformed into a binary matrix, called the reachability matrix by substituting V, A, X, O by 1 and 0 as per the case. The rules for the substitution of 1's and 0's are the following:

- If the (*i*, *j*) entry in the SSIM is V, then the (*i*, *j*) entry in the reachability matrix becomes 1 and the (*j*, *i*) entry becomes 0.
- If the (*i*, *j*) entry in the SSIM is A, then the (*i*, *j*) entry in the reachability matrix becomes 0 and the (*j*, *i*) entry becomes 1.
- If the (*i*, *j*) entry in the SSIM is X, then the (*i*, *j*) entry in the reachability matrix becomes 1 and the (*j*, *i*) entry also becomes 1.
- If the (*i*, *j*) entry in the SSIM is O, then the (*i*, *j*) entry in the reachability matrix becomes 0 and the (*j*, *i*) entry also becomes 0.

Following these rules, and after incorporating the transitivities the final reachability matrix is shown in Table II.

Table II: Final Reachability Matrix

Enablers	1	2	3	4	5	6	7	8	9	10	**Driver**
1. Information Sharing	1	1	1	1	1	1	1	1	1	1	10
2. Supply Chain Responsiveness	0	1	0	0	0	0	0	0	0	0	1
3. Trust among SC partners	1	1	1	1	1	1	1	1	1	1	10
4.Collaborative Relationships	1	1	1	1	1	1	1	1	1	1	10
5. IT enablement of Supply chain	0	1	0	0	1	0	0	0	0	1	3
6. Aligning incentives and Revenue sharing policies	0	1	0	0	1	1	1	1	1	1	7
7. Strategic risk planning	0	1	0	0	1	0	1	1	0	1	5
8. Continual Risk analysis and assessment	0	1	0	0	0	0	0	1	0	1	3
9. Knowledge about various types of risks in a supply chain	0	1	0	0	1	1	1	1	1	1	7
10. Benchmarking	0	1	0	0	0	0	0	0	0	1	2
Dependence	3	10	3	3	7	5	6	7	5	10	

In Table II, the driving power and the dependence of each enabler are also shown. The driving power for each enabler is the total number of enablers (including itself), which it may impact. Dependence is the total number of enablers (including itself), which may be impacting it.

Level partitions

From the final reachability matrix, the reachability and antecedent set (Warfield, 1974) for each enabler are found. The reachability set consists of the element itself and the other elements which it may impact, whereas the antecedent set consists of the element itself and the other elements which may impact it. Thereafter, the intersection of these sets is derived for all the enablers. The enablers for whom the reachability and the intersection sets are the same occupy the top level in the ISM hierarchy. The top-level element in the hierarchy would not help achieve any other element above its own level. Once the top-level element is identified, it is separated out from the other elements (Table III). Then, the same process is repeated to find out the elements in the next level. This process is continued until the level of each element is found. Results for Iteration ii-Iteration vi are summarized in Table IV. These levels help in building the digraph and the final model.

Table III -Iteration i

Enabler	Reachability set	Antecedent set	Intersection set	Level
1	1,2,3,4,5,6,7,8,9,10	1,3,4	1,3,4	
2	2	1,2,3,4,5,7,8,9,10	2	I
3	1,2,3,4,5,6,7,8,9,10	1,3,4	1,3,4	
4	1,2,3,4,5,6,7,8,9,10	1,3,4	1,3,4	
5	2,5,10	1,3,4,5,6,7,8,10	5	
6	2,5,6,7,8,9,10	1,3,4,6,9	6,9	
7	2,5,7,8,10	1,3,4,6,7,9	7	
8	2,8,10	1,3,4,6,7,8,9	8	
9	2,5,6,7,8,9,10	1,3,4,6,9	6,9	
10	2,10	1,3,4,6,7,8,9,10	10	

Table IV-Iteration ii-Iteration vi

Iteration	Enabler	Reachability set	Antecedent set	Intersection set	Level
ii	10	10	1,3,4,6,7,8,9,10	10	II
iii	5	5	1,3,4,5,6,7,8,10	5	III
iii	8	8	1,3,4,6,7,8,10	8	III
iv	7	7	1,3,4,7,10	7	IV
v	6	6,9	1,3,4,6,9	6,9	V
v	9	6,9	1,3,4,6,9	6,9	V
vi	1	1,3,4	1,3,4	1,3,4	VI
vi	3	1,3,4	1,3,4	1,3,4	VI
vi	4	1,3,4	1,3,4	1,3,4	VI

Building the ISM-based model

From the final reachability matrix (Table II), the structural model is generated by means of vertices or nodes and lines of edges. If there is a relationship between the enablers *j* and *i* this is shown by an arrow which points from *i* to *j*. This graph is called a directed graph or digraph. After removing the transitivities as described in ISM methodology, the digraph is finally converted into ISM as shown in Figure 1.

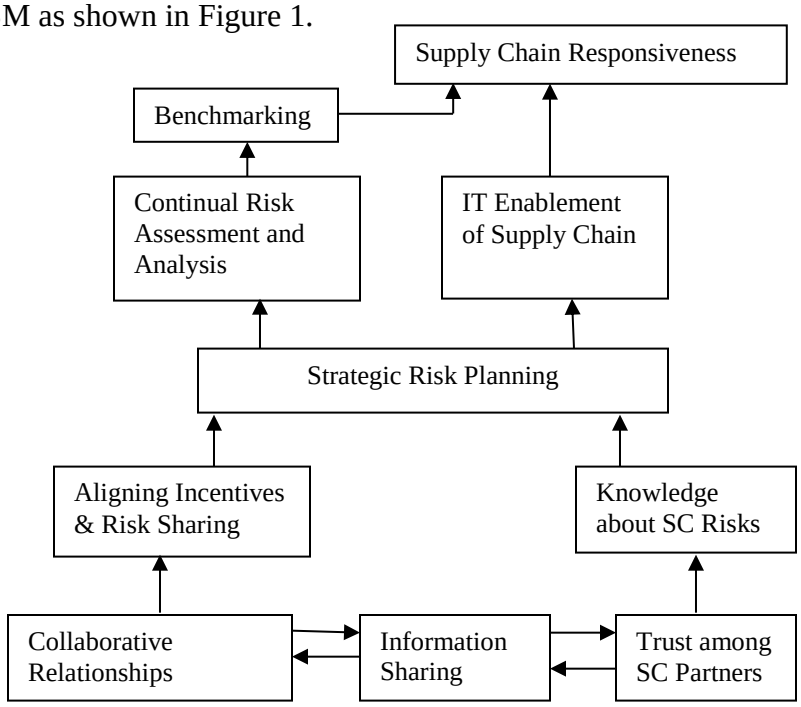

Figure 1: ISM based model for risk mitigation in a pharmacy supply chain

Discussion and Conclusions

The objective of the ISM model in this research was to develop a hierarchy of variables that would help to mitigate risks in pharmacy supply chain. A supply chain can counter the risks in an effective manner when all the partners in that chain trust each other and frequently share information which is facilitated by collaborative relationships among the supply chain members. Generally, risk analysis in pharmacy supply chains follows a single organization perspective but knowledge about risks expands when the whole supply chain is considered because new partners and new markets bring with them new forms of risks previously never been considered but may be very important for overall risk mitigation strategy.

An emerging area is that of rapid response vaccines and other treatments arising out of possible emergencies (e.g. bioterrorism or very fast developing epidemics). Again the traditional supply chain (particularly for vaccines) is very slow and unresponsive. If national governments are to implement emergency preparedness programs, the entire infrastructure must be well designed and tested through simulation (Shah, 2004).

Pharmacy supply chains in Qatar are dependent on global sourcing. Risks in global sourcing are related to delays and hold-ups in transportation, different negotiation cultures, language or cultural misunderstandings, and the sheer distances involved, making it difficult to know more about the supplier and ethical issues involved (Slack *et al*., 2001).

Risk control through government regulation and inspections may be ineffective in detecting all the risks that can occur at each point in a multitier supply chain, particularly when

the contamination is intentional or when there is fraudulent certification that the product has met all regulations and passed inspection (Tang, 2008). Grackin (2008) argues that risk prevention may be better served by using a total sourcing model, rather than the cost-based models that are commonly used in sourcing decisions. This can be achieved if firms focus on collaborative relationships with rewards and risk sharing policies.

The ISM model shows that to tackle risks in pharmacy supply chains require a careful consideration of issues like trust, collaborative relationships, information sharing which are of strategic nature. These variables assumes importance as they affect the supply chain's traceability. With respect to medical products, such as pharmaceuticals and medical devices, traceability is critical to detecting if a product is counterfeit while also deterring intentional contamination, adulteration and diversion of legal products. Companies must invest time and effort in developing not only standards and principles of safety for their suppliers, but must also invest in education and training to build the skills and abilities within the supplier network to assure product safety. The pharmacy supply chains also need to benchmark to improve its performance on different dimensions in particular responsiveness dimension as delays might turn costly due to the involvement of human lives.

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