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Introducing the Theory of Constraints-Based Methodology to Identify the Hospital Supply Chain Shortcomings

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Abstract: Performance improvement of the healthcare supply chain with minimum costs and maximum responsiveness is an important challenge of the hospitals. Theory of Constraints (TOC) as a continuous improvement philosophy can be applied to help organizations for achieving the above goals. In this study, we applied one of the TOC's Thinking Process (TOC-TP) tools to find critical constraints of the Hospital Supply Chain (HSC) in five major hospitals in Tehran the capital city of Iran. In particular, study on pharmaceutical supply chain and main drug distribution hub of country is discussed. Using questionnaire, the Current Reality Tree (CRT) was drawn to illustrate the Undesired Effects (UDEs), Root Causes (RCs) and finally Core Problem (CP) of the supply chain. It is found that environmental instability is the CP of the HSC in Iran which is located beyond the span of control and sphere of influence of HSC members. It is discovered that eight RCs in which four of them are in span of control and three are in sphere of influence of HSC members and one left out of both areas.

Key words: Theory of constraint thinking process, hospital supply chain, current reality tree

INTRODUCTION

In the profit and customer oriented market, the competition is no longer among organizations but among supply chains. A supply chain will not survive unless improve its performance continuously. A continuous improvement does not occur in a supply chain that could not identify their constraints. Constraints are bounding the productivity and performance that causes customer dissatisfaction and as a result decrease the market share. Therefore, identification of the constraints is a vital principal for supply chains especially in the hospital industry. Furthermore, since HSC is dealing with humans and lives, any shortage in supply chain functionality may lead to a considerable problem.

Theory of constraints is a well-known methodology to discover three main questions of a performance improvement project especially in complex systems; "what to change, what to change to and how to make changes" (Dettmer, 1997).

According to literature reviewed Eliyahu M. Goldratt in 1980s (Goldratt and Cox, 1984) introduced TOC as a method to find and solve problems of a system. This approach was soon became famous and being used among researches and practitioners. The TOC is applied to different industries and different majors.

Bashiri and Tabrizi (2010) use TOC methodology to propose a systematic approach in supply chain and to prevent from partial focus. They optimize the chain layout using such an approach considering the situation when new distributors are adding to the system. Tsou (2013) based on TOC, review the cooperation among members of supply chain focusing on the adjustment of inventory level in a dynamic manner.

Wu *et al.* (2007) utilized four tools from TOC-TP to find and analyze and resolve problems in an expert production system in the global automobile motor market. Similar study in service industry from exploits TOC-TP along with process engineering theory techniques to analyze organizational processes (Lacerda *et al.*, 2010). It considers complimentary aspects of both theories as well as their benefits for organizations.

Unfortunately, there are few studies about application of TOC in healthcare supply chain. Kriegel *et al.* (2013) identifies problems, requirements and visions in Germany healthcare system. Their study introduced the critical factors of hospital supply chain

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design. On the other hand, Kumar *et al.* (2009) determine the most effective and the most costly factors in healthcare supply chain. They use RFID technology to reduce the cost of the supply chain.

In this study, we describe an application of one of the tools of TOC-TP not only to recognize critical problem and factors of the hospital supply chain, but also to understand causal relationships among these factors. Using TOC-TP identification of the most important problems of the pharmaceutical supply chain and its core problem are discussed. Finding true problems of a complex system such as HSC and resolving these problems, which are the critical constraints of the system, can improve total performance of HSC with minimum costs and maximum responsiveness.

MATERIALS AND METHODS

Four steps are performed here which are given as following:

- Interviews are occured with key members involved in the pharmaceutical supply chain such as hospital managers, members of demand and supply departments and managers of distribution departments
- Preparation of a questionnaire based on the information from first step and also previous studies. In this questionnairey, 48 problems of healthcare

supply chain were listed as shown as in Table 1 and asked 40 participants whether each problem exists in pharmaceutical supply chain or not. The partakers who take part in this study are engaged in different parts of supply chain, such as: Demand and supply management department, pharmacies, warehouses, distribution management department, IT department, etc. Of 40 questionnaires distributed, 37 questionnaires were complete and verifiable

- Building Current Reality Tree (CRT) based on the information from previous steps. A CRT is a logical structure including some sort of snapshot of the current status of a given system and indicates the state of reality. The CRT is made up of cause and effect chains as an outcome of a particular set of evidences. The CRT looks for cause-and-effect relationships among visible conditions of a system way back to the original causes that produce them. The important point about CRT is that it illustrates functional aspects of the system rather than seeking organizational entities. Moreover, it produces a faithful representation of the system as it is blind to external system boundaries
- Using Categories of Legitimate Reservation (CLR) which are proof-reading tools to verify the validity of entities and arrows in casual relationships. The CLR ensures a logical consistency among tree entities and results in an improved tree. All relationships that pass CLR tests are sound

Table 1: Forty eight problems of healthcare supply chain

Health care problems	Health care problems
Drug overstocking	Drug corruption due to exp. date
Lack of proper warehousing instructions	Lack of proper warehousing facilities
Impossibility of performing storage policies due to shortage of budget	Materials management considering the diversity of products
Inappropriate ordering of drugs	Overstocking unnecessary drugs due to wrong demand forecast
Sudden lack of supply	Sudden price changes
Non-compliance with insurance obligations	Inability of economic exchange at the global level
Lack of proper demand forecasting	Lack of proper storage facilities
Shortage of capital for safety stock storage	Buying drugs with improper delivery due date
Inappropriate distribution planning	Shortages of essential drugs, due to inaccurate demand forecasts
Shortage of packaging containers due to environmental conditions	Improperly performed activities due to lack of sufficient expertise
Improperly performed process due to individual faults	Improperly performed process due to lack of inspections and quality control
Processes performed incorrectly due to poor material storage	Processes performed incorrectly due to improper sorting of materials
Inefficiency of distributors	Inappropriate management of products' distribution
Delivery of wrong drugs on due date	Occurrence of errors in orders' submissions
Lack of proper distribution planning	Lack of distribution facilities
Lack of distribution experts	Diversity of distributors
Drug corruption due to improper warehousing	Lack of access to medicines in certain circumstances
Shortage of materials management professionals	Shortages of essential drugs, due to environmental conditions
Materials management considering the diversity of suppliers	Processes performed incorrectly due to incorrect process design
Sudden demand	Improperly performed process due to crisis
Problems occured in distribution centers (incorrect orders' submissions)	Monopoly in some drugs' supply
Shortages due to a sudden increase in demand in times of crisis	Undelivered drugs on due date
Expiry date of drugs' inventory	Lack of supply of some products in particular times
Inappropriate policies	Distribution delay

There are eight reservations include: Clarity, entity existence, causality existence, predicted effect existence, insufficient cause, additional cause, cause-effect reversal and tautology.

RESULTS

Using data from questionnaires, we list a group of undesirable effects (UDEs) are prepared and started to build CRT. Based on interviews and previous studies, we select the five most important UDEs which are: Overstocking of unessential drugs, lack of drugs, inefficient distribution, non-compliance with insurance obligations and improper execution of processes. Each UDE is the beginning of a branch of CRT. As "high costs of supply chain" was the most important problem of HSC, we connect all five UDEs to this major problem. Using cause and effect logic, we continue to make every branch downwards to achieve a Root Cause (RC). The RC is an entity with no incoming arrow and some outgoing arrows. Then, incorporation of all branches used to achieve the complete CRT (Fig. 1). In this figure, we used boxes with dotted lines to show five UDEs, light gray boxes with bold lines to display RCs and a single dark gray box with extra bold line to present system's CP. The rest of the boxes are intermediate effects. Each arrow represents a cause and effect relationship. The directions of arrows are from cause to the effect entity. After finalizing the CRT, we used Categories of Legitimate Reservations (CLR) to check the validity of CRT.

By the definition, the Core Problem (CP) of the whole system is the one which is responsible for at least 70% of UDEs. Based on the above mentioned analysis, it is found that "Environmental Instability" entity met the criteria.

Hence, it is the core problem of pharmaceutical supply chain.

DISCUSSION

Through interviews with members involved in healthcare supply chain we found that the CP of the system is located beyond the span of control or sphere of influence of supply chain members. Therefore, the members of healthcare supply chain are not able to resolve the problem or influence on it. In such situations, we should find other root causes which are located in span of control or sphere of influence of members involved. The root causes of the system are as follows: Inappropriate healthcare policies, lack of budget,

monopoly in some products' supply, individual faults, diversity of distributers, lack of proper warehousing instructions, sudden increase in demand in crisis and an epidemic of disease.

Among these root causes, four of them are located within the span of control of the members involved in HSC including Individual faults, Diversity of distributers, lack of proper warehousing instructions, sudden increase of demand in crisis. Indeed the members of HSC can directly influence and resolve the problem via appropriate preventive policies. Three root causes are located inside of sphere of influence of supply chain members including inappropriate healthcare policies, lack of budget and monopoly in some products' supply. In the other word, the members involved in HSC may have indirect influence on problems by convincing upper levels of managements at the country level. The last root cause which is "An epidemic of disease" is located beyond the span of control of HSC members, which means the members cannot have any influence on the problem.

There are some similarities and differences between our findings and related studies. In the literature, there are different studies that try to investigate UDEs and problems in the HSC similar to this stdy. The following problems are discussed in the study of Beier (1995), Lauer (2004) and McKone-Sweet *et al.* (2005) that can be considered as UDEs or root causes of the HSC:

- The HSC is highly dependent on individual physicians. They may elevate a drug or device over another because of many different reasons including their education institutions. This may cause some monopolies in the HSC and may affect its performance
- High diversity in the stockholders in terms of expertise causes more complexity in the chain. Different specialists such as nurses and pharmacists work in autonomous entities in the chain
- Basic awareness about SCM in the hospitals causes some shortcomings in HSC
- HSC is sensitive in terms of accessing resources (including human resources) at the right time and place (Rego and de Sousa, 2009)

Among the above mentioned problems, the monopoly which causes some factors, looks similar to our finding while the rest of the problems look different. The difference is mainly because of the strong geopolitical differences between Iran and other countries that makes our environment very special.
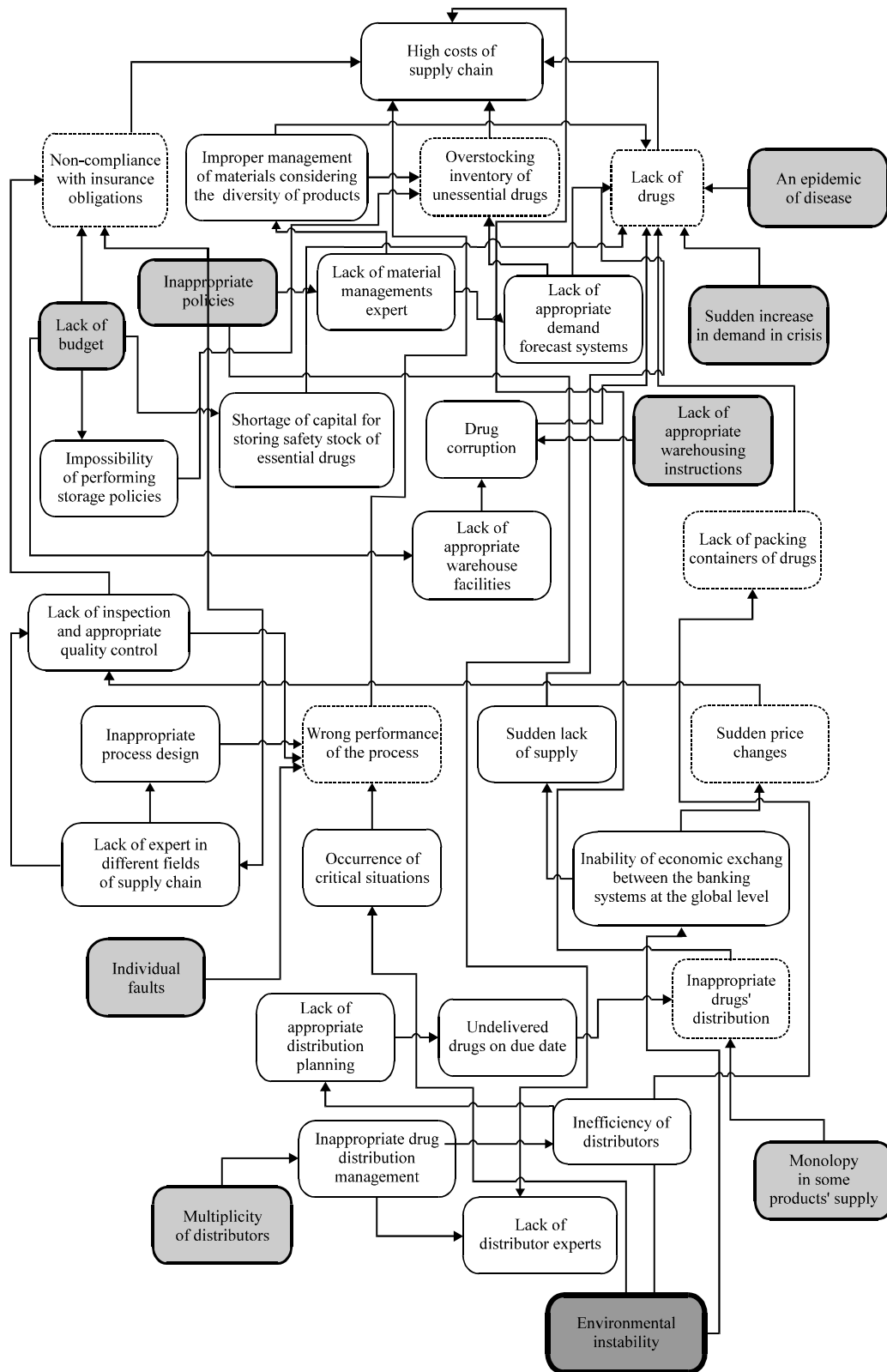
Fig. 1: Complete current reality tree

CONCLUSION

In this study, we used one of the tools provided by Theory of Constraint's Thinking Process to model healthcare supply chain in five major hospitals in Tehran, the capital city of Iran. In particular, this study focus on pharmaceutical supply chain and studied the main drug distribution hub of the country. This study used current reality tree to find root causes and the core problem of the pharmaceutical supply chain. To the best of our knowledge, this study is the first effort towards modeling healthcare supply chain using Theory of Constraints in the country. It is believed that this could be useful tool for high level decision making of the healthcare supply chain.

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