Inventory Management in Healthcare Supply Chain under Uncertainty and Emergency: A Literature Review

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Abstract--- Pharmacy have important role in the success of healthcare system because of the cost invested in product and inventory storage. Minimize inventory costs and maximize the quality of healthcare service must be achieved in the healthcare industry. Hospitals as healthcare service providers have a significant role in the healthcare industry. Supply chain disruption such as a natural disaster can affect the inventory level and quality of health services at the hospital. This paper presents a literature review of logistic and inventory management in healthcare that are related to an emergency and uncertainty situation because of natural disasters. Some research opportunities in the field of healthcare logistic and inventory management in disaster situations will be discussed and may be addressed for future research.

Keywords--- Inventory Management, Healthcare, Natural Disaster, Logistic, Uncertainty, Emergency.

I. Introduction

In the healthcare industry estimated investment cost for inventory pharmaceutical component ranges between 10% -18% of total revenue [1, 2]. Inventory investment cost in the healthcare industry to provide a challenge for researchers to conduct studies in the field of Supply Chain Management (SCM) and Operations Management (OM). So research in the field of SCM and OM in the healthcare system showed an increasing trend in the last ten years [3]. Inventory management became one of the issues addressed in the SCM field and OM in the healthcare system, but a research that addresses issues of healthcare inventory management (HIM) considering the emergency situation is still relatively little attention by the researchers.

Disasters can result in great damage and loss of lives. To mitigate the impact of the damage and loss that caused by the disaster, a study in pre-disaster, during disaster and post-disaster issues have been carried out in recent years [4]. Almost all kinds of disastrous consequences of health disorders which caused by disruption of sanitation, lack of water, cleanliness and poor environmental conditions and routine health problems that afflict the victims [5]. When a disaster occurs, typically the demand for medical needs will increase sharply. Healthcare logistics management must have the resilience to face disaster crisis in order to meet all medical needs [6]. Healthcare as a commercial industry was expected to achieve efficiency in inventory cost. On the other hand, healthcare as health care providers are required to maximize the quality of health services. The combination of healthcare as an industry and the health care provider are considering a disaster situation will be an interesting issue to be discussed [40].

In the last ten years, the International Federation of Red Cross and Red Crescent Societies (IFRC) in [7] reported that the numbers of natural disaster occurrences are still relatively high about 3809 events in the world (Fig 1). The amounts of disasters encourage researchers to conduct research in the field of disaster management or disaster supply chain (DSC). So research in the field of disaster management into a research area that has a potentially quite large [8]. The issues which often have been discussed are how to make a framework for disaster management and logistics management. The framework discussed about coordination, collaboration and integration between the parties involved in disaster operations. In the field of logistics management, hot issues studied on the distribution and supply of materials for the needs of the disaster relief. Because of the importance of disaster problem, many researchers are interested and challenged to create a framework of disaster operations and logistics management more effective and efficient, as in [8, 9, 10, 11, 12] and others.

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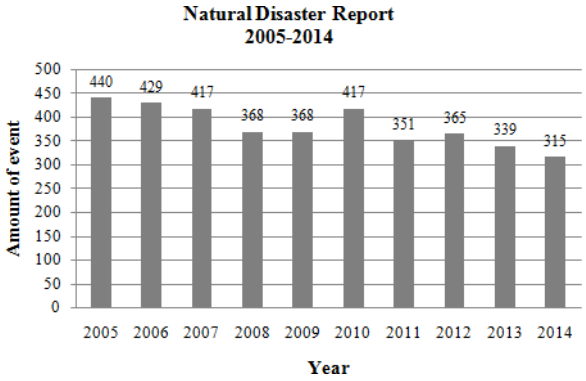

Fig. 1: Number of Reported Disasters, by Type of Phenomenon

(Source: EM-DAT, CRED, University of Louvain, Belgium)

Most papers that discuss the handling of the disaster are still talking logistics operations in general. Research that specifically discuss logistical operations in the healthcare supply chain (HSC) in disaster situations is still a little [14]. One of the most important activities to meet requests for assistance during disaster relief operations are logistics and supplies [15]. Medical logistics and inventory needs are an important part of the DSC. So the issues are discussed logistics and medical inventory in healthcare to disaster situations would be an interesting study. In this paper we will discuss research opportunities in the area of HSC in disaster relief which focuses the field of logistics and inventory management [37-40].

Inventory and Control Management in Healthcare

Inventory management is a science that studies how to set the appropriate amount of inventory and the maintenance costs are minimal. Inventory management which is able to achieve a good level of inventory will be able to improve the supply chain performance [16]. Therefore, a good inventory management required to achieve the performance of supply chain efficient and effective [36-38].

Inventory control is an inventory management processes that regulate the amount of inventory in order to meet customer needs at the lowest possible cost and minimal investment [17,35]. To achieve optimal inventory costs, some researchers have proposed a numerical method [18] and simulation [19]. Al-qatawneh & Mohammed in [19] proposed a simulation method by evaluating inventory management costs item based on the need of critical products, service level and consumption level in hospitals (healthcare).

Pharmaceutical plays an important role in the healthcare industry because of the significant cost in products, storage and control needs [2, 19]. Therefore, the investment cost of pharmaceutical optimal inventory the main goal to be achieved in the Healthcare Supply Chain Management (HSCM). In such cases, the inventory management in healthcare are fully responsible for the performance efficiency of the healthcare supply chain. Inventory management capabilities to plan and manage inventory levels will be able to determine the level of customer satisfaction with the service needs of the medical / pharmaceutical (drugs). In the process of health care delivery, medication is an important component that must be met [21,36]. Unavailability of medicines when needed will be able to lower customer satisfaction and jeopardize patient safety. Therefore, healthcare management is required to achieve a high level of inventory

Management's ability to plan and set the amount of medical supplies in the healthcare system will be able to influence the health care supply chain performance. So the inventory levels of medical needs can also affect the quality of health services. Unavailability of supplies medical needs in the process of health care delivery will be able to jeopardize the safety of patients. Inventory management in the healthcare system became a field of research that is much in demand by researchers in recent years.

II. Methodology

In this paper we have collected and randomly selected number of papers related to the healthcare area that concentrate discussion on issues in the field of logistics and inventory management. Some papers are obtained through www.sciencedirect.com with the keyword "Healthcare Inventory" and "Healthcare Inventory in Disaster". Paper in the healthcare area is classified into two types: Healthcare Supply Chain (HSC) and the Healthcare and Disaster Supply Chain (HDSC).

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On the HSC area have been selected some paper that discuss the field of logistics and inventory management with regular demand patterns. By contrast, in areas HDSC have been selected with irregular demand patterns such as uncertainties and emergency due to a disaster. After that, we are discussed based on the research methods and problem formulation approach. From the analysis and discussion are expected to be obtained many directions of research that can be done in the future, especially focusing the field of logistics and inventory management in healthcare for disaster situations.

III. Results

The papers selected can be classified based on the interest area, goal and solution methods (see Table I). Based on the purpose of research, studies in the field of logistics and inventory management of healthcare can be grouped into four functions goal of achieving the fulfillment of demand satisfaction, increase profits, minimize inventory costs and distribution time. Furthermore we classified papers based on solution method namely numerical approach, simulation/dynamic system, information system, statistical description and qualitative analysis.

As in Fig 2, paper selected have been grouped are based on the both of research area, HSC and HDSC in sequence from the highest obtained 9 papers and 6 papers. This result show that HDSC area is still less than the HSC area. In general, research in the HSC area is still considering the logistics and inventory management operations under normal conditions without supply chain disruption caused by the disaster.

Solution methods were used to obtain optimum solutions and analysis of the problem are with the numeric calculation (8 papers), simulation (3 papers), statistical description (1 papers), information systems / IT (2 papers) and qualitative analysis (1 paper). Numerical methods have become a research solution which are more interest than to other methods. Mathematical models in inventory and logistics problems would be more easily resolved by using numerical methods. Therefore, some researchers prefer to use numerical approach.

Stochastic Programming logistics and inventory levels (see Table II). Number of paper based on the research object in order from the highest, namely, optimal inventory (9 papers), logistic operation (4 papers) and inventory levels (2 papers). The papers are classified based on the objective function namely the optimal inventory, operational

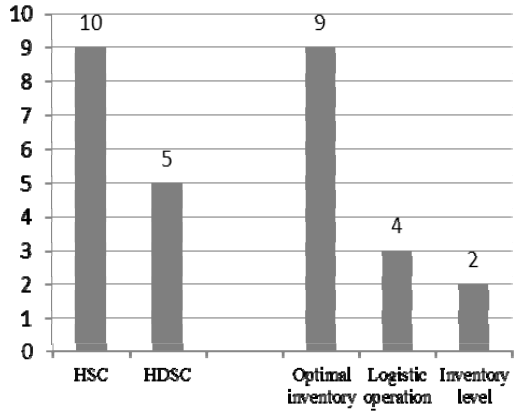

Fig. 2: Number of Paper based on Research Area and Object Function

IV. Discussion

The researchers on HSC generally discuss about how to improve performance in the healthcare supply chain. HSC important parts are the logistics and inventory management operations. Studies in the field of logistics and inventory management for healthcare is usually focused on four important parameters, namely the amount of inventory, distribution time, the allocation of the placement and maintenance costs. To achieve optimization in all four parameters were carried out various strategies that information sharing [5], collaboration [24, 31] and IT integration [22, 25, 32] in the healthcare supply chain system. Optimal inventory in healthcare will be able to improve the efficiency of supply chain performance. To increase performance efficiency in inventory management at the level of decision strategy can also be through controlling on service level (emergency refill workload), available space (depending on the variety of drugs-formulary), and the number of orders (refill workload) per day [2].

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Target operational efficiency in healthcare is to manage logistics operations and inventory system in order to achieve a minimum investment costs. Al-qatawneh & Mohammed in [19] say that hospital management always concentrate on optimizing the operational costs of logistics in HSC.

Solution methods which are used by researchers in solving problems for the mathematical model of inventory and logistics, namely simulation [18, 23, 27-50] and numerical solution [26, 19, 28]. Simulation methods are commonly used to determine changes in the scenario associated with inventory management and logistics. As did Al-qatawneh & Mohammed in [19] which uses simulation methods to evaluate how the cost of inventory management can be optimized using a classification system based on products that are critical item in the healthcare system. [24] also uses dynamic simulation system for analyzing and evaluating the relationship between logistics outsourcing, cost and performance of healthcare to investigate changes in the key variables of the logistics provider. To overcome the problems of mathematical models in search of the optimal inventory solution can use numerical methods. Uthayakumar & Priyan in [18] proposed numerical solutions to develop procedures for determining the optimum solution for inventory lot size, lead time, and number of deliveries to reach hospital customer service level (CSL) with a total minimum cost for supply chain.

A formulation problem in studies in the field of logistics and inventory management in the HSC can be done with two approaches, deterministic and stochastic. Deterministic approach has been made by Uthayakumar & Priyan in [18] who proposed the model of pharmaceutical product inventory optimization by integrating two-echelon supply chain in healthcare, the pharmaceutical industry and hospitals. With the integration between healthcare echelon supply chain is expected to achieve high inventory levels and effective inventory policies. Furthermore Priyan & Uthayakumar in also developed a model in healthcare pharmacy inventory optimization with fuzzy stochastic approach. The achievement of the inventory level is intended to avoid a shortage of medicines in healthcare. Shortage of drugs is a condition that greatly avoided by healthcare inventory management. To prevent shortages of medicines in healthcare facilities because of uncertainty disruption and demand, Saedi et al. in [31] proposed a stochastic model to find the optimal inventory policy. The risk of medicines shortage can also be avoided with a demand forecast approach. Niakan & Rahimi in [30] developed a mathematical model to minimize total inventory and transportation costs of medicines in healthcare facilities by minimizing forecast errors which caused by product shortage and the amount of drug expired.

The pattern of healthcare demand on normal operation without supply chain disruption shock is mentioned to as a regular condition. On the other hand when healthcare supply chain gets disruption such as disaster occurred is said to as a surge condition. Differences in the pattern of demand that are regular and surge can be approximated by a combination of several areas, such as healthcare inventory management and humanitarian supply chain management. To solve the both problem, Roni et al. in developed a stochastic model based on hybrid inventory policy with both regular order and emergency to response regular demand and emergency as a result of the disruption.

Most natural disasters have a stochastic pattern, such as hurricanes, floods, infectious diseases (dengue, diarrhea, respiratory infections, etc.). Some types of disaster can be affected by climate change. Region climate has the relative same of time pattern within a specified period. By knowing the pattern of climate data change then we will be able to forcast a disaster occurrence and the number of demand. Inventory planning will be done if the pattern of disastrous events can be predicted. As performed by Davis et al. in [33] who proposed the stochastic programming model to determine what needs should be placed and distributed among warehouses during a hurricane. Planning placement of inventory, capacity and coordination between the networks by using the disaster predictions are intended to avoid shortages of goods when disasters occur. One of the natural disasters that have a seasonal pattern is the influenza epidemic outbreak. Planning inventory and distribution model of influenza vaccines to cope with disaster outbreaks of epidemic diseases has been proposed by Hovav & Tsadikovich in [29]. Author in [29] have developed a mathematical model to optimize the cost of influenza vaccine supply chain.

When a disaster occurs, it usually will be increased demand quickly. Disaster needs of the most basic are food, drink, clothing, shelter and drug. Drug is one of the most important needs and emergencies. Hospital as healthcare service provider is required to meet all the medical needs such as medicines. So that healthcare inventory management should be make a planning strategic to fulfil any demand. For the types of disasters that have history patterns, predictions of disaster can also be used to plan the number of medical needs that should be provided by healthcare when disasters occur. As performed by Mete & Zabinsky in [22] which proposes a stochastic optimization approach to planning the storage and distribution of medical supply in responding to the earthquake. The capability of logistics and inventory management in healthcare to forecast disaster response planning could affect supply chain performance.

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Logistics and inventory healthcare planning become very important in handling disaster situations. The availability of drugs in the healthcare during a surge in demand for medical needs will be able to save many human lives.

Hospital in disaster relief has a significant role, particularly in supplying drugs to patients. Hospital as health care provider should be able to cope an uncertainty and emergency of demand in humanitarian operation. Knowledge and skill to manage the drugs supply chain by effectively and efficiently in service providing on the hospital to cope extreme condition becomes very important. Unavailability of medicines when there is a surge in demand caused by the disaster will be able to endanger human safety. Therefore an inventory shortage in hospital must be avoided. However, Author in [21] found an imbalance between the amount of available drugs with the number of patients affected by epidemics diseases such as acute respiratory infection (ARI), diarrhea and malaria. Problems of drugs shortage in hospitals are very risky and harmful. To overcome these problems needs the capability to plan needs medicine that can forcast the demand for drugs in extreme situations. Therefore a good inventory planning of drugs in hospitals to respond disaster event is become very important and urgent

Research in the field of logistics and inventory management in healthcare that addresses the catastrophic situation becomes very hot issue discussed by researchers in the world. Saedi et al. in [31] said that inventory management in healthcare aims to minimize inventory shortages and maximizing the quality of service. Inventory shortage of drugs is a situation that is avoided by the logistics and inventory management of healthcare. Techniques to obtain the optimal amount of inventory and maximize the quality of service in healthcare are challenge for researchers. Therefore, research in the field of logistics and inventory management can still be expanded again, especially considering the conditions of uncertainty and emergencies such as natural disasters.

V. Conclusion

Healthcare Supply Chain and Disaster Supply Chain have different demand characteristics. Healthcare Supply Chain in the commercial industry has a characteristic demand regular and considers the benefit cost in its operations. Instead, Disaster Supply Chain in the disaster reliefs has an irregular pattern of demand and prioritizes social services. The combination of the characteristics of demand in the healthcare supply chain and humanitarian logistics would be a challenging study. So that research in the area of healthcare that considers the situation as a disaster emergency and uncertainty will be an interesting challenge. Based on the discussion a number of papers above, it can be taken several conclusions that can be used toward future research in the field of logistics and inventory management of healthcare in disaster reliefs, namely:

1. The study that focuses on the fields of logistics and inventory management in Healthcare and Disaster Supply Chain area with inventory optimization attribute to achieve minimal investment costs and high inventory levels.
2. Most natural disasters have a historical pattern, so that the inventory planning which consider the stochastic approach could be a solution to overcome the problem in disaster relief.

Acknowledgment

On this paper, the author presents only several paper which are obtained and related with the future of author research. This paper is still need any suggestion from other researchers for extending discussion in the next research. So that, the author could get more comprehensive study and become an addition information beside other researches before.

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