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Full Length Article

Medicine supply chain model for an integrated healthcare system with uncertain product complaints

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ABSTRACT

To date, multi-period optimization using modified interactive multi-objective fuzzy programming for an uncertain number of product complaints in the medicine supply chain, has not been sufficiently reported in the literature. Therefore, the aim of this paper is to formulate and optimize a multi-period, multi-objective medicine supply chain model for an integrated healthcare system. It considers an uncertain number of medicine complaints received by manufacturers. The multi-objectives are time, quality and cost and their combination is called the business triad. This research comprises three steps. Firstly, the formulation of a mathematical model for the business triad. Secondly, the modified interactive multi-objective fuzzy programming has been suggested for the optimization of business triad. The proposed approach uses fuzzy linguistic variables and a triangular membership function that integrates expert opinion along with their experience. Finally, a numerical example is used to elaborate the practical significance of the model. The results of the numerical example showed a 31.95% satisfaction level for the cost, 41.99% satisfaction for the time, and 92.90% satisfaction for the quality of the medicines. This supply chain model assists decision makers in the healthcare systems to procure medicines with the required satisfaction level in terms of quality, time, and cost.

1. Introduction

Recent technological, organizational, and economic advancements in healthcare systems have provided increased access of treatment to patients. According to a report by the World Bank, world death rates have been reduced from 17.8 in 1960 to 7.75 per thousand people in 2014 [1]. There have been many driving factors behind this reduction in the death rate such as improved treatment, availability of medicines, and better-equipped healthcare facilities. Despite these advances, improvement in healthcare infrastructure and supply chain management is inevitable. Therefore, the availability of the right medicine with the right composition for the right patient in the right quantity at the right time is essential for patient's safety and recovery [2].

In this paper, we focus on the supply chain of medicines among manufacturers, health department, and healthcare system. Fig. 1 shows two channels in the medicine supply chain. The first channel links the manufacturers, distributors or pharmacies, clinics, and finally the patients. The second channel connects the manufacturers, hospitals, hospital pharmacies, and patients. Although both of these channels are equally important, the second channel is more focused because low or average income people usually visit hospitals for treatment instead of private clinics. In developed countries, the healthcare department of the government controls the hospitals and the medicine supply chain. Therefore, the role of the government must be considered in the medicine supply chain. Government policies and strategies decide the rules and regulations of medicine supply chains. The term integrated healthcare system refers to pharmaceutical companies, health departments, and hospitals. Fig. 2 shows the integrated healthcare system.

The traditional healthcare supply chain is limited to pharmaceutical companies, hospitals, and patients. In the proposed research, we consider an integrated healthcare system which also includes the government (health department). This integrated network involves the flow of medicines and information among pharmaceutical companies, health departments, and the network of hospitals. The health department consists of drug testing laboratories, and provides quality services to pharmaceutical companies. It is administered by government officials including pharmacists and other administrative staff. The healthcare department defines, verifies,

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0278-6125/

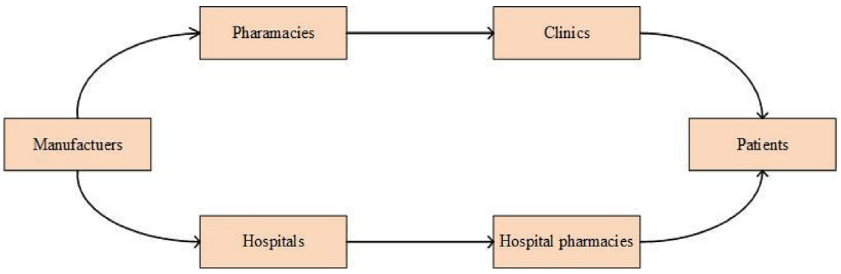

Fig. 1. Channels of the medicine supply chain.

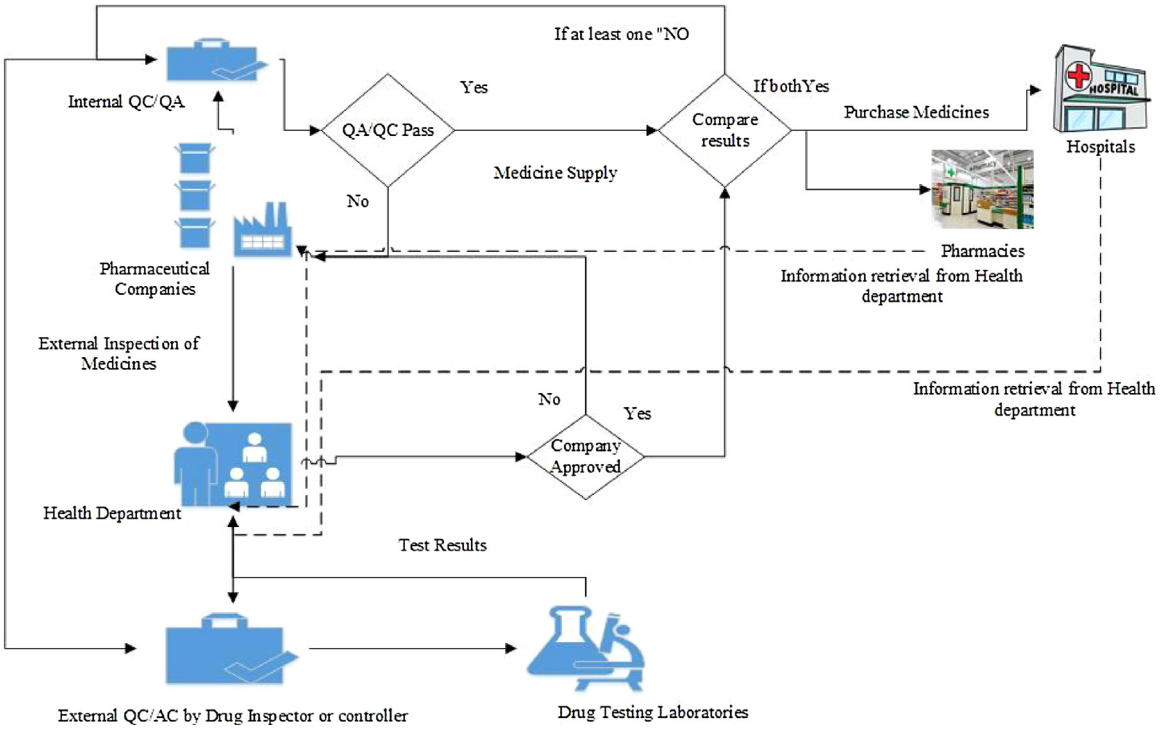

Fig. 2. Integrated network of healthcare systems.

and approves the drug standards keeping in mind the government's rules and regulations in the drug manufacturing and supply chain. The demand for medicines is generated by hospitals that select the best medicine supplier on the basis of time, cost, and quality. The health department approves the quality of medicines and communicates it to the network of hospitals. The medicines received at hospitals should be quality ensured by both pharmaceutical companies and the government (health department).

This research presents a supplier selection and order allocation model in multi-periods for an integrated healthcare system with multi-objectives. There are three main objectives: time, cost, and quality. The combination of objectives is called the business triad. Time includes the production time, inspection time, and transportation time. The cost is composed of the production cost, logistics cost, product cost, and quality assurance cost. The quality of medicine is measured by the number of complaints received by the manufacturer per million units of medicine released. It has been found from the literature that the conventional medicine procurement process usually consists of cost and on time delivery. Very few researchers have focused on quality in the supply chain of medicine [3–5]. Also, a combination of time, quality, and cost has not been widely addressed in the medicine supply chain.

It is very difficult for healthcare systems to analyze the performance of a medicine by relying only on the medicine consumer's perspective. Therefore, healthcare systems have their own quality assurance divisions for medicines. The quality control department ensures the quality of medicines in terms of composition (conformance), durability (expiry date), reliability (no side effects), and cost. The quality of medicines is ensured at each node including the manufacturer, health department, and hospitals. Although pharmaceutical companies try to ensure the quality of medicines, the chance of shipping low-quality medicines still remains due to human error, technical, and/or environmental issues. The quantification of the quality of a medicine from the patient's perspective is very difficult; therefore, the number of complaints received is a more practical criterion for quality assessment.

The supply chain of medicines is a multi-period process because of the continuous requirements of medicines. Therefore, the number of medicine complaints received in a specific period is uncertain. To model a random process or event, a random variable is used that is a function defined on a sample space. Functions defining the random variable are very few for which a probability distribution exists. As the number of complaints received within a period may or may not follow the same distribution for all periods, identification of the exact distribution of the data in every period is very challenging. Moreover, probability theory provides good predictions of historic events. However, fuzziness unfolds into new situations that have not been seen before [6]. It is also difficult to