Simulation Models to Enhance Distribution Networks in Pharmaceutical Supply Chains

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***Abstract*— This paper emphasis the most important factors to be considered when designing distribution network for pharmaceutical supply chains (PSC). Pharmaceutical products are clustered based on their prominent characteristics and distribution network models are developed to simulate the pre-identified clusters of the pharmaceuticals. These models helps to make strategic decisions such as designing and operating different distribution networks to better suit the product characteristics of a given PSC in order to deliver better quality products to the patients in need.**

Key words: - Distribution networks, Pharmaceutical supply chain, Simulation and modelling

I. INTRODUCTION

At present, the distribution process of the Pharmaceutical Supply Chains (PSC) is more important than those of other commercial goods and services. When considering about the demand and supply characteristics, pharmaceutical products have some special characteristics rather than the other commercial products [1]. Hence their distribution from the manufacturers till the final consumer is heavily regulated to ensure that drugs are accessible, affordable, and safely consumed. According to the statistical reports, it costs an outrageous amount of money to distribute pharmaceutical products all around the world, since the distribution networks of PSC are not well-managed, thousands of patients have to suffer and significant amount of investments are wasted.

According to the literature, PSC are inherently dynamic and risky process. The movement of pharmaceutical products from manufacturer to its consumer involves multiple players such as suppliers, manufacturers, distributers, pharmaceutical benefit managers, health insurance companies, hospitals and pharmacies [2]. Therefore, pharmaceutical distribution process becomes highly complex and fragmented.

When consider about all the other approaches for network optimization simulation and modelling techniques are well-founded to address aforementioned uncertain environments [3]. When using simulation and modelling techniques, it is composed to use different sourcing policies, different number of players and to model inherent product characteristics in order to determine the most suitable network design need to be use.

II. METHODOLOGY

The author concentrated to develop most efficient distribution network design for PSC. At the first stage of the study the author arises with a review of literature on PSC in order to identify fundamental characteristics in PSC. According to the literature it is difficult to use typical distribution network designs for PSC, since there are special characteristics to be consider.

As the literature emphasis it is ineffectual to use same distribution network for all the pharmaceutical products since one product is highly deviated from the other product [4]. Therefore, at the second stage of the study pharmaceutical products are clustered based on their prominent characteristics. The author has identified four main pharmaceutical product clusters as mentioned in the Table 1 throughout the literature [5], [6].

Table 1-Pharmaceutical Product Clusters

No	Cluster Name	Description
1	Time Sensitive Pharmaceutical Product Cluster	Products should be distributed within minimum time period
2	Hazardous Pharmaceuticals Product Cluster	Products should be transported individually
3	Hybrid Pharmaceutical Product Cluster	Products should be transported individually and within minimum time period.
4	General Pharmaceutical Product Cluster	Products can be distributed as the commercial goods.

The models related to the each and every cluster are designed based on the prominent characteristics of the products. Then the different simulation models are build using simulation and modelling tool. The models are compared by running interactive sensitivity analysis. The models are analyzed with respect to different scenarios with predefined KPI related to each cluster as mentioned in the Table 2.

Table 2-KPI for Pharmaceutical Product Clusters

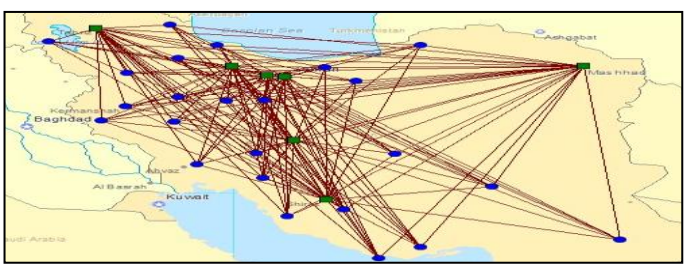
No	Cluster Name	KPI
1	Time Sensitive Pharmaceutical Product Cluster	Distribute products using minimum time Distribute Products before the due data Minimize the product exchanging rate among distribution centers.
2	Hazardous Pharmaceuticals Product Cluster	Maximize the usage of possible warehouses.
3	Hybrid Pharmaceutical Product Cluster	Distribute products using minimum time Distribute Products before the due data Minimize the product exchanging rate among distribution centers. Maximize the usage of possible warehouses.
4	General Pharmaceutical Product Cluster	Minimize the total cost (Inventory cost, Distribution cost, Operational cost)

The models are analyzed with respect to different scenarios with predefined KPI to enhance the distribution networks in PSC.

III. RESULTS

For the model development process, the author derived test cases from the literature and use them as the input data of the model development process [7]. When the basic scenario is simulated for the derived test cases, a multi sourcing distribution network is populated as displayed in the Figure 1. This network design is used to distribute all the types of pharmaceutical products in the industry.

Figure 1- Current Distribution Network Design



The basic model was simulated with the different scenarios to develop efficient distribution networks for each and every pharmaceutical product clusters. Four different distribution network designs were populated as displayed in Figure 2, Figure 3, Figure 4 and Figure 5

Figure 2- Optimized Distribution Network Design for Time Sensitive Pharmaceutical Cluster

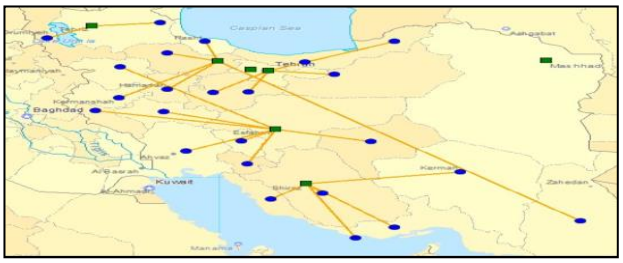


Figure 3-Optimized Distribution Network Design for Hazardous Pharmaceutical Product Cluster

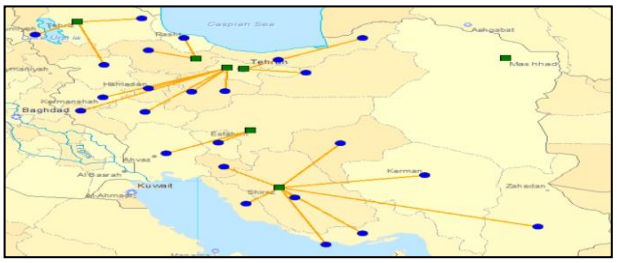


Figure 4-Optimized Distribution Network Design for Hybrid Pharmaceutical Product Cluster

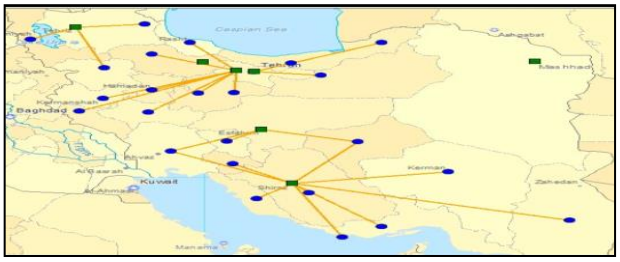
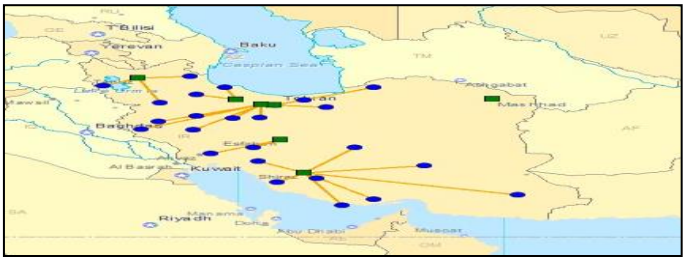
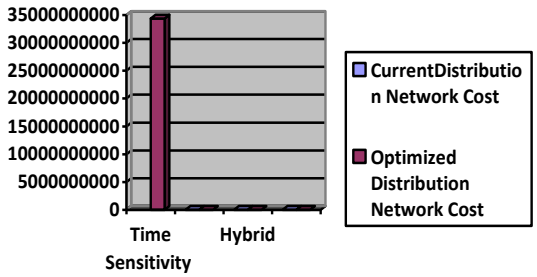


Figure 5-Optimized Distribution Network Design for General Pharmaceutical Product Cluster



When the distribution network design change from one cluster to another, the total distribution network cost reduces in considerable amounts as displayed in the Figure 6.

Figure 6-Cost Differences



IV. Conclusion

In this study the author defines the percentages of costs which can affect the clusters as mentioned in Table 3

Table 3 - Percentage of Costs Changes

No	Cluster Name	Percentage
1	Time Sensitive Pharmaceutical Product Cluster	5.88%
2	Hazardous Pharmaceuticals Product Cluster	10.82%
3	Hybrid Pharmaceutical Product Cluster	6.34%
4	General Pharmaceutical Product Cluster	72.1%

It proposes new avenues in designing and operating different distribution networks to better suit the product characteristics of a given PSC in order to deliver better quality products to the patients in need.

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