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Providing a Model for Reducing Drug Supply Chain Cost with using Design of Experiments; Case Study: Imam Ali (As) Cardiovascular Hospital of Kermanshah City

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ABSTRACT

The objective of this study was to optimize the costs of health logistics in the studied system and to cope with the planned budget cuts for health and treatment for the studied system. The question was that; what was the most influential factor in increasing costs, which reduced the planned healthcare budget concerning the studied system? At first a number of variables were defined. Using one-way analysis of variance, we examined the costs in the 12 months of 2016, whether the total costs in the 12 months of 2016 were equal or not. Then, using the Fisher test investigated among the 12 months, which month (s) were the most expenditure; after that, it is important to determine what has caused this high costs. Finally, we presented a model for optimizing and reducing costs. For these cases, the design of experiments and the full factorial design were used. The results of one-way ANOVA showed that the total amount of costs in the 12 months of 2016 were not equal. Fisher test showed that the second and fifth months had the highest cost; also, design of experiments with full factorial method showed that the cost-increasing factors were orders, stockroom and demand, respectively.

1 Introduction

Health care organisations all over the world are looking for ways to improve operational efficiencies and reduce costs without affecting patients care and service.The pharmaceutical supply chain provides the means through which prescription medicines are delivered to patients. The pharmaceutical supply system is complex, and involves multiple organizations that play

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differing but sometimes overlapping roles in drug distribution and contracting[1]. Providing health services with high-quality standards and containing public expenditure are increasingly important objectives to be achieved in the context of public healthcare. In this way, healthcare managers try to reduce spending without affecting the quality of service offered[2]. Recently, most healthcare organizations focus their attention on reducing the cost of their supply chain management (SCM) by improving the decision making pertaining processes' efficiencies. The availability of products through healthcare SCM is often a matter of life or death to the patient; therefore, trial and error approaches are not an option in this environment[3]. DOE is a method of systematically applying statistics to experimentation DOE identifies factors that have the significant impact for design alternatives.

A traditional DOE application analyzes factors and response variables in a system or process. DOE has been applied in fields of engineering and manufacturing for the quality improvement[4]. In addition, the certification and implementation of occupational health and safety management systems have become a priority for many organizations. To investigate the status of implementing occupational health and safety management systems[5]. The increasing pressure on the healthcare industry due to new competitive priorities and resource constraints has led to increased attention on continuous improvement of practices across various impact areas including financial, process, resources and innovation operations[6].The output of this study provides useful insights and suggestions for optimizing health logistics and drug supply chain. In the following, previous research in this area is reviewed, and then the method and manner of conducting the research are discussed. after that, we describe and interpret the results. Next, we compare this research with the researches done in this field, and finally the conclusion is reached.

Literature Review:Mensah and his colleagues conducted a study in 2015 called optimizing drug supply chain in hospital pharmacy department: an empirical evidence from a developing country. This study was undertaken to first and foremost examine the supply chain practices at KATH Pharmacy, and secondly to assess those practices in the light of industrially accepted best practices[1]. Paltriccia and his colleague conducted a study in 2016 called supplying networks in the healthcare sector a new outsourcing model for materials management. The purpose of this paper is to present a new outsourcing model for materials management related to the operating theatre of hospitals. They found that the optimal inventory management policy strongly depends on the mutual distances of supplying companies and the hospital[2]. Abukhousa and his colleagues conducted a study in 2014 called simulation and modeling efforts to support decision making in healthcare supply chain management. This paper presents and analyzes past SM efforts to support decision making in healthcare SCM and identifies the key challenges associated with healthcare SCM modeling. They said: we also present and discuss emerging technologies to meet these challenges[3]. Zhao and his colleagues conducted a study in 2015 called bottleneck detection for improvement of Emergency Department efficiency. Using the design of experiments, they found that it is identified that the long waiting time is accumulated by previous arrival patients waiting for treatment in the ED. Comparing the processing time of each treatment procedure with the benchmark reveals that increasing the treatment time mainly happens in treatment in progress and emergency room holding (ERH) procedures. The DOE also speeds up the search process for bottlenecks[4]. Azadeh and his colleagues conducted a study in 2016 called optimization of supply chain based on macro ergonomics criteria: a case study in gas transmission unit.

They found that natural gas supply chain is potentially susceptible to high costs caused by horrible outcomes such as explosion, injuries and mortality of workers, greenhouse gas emissions and production process halt. Macro-ergonomics analysis and design method is an efficient methodology which can lead to an overall gas supply chain optimization. This study presents a novel concept of macro-ergonomics analysis and design method, in form of a multi-objective mathematical model[5]. Adebanjo and his colleagues conducted a study in 2016 called prioritizing lean supply chain management initiatives in healthcare service operations: a fuzzy AHP approach. The objective of this study is to investigate the perceptions of practitioners/experts about the prioritization of healthcare performance measures and their relationship with lean supply chain management (LSCM) practices. The study also prioritised the drivers and resources required to implement LSCM in a healthcare operations context[6]. In 2005, Montgomery said: I believe that the use of experimental design can substantially reduce time and cost, and have higher reliability than those developed using other approaches. [7]. Behzad and his colleagues conducted a study in 2011 called modelling healthcare internal service supply chains for the analysis of medication delivery errors and amplification effects. The main research goal of this paper is to model and simulate the internal service supply chains of a healthcare system to study the effects of different parameters on the outputs and capability

measures of the processes. This paper points out the conditions for reducing the medication delivery error in a hospital[8]. Stecca and his colleagues conducted a study in 2016 called design and operation of strategic inventory control system for drug delivery in healthcare industry. The developed work includes into the decisional model also a partial decisional independence of wards and the special requirements of drugs delivery. Results and tests of the model's implementation on real data are reported to evaluate the goodness of offered tool and to discuss of potential real application[9]. The minitab site was used to interpret some results[10].
Lega and his colleagues conducted a study in 2013 called an evaluation framework for measuring supply chain performance in the public healthcare sector: evidence from the Italian NHS. They said: we argue that the public nature of healthcare and the specificities of the healthcare context require a specific theoretical approach to identifying the appropriate dimensions of SC initiatives to evaluate[11]. Jayaraman and his colleagues conducted a study in 2015 called an exploratory pilot study on supply chain data standards in a hospital pharmacy. They said: through an exploratory pilot study at a healthcare provider site focused on pharmaceutical operations, we identify the key challenges in implementing data standards in a pharmaceutical setting[12]. Izadi and his colleague conducted a study in 2014 called distribution network design under demand uncertainty using genetic algorithm and Monte Carlo simulation approach: a case study in pharmaceutical industry.

They found that distribution network design as a strategic decision has long-term effect on tactical and operational supply chain management. In this research, the location– allocation problem is studied under demand uncertainty[13]. Huq and his colleagues conducted a study in 2016 called supply chain configuration conundrum: how does the pharmaceutical industry mitigate disturbance factors? This paper focuses on endogenous, exogenous and environment-related SC disturbance factors and their relative importance when configuring global SCs. This study is able to provide insights into the impact of disturbance factors on the SC configuration strategy for Big Pharmas (BPs)[14]. Holm and his colleagues conducted a study in 2015 called medication supply chain management through implementation of a hospital pharmacy computerized inventory program in Haiti. They found that the Pharmacy Computerized Inventory Program (PCIP) allows the hospital staff to identify and order medications with a critically low supply as well as track usage for future medication needs. The pharmacy and nursing staff found the PCIP to be efficient and a significant improvement in their medication utilization[15]. Postacchini and his colleagues conducted a study in 2016 called a way for reducing drug supply chain cost for a hospital district: a case study. They said: this work aims at providing insights to optimise healthcare logistic of the drug management, in order to deal with the healthcare expenditure cut. The output of this paper provides useful insights and suggestions to optimize the healthcare logistic and drug supply chain[16].Aljbouri and his colleagues conducted a study in 2013 called impact of clinical pharmacist on cost of drug therapy in the ICU. This study compares the consumed quantities of drugs over two periods of time. Each period was ten months long. In the second period there was a Clinical Pharmacist. The total reduction of drug therapy cost after applying Clinical Pharmacy practices in the ICU over a period of ten months was 149946.80 JD (211574.90 USD), which represents an average saving of 35.8% when compared to the first period in this study[17].

Ozceylan conducted a study in 2016 called simultaneous optimization of closed- and open-loop supply chain networks with common components. In this paper, an integrated model that simultaneously optimizes the closed-loop supply chain (CLSC) and open-loop supply chain (OLSC) networks which use common components is described. A novel mixed integer programming (MIP) model is proposed to guarantee the optimal values of transportation amounts of assembled components and disassembled end-products in the CLSC and OLSC – which is also fed by CLSC – simultaneously while determining the location of facilities. Results show that the simultaneous approach results in cost savings of 4.07% and 37.24% over the individual CLSC and OLSC solutions, respectively[18]. Khan and his colleagues conducted a study in 2016 called information sharing in a sustainable supply chain. Whilst information sharing is frequently cited as being the key to reducing supply chain cost, one may wonder if this claim holds true for sustainable supply chains. This paper addresses this gap in the literature by introducing information sharing in a two level sustainable supply chain model.

They found that information sharing results in better annual profit with a drop in buyer's price[19]. Godichaud and his colleague conducted a study in 2015 called efficient multi-objective optimization of supply chain with returned products. They found that the return flows generate new uncertain elements (returns and leadtimes) and optimization of inventory control in this context is a complex issue. In this study a supply chain model based on simulation and multi-objective optimization is proposed to optimize control policies for multi-echelon supply chain with returned products[20]. Singh and his colleagues conducted a study in 2016 called strategic issues in pharmaceutical supply chains: a review. This paper aims to find the gaps in the literature by reviewing research papers on different strategic issues of supply chain management in the pharmaceutical sector. It is observed from review that the pharmaceutical sector is not widely researched in developing countries because of many complexities in this supply chain[21]. Paksoy and his colleague conducted a study in 2014 called environmentally conscious optimization of supply chain networks. This paper proposes an environmentally conscious optimization model of a supply chain network with a broader and more comprehensive objective function that considers not just the transportation costs, but also the costs for the amount of greenhouse gas emissions, fuel consumption, transportation times, noise and road roughness[22].

Merguerian and his colleagues conducted a study in 2015 called optimizing value utilizing toyota kata methodology in a multidisciplinary clinic. Multidisciplinary clinics have been shown to be effective in providing coordinated and comprehensive care with improved outcomes, yet tend to have higher cost than typical clinics. They said: we achieved a 69% reduction in clinic preparation costs. Despite this reduction in costs, we were able to maintain VAT and sustain improvements in family experience[23]. Elleuch and his colleagues conducted a study in 2013 called a combined approach for supply chain risk management: description and application to a real hospital pharmaceutical case study. In this paper, a SCRM framework comprising of different techniques and specialized procedures is proposed that can assist supply chain decision makers to risk identification, assessment and management[24].

Sari conducted a study in 2015 called Investigating the value of reducing errors in inventory information from a supply chain perspective. Results show that lead time reduction is the most important strategy for a supply chain in reducing total supply chain cost. In terms of customer service level, on the other hand, strategy of reducing errors in inventory information is observed as the most considerable strategy[25]. Woo and his colleagues conducted a study in 2016 called optimization-based approach for strategic design and operation of a biomass-to-hydrogen supply chain. They said: we develop an optimization model (mixed integer linear programming) which determines the optimal logistics decision-making to minimize the total annual cost for a comprehensive biomassto-hydrogen (B2H2) supply chain with import and inventory strategies[26]. Low and his colleagues conducted a study in 2016 called systematic framework for design of environmentally sustainable pharmaceutical supply chain network. In this study two network alternatives were proposed and analyzed based on their metrics together with synergies and trade-offs highlighted[27]. Zhen and his colleagues conducted a study in 2016 called supply chain optimization in context of production flow network. This study proposes a stochastic programming model for the production flow network oriented supply chain network design problem, which optimizes the decision of allocating stages to suppliers with the objective of minimizing the total expected costs of production and transportation among suppliers under uncertain demands of customers[28]. Bai and his colleague conducted a study in 2014 called robust optimization of supply chain network design in fuzzy decision system. This paper presents a new robust optimization method for supply chain network design problem by employing variable possibility distributions[29]. Friemann and his colleague conducted a study in 2016 called reducing global supply chain risk exposure of pharmaceutical companies by further incorporating warehouse capacity planning into the strategic supply chain planning process. They found that warehouse capacities must be further considered in strategic supply chain planning in order to mitigate the risk of exhausting logistics capacities after business developments such as the market entry of new products[30]. Papalexi and his colleagues conducted a study in 2015 called a case study of kanban implementation within the pharmaceutical supply chain.

This study explores the implementation of the kanban system, which is a Lean technique, within the pharmaceutical supply chain (PSC). The reported case study contributes to the longer term debate on assessing the Lean maturity level within the health-care sector[31]. Uthayakumar and his colleague conducted a study in 2013 called pharmaceutical supply chain and inventory management strategies: optimization for a pharmaceutical company and a hospital. They said: we present an inventory model that integrates continuous review with production and distribution for a supply chain involving a pharmaceutical company and a hospital supply chain. The model considers multiple pharmaceutical products, variable lead time, permissible payment delays, constraints on space availability, and the customer service level (CSL)[32]. Jamshidi and his colleague conducted a study in 2013 called a novel hybrid method for supply chain optimization with capacity constraint and shipping option.

They said: in this paper, we formulated an integer programming model for a five-tier supply chain with capacitated facility and multiple transportation option with fixed lead time. We also proposed a novel meta-heuristic solution methodology that combines the Taguchi's feature with artificial immune approach in order to solve the proposed model[33]. Elmuti and his colleagues conducted a study in 2013 called challenges and opportunities of healthcare supply chain management in the United States. This article explores current supply chain management challenges and initiatives and identifies problems that affect supply chain management success in the U.S. health-care industry[34]. Dobrzykowski and his colleagues conducted a study in 2014 called a structured analysis of operations and supply chain management research in healthcare (1982–2011). The purpose of this research is to conduct a structured analysis of OM. They found that the healthcare industry represents an important sector within services, however, little is known about the current state of research into healthcare OM and SCM[35]. Fleischhacker and his colleagues conducted a study in 2015 called positioning inventory in clinical trial supply chains.

They found that certain clinical trial supply chains, especially those supplying biologics, have a combination of unique attributes that have yet to be addressed by existing supply chain models. They said: we provide a new class of multi-echelon inventory models to address these unique aspects[36]. Bevilacqua and his colleagues conducted a study in 2013 called the impact of RFID technology in hospital drug management: an economic and qualitative assessment. This study examines the changes in costs and benefits associated with technology process innovation adoption as the innovation diffuses across healthcare field[37]. Bertolini and his colleagues conducted a study in 2011 called Business process re-engineering in healthcare management: a case study. The purpose of this paper is to carry out the business process re-engineering (BPR) of a surgical ward in a hospital in order to improve the efficiency of the ward. This work was developed using a case study on a surgical ward[38]. Ivan Su and his colleagues conducted a study in 2011 called logistics innovation process revisited: insights from a hospital case study. The purpose of this paper is to learn more about logistics innovation processes and their implications for the focal organization as well as the supply chain, especially suppliers. This approach made it possible to revisit theory on logistics innovation process[39].

Katsaliaki and his colleagues conducted a study in 2011 called applications of simulation within the healthcare context. This study facilitates the understanding of the potential of different simulation techniques for solving diverse healthcare problems[40]. Lee and his colleagues conducted a study in 2011 called supply chain innovation and organizational performance in the healthcare industry. The purpose of this paper is to examine supply chain (SC) innovation for improving organisational performance in the healthcare industry. The results of the study support that organisational performance is positively associated with constructs of each SC innovation factor[41]. Rossetti and his colleagues conducted a study in 2011 called forces, trends, and decisions in pharmaceutical supply chain management. The purpose of this paper is to identify and examine the major forces that are changing the way biopharmaceutical medications are purchased, distributed, and sold throughout the supply chain[42].

2 Materials and Methods

Regarding the type of research method, it should be said that this research is practical based and in terms of type, is one of developmental research. The data collection methods include the field method for gathering information about the investigated surfaces and parameters and the library method for selecting the appropriate method for conducting the research. The data collection tool was interviews with the personnel of the study system and the archived and recorded information in the study system. Analysis of variance and design of experiments were also used to describe and analyze the data. The study was conducted at Imam Ali Cardiovascular Hospital in Kermanshah, Iran which has 238 approved beds and 192 active beds and the time frame for doing the research is set at 12 months in 2016. The software used in this research is also the minitab software, version 18.1. What we want to examine first is the following hypothesis:

Null Hypothesis (H_0): The total available costs were equal to twelve months in 2016 .

Alternative Hypothesis (H_1): There is at least one month which the total costs in that month varies with other months.

To consider the assumption, such as selecting variables, there are principles and rules that must be followed. To pose a hypothesis, one should consider comparing the mean of several groups or the effect of one factor on a variable, that is, the effect of independent and qualitative variables on the dependent variable that is quantitative must be examined.

On this basis we should say that here we want to examine the effect of different levels of order,stockroom and demand in different months over cost, which led to the test of the above hypothesis[7]. To this end, we first identify the supply chain, the supply chain examined in this study is that supply chain which flows inside the hospital[8]. The supply chain is as follows:

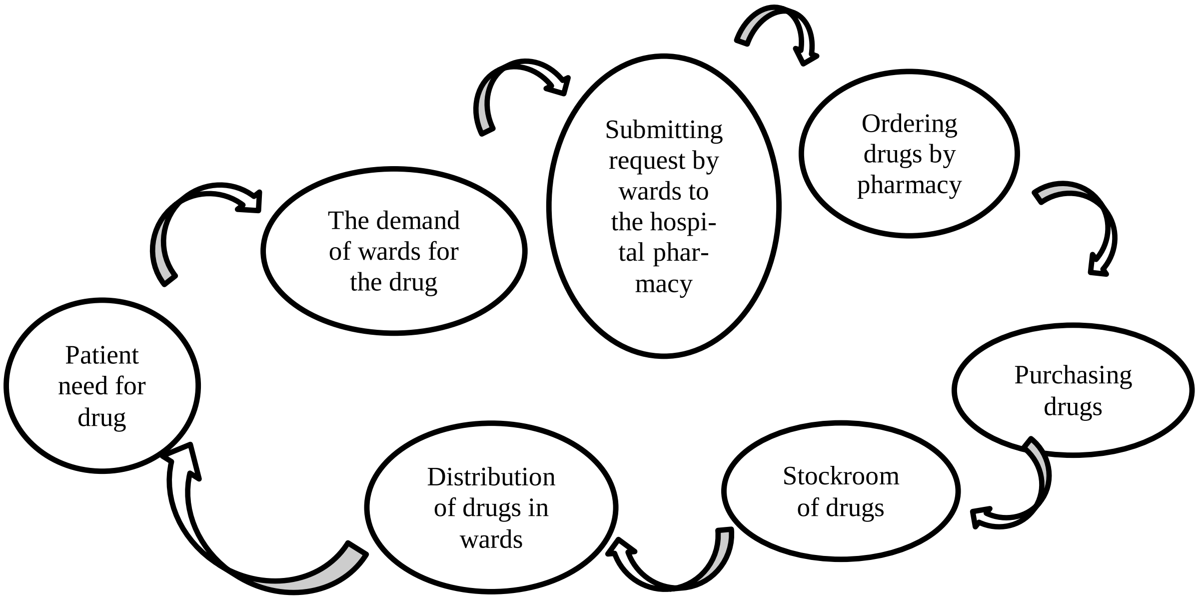

Figure 1: Supply Chain[8]

After identifying the supply chain in question, we need to define some variables. regarding the research design method was used in this study, we have to select a number of variables, including independent variables (stimulus) and dependent variables (response). There are some principles to choose these variables, including: Independent and dependent variables should be correlated and paired with data. Independent variables should influence the dependent variable, but independent variables should not be affected by the dependent variable. The independent variables must be qualitative and the dependent variables should be quantitative. The data concerning the dependent variable must be continuous. These principles and rules are followed in the selection of variables[7]. Also, the variables considered arevariables that are very important and influential in the supply chain. These variables were also used in an authoritative paper[9], and that the pharmacy staff had a great stress on them, given the experience they had in their field. the variables are as follows:

Dependent variable: The cost of hospital drugs

Independent variables: 1. Drugs order

2. Stockroom of drugs

3. Demand of wards for drugs

It should be noted that the independent variables were examined at two levels. Drugs ordered by the hospital are either inside the hospital pharmacopoeia, or outside the hospital pharmacopoeia. Stockroom of drugs at the hospital includes a refrigerated stockroom for refrigerated drugs and a non-refrigerated stockroom for non-refrigerated drugs. The drugs that are requested by the wards are either inside the hospital pharmacopoeia or outside the hospital pharmacopoeia. to select the levels of study related to each variable, some cases were considered that were considered in the study system. In summary, the variables examined are as follows:

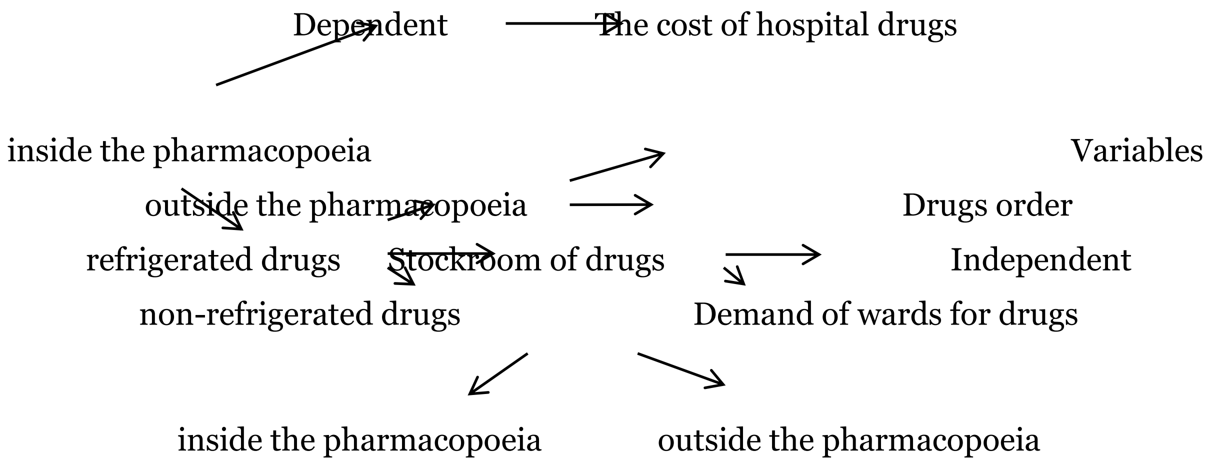

Figure 2: Variables[9]

It is necessary to explain that the data for each of these variables were examined monthly. For example, in relation to the drugs order variable, the orders the hospital has recorded each month are reviewed. That is, orders for January, February to December have been reviewed. The order list was obtained from the pharmacy. The data were analyzed to determine, for example, January, each of the drugs ordered by the hospital inside or outside the pharmacopoeia. After determining which drug was in and out of pharmacopoeia, their rial value was examined concerning to the dependent variables of the cost of hospital drug supply. Thus, the rial value of drugs that were in the pharmacopoeia was aggregated per month, and the sum of the rial value of the drugs in the pharmacopoeia was calculated for each month. The value of the rial concerning the order is the price given by the drug distribution companies, which the hospital has given its orders. In fact, we mean the price of drug on the market. In relation to the independent variable, stockroom of drugs per month, both at the refrigerated and non-refrigerated levels. It was determined which drugs is refrigerated or non-refrigerated. Rial value for refrigerated drugs and Rial value for non-refrigerated drugs were calculated separately per month. Here, the Rial value is the amount that hospital has paid to drug distribution companies for drugs. It is now time to investigate the independent variable of wards demand for drugs in each month examined at both the intra-pharmacopoeic and non-pharmacopoeial levels. Data for this variable were obtained from the Hospital Information System (HIS). In this section, the process of determining whether or not the pharmacopoeia of the drugs was exactly the same as the drugs order. Thereafter, the rial value of pharmacopoeial drugs and the rial value of non-pharmacopoeial drugs were also aggregated.

So, the total cost of drugs inside and outside the pharmacopoeia was obtained separately and each month. Rial value is the amount derived from the sum of the organization's share and the patient's share. Another point is relates to the month. The month is not part of our independent or dependent variables. But the unit of measure for each of those variables is the month. For example, we say the independent variable of ordering the drugs in each month. The month itself is a factor. We can take months to test. The data were prepared for entry into the software. They are in Appendix.As you can see, the data for each month contains eight rows. We were supposed to have a group for each month. It was mentioned earlier that we used the Fisher test method. Accordingly, the data were sorted into Table of software input data(Appendix) and entered into the software. In this study, the drug was considered as a treatment. As it is shown in Table of software input data(Appendix), the table for each month contains a number of columns, each column containing numbers that are all relates to drugs. In the above table there are numbers 1 and 2 for the independent variables in under the columns. The reason is that we specify different levels of each variable with numbers 1 and 2.

It was intended for intra-pharmacopoeia order code 1, for ex- pharmacopoeia order code 2, for non-refrigerated stockroom code 1, for refrigerator stockroom code 2, for intra-pharmacopeia demand code 1 and for ex- pharmacopoeia demand code 2. Regarding the arrangement of numbers within the table and the amount of the expense, for example, consider the first row of the table that corresponds to the first month. It should be said about the arrangement of numbers in the table and the amount of expenses. The interpretation is that when the order was in the pharmacopoeia and the stockroom was non-refrigerated and the demand for the drugs in the pharmacopoeia was 4516041851IRR. For the other rows and other months, the amount of the expense calculated for all different states and levels of the independent variables. All costs are in Rials. We said earlier that prepared the data to import into the software, which came as a table of appendix.This table contains the data we entered into the software. What we wanted to find out from this data was whether the sum of total costs in the 12 months in 2016 was equal or there was at least one month where the sum of total costs in that month was different from other months that was our research hypothesis. We used one-way analysis of variance to test this hypothesis.

We tested the confidence interval by 95 %. It is necessary to explain that in this study, the amount of confidence interval is taken into account 95%(1-α=95%), means α=0.05. The hypothesis was investigated. If the H_0 hypothesis is confirmed, the work is done and if rejected, the most expensive month(s) should be identified. For this purpose, the LSD method is considered, using this method you can find out which months were the most expensive. After the most expensive months were identified the question arose as to what factor(s) made those months the most expensive month(s). The design of experiments was used to answer this question and a full factorial design was used to implement this method. The result of design the experiments with the full factorial method the software has given us is as follows:

Table 1: Table of Design of Experiments

↓	C1 StdOrder	C2 RunOrder	C3 PtType	C4 Blocks	C5-T Order	C6-T Stockroom	C7-T Demand
1	12	1	1	1	2	2	1
2	13	2	1	1	1	1	2
3	2	3	1	1	2	1	1
4	4	4	1	1	2	2	1
5	1	5	1	1	1	1	1
6	15	6	1	1	1	2	2
7	10	7	1	1	2	1	1
8	14	8	1	1	2	1	2
9	16	9	1	1	2	2	2
10	5	10	1	1	1	1	2
11	8	11	1	1	2	2	2
12	6	12	1	1	2	1	2
13	9	13	1	1	1	1	1
14	7	14	1	1	1	2	2
15	11	15	1	1	1	2	1
16	3	16	1	1	1	2	1

The table above contains sixteen runs. After that, we examined the runs and obtained the variable values of the response, which is the cost. That is, the last three columns: the C5-T, C6-T, C7-T columns that are related to our factors were tested. In our first run we were asked to consider a second type-order and a second type- stockroom and a first type-demand. This means outside the pharmacopoeia and refrigerated stockroom and inside the pharmacopoeia. That is, we need to check if in-demand drugs of wards are inside the pharmacopoeia in may month and is the case of hospital order- outside the pharmacopoeia and in terms of maintenance status is refrigeratered level.

How much does it cost? 3392467162 IRR. As is evident, each run is repeated twice. This is because we have doubled the number of duplicates in the settings we introduced to the software to design of experiments for us. we have two months out of twelve months, which are the fifth and second months. Therefore, each run was repeated twice, considering the first repeat for the fifth month and the second repeat for the second month. If we considered the first duplicates for the second month and the second duplicates for the fifth month, there would be no change in the result. Likewise, for each of the sixteen runs designed, we obtain the variable response value as follows:

Table 2: Table of response variable

C8
Cost
3392467162
7128994591
6029161298
2571463317
8435042798
4492300455
5849318466
4723113091
2084618955
8233210821
881664502
4159519651
9923009636
4955355672
5798348662
6645154487

We entered the results in Table 2 into column C8 of the software and analyzed the designed experiments, which were accomplished with the software. Based on this, one can identify the most effective factor(s) that made the month(s) identified by method LSD as the most expensive month(s).

3 Results

In the previous section we discussed the research hypothesis. After entering the data into software that were in Table of appendix and using the one-way analysis of variance, we examined the hypothesis. The software provided us with a variance analysis table as follows:

Table 3: Analysis table for one-way analysis of variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Month	11	6.72508E+19	20.37%	6.72508E+19	6.11371E+18	1.95	0.044
Error	84	2.62956E+20	79.63%	2.62956E+20	3.13042E+18		
Total	95	3.30206E+20	100.00%				

Table 4: Table of information grouping using LSD method

Month	N	Mean	Grouping				
2	8	5402337069	A				
5	8	5260730877	A				
10	8	4850845355	B	C			
8	8	4779364345	B	C	D		
12	8	4317632620	B	C	D	E	
3	8	3819152308	B	C	D	E	
11	8	3742047042	B	C	D	E	
7	8	3530448891		B	C	D	E
4	8	3324278955			C	D	E
1	8	3153041943			C	D	E
9	8	3032636787				D	E
6	8	3003724936					E

From this table you can see that the H_0 hypothesis has been rejected. This means that the sum of the total costs in the twelve months of the 2016 was not equal together. And there has been at least one month, the sum of all the costs in that month being different from the other months. We also gave a brief explanation of LSD method in the preceding section, saying that this method identifies the most costly month(s). Software was applied to implement this method. The software provided the result in Table 4.

From this table you can see that the second month (February) is the most expensive with an average cost of 5402337069 Iranian Rials. And the fifth month, May, is, on average, at a cost of 5260730877Iranian Rials after the second month. Another point mentioned earlier was the question of what factor(s) made the identified month(s) the most expensive month(s). It was said that this was done through the software and the result is shown in Table 1. And the response variable values were also obtained mentioned in the table 2 and entered into the software to analyze the design, which the result can be seen in the following graph:

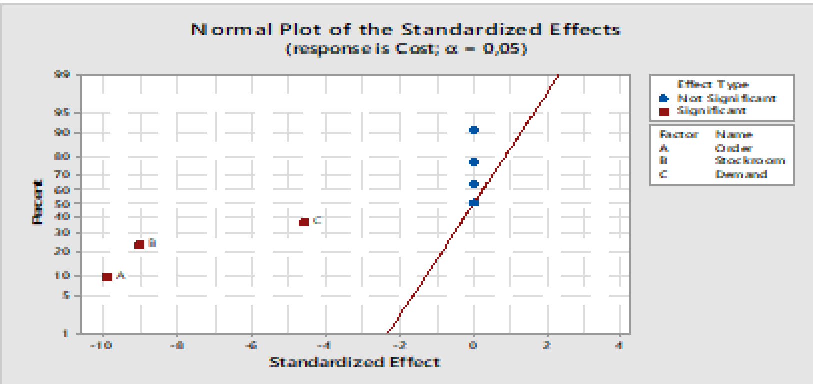

Figure 3: Normal Plot

The most effective factors that made the fifth and second months becomes as the most expensive months were identified. From the above graph, it is clear that ordering is the first factor and stockroom as the second factor and demand were identified as the third factor, also it is clear that the interaction between the factors is zero. The following graph also shows the interactions between the factors:

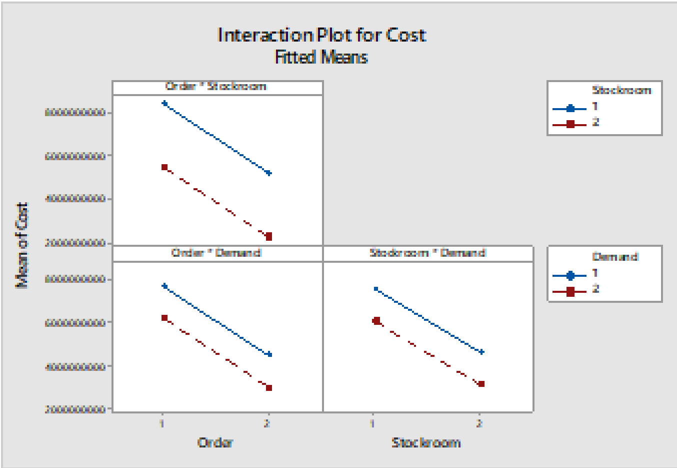

Figure 4: Interaction Plot

Finally, the software provided an optimal model for cost reduction is as follwes:

Cost=5331421473-1620005667Order-1478749821Stockroom -749074256Demand-112500Order*Stockroom-112500Order* Demand-112500stockroom*Demand-112500Order*Stockroom*Demand (2)

In addition, the software also provided us with another table where the fit numerical value is given, which is as follows:

Table 5: Table of prediction

Fit	SE Fit	95% CI	95% PI
1483141729	462194723	(417318787, 2548964670)	(-362917758, 3329201215)

The software also provided us with a solution that can reach the expected cost in Table 5, which is as follows:

Table 6: Table of Solution

Solution	Order	Stockroom	Demand	Cost Fit	Composite Desirability
1	2	2	2	1483141729	0.933475

The software also provides a graph that is as follows:

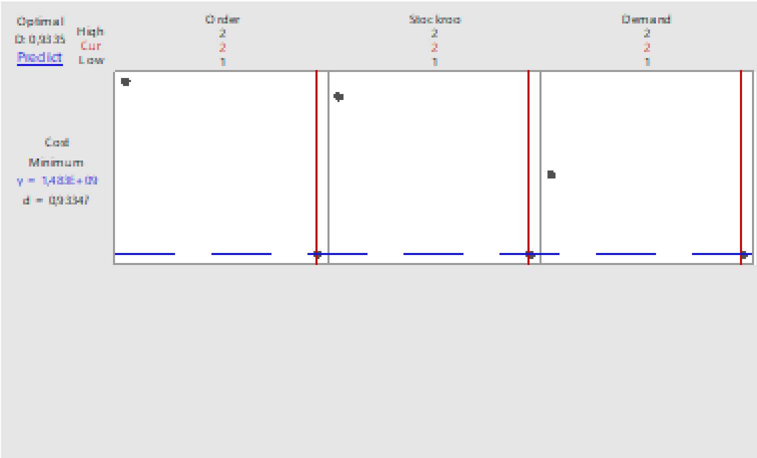

Figure 5: Optimal plot

In addition, the software has provided us a table under title Model Summary, through which the model accuracy can be verified. That is, we can see how trustworthy the model is and how much data it has covered. The table is as follws:

Table 7: Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
653642045	96.18%	92.83%	84.70%

4 Discussion

The overall purpose of this study was to identify and evaluate the factors that led to high hospitalizations using statistical methods to provide a solution to reduce these costs. In the previous section; in the test case section, it was stated that from Table 3, we found that the H_0 hypothesis was rejected. We used the value of P-Value that was stated in the variance analysis table. So we compared the number of probability values with $\alpha=0.05$, if: P-Value$<\alpha$, so the H_0 hypothesis is rejected and if P-Value$>\alpha$, the H_0 hypothesis is accepted. Here is P-Value $< \alpha$ $(0.04<0.05)$.Thus, the null hypothesis (H_0) was rejected with 95 percent confidence[7]. It was said that after examining the hypothesis test using the LSD method, we identified the costliest months[7], the result is in Table 4.

In this table, we only consider the months in group A. Other groups were less important than group A and were ignored. Priority has been given to months in group A. After that, we investigate the factor(s) that caused the cost increasing in February and May, and the result is illustrated in Figure 3. In this graph there was a red line that the software itself had defined, this was our basis for decision making and interpretation, and we made decisions based on that and made our own interpretation. Here, the small red squares became important and effective, and the greater their distance from the red line, they are more important and effective and they have a priority. Another point is that the important factors are in the negative numbers axis and this means, the factors were inversely correlated with the response variable[7], that is, if the target factor is at a low level, the cost will go up and in its high level, the cost will come down, that is, one(inside the pharmacopoeia), the cost will go up and in its high level, that is two (outside the pharmacopoeia), the cost will come down.

In relation to the interaction between the factors, Figure. 4 was obtained, in this graph, the lines and the dashed lines of the factors are parallel and never intersect together, this means that the interaction between the factors was zero and there was no interaction between the factors[7]. Finally, the software provided the model as the optimal model mentioned earlier(Eq. "(2)"), which can be written as follows[7]:

$$y=5331421473-1620005667x1 -1478749821\ x2-749074256\ x3 \tag{3}$$

In the Eq. "(2)", we consider Cost=y; Order=x_1; Stockroom=x_2; Demand=x_3; y-intercept =5331421473, therefore, the above model(Eq. "(3)") was obtained. In this model, the negative signals indicate that the factors are inversely correlated with the response variable which explained about that in the normal graph section. The software had an fit numerical value for cost predicted in Table5, as is specified, the fit numerical value for cost is predicted as 1483141729 Iranian Rials[10].The software also provided us with a solution in the form of table 6, which showed that if the order and demand were outside the pharmacopoeia and refrigerated stockroom, the cost would ideally be 1483141729 IRR[10]. In addition, the software provided an optimal plot (Figure 5) this graph showed us that if order and demand were outside the pharmacopoeia and refrigerated stockroom, we would have the lowest cost it also gave us a y value=1483000000 IRR that is the lowest we can afford; this is a rounded value of 1483141729 IRR, as shown in Tables 5 and 6 and d signify the desirability, desirability means how well these factors worked to satisfy the goal, which equals 0.93347, desirability at its highest value can be 1[10]. The last point mentioned in the preceding section was about the accuracy of the model, which is presented in Table 7. In that table, from the R-sq(adj) (R^2(adj)) and R-sq(R^2) investigate the model's accuracy, of course R- sq(adj) from the R-sq is more reliable and accurate, because it uses the mean of squares instead of the sum of squares, has benefit of degrees of freedom, which represent the number of factors, are taken into account and involved in the calculations. Here the value of R-sq(adj)=%92.83, that is, the resulting model covers more than %92 of data and is reliable, so the accuracy of the model was confirmed. The closer this value to 1 or %100, the better and the more reliable the model[7].

In previous researches, there has been little use of statistical methods, in the event that these methods can be more efficient and effective. In 2013, Lega and his colleagues drawing from an extensive literature review and a longitudinal analysis of an inductive case study – a public hospital network developed in Tuscany (ESTAV), Italy – this work proposes a framework for assessing supply chain performance in the public healthcare sector[11]. In 2015, Jayaraman and his colleagues said: we document the required technology functionality, clinical and financial workflows, and information systems, as well as articulate the challenges in implementing data standards. The lessons learned from the study offer valuable insights for supply chain executives, engineering managers, and pharmacy directors to plan and implement GS1 standards in their facilities[12]. Izadi and his colleagues conducted a study in 2014 that the purposes of this study were to specify the optimal number and location of distribution centers and to determine the allocation of customer demands to distribution centers.

The main feature of this research is solving the model with unknown demand function which is suitable with the real-world problems[13].In 2016, Huq and his colleagues said: through a multi-phase, mixed-methods approach we find that the top five disturbance factors managers should be aware of while configuring their SCs are quality defects, unforeseen and random interruptions in manufacturing processes, order processing difficulties, untimely delivery of products and a mismatch between market demand and supplier responsiveness[14]. In 2015, Holm and his colleagues said: we conducted the research by examining how medications were being utilized and distributed before and after the implementation of PCIP. We measured the number of documented medication transactions in both Phase 1 and Phase 2 as well as user logins to determine if a computerized inventory system would be beneficial in providing a sustainable, long-term solution to their medication management needs[15].

In this study statistical methods were used in all stages of the research. Previous articles related to reducing supply chain costs were used to determine the investigated supply chain and variables. In this study, a hypothetical test was considered which was evaluated using one-way analysis of variance and the Null hypothesis (H_0), was rejected. This meant that the sum of total costs in the twelve months in 2016, was not equal together and there has been at least one month where the total cost of that month has been different from other months, therefore, using the LSD method, the months that were more expensive than the other months were identified, which were February and May, respectively. We then sought to identify the factors that made February and May the most expensive months, for which the design of experiments was performed using a full factorial. As a result, it turned out, first of all the order, then the stockroom and then the demand led to the two months being costly. Finally, a model was presented to reduce the cost of the supply chain and its validity was investigated, the fit cost and the way to achieve it were also discussed.

The present study has encountered some limitations, which are as follows:

1.Unable to access shipping data and information. The reason the study considered the only supply chain within the hospital was because it did not have access to transport data and information. On the other hand, this type of supply chain was also used in one of the articles.

2.Lack of attention and cooperation of other hospitals to make it possible to compare several hospitals together. Design of experiments for this study would have resulted in a better outcome if it were possible to compare data and information from several hospitals[16].

5 Conclusions

The purpose of this study was to identify and evaluate the factors that impose significant costs on the hospital. The question of this study was to provide practical recommendations for the system under study in order to reduce costs and achieve a satisfactory level of service. Minitab software was used in this study and field and interview methodologies and existing records were used to gather information and library method to find suitable method for doing research. In this study, we hypothesized that we tested it using one-way ANOVA, and the Null hypothesis (H_0), was rejected. And we realized that the sum of total costs in the twelve months in 2016 was not equal and using the LSD method, we found that February and May were the most expensive months, respectively. And by design of experiments with the full factorial method, we found that the order, stockroom and demand, respectively, made the cost of February and May higher than the other months. Finally, an optimal model was presented for cost reduction, the accuracy of the model was investigated, and the fit cost and the way to reach it were also discussed. The study sought to provide a way to optimize and reduce hospital costs. However, due to the increasing scope and importance of supply chain costing in the health system, some future research can be suggested:

1.It is recommended to use statistical methods for topics such as optimization and reduction of health costs, as mentioned earlier, the use of statistical methods in this field is very low; however, they can be much more efficient and accurate than other methods.

2.It is recommended that other important and influential variables such as transport should be considered as possible.

3.In addition to drugs, it is recommended that other important factors in the health system be analyzed, such as medical equipment.

4.In the design of experiments, it is much more appropriate to compare research in several hospitals.

Appendix

Table A: The input data

↓	C1	C2	C3	C4	C5
	Month	Cost	Order	Stockroom	Demand
1	1	4516041851	1	1	1
2	1	1790042034	2	2	2
3	1	2714733534	1	2	2
4	1	3591350351	2	1	1
5	1	2753298233	2	2	1
6	1	3677989733	1	2	1
7	1	2628094152	2	1	2
8	1	3552785652	1	1	2
9	2	6841637850	1	1	1
10	2	1793627389	2	2	2
11	2	4214135389	1	2	2
12	2	4421129850	2	1	1
13	2	2684017164	2	2	1
14	2	5104525164	1	2	1
15	2	3530740075	2	1	2

Table A: The input data

↓	C1	C2	C3	C4	C5
16	2	5951248075	1	1	2
17	3	8435042798	1	1	1
18	3	2086418955	2	2	2
19	3	4492300455	1	2	2
20	3	6029161298	2	1	1
21	3	3392467162	2	2	1
22	3	5798348662	1	2	1
23	3	4723113091	2	1	2
24	3	7128994591	1	1	2
25	4	4528295218	1	1	1
26	4	2120262692	2	2	2
27	4	2900421392	1	2	2
28	4	3748136518	2	1	1
29	4	2820428746	2	2	1
30	4	3600587446	1	2	1
31	4	3047970464	2	1	2
32	4	3828129164	1	1	2
33	5	6343638706	1	1	1
34	5	1294665909	2	2	2
35	5	3319567509	1	2	2
36	5	4318737106	2	1	1
37	5	2271383667	2	2	1
38	5	4296285267	1	2	1
39	5	3342019348	2	1	2
40	5	5366920948	1	1	2
41	6	4332705120	1	1	1
42	6	1674744751	2	2	2
43	6	2624042101	1	2	2
44	6	3383407770	2	1	1
45	6	2698438654	2	2	1
46	6	3647736004	1	2	1
47	6	2359713867	2	1	2
48	6	3309011217	1	1	2
49	7	6343699737	1	1	1
50	7	717198044	2	2	2
51	7	3324086044	1	2	2
52	7	3736811737	2	1	1
53	7	1757974216	2	2	1
54	7	4364862216	1	2	1
55	7	2696035565	2	1	2

Table A: The input data

↓	C1	C2	C3	C4	C5
56	7	5302923565	1	1	2
57	8	7727396584	1	1	1
58	8	1831332105	2	2	2
59	8	4327519575	1	2	2
60	8	5231209114	2	1	1
61	8	2930377442	2	2	1
62	8	5426564912	1	2	1
63	8	4132163777	2	1	2
64	8	6628351247	1	1	2
65	9	5024361080	1	1	1
66	9	1040912493	2	2	2
67	9	2689390313	1	2	2
68	9	3375883260	2	1	1
69	9	2093454402	2	2	1
70	9	3741932222	1	2	1
71	9	2323341351	2	1	2
72	9	3971819171	1	1	2
73	10	8320654914	1	1	1
74	10	1381035795	2	2	2
75	10	4517822145	1	2	2
76	10	5183868564	2	1	1
77	10	2558477820	2	2	1
78	10	5695264170	1	2	1
79	10	4006426539	2	1	2
80	10	7143212889	1	1	2
81	11	6740678829	1	1	1
82	11	743415255	2	2	2
83	11	3366983565	1	2	2
84	11	4117110519	2	1	1
85	11	2000864592	2	2	1
86	11	4624432902	1	2	1
87	11	2859661182	2	1	2
88	11	5483229492	1	1	2
89	12	9923009636	1	1	1
90	12	881664502	2	2	2
91	12	4955355672	1	2	2
92	12	5849318466	2	1	1
93	12	2571463317	2	2	1
94	12	6645154487	1	2	1
95	12	4159519651	2	1	2
96	12	8233210821	1	1	2

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