International Journal of Industrial Engineering & Production Research March 2020 Vol. 31, No. 1: 115- 130
DOI: 10.22068/ijiepr.31.1.115

RESEARCH PAPER

Managing Hospital Medicine Costs in Healthcare Reform Plan: Real Case of Shari'ati Hospital

Mehrdad Kargari[*1] & Susan Sahranavard[2]

Received 27 April 2019; Revised 24 September 2019; Accepted 30 December 2019; Published online 31 March 2020

ABSTRACT
A continuous growth in the costs of healthcare and medicine as a strategic commodity has prompted researchers to seek tools to identify high-cost populations and achieve cost control. In the case of Iran, after implementing the healthcare Reform plan in the country, a huge share of hospital funding was spent on undesirable costs due to changes in the use of medicines and instruments. The aim of this study is to compare the cost of medicines in both pre and post periods of health plan implementation to detect abnormalities and low-frequency patterns in medical prescriptions that account for more than 30% of hospital budget funds. For this purpose, a data mining model was used to detect anomalies in the prescription information; first, by forming cross-over matrices on the cross-attributes, the prescription data were categorized; then, by applying a normalized distance-based risk function, anomalies and high-cost elements were identified based on the distance between the input data and the mean data. The data used included 15078 records containing information of patients' records during the years 2012-2016 of Tehran Shariati Hospital Information System. According to the results, the model presented at a positive likelihood ratio of 6.35 was viably able to identify domains and drugs whose costs have skyrocketed following the implementation of the health reform plan. Based on the results, among the 5 costly drugs to which the highest hospital budget was dedicated, Albumin had the highest unbalanced cost growth after the implementation of health reform plan; Pantoprazole and Ciprofloxacin were next in line regarding the unbalanced cost growth. These cases require to be reviewed by the hospital's Pharmacy Committee to keep costs down in order to prevent their inflation. Although imipenem and Meropenem are both expensive, common drugs need to be redefined in order to rationalize their use. According to the heat map charts, the highest average prescription cost per medication and age in the pre-treatment period belonged to a group of people with 80 years and above; a significant decrease in cost was observed after the Reform Plan. The most expensive category was allocated to the age group of 5 to 14 years. Thus, applications whose cost of prescriptions with data usage patterns before the Reform Plan has been identified are given to experts for further consideration.

KEYWORDS: *Detection of anomalies; Data mining; Health system; medicines cost; Reform Program.*

1. Introduction

The growing costs of health systems around the world have become one of the main concerns of health managers and decision-makers [10]. Iran's health system, like other countries, faces the challenge of rising costs.

In the health system, medical behaviors and medicines play a significant role in ensuring high-quality and cost-effective health services (Yin et al. (2017)) and curing patients; in most cases, prescribing is an integral part of a patient's treatment process [36]. One of the problems encountered today by many countries, especially developing countries, is the increase of pharmaceutical costs (Imamgholipour, Rashidian and Nakha'I (2014)) [12]**.** Studies indicate that

* Corresponding author: ***Mehrdad Kargari***
m_kargari@modares.ac.ir

1. *Faculty of Systems and Industrial Engineering , Tarbiat Modares University, address: Jalal-e Al-e-Ahmad St., Tehran, Iran.*
2. *Faculty of Systems and Industrial Engineering , Tarbiat Modares University, address: Jalal-e Al-e-Ahmad St., Tehran, Iran.*

medicinal costs constitute the second or third part of health expenditure in all countries after hospital admissions and physician visits; the cost of medicines in developing countries is 20 to 60 percent of the total expenditure on health systems (Rahbar et al. (2013)), and Iran is considered to be one of the highly medicine-consuming countries in the world [26]. This problem mainly results from the misleading culture of prescribing and taking medication, as argued by Ebadifard et al. (2013) [7].

On the other hand, the health system should be designed so as to reduce inequalities in the community health so that all groups of a society can benefit from health services (Sarkhanlou et al. (2016)); hence, reforming the health system and improving the quality of health services have always been important [30]. In this regard, the healthcare reform plan was implemented in Iran in May 2016; the plan was aimed at protecting citizens against healthcare costs, organizing hospital services, improving their quality, and ensuring fair access to healthcare services by providing medical services and reducing the number of patients in hospitals affiliated to the Ministry of Health and Medical Education. According to the plan, patients with basic health insurance pay only 6% of the regulatory bills covered by this plan based on the tariffs and fees approved by the Deputy of Therapy Ministry of Health and Medical Education (2013) [6].

In an interview with the managers of Shariati Hospital in Tehran, it was found that the implementation of the health reform plan led to a significant increase in the hospital costs, averaging 2.4 times the monthly increase of medication costs in the hospitalized patients' files in the second half of 2014 compared to 2013. However, during this period, there were no particular external events such as the outbreak of an epidemic, etc. to cause any cost transfer. In fact, these undesirable costs are due to:

- the high number of requests from the recipients of the services and
- higher willingness of service providers to provide unnecessary and surplus services on demand (induction demand)

This leads to the over-consumption of services and economic inefficiency through the improper use of financial and human resources. By identifying ways that waste resources, cost analysis provides the basis for reducing costs.

According to literature reviews, no research has been undertaken to evaluate and analyze the economic and pharmaceutical costs of the health reform plan. The purpose of this study is to investigate the effect of health reform plan on pharmaceutical costs and management of undesirable costs caused by the implementation of health reform plan. For this purpose, five costly drugs that account for approximately 30% of hospital budget were selected, and data mining methods (detection of outliers through a distance-based risk function) were used to identify cost abnormalities in post-health reform prescriptions. Moreover, this study identified and presented age, diagnosis, and gender ranges in which a drug underwent adverse cost changes; moreover, a complete comparison of the cost changes and their causes in the period before and after the health reform plan for selected high-cost medications was made.

The remainder of this paper is organized as follows. Section 2 provides a review of the related articles. Section 3 describes the proposed method. Section 4 discusses the results obtained from the implementation of the model in detail; finally, Sections 5 and 6 present the corresponding discussion and conclusion.

The purpose of this study is (a) to evaluate the effect of Health System Reform Plan on hospital costs and the usage of the most expensive medications and (b) to provide a model for managing surplus and undesirable recurring costs of the plan. There has been no literature on the economy and costs of the project. This study presents a data-mining model to identify abnormalities among versions after the Health System Reform Plan. In Iran, since it is based on paper versions, no comprehensive model for detecting malformations and fraud has been developed so far. The present study attempts to provide a model for identifying abnormal patterns and abuses in medical prescriptions that lead to higher costs.

On the one hand, most of the health fraud and anomaly detection techniques have been implemented using neural network and clustering methods, while other mathematical and risk management methods have been underused. In this study, a normal risk function based on distance has been used for modeling.

Another case that can be noted is the use of both treatment-related and demographic-specific sets of characteristics (such as age and gender), while most studies have ignored the link to these two groups of features.

In the health context, any diagnosis requires some tests, medications, and health services. These services are offered to patients for a fee. Therefore, similar diagnoses are expected to be of similar costs; on the other hand, the demographic characteristics of patients such as age and gender also play an important role in treatment because

[DOI: 10.22068/ijiepr.31.1.115]

[DOI: 10.22068/ijiepr.31.1.115]

some diseases are more common in certain groups of patients. For example, Type-2 Diabetes and Hypertension are more common among adults, and ear pain is more common among children.

According to these rules, the correlation between medication-diagnosis characteristics and medication-age and medication-gender characteristics is clarified, while there is no correlation between age-gender characteristics. On the other hand, the interplay between diagnosis-age and diagnosis-gender can be overlooked because any diagnosis necessarily leads to the prescription of certain medications; thus, a medication error can identify a diagnosis error. Accordingly, in the proposed method of this research, a five-step method is used. In the first step, by defining intersection matrices, the number of times the cross-attributes that occurred together in the database is determined; the second step involves creating a matrix. The average cost is associated with various cross properties. Step 3 introduces risk matrices based on a normalized risk function and the distance between intersecting features. This function is applied to calculate the distance between the input data sample from the mean and returns of a value between zero and one. The closer the value is to one, the more the malformations are. Step 4 involves calculating the threshold values corresponding to each risk matrix. In Step 5, the model compares the risk value of each request with the calculated threshold value; if the risk value of the request exceeds the threshold values associated with it, the request as the case that needs to be made should be modeled. Herein, a higher volume of output is in favor, and if the risk value of each request is lower than the associated threshold values, it is considered a standard request and will be added to the previous database in case the user agrees.

2. Literature Review

2.1. Background of planning in healthcare systems

Ilyas and Moncrieff (2012) examined the trend of prescriptions and cost of medicines for mental disorders in England in the years between 1998 and 2010 by applying linear regression analysis [13]. Ozieh et al. (2015) also examined the trend of health care costs among adults with diabetes in the United States in the years between 2002 and 2011, and the results indicated that diabetes was an important cost driver in the United States, where a major part of these costs results from the hospitalization of patients and the cost of prescribed medicines [23]. There are numerous articles on future pharmaceutical costs in the United States from 1992 to 2016, which discussed the annual trend of changes in pharmaceutical costs; they have also discussed factors affecting costs over the years. Among these articles, a number of studies like the one conducted by Schumock et al. (2016) discussed past trends and factors that were more likely to affect pharmaceutical costs, and the cost forecast for the year 2016 was made based on a combination of quantitative analyses and the opinion of the experts [31]. According to their research, pharmaceutical costs both in clinics and non-federal hospitals increased, and the increase of 11% to 13% was estimated for the overall medicinal costs in the United States in 2016. Ravichandran (2016) studied the responsiveness of Hospitals in Healthcare Financing [27]. The results of his study showed that hospitals had some forms of healthcare financing mechanisms to purchase drugs for the benefit of patients. The studied hospitals have modified and developed various criteria and policy initiatives to improve the outcome, i.e., patient inflows. Bojakowski and Filer (2009) examined a major impediment to an integrated approach constituting different beliefs and interpretations of what medicine management actually means and involves [3]. They pointed out that the term 'medicines management' was adopted as the umbrella term for medicine-related issues. Different priorities were allocated to each stage by key organizations within health services. As a result, the activities are disjointed, and an efficient system demands an integrated approach for it to work well. Highfill and ozcan (2016) evaluated the productivity and quality of the first hospitals to join the Medicare Shared Savings Accountable Care Organization (ACO) Program, compared to similar hospitals [11]. These results showed the hospitals that joined Medicare ACO Program to be more productive than non-ACO hospitals between the years 2008 and 2012, driven entirely by gains in technical efficiency. All hospitals undergo a decline in innovation during the time period. ACO hospitals were also more likely to be high performers in both productivity and quality measures. Moreira (2013) investigated the key challenges of Health Management systems in Europe [21]. Mehrjerdi et al. (2012) presented a multi-objective model for the weekly planning and scheduling problem of surgeries of elective patients in operating rooms [19]. The objectives were to minimize the waiting time of the patients according to their medical priority, the undertime and overtime costs of operating rooms, and the sum of completion times of surgeries. Their proposed model was solved by the ε-constraint method in GAMS software. Then, data envelopment analysis (DEA) was employed to obtain the best solution among the Pareto solutions obtained by ε-constraint method. Roshan, Seifbarghy and Pishva (2017) proposed a bi-objective mathematical model to design a network of preventive healthcare facilities [29]. Each facility acts as an M/M/1 queuing system so as to minimize total travel and waiting time and the establishment and staffing costs. Tri-meta-heuristic algorithms were proposed to solve the problem. They used multi-objective simulated annealing (MOSA) to solve the problem and, then, obtained results as validated by using two popular algorithms (non-dominated sorting genetic algorithm and non-dominated ranking genetic algorithm). Their computational results of multi-sized problems demonstrated that it efficiently minimized the establishment and staffing costs and the total time required for the service. A system dynamic model based on system thinking concepts was presented to study interconnections among human weight, eating habits, exercise, body fat, take-in medication, drug-uses, and health problems. In his research, a flow diagram was constructed, and the overall expenses were studied [19]. To clearly identify expense rates, they were broken into operational expense rate (OE), treatment expense rate (TE), Medication expense rate (ME), Hospitality expense (HE), and Drug treatment expense rate (DE). Obtained results showed how a factor such as weight could impact heart attack, blood pressure, and blood sugar and how all these relate to the overall expenses that an insurance company has to pay at last. Calderón et al. (2010) introduced a new method for interpreting drugstore costs and checking compliance with each patient's medical costs and severity of illness [4]. Since patients with the same type and severity of illness are more likely to need the same level of health services and resources, they are able to analyze the variables of disease and demographics along with the variable of medicine cost per patient. In addition, outlier patients were identified in accordance with the plot box method.

In the 70s in Iran, an average annual growth rate of medicine consumption by 11.5% has been one of the most widely consuming countries in the field of pharmaceutical products around the world in comparison to an average growth rate of 7% in developing countries or 9% in the world (Ebadifard et al. (2013)) [7]. Therefore, in Iran, different studies have been conducted on the amount of medicine consumption including the studies conducted by Imamgholipour et al. (2014), Jebeli et al. (2015), and Ebadifard et al. (2013) who investigated factors affecting medicine demand and costs and providing a function of pharmaceutical demand estimation in different years (see[12],[14],[7]).

2.2. Background of reform plan in healthcare systems

Health efforts to maintain and promote the system are always of high priority, and the main mission of the health system is to promote health and meet the people and society needs, as maintained by Ministry of Health, Medical Education, and Policy Council (2011).

The main objectives of the health care reform program are to protect citizens against health costs, organize hospital services and improve their quality, and provide people with fair access to health care by organizing hospital services and reducing patient contributions in hospitals affiliated with the Ministry of Health, Medical treatment and education. This plan took effect on May 15, 2014 in Iran. Accordingly, hospitalized patients with basic health insurance pay only 6% of the billing amount of the program under the tariff and the price approved by the Deputy of Therapy Ministry of Health and Medical Education (2013) [6].

With the implementation of the Healthcare Reform Plan, various studies have been conducted to evaluate and study its effects on various health and health care factors. For example, Khodadadi et al. (2015) compared the satisfaction of patients with the services provided before and after the health reform plan at the hospital admission centers [17]. Moreover, Godarzi et al. (2015) examined the satisfaction of patients and treatment staff with the implementation of Health Reform plans; in addition, Soleimani et al. (2015) studied the satisfaction rate of patients with the implementation of the third step of the health reform plan in hospitals affiliated to Shahrekord University of Medical Sciences; moreover, all of these studies have somehow shown the increased satisfaction of patients with the implementation of the health reform plan and have particularly reduced the payment and costs by the patients (see[9],[32]). Faridfar et al. (2016) investigated the effect of the reform plan on different types of clinical, Para clinical, surgical, and patient satisfaction levels in Hazrat Rasool Hospital [8].

Several studies have also examined the effect of the health reform plan on the performance

[DOI: 10.22068/ijiepr.31.1.115]

indicators and quality of hospitals quantitatively (including Rezaei et al. (2016)) [28]. Piroozi et al. (2019) evaluated the effects of Health reform plan in Iran on the hospitalization rate [25]. They collected monthly hospitalization data over a period of 50 months in Kurdistan province. Interrupted time series was carried out, and segmented regression analysis was carried out to assess the abrupt (or short-term) and gradual (or long-term) effects of health reform plan on the hospitalization rate, and their results showed a statistically significant increase in the hospitalization rate. Tabari-Khomeiran et al. (2019) showed the effects of health reform plan on costs of coronary artery bypass surgery [33]. Patients' total cost and out of pocket payments were calculated before and after the reform in three private hospitals. Econometric models were estimated after the adjustment of confounding variables, and the results of the regression model showed that the total costs increased significantly; however, no significant changes were found in out-of-pocket payments and out-of-pocket percentage. In another study, Moradi et al. (2018) evaluated the prescriptions in Zabol city before and after the implementation of the health system reform [20]. They selected six pharmacies and studied the prescriptions once in April 2014 and once in April 2015 (before and after the health reform plan); they used statistical tests to analyze data. The results of this study showed that the health reform plan reduced the number of drugs prescribed, but not the price, although the type of drugs most commonly prescribed varied between the two study phases.

2.3. Anomaly detection in health data

Data mining techniques and tools can be used to identify abnormalities and fraud in a large set of data. The purpose of these techniques is to detect outliers or abnormalities that are diverted from typical patterns. Generally, the detection of abnormalities in the general health system records is an important measure in health management that can indicate logistical problems, overload, lack of specialists and services in one area, an outbreak of a disease, data errors, and suspicious activities. Hence, identifying anomalies is a key activity in supporting cost reduction, improving records documentation, supporting investment planning, and in particular reducing anomalies (Carvalho et al. (2015)) [5]. In traditional methods of detecting anomalies, some auditors have a responsibility to handle thousands of paper healthcare applications. In fact, they have little time for each case and they focus on the specific features of it regardless of the comprehensive view of the behavior provider. This method is time consuming and inefficient. One way to identify and determine unnecessary adverse costs is anomaly detection in data mining; in addition, these models are used to identify inappropriate prescriptions, and irregular and inappropriate patterns in health claims from doctors or patients or hospitals are used. Doctors' prescriptions and therapeutic cases produce a huge amount of data that can be used to discover hidden and useful information to detect abnormalities and abuses (Tomar and Agarwal (2013)) [34].

The most common and acceptable classifications that are used by experts put the existing methods for identifying anomalies in the field of health into the following three categories: 1. Supervised methods, 2.Unsupervised methods, and 3.Hybrid methods.

Supervised methods

In a supervised learning setting, a set of records previously known as normal or abnormal cases is used to create a model, and new entry records belong to one of the two groups. Therefore, these methods can be used to identify the previously known patterns; however, these models should be updated regularly to reflect new changes in the rules (Joudaki et al. (2016)) [16]. The key issue of classification-based methods is the need for tagged data that is not always available (Xu et al. (2013)) [35]. The algorithms that are widely used in this field include decision trees, fuzzy logic, naive **Bayesian network**, genetic algorithms, neural networks, and support **vector machines [1].** The most popular algorithms include neural networks and the decision tree.

Unsupervised methods

There is no target variable in the unsupervised learning setting, and data mining techniques are used to explore patterns, clusters, and relationships in the target dataset (Iavindrasana et al. (2009)) [18]. In cluster-based methods, it is assumed that the normal data belong to large and dense clusters. In contrast, anomalies belong to small or scattered clusters (Xu et al. (2013)) [35]. Clustering algorithms can detect anomalies without prior information, which are commonly used in unsupervised method, K-means, K-medoids, EM Clustering, and outlier detection algorithms [1].

Hybrid methods

Methods that combine or integrate different algorithms are applied to increase the accuracy of

[DOI: 10.22068/ijiepr.31.1.115]

the final results and reduce the weaknesses of an algorithm such as the use of continuously supervised techniques or the combination of supervised and unsupervised techniques [24].

The aim of this study is to investigate the management and planning of surplus and undesirable medication prescription costs in prescriptions for similar patients using fraud and abnormality detection methods. Thus, the most recent studies in this area have been investigated.

In the process of health insurance, different individuals and legal entities such as hospitals, clinics, laboratories, doctors, pharmacies, etc. insured patients; moreover, offices and insurance centers that carry out all operations related to the insurance process are involved as the third parties to the process. In this process, fraud and anomalies may occur at any stage of the process and by any of the participants.

Most researchers in the field of anomaly and fraud detection in healthcare data have applied data mining techniques, such as clustering and neural networks, to perform analysis and modeling, while mathematical models and risk management have received insignificant attention. On the other hand, in most studies, the link between medications and patient demographic data has been neglected.

3. Research Methodology and The Proposed Model

The present paper is applied research, and its strategy is depicted in Figure 1.

The method of this study is proposed in five steps:

In the first step, by defining the intersection matrices, the number of times the cross-attributes occurred in the database is calculated.

The second step involves the development of average cost matrices in which the average cost is calculated for the various intersection properties.

Step 3 introduces risk matrices according to normalized risk function based on the distance between intersecting features using this function to calculate the distance between the input data sample and the mean; moreover, a value between zero and one is returned where the closer this value is to one, the greater the anomaly will be.

Step 4 involves calculating the threshold values corresponding to each risk matrix.

In Step 5, the model compares the risk value of each request with the calculated threshold value. If the risk value of the request exceeds the threshold values associated with it, the model considers the request as the case that requires much serious consideration. Moreover, if the risk value of each request is less than the associated threshold values, it is considered as a standard request and will be added to the previous database based on users' consent.

[DOI: 10.22068/ijiepr.31.1.115]

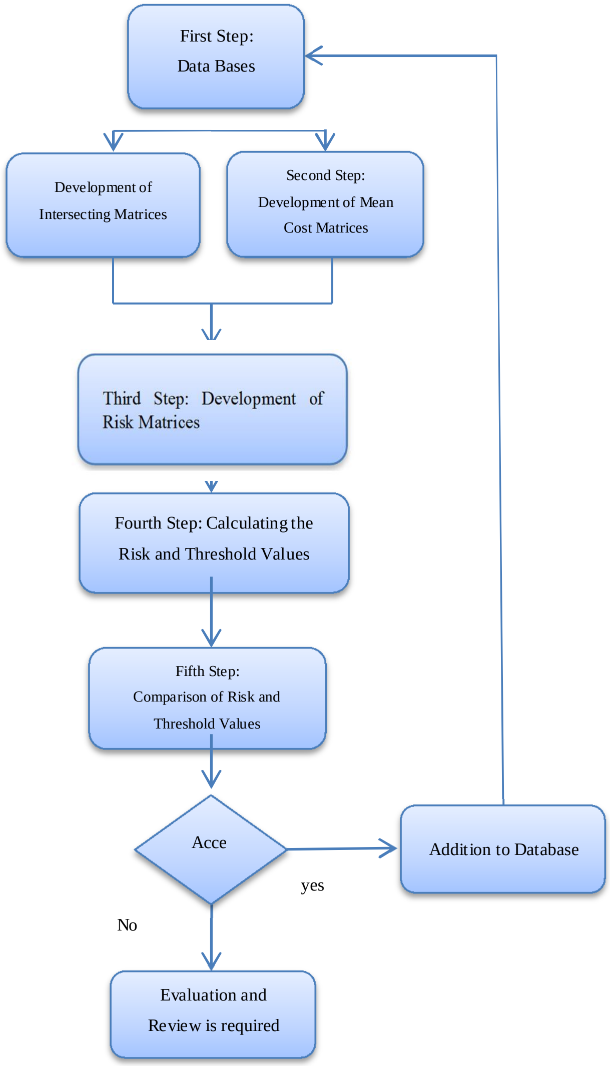

Fig.1. The proposed model flowchart

The proposed model of this study is based on a normalized risk function based on the distance between crossover features, introduced by Aral et al. (2012) [2].

Moreover, in this study, both sets of treatment-related and demographic related features of the patient (such as age and gender) were used, whereas most studies ignored the relationship between these two groups of features, and only the cost variables were taken into account.

The data used in this study are the data available in the Medicinal section of the hospital information system at two time intervals before the Reform plan and after the implementation of the Health Reform Plan, including 15078 records. Due to the enormous volume of data stored in information systems and the inability to investigate and process large-scale data, the present study focuses on the five most expensive drugs between 2013 to 2016 that account for 30% of the hospital budget. These drugs include 1) Albumin 20%, 2) Imipenem 500 mg, 3) Meropenem 500 mg, 4) Pantoprazole 40 mg, and 5) Ciprofloxacin 200 mg.

Since this research aims to detect abnormal patterns and abusive use of prescription, the features introduced in Table 1 are used. Since the proposed research focuses on the detection of unusual patterns and abuses in prescription with respect to the features expressed in the research related to this section and given the limited access to many features due to the inadequacy of hospital HIS system information, this study applied the features, introduced as outlined in Table 1. These features are selected among those presented in the article [2].

[DOI: 10.22068/ijiepr.31.1.115]

Tab. 1. The features used in the study [2]

Row	Features
1	Brand of the prescribed medicine
2	Total price of the prescribed medicine
3	File No.
4	Age
5	Gender
6	Diagnosis

In order to collect the data in accordance with the subset of the desired features, the reports in the hospital information system were used including the fields of file number, the name of the medicine, the hospital admission department, the hospitalization and discharge date, age, sex, the number of medicines used for the patient, and the total cost of the prescribed medicines. In addition to the above fields, the diagnostic data is also required, which has not been documented in the hospital information system for cases before the implementation of the reform plan. For this purpose, according to the patient's hospitalization information and its combination with the patient's length of stay, the detection codes of the disease were obtained (as shown in Appendix A.). In order to apply the study results, the sectors characterized by the highest cost in the five selected medicines were selected as the sections for study.

Tab. 2. Costly department of the hospital

Ward code	Ward name
1	Clinic of the Urgency
2	Neurology (medicinal 1)
3	Blood B
4	Blood A
5	Blood Urgency
6	Digestion (medicinal 2)
7	POST HST
8	Lung

In the area of health, any detection requires some tests, medicines, and healthcare services. These services are provided in return for payment to patients. Therefore, similar diagnoses are expected to produce the same cost; on the other hand, demographic characteristics of patients, such as age and gender, also play an important role in treatment because some diseases are more likely to occur in a particular group of people; for example, diabetes type 2 and more hypertension are common among adults, and ear infection is common among children (Johnson and Nagarur (2016)) [15].

Based on the above rules, the correlation among drug characteristics of medicine-diagnosis, medicine-age, and medicine-gender becomes obvious, whereas there is no correlation between age-gender characteristics.

The implementation process of the proposed model consists of five steps, which are briefly described below.

In the first step, by defining the cross-over matrices, the number of times that the crossover features occurred together in the database is computed. Based on the existing features, three cross-matrices are constructed as follows:

Drug-age cross-over matrix (MA), drug- gender cross-over Matrix (MS), and Drug-Diagnosis cross-over matrix (MD), such that each element of the cross-over matrix (i, j) is equal to the number of times the character i has occurred together with the character j in the database. Figure 2 presents a sample of the cross-over matrix for drugs and age feature.

[DOI: 10.22068/ijiepr.31.1.115]

CrossMtx.MA <6x9 cell>

	1	2	3	4	5	6	7	8	9
1	[]	0-4'	5-14'	15-19'	30-44'	45-59'	60-69'	70-79'	>80'
2	Albumin'	0	8	25	29	58	35	30	3
3	ImiPenem'	5	21	749	702	801	515	284	202
4	PantoPrazole'	16	78	955	1085	1411	1186	965	613
5	MeroPenem'	7	35	90	87	71	36	38	13
6	Ciprofloxacin'	4	31	163	188	334	232	186	124

Fig. 2. Drug-age cross-over matrix

The second step involves creating a matrix of average cost, where the average cost matrix is associated with each cross-over matrix. Each element of the matrix (i, j) is the average cost of a feature i in a range of features j. The third step is the introduction of Risk Matrix based on the normalized risk function in Equation 1. The distance between the input data of the mean of data is calculated using this function.

$$Risk_{MF}(i,j) = \frac{e^{-\left(MF(i,j)/Max_{MF}(i)\right)} - e^{-1}}{1-e^{-1}} \tag{1}$$

As noted above, MF (i, j) where F represents the feature domain equal to the number of times the drug i is given for feature j, and $Max_{MF}(\mathrm{i})$ is the maximum number of times the drug i is used for a feature. The risk estimate function returns a value between 0 and 1, where 1 and 0 represent the maximum amount of the anomaly and the minimum abnormalities, respectively.

Since the main objective of the proposed research is to manage additional and abnormal costs after the reform plan, this study multiplies the average cost element in the matrix of the initial risk to calculate the final cost of the risk matrix. The results are discussed in the cost sector.

The fourth step defines a threshold value to distinguish the risky prescriptions from the normal form. If the risk value is higher than the threshold, this prescription needs to be addressed. ROC curve and the cut-off amount of aid have been used to obtain a threshold value that can well identify normal and logical prescriptions from the risks and abnormal prescription after tagging a subset of the data by experts.

In the fifth step of the model, the risk value of each prescription and the calculated threshold value are compared. If the prescription risk is more than the threshold values, it is shown in the output window as the case to be addressed; if the risk value of each prescription is less than the threshold values associated with it, it is considered as a conventional request and is added to the previous database in case of user agreement.

4. Results

4.1. Comparison of the costs before and after the implementation of the Healthcare Reform Plan

The average cost of drugs in various diagnoses, the average cost of drugs in different age categories, and the average cost of drugs in different genders have been calculated in two periods before and after the implementation Reform plan based on the average cost matrix, in which each element of the matrix (i, j) represents the average cost of the features i within the feature j.

Finally, heat map graphs are applied to describe the results and provide a more comfortable and understandable representation on the basis of graphs. In order to provide the data before and after the plan on a whole graph and facilitate a better understanding, this study multiplies the average cost matrix of the data before the plan by (-1) and aggregates the average cost matrix of the data after the reform plan. The bottom of the chart, which is shown in blue, represents larger data before the reform plan, and moving upward to the red color represents larger data after the health reform plan.

Blue spectrum: Records before the reform plan show a high average cost, but demonstrate a reduction in the average cost after the plan.

White Spectrum: Records show the same average cost in the period before and after the implementation of the reform plan and remain unchanged.

Yellow-red Spectrum: Records prior to the implementation of the plan show lower average costs and with a growing rate of an average cost after the reform plan.

According to the results, the use of Albumin after the reform plan increased by 1.6 times, while there was almost no change in the average cost of Imipenem and Pantoprazole and Ciprofloxacin

[DOI: 10.22068/ijiepr.31.1.115]

average costs increased 1.1 times; however, the average cost of Meropenem reduced after the reform plan implementation.

According to the average cost matrix per drug and age level (Figure 3), the maximum difference in the average cost of data before and after the **HealthCare** Reform **Plan** is related to Albumin for the ages between 5 and 14, in which the cost increased after the reform. Moreover, the cost decreases for the age group over 80 years after performing the **HealthCare** Reform **Plan**. Other drugs did not experience significant cost fluctuations in different age ranges, and the cost was similar before and after the plan parts in white or was reduced after that.

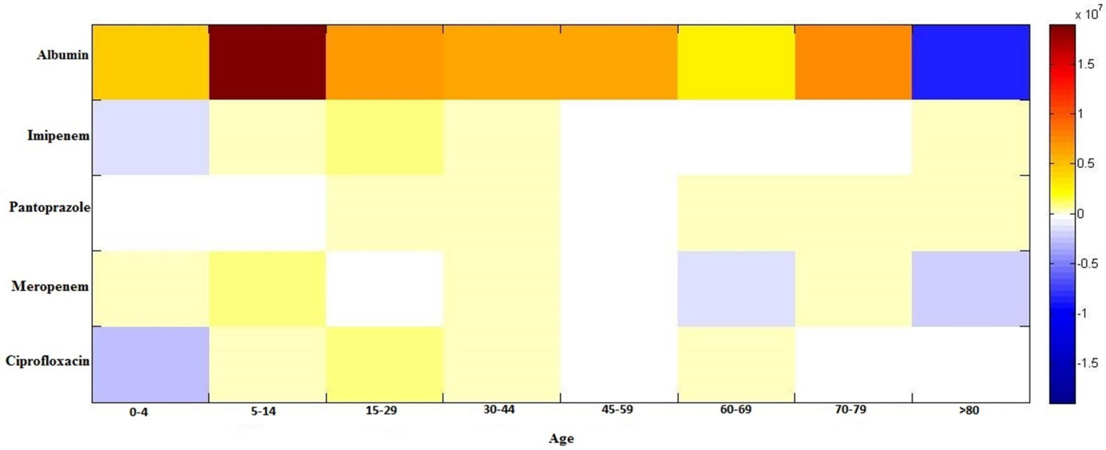

Fig. 3. Heat map for the average cost comparison of two periods in terms of drug and age

The reasons causing an increase in the cost of Albumin after the plan are given below.

Before the implementation of healthcare reform, the hospital pharmacies were not required to provide certain expensive drugs and the patient had to prepare them by themselves, e.g., Albumin as an expensive drug was provided by the hospital only in emergency cases and the patients had to procure them in case of other uses. After implementing the healthcare reform plan, all patients' drugs would have been required to be available in pharmacies, and since the payment by the patient dropped to about 6%, this has led to the increased consumption of expensive drugs such as Albumin. However, whether prescribed or not, it is not necessary to take the drug in some cases. Nonetheless, its consumption is excessive due to the lack of proper control in the hospital. On the other hand, the highest average cost is incurred between ages 5-14, because the drug dosage is determined based on age and the weight of patient; therefore, the amount of drug demands increases because the drug remains unusable. However, the length of stay and hospitalization in this age group is also longer.

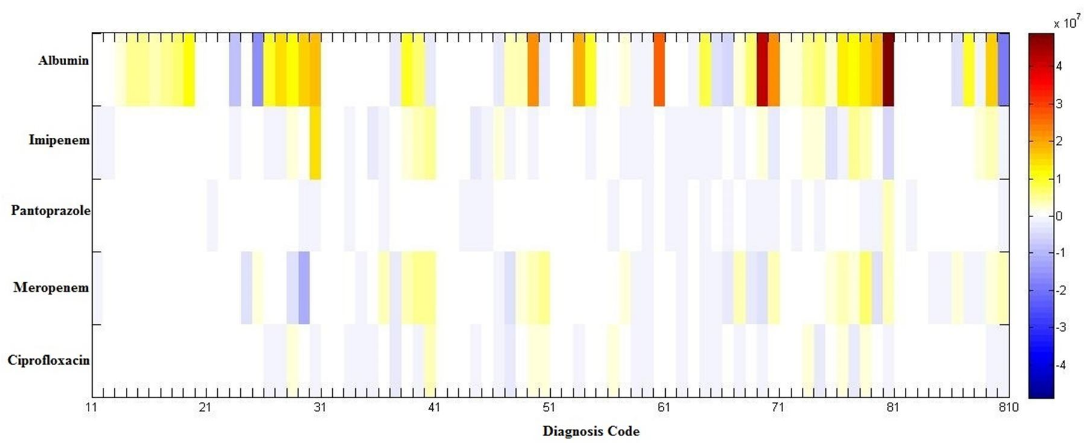

Fig. 4. Heat Map for average cost comparison of two periods in terms of drug and diagnosis

[DOI: 10.22068/ijiepr.31.1.115]

As shown in Figure 4, the average cost difference has been presented in terms of both diagnosis and drug. According to Fig. 3, Albumin experienced the highest variations in the average cost both before and after the reform plan. A large increase in the cost was observed on the diagnosis code 710 (Patients in HSCT with more than 29 days of stay) and diagnosis code 69 (patients in gastroenterology with a stay between 19 and 29 days).

In general, the highest consumption of Albumin is in gastroenterology, neurology, and Hematopoietic Stem Cell Transplantation (HSCT), because the number of patients with an urgent need for Albumin is hospitalized into these three parts.

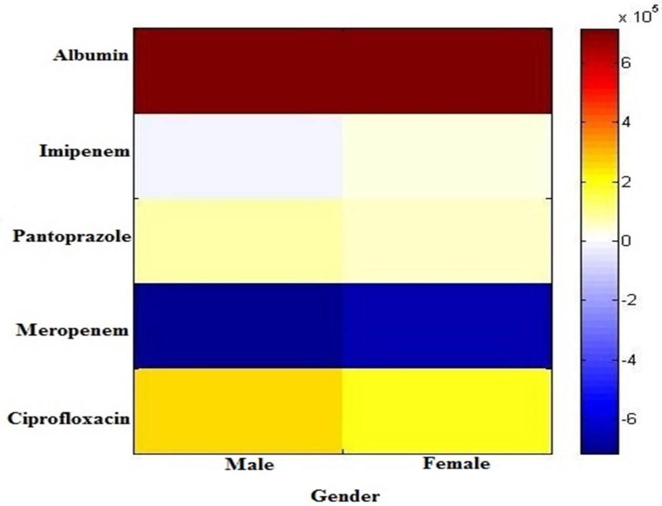

Fig. 5. Heat Map for average cost comparison of two periods before and after Health Reform in terms of drug and gender

Figure 5 shows the average cost difference in terms of drug and gender. It is clear that the greatest difference relates to Albumin in both females and males, undergoing an increase in the average cost after the reform plan, while Imipenem almost undergoes no change in the average cost. Both Pantoprazole and Ciprofloxacin show an increase in the average cost. Imipenem shows lower average cost after the implementation of the reform plan than that in the previous period for both men and women. The average consumption of five drugs is higher in men than women, resulting in the difference between the physics and anatomy (size and composition of the body) and differences in the body processes (differences in endocrine and hormonal and different metabolic patterns between men and women). Women are physically smaller than men, but receive the same dose of drug and, thus, the sensitivity response to the drug in women is higher than men.

Comparison of the cost risk heat map charts:

Risk matrix represents the distance of new data from the mean of available data and is computed based on Equation 1. The higher risk number shows a considerable distance between the input data and the average data and more anomalies than the previous data. Cost risk matrix is calculated based on the multiplication of average cost matrix by a risk matrix.

The areas with abnormal costs can be determined according to the cost risk matrices.

According to the results, Albumin shows the highest cost risk at the ages of 5 to 14. It is implied that the cost of Albumin for this age range is abnormal and unreasonable.

The highest cost risk in the period after the plan was associated with Albumin and the diagnosis code 69 (patients in gastroenterology with a stay between 19-29 days) and diagnosis code 710 (patients in HSCT with a stay longer than 29 days). That is, the use and cost of Albumin drug for these two diagnostic codes was unreasonable in the post-health reform period.

4.2. Model accuracy

Due to the high volume of data and the impossibility of labeling all of them, a set of patient prescription data in the hospital HIS system was randomly selected and labeled by two experts. An image of the data is given in Appendix B. The indicators of the area under the curve and the positive likelihood ratio were used to calculate the model performance.

[DOI: 10.22068/ijiepr.31.1.115]

Tab. 3. Comparison of the research model and the one in the previous research

	Methodology	AUC	LR+
Current research	Our method	81.6 %	6.35
Ortega et al. (2006) [22]	MLP	82.5 %	-

Based on the output of the algorithm and data tagged, the amount of the area under the curve equals 81.6% and the positive likelihood equals 6.35. Compared with the existing models in previous studies including the research of Ortega et al. (2006), they applied MLP to the fraud/abuse problem with the AUC; 82.5% represents that the employed algorithm has the ability to recognize the risky cases and abnormalities in the data [22].

In addition, the proposed method is used to evaluate the effect of the Iranian Healthcare reform Plan on the costs of Hospital drugs through a data representation obtained from cost and risk matrices. Figure 6 shows the comparison of the average cost of the albumin medication at different segments in periods before and after the health Reform Plan.

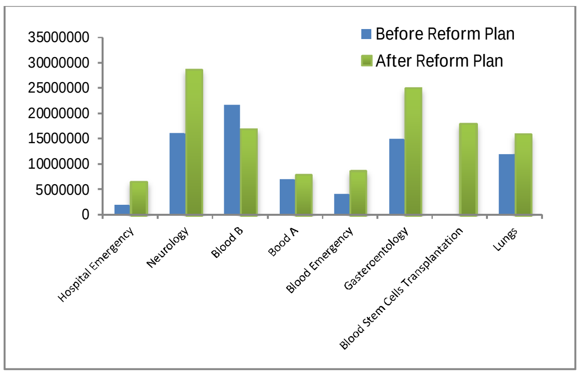

Fig. 6. Comparison of the average cost of albumin in different sections before and after the Reform Plan.

5. Discussion and Managerial Insights

This study presents a data mining model that uses both sets of treatment-related features and demographic characteristics of patients (such as age and gender) to identify cost anomalies in prescriptions after the implementation of the Healthcare Reform Plan. Then, this paper also identifies a range of ages, diagnoses, and genders in which drugs have undesirable cost changes.

Generally, when cost and risk areas coincide in the cost and risk matrices, the field becomes subject to a higher priority in the review of the cost and consumption amount of medication, showing the lowest amount of observation in the database and the highest cost. Accordingly, Albumin has the highest priority for drug administration.

Departments of Gastroenterology, Neurology, and HSCT have been the most extravagant sectors responsible for the expensive consumption of Albumin, and each of these sectors has been identified as an area with a high-cost risk that indicates the need to investigate the cost and pattern of drug consumption in these sectors.

When an area has high average cost and, yet, low cost risk, it takes precedence in the next step. Existing drugs in this range are costly, yet common, drugs that require establishing guidelines on the medication to manage costs of this area and for a rational drug use.

Antibiotic drugs such as Imipenem, Meropenem, and Ciprofloxacin are among the drugs that are used in the hospital in both pre- and post-transition periods. This unnecessary consumption usually results from the fact that patients with antibiotics do not receive, or procrastinate the need for, infection counseling until their illness has turned acute. In infection consultations, the results of antibiograms (drug sensitivity tests based on urine samples, blood, stools, etc.) determine what type of antibiotic the patient

[DOI: 10.22068/ijiepr.31.1.115]

should receive and at what dosage so that the treatment can be effective; then, following the administration approval, the infection consultants will follow the patient's treatment process and advise the patients about when to stop taking the drug or when to replace it. However, in many cases, patients are prescribed antibiotics without infection counseling, usually because the patient pays for it and does not complain about the conditions such as discontinuing antibiotic use or its continuous use even after his/her discharge from the hospital. Shortly after the implementation of the health reform plan and an increase in the cost of medicines, the Hospital Medicines and Treatment Committee developed medication prescription protocols for high-dose medicines and specified a stop order for carbapenem to justify their prescribing process. This is the reason for a decrease in Meropenem consumption and the unchanged cost and consumption of Imipenem after the health reform plan.

Similarly, the definition of a drug prescription protocol for Pentoprazole and Ciprofloxacin, whose costs increased by 1.1 times after the health reform plan, controls the rising costs. When an area has a high cost risk and, yet, low average cost, it is considered suitable for rare, but low-cost, drugs, and care must be exercised that the area does not coincide with the costly and risky areas by increasing the amount of the consumed drug over time. Finally, the ranges with low average costs and low-cost risk are considered as safe areas. In the case of drugs examined in this study, despite the existence of expensive or costly drugs, none of them was within the category of safe or low-cost or rare drugs. Figure 7 shows the range of each drug.

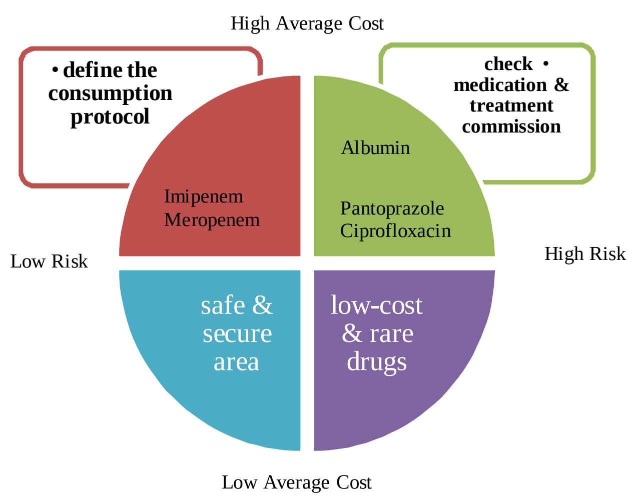

Fig. 7. Cost Analysis

Based on the range of each prescribed drug, the Commission of Medication and Treatment in Hospital can provide drug protocols and determine the stop orders to have more logical prescription patterns.

6. Conclusion

The aim of this study is to (a) evaluate the effect of the healthcare reform plan implementation on hospital drug costs and (b) provide a model for managing undesirable costs. According to the literature review, a study that evaluates and analyzes the effect of the Iranian Healthcare reform Plan on Hospital drugs cost is not available.

This study compared hospital drug costs in the two periods before and after the reform plan using a data mining model and identified a costly anomaly in the prescriptions after the Reform plan.

In order to measure the normalization of input prescriptions, by forming cross-over matrices on cross-features, risk matrices associated with each of them were calculated by the introduced risk function, and its values were compared with the threshold values. If the risk value is greater than the threshold, the request is marked as a suspected request with abnormal cost compared to other historical data and is displayed in the output.

Thus, such requests in which the cost of prescriptions and consumption pattern contradicts previous data were identified and referred to the experts. The proposed model with an AUC score of 81.6 and a positive likelihood score of 6.35 enjoys the ability to recognize the risk and

[DOI: 10.22068/ijiepr.31.1.115]

abnormalities in the data. Moreover, the results of the study were approved by experts and were in accordance with the hospital cost statistics. Due to the large volume of data, this study investigated 5 drugs with a higher priority for hospital costs, and prescription data were extracted from the records of hospitalized patients at the eight most expensive Departments; therefore, it is recommended that future investigations consider other priority drugs, identify and analyze them in detail or more Departments to develop a comprehensive model for the entire hospital. Further, considering that consumables in the hospital are costly, a model is proposed to identify cost anomalies in consumables, especially in the operating rooms of the hospital.

References

[1] Agrawal, Shikha, and Jitendra Agrawal. "Survey on anomaly detection using data mining techniques." *Procedia Computer Science* Vol. 60, (2015), pp. 708-713.

[2] Aral, Karca Duru, Halil Altay Güvenir, İhsan Sabuncuoğlu, and Ahmet Ruchan Akar. "A prescription fraud detection model." *Computer methods and programs in biomedicine* Vol. 106, No. 1, (2012), pp. 37-46.

[3] Bojakowski, Steve, and Lynda Filer. "Medicines management: An integrated approach?." *Journal of Management & Marketing in Healthcare* 2, No. 1, (2009), pp. 102-111.

[4] Calderón-Larrañaga, Amaia, Beatriz Poblador-Plou, Anselmo López-Cabañas, José Tomás Alcalá-Nalvaiz, José María Abad-Díez, Daniel Bordonaba-Bosque, and Alexandra Prados-Torres. "Does the pharmacy expenditure of patients always correspond with their morbidity burden? Exploring new approaches in the interpretation of pharmacy expenditure." *BMC public health* 10, No. 1 (2010), p. 244.

[5] Carvalho, L. F., C. Teixeira, Ester C. Dias, W. Meira, and O. Carvalho. "A simple and effective method for anomaly detection in healthcare." In *Proceedings of the SIAM International Conference on Data Mining Workshop*, (2015), pp. 16-24.

[6] Deputy of Therapy Ministry of Health and Medical Education, "A set of guidelines for the development of health system", Tehran, (2013).

[7] EbadifardAzar, Farbod, Aziz Rezapoor, Ahmad Rahbar, Hosseini Shokouh, Sayyed Morteza, and Saeed Bagheri Faradonbeh. "Estimation of the Function of Medicine Demand in Islamic Republic of Iran." *Journal Mil Med* 15, No. 2, (2013), pp. 163-168.

[8] Faridfar, Niloufar, Khalil Alimohammadzadeh, and Seyed Hesam Seyedin. "The impact of health system reform on clinical, paraclinical and surgical indicators as well as patients' satisfaction in Rasoul-e-Akram hospital in 2013 to 2014." *Razi Journal of Medical Sciences* 22, No. 140, (2016), pp. 92-99.

[9] Godarzi, L., F. Khayeri, A. Meshkini, and A. Khaki. "Patient satisfaction and staff development programs of the health system." *Criticism of the government in health XI* (2015).

[10] Hamid, Mojtaba, Mahdi Hamid, Mohammad Mahdi Nasiri, and Mahdi Ebrahimnia. "Improvement of operating room performance using a multi-objective mathematical model and data envelopment analysis: A case study." *International Journal of Industrial Engineering & Production Research* 29, No. 2, (2018), pp. 117-132.

[11] Highfill, Tina, and Yasar Ozcan. "Productivity and quality of hospitals that joined the Medicare shared savings accountable care organization program." *International Journal of Healthcare Management* 9, No. 3, (2016), pp. 210-217.

[12] Imamgholipour, Sara, Arash Rashidian, & Majid Nakha'i, "Estimation of Medication Demand Function in Iranian Households using Panel Data, 2004-2011," Hakim Health Sys Res (2014), pp. 235-241.

[13] Ilyas, Stephen, and Joanna Moncrieff. "Trends in prescriptions and costs of drugs for mental disorders in England, 1998–2010." *The British Journal of Psychiatry* 200, No. 5, (2012), pp. 393-398.

[DOI: 10.22068/ijiepr.31.1.115]

[14] Jebeli, Seyedeh Sedighe Hosseini, Aidin Aryankhesal, Mohsen Barouni, Parvane Heidari Orojloo, and Mahdi Khakian. "Estimating the Demand Function of Specialty Medicines in Iran, Using Household Budget–2013." *Journal of Health and Development* 4, No. 2, (2015), pp. 89-101.

[15] Johnson, Marina Evrim, and Nagen Nagarur. "Multi-stage methodology to detect health insurance claim fraud." *Health care management science* 19, No. 3, (2016), pp. 249-260.

[16] Joudaki, Hossein, Arash Rashidian, Behrouz Minaei-Bidgoli, Mahmood Mahmoodi, Bijan Geraili, Mahdi Nasiri, and Mohammad Arab. "Improving fraud and abuse detection in general physician claims: a data mining study." *International journal of health policy and management* 5, No. 3, (2016), p. 165.

[17] Khodadadi, J., K. Vafaie, F. Aahmadi, and F. Razavian. "Comparing patient satisfaction with health services provided in the Kamkar hospital before and after the health reform." *Criticism of the government in health XI* (2015).

[18] Iavindrasana, Jimison, Gilles Cohen, Adrien Depeursinge, H. Müller, R. Meyer, and Antoine Geissbuhler. "Clinical data mining: a review." *Yearbook of medical informatics* 18, No. 01, (2009), pp. 121-133.

[19] Mehrjerdi, Y. Zare. "A system dynamics approach to healthcare cost control." International Journal of Industrial Engineering 23, No. 3, (2012), pp. 175-185.

[20] Moradi, Mandana, Hamed Jami, and Fatemeh Izadpanah. "Comparing the Drug Prescription before and after the Implementation of Health System Reform Plan in Southeastern Community Pharmacies of Iran." Journal of Pharmaceutical Care 6, Nos. 1-2, (2018), pp. 13-18.

[21] Moreira, Paulo. "The health management key challenge: how do we save European Health Systems?." (2011), pp. 145-147.

[22] Ortega, P.A., Figueroa, C.J. & Ruz, G.A., 2006. A Medical Claim Fraud/Abuse Detection System based on Data Mining: A Case Study in Chile. In in Proceedings of International Conference on Data Mining. Las Vegas,Nevada, USA, (2006).

[23] Ozieh, Mukoso N., Kinfe G. Bishu, Clara E. Dismuke, and Leonard E. Egede. "Trends in health care expenditure in US adults with diabetes: 2002–2011." *Diabetes Care* 38, No. 10, (2015), pp. 1844-1851.

[24] Parvaneh A., Tarokh M. J. & Abbasimeh H. , " Combining Data Mining and Group Decision Making in Retailer Segmentation Based on LRFMP Variables", international Journal of Industrial Engineering & Production Research Vol. 25, (2014), pp. 206-197.

[25] Piroozi, Bakhtiar, Arash Rashidian, Amirhossein Takian, Mohammad Amerzadeh, Minoo Alipouri Sakha, Obeidollah Faraji, and Ghobad Moradi. "The impact of health transformation plan on hospitalization rates in Iran: An interrupted time series." *The International journal of health planning and management* 34, No. 1, (2019), pp. e264-e273.

[26] Rahbar, A., M. Barouni, M. Bahrami, and A. Saber Mahani. "Estimation of Drug Demand Function in Iranian Urban Population through Household Budget, 1990-2011." *J Tolooe Behdasht* 12, No. 3, (2013), pp. 44-58.

[27] Ravichandran, N. "The responsiveness of hospitals in healthcare financing: Pharma-equity problems and pitfalls." *International Journal of Healthcare Management* 10, No. 2, (2017), pp. 97-106.

[28] Rezaie, Shirin, Mohammad Arab, Abbas Rahimi-Forushani, and Ebrahim Jafari Pouyan, "Effects of the New Health Reform Plan on the Performance Indicators of Health Reform Plan on the Performance Indicators of", Scientific Journal of School of Public Health and Institute of Public Health Research 14, No. 2, (2016), pp. 51-60.

[29] Roshan, Keyvan, Mehdi Seifbarghy, and Davar Pishva. "Multi-objective evolutionary algorithms for a preventive healthcare facility network design." International

[DOI: 10.22068/ijiepr.31.1.115]

Journal of Industrial Engineering & Production Research 28, No. 4, (2017), pp. 403-427.

[30] Sarkhanlou, Farzaneh, Majid Saeedi, Ghasem Janbabai, Shokoufeh Nikfar, Katayoun Morteza-Semnani, and Pardis Zaboli. "Comparative Study of Direct Patient and Drug Costs before and after the Implication of Healthcare Reform Program in Sari, Iran." *Journal of Mazandaran University of Medical Sciences* 26, No. 142, (2016), pp. 228-232.

[31] Schumock, Glen T., Edward C. Li, Katie J. Suda, Michelle D. Wiest, JoAnn Stubbings, Linda M. Matusiak, Robert J. Hunkler, and Lee C. Vermeulen. "National trends in prescription drug expenditures and projections for 2016." *American Journal of Health-System Pharmacy* 73, No. 14, (2016), pp. 1058-1075.

[32] Soleimani, A., M. Abdullah, F. Hoseini, S.Forghani, S. Allah Verdi , and A.Khalili. “The third step is the implementation of health reform program patient satisfaction in hospitals affiliated to Shahr kurd of medical university.” *Criticism of the government in health XI* (2015).

[33] Tabari-Khomeiran, Rasoul, Sajad Selavari, Satar Rezaei, Enayatollah Homaie Rad, and Mostafa Shahmoradi. "The effect of Iranian health system reform plan on payments and costs of coronary artery bypass surgery in private hospitals of Iran." *International Journal of Human Rights in Healthcare* (2019).

[34] Tomar, Divya, and Sonali Agarwal. "A survey on Data Mining approaches for Healthcare." *International Journal of Bio-Science and Bio-Technology* 5, No. 5, (2013), pp. 241-266.

[35] Xu, Lin, Yi-Ren Yeh, Yuh-Jye Lee, and Jing Li. "A hierarchical framework using approximated local outlier factor for efficient anomaly detection." *Procedia Computer Science* 19 (2013), pp. 1174-1181.

[36] Yin, Liangying, Zhengxing Huang, Wei Dong, Chunhua He, and Huilong Duan. "Utilizing Electronic Medical Records to Discover Changing Trends of Medical Behaviors Over Time." *Methods of information in medicine* 56, No. S 01, (2017), pp. e49-e66.

Follow This Article at The Following Site:

kargari M, Sahranavard S. Managing Hospital medicine Costs in Healthcare Reform: Case Shari'ati Hospital. IJIEPR. 2020; 31 (1) :115-130
URL: http://ijiepr.iust.ac.ir/article-1-894-en.html

[DOI: 10.22068/ijiepr.31.1.115]