



## How Radio Frequency Identification Improves Pharmaceutical Industry: A Comprehensive Review Literature

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### ABSTRACT

According to the vital role of pharmaceutical industry in health care system, pharmaceutical supply chain security, standard production and distribution of the pharmaceutical products are of great importance for pharmaceutical companies. Therefore, applying technology, especially Radio Frequency Identification (RFID), is essential to achieve these goals. Moreover, due to the importance of security in production and distribution and also the quality of pharmaceutical products, international pharmaceutical Institutes such as Food and Drug Administration (FDA) and huge pharmaceutical companies apply RFID to increase their success and improve their efficiency and effectiveness. The present study explains the concept of RFID, its application and importance in pharmaceutical industry, and its role in struggling against counterfeit medicines in addition to presenting a framework of RFID in struggling against counterfeit medicines. It is discussed that RFID has various applications in pharmaceutical industry such as inventory and property management system, access control and machines' performances, producing sterile pharmaceutical products, anti-thieving mechanism, preventing medicines' diversion Counterfeit medicines and recognition of counterfeit medicines. As a conclusion RFID can be suggested to make the pharmaceutical industry and health system smart. Therefore, it is suggested to establish this technology in pharmaceutical supply chain by the use of Information Technology and create a team of related specialists in order to successful application of this technology and gain the positive related results.

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### Introduction

Pharmaceutical industry is one of the biggest industries which is directly in relation with health care. Activities of this industry are divided into two parts; producing pharmaceutical products and distributing them to people. Moreover, producing and selling pharmaceutical products made this industry one of the most important industries which plays very important role in health care all around the

world (1). However, this industry is totally different from other industries in a way that it is not possible to sell any faulty products in this industry. Therefore, pharmaceutical companies tried to apply special parameters to guarantee the quality of their products. These parameters include 4 general categories: "Identification (ID), resistance, security, and purity". Among these parameters "ID" is the most important characteristic of the pharmaceutical products. "ID" refers to the correctness and identification of the pharmaceutical products, personnel, production procedures, raw materials, machines, equipment, production processes, and production locations (2). Besides, identifying distributors of the raw materials,

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**Table 1.** Search strategy.

Search Strategy	
<b>Search Engines and Databases:</b> Google, Google Scholar, PubMed, ISI web of science, Science Direct, EMBASE, Scopus (2004 to present)	
<b>Limits:</b> Language (only resources with at least an abstract in English)	
<b>Date:</b> Monday - 2015 05 January	
<b>Strategy:</b> #1 AND #2 AND #3	
# 1	Application OR Assessment OR Assessment of Feasibility OR Feasible OR possibility OR Challenges OR Barriers
#2	RFID technology OR Radio Frequency Identification OR AIDC OR Automatic Identification and Data Capture
#3	Health care System OR Pharmaceutical Industry OR Health Care Industry OR Pharmacy OR Medical care OR Hospital OR E-Health

agents, distributions, and locations are of great importance. For this purpose, some international institutes (such as Food and Drug Administration (FDA), European Medicines Agency (EMA), and European Federation of Pharmaceutical Industries and Association (EFPIA)) emphasize on the application of creative solutions in health care and pharmaceutical supply chain in order to improve the patients' safety and increase the efficiency of the pharmaceutical supply chain (3) which not only help the producers and distributors of pharmaceutical products but also is useful for FDA procedures(4). In this regard, for creating secure and efficient pharmaceutical supply chain, one of the most useful technologies in pharmaceutical industry is Radio Frequency Identification (RFID) which introduces the importance and sensitivity of this industry (5). RFID is an automatic wireless identification technology which has become very famous in vital industries such as pharmaceutical industry and health care in a very short period of time (6). Pharmaceutical industry, with millions of pharmaceutical products all around the world which need to be traced and identified, showed a huge tendency to apply this technology. Moreover, increasing problem of counterfeit medicines threatens the pharmaceutical industry in different ways (7). RFID has developed in Auto-ID center of Massachusetts Institute of Technology (MIT) in order to trace and identify objects by the help of radio frequencies (8). RFID works with a combination of Electronic Product Code (EPC) that has made it a very powerful and efficient technology in pharmaceutical industry and health care systems (9). Furthermore, this technology is a powerful commercial tool which will be used instead of other identification tools such as bar code in early future. On the other hand, RFID has lots of strategic benefits for business due to the effective stock tracking ability in supply chain, estimating the real time in controlling the transferring of the products, and controlling general properties of institutes (10). Also, appropriate identification of the elements of

different materials such as pharmaceutical raw materials and packing pharmaceutical products are preliminary steps in improving the quality of pharmaceutical industry. Besides, identification in each step and range of production and distribution is essential. In this regard, RFID can be introduced as an effective solution to improve the performance of pharmaceutical industry. Therefore, because the pharmaceutical industry needs competitive advantages in today's world, applying RFID is useful in improving the performance (11). By the same token, this study discusses the potential of RFID in pharmaceutical industry, the applications of RFID technology in this industry, and also different issues related to counterfeit medicines and applying RFID against them in addition to introducing the RFID technology by reviewing the previous studies.

## Methods

The present study is a review study which aimed to determine the role of RFID technology in pharmaceutical technology. In this regard, different search engines and data-bases such as "Google Scholar", "Emerald", "Science Direct", "Iran Medex", "SID", "Magiran" and "Pubmed" were applied and "MESH Terms List" and keywords like "pharmaceutical industry, RFID technology, radio frequency identification, health care system, and health care industry" were searched (Table 1). Different guides, outlines, and related reports were investigated in addition to the articles. Descriptions, characteristics, and advantages of RFID technology were mentioned in all articles, guides, and reports.

The results of searching the references related to RFID technology in pharmaceutical industry were consisted of 1850 references from October 1, 2004 to January 10, 2015. The references were investigated based on their relationships to the subject matter which leads to the exclusion of 1440 irrelevant references according to their abstracts as a characteristic for the whole papers. 48

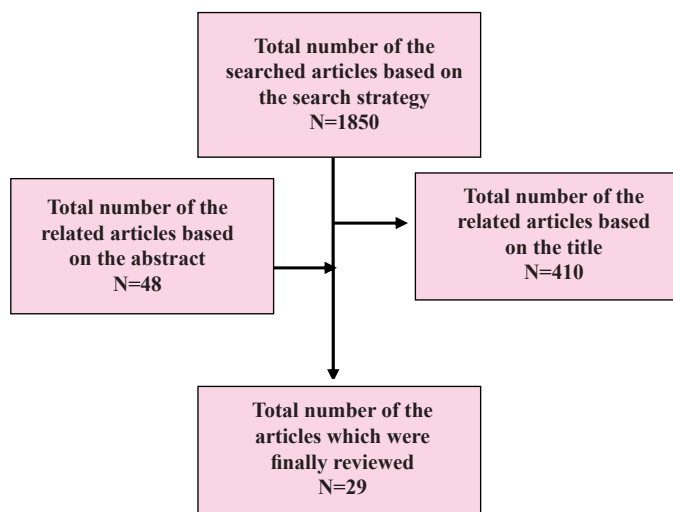


Figure 1. The process of selecting relevant references.

studies were included after investigating their abstracts and finally, 29 studies were selected as related references after studying their full texts. Figure 1 shows the summary of selecting the relevant references.

## Findings

### *The concept of RFID*

RFID as a wireless technology uses radio frequency signals to send and receive data via wireless signals from RFID tags to data readers to detect different objects, properties, people, industrial products, and create data-collection process or transform the manual processes to the automatic ones (12). Generally, RFID system consists of three sections. First, RFID tags which include unique identifiers and can be active, semi-passive, or passive. Second, RFID data readers which read or write data from the tags and they have variety of shapes and sizes such as portable or stationary. The third part includes a data base to store the data which were collected from the tags and a middleware to process the data (13). Each RFID tag includes a microchip which is able to perform logistic calculations and storing data. Therefore, data storage can be “read only”, “write only”, or a combination of these two. Also there is a small antenna in each tag to receive radio frequencies (14). RFID data reader sends radio frequencies to the tags in order to access the data and the tags receive and send the data to the readers. Moreover, data readers are able to process and store data. Also, data readers are connected to back up storage via the middleware to perform compact calculative processes. RFID middleware is designed for messaging, tracking, connecting, and integrating data with the backup systems such as Enterprise Resource Planning (ERP)

and Warehouse Management System (WMS). At the end, back up data base stores all the registered data of the tags (15). Figure 2 displays the design of RFID system.

### *Applications of RFID in pharmaceutical industry*

FDA desires to identify the pharmaceutical products, raw materials in producing these products, equipment, and production locations in an appropriate way. In this regard, identifying them need documentary evidences. Currently, this organization emphasizes on applying a special technology to accelerate these processes. Thus, RFID technology can be a very good choice to solve this problem (16). Therefore, it seems that FDA will start using this technology soon. Although, there are several debates on the applications of RFID technology in pharmaceutical technology, these applications are categorized as follows:

- 1) Inventory management system: Pharmaceutical industry uses variety of materials in the production circle of pharmaceutical products. Therefore, identifying their identity and existence is very crucial. Also, pharmaceutical products are classified in different categories and identifying and tracking them is of great importance for product management units and FDA. In this regard, tracking and identifying pharmaceutical products in a very important domain in controlling and managing the stuck and RFID technology plays a decisive role in it by applying the ability of tracking and unlimited tagging of the products. More than identifying and tracking in inventory management, some items such as tracking entering and exiting raw materials and final products, smart shelves, surface tagging, vital processes domains, documentation, and entering and exiting to the building are the abilities of this technology (17, 18).

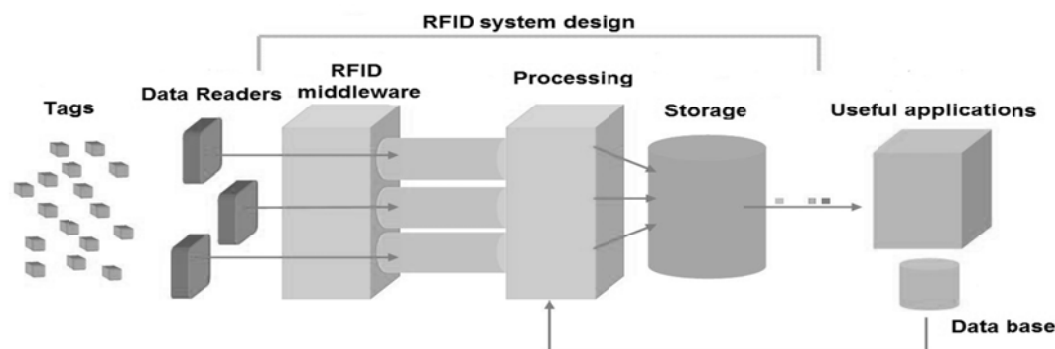


Figure 2. RFID system design (16).

2) Access control: In the production process of pharmaceutical products, the documents of the materials which were used by different people are needed. However, some of these documents are confidential; therefore, this industry needs a high level of security and performance security. Thus, one way to obtain this security is selective accessibility. In this regard, access control is one of the important applications of RFID technology in pharmaceutical industry and it is possible to apply the abilities of this technology to control and limit the accessibility (18, 19).

3) Producing sterile pharmaceutical products: Sterile products are those without any microorganisms. Therefore, production locations of these products are class A locations in medicines production unit. Thus, only the personnel who are approved by Security System Technology (SST) are permitted to enter these locations. In this regard, RFID tags can help SST system in identifying and tracking persons who have access to these locations (18).

4) Access to the machines' performances: Most of the machines in pharmaceutical industry are automatic which work based on Programmable Logic Controller (PLC) algorithm. Thus, there are two important issues in this regard; first, only trained personnel must work with these machines, and second, they should not be able to change PLC without necessary permits, because changing important parameters in producing pharmaceutical products can have adverse effect on the quality and standards of production (some of these parameters are sterilization time and temperature, steam pressure, round per minute in mixer, mixing time, and etc.). Therefore, applying RFID technology in this procedure leads to control the performances of the machines and improve the quality of the products (20).

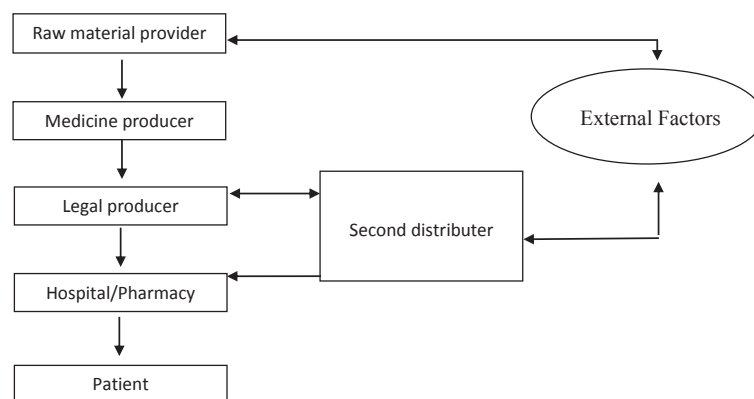
5) Anti-thieving mechanism: thieving is one of the important challenges in pharmaceutical industry and it includes expensive parts, electronical motors,

expensive medicines, toxic materials, and confidential archives. In this regard, paying attention to the effective applications of information technology and especially RFID technology is of great importance in preventing thieving in pharmaceutical industry. For example, spare parts and expensive machines are classified as Class A or Class X (vital and expensive parts) which can be traced and identified anytime and anywhere by RFID tags. Also, adding permanent tags to them in their locations and knowing their locations in each time is another apparent ability of RFID technology in pharmaceutical industry that no other similar technology can compete with it. Moreover, this technology is able to trace valuable properties through syncing with cc-cameras and alarm systems to inform while bringing out the items without permission (21).

6) Property management: Pharmaceutical industry is a vast industry which has valuable resources such as equipment, medicines analyzing and laboratory tools, computers, etc. therefore, managing these properties is really crucial for this industry. Furthermore, the role of this technology in managing organizations and industries is inevitable. In this regard, RFID is one of the important and practical technologies in managing the properties of pharmaceutical industry. This technology accelerates tracking different properties by tagging and tracing all of them in medicines supply chain (22).

7) Preventing medicines' diversion: Medicines' diversion means bringing pharmaceutical products to the black market with high prices, so without applying RFID, it is almost impossible to trace these violations and the technology enables us to prevent entering illegal products into medicine supply chain (17).

8) Counterfeit medicines: Once a produced medicine which has a specific name and the logo of the manufacturer being produced by another company, the medicine will be known as counterfeit medicine. Counterfeit medicine is a medicine with less principal



**Figure 3.** Distribution and consumption of counterfeit medicines.

ingredients, lack of active ingredients, inappropriate and insufficient ingredients, and fake packaging (23). Counterfeit medicines are produced by illegal producers in order to sell in the areas that health care information is almost unavailable. These companies do not have any invention right and appropriate team and facilities to produce qualified medicines. Moreover, consuming these medicines is very harmful for the patients in a way that inappropriate dosages may kill them (Figure 3).

Therefore, counterfeit medicines are very dangerous in health care industry all around the world (24). According to the reports of Pfizer pharmaceutical companies, more than 200000 bottles of cholesterol pills related to these companies were fake which cost about 55 million dollars. Also, based on the report of Pharmaceutical Security Institute in 2010, producing counterfeit medicines increased about 9% all around the world. According to the National Crime Prevention Council (NCPC), more than 10% of the pharmaceutical products in pharmaceutical supply chain are counterfeit (25).

In this regard, FDA has moved against producing, distributing, and selling counterfeit medicines. Therefore, increasing the security of producing pharmaceutical products in today's business world which products are sold online is a must for this industry. Therefore, for keeping the customers away from counterfeit medicines, it is necessary to use RFID technology to establish a logistic security in pharmaceutical industry. Moreover, applying this technology is a competitive advantage in pharmaceutical industry to battle counterfeit medicines (26).

### **Recognition of counterfeit medicines via RFID technology**

Applying RFID technology in pharmaceutical industry ensures us that the medicines are authentic. This technological tool enables tracing the medicines from production to sell. Thus, successful establishment of

this technology will equip the pharmaceutical industry with an advanced tool against counterfeit medicines and therefore customers of pharmaceutical products can buy standard and safe products. Nevertheless, this technology is of great value in pharmaceutical industry and for the patients as well. Because this technology is a systematic solution for tracing and identifying authentic medicines from counterfeit ones (27). Tagging pharmaceutical products gives a specific identifier to each product which leads to concise tracing and identifying of that product in pharmaceutical supply chain. In this regard, all of the materials which are used as raw materials were tagged before arriving in producing companies. Therefore, the information of raw pharmaceutical products is stored and the information of the tag related to one specific medicine is scanned and kept for further processing. In the next stage, the information of the ingredients is updated based on production and expiry date, raw data resources, and information resources, and then it is connected to the medicines' packages. Moreover, the information of RFID tags were transferred to a data base and the information are updated based on the movement of pharmaceutical products in the supply chain. The system will automatically send alarms in case of any diversion (28). Thus, pharmaceutical products will move from the producer to the distributor, wholesaler, pharmacy, and hospital in a secure way. In this regard, tracing and following the specific information of the medicines such as weight, shape, size, and color of the medicines are of great importance in identifying counterfeit medicines. Analyzing the data base and receiving the information of RFID tags enables producers, wholesalers, pharmacies, hospitals, and pharmacists to identify the medicines and the exact amount of ingredients and the way to way to the costumers. In this way, RFID presents a security framework which can be applied in pharmaceutical supply chain in order to battle against counterfeit medicines (12, 29). Considering the effective role of RFID technology



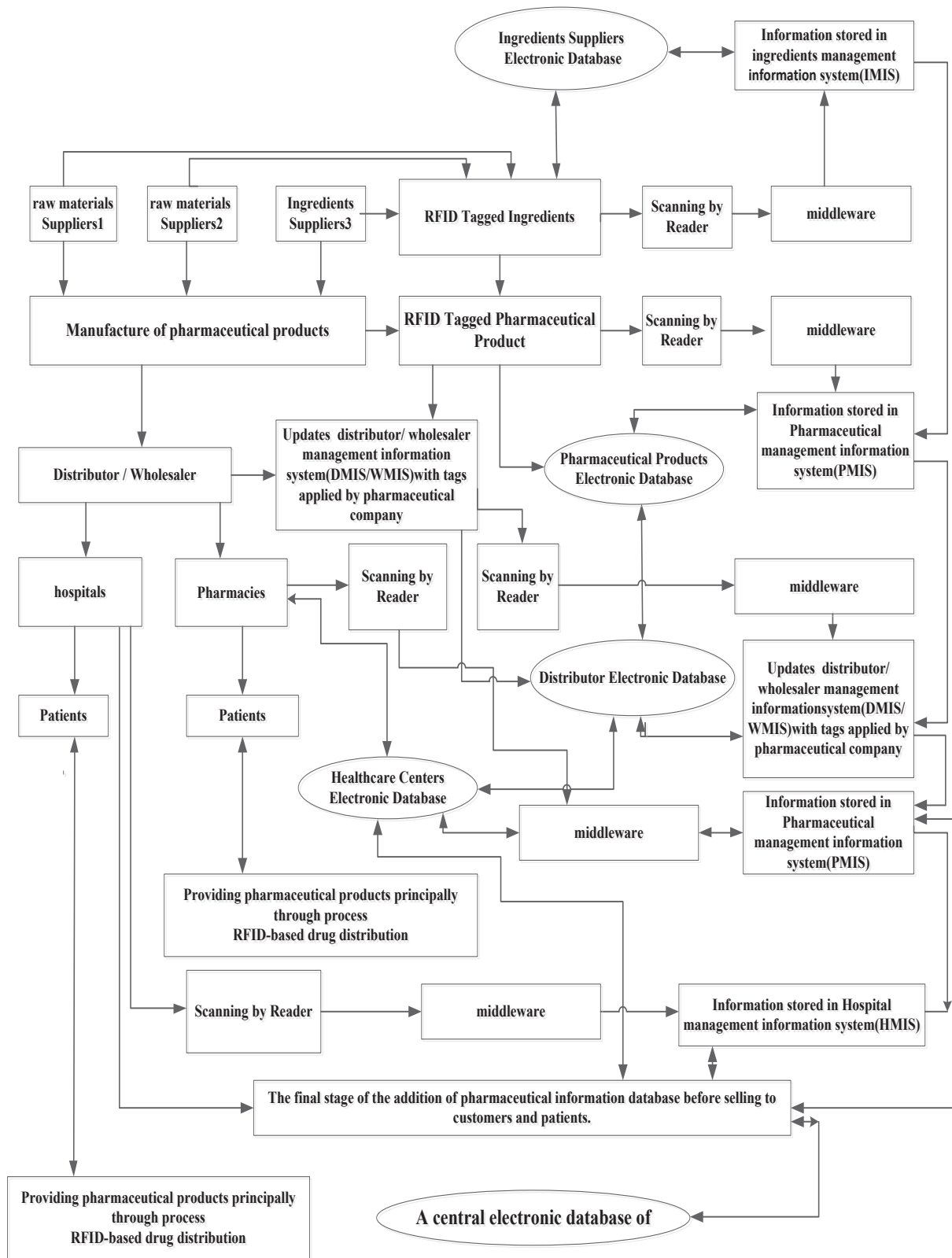


Figure 4. RFID-based drug distribution process for dealing with counterfeit drug (30).

in managing and decreasing the counterfeit medicines in the market, a framework of battle against counterfeit medicines in pharmaceutical supply chain is presented in Figure 4 (30).

## Discussion

According to the present findings RFID has various applications in pharmaceutical industry such as inventory and property management system, access control and machines' performances, producing sterile pharmaceutical products, anti-thieving mechanism, preventing medicines' diversion Counterfeit medicines and recognition of counterfeit medicines. On the other hand, applying this technology in different industries can increase the efficiency and effectiveness of them as well. Applying this technology was successful in many countries in order to establish high quality health care for people. Applications of RFID in pharmaceutical industry for different aims have proved advantages which are discussed in this study. However, preventing and battling against counterfeit medicines are the most important and practical benefits of this technology in pharmaceutical industry. In this regard, considering the importance of RFID technology in management and decreasing counterfeit medicines in pharmaceutical supply chain, the mentioned framework was presented to battle against counterfeit medicines in the pharmaceutical industry. This framework explains the possible way of preventing the counterfeit medicines in pharmaceutical supply chain via using RFID technology. In this regard, this technology is able to trace pharmaceutical products from production to consumption. It is mentioned in the first phase of the framework that raw material producers put tags on their packages and the information of these tags will transfer to data readers through a complicated process and this information will go to a host system via a middleware. Moreover, the information will transfer to the central data base and the information will be updated there in each stage. In the second phase, tagged raw materials will move in pharmaceutical supply chain and receive by the pharmaceutical producers. In a similar process, the pharmaceutical product producers update the system and the data base will be updated by the pharmacists and wholesalers. In the third phase, the products will be tagged and move towards distributors. The information will be updated in their system and in fourth phase, the distributors deliver the products to the hospitals and pharmacies. The information will be updated again at the time of entering there and the information will come to the data base. Finally, the authentic and high quality product will be sold to the costumers. Thus, RFID technology will improve the distribution process in pharmaceutical supply chain and make the process smarter and also prevent huge losses to the supply chain because of counterfeit medicines and entering authentic and expensive medicines to the black

markets as well. In conclusion, it is worth mentioning that in developing countries such as Iran which the cost per person of healthcare is not too much, and also the health budget is not impressive and there are no stable resources for that, RFID technology can suggest useful suggestions in order to make the pharmaceutical industry and health system smart. Therefore, it is suggested to establish this technology in pharmaceutical supply chain by the use of IT and create a team of related specialists in order to successful application of this technology and gain the positive results, and also controlling the huge costs of RFID technology and harness the barriers by concise investigations.

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