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Counterfeit Drugs Prevention in Pharmaceutical Industry with RFID: A Framework Based On Literature Review

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Abstract**—**The purpose of this paper is to focus on security and safety issues facing by pharmaceutical industry globally when counterfeit drugs are in question. Hence, there is an intense need to secure and authenticate pharmaceutical products in the emerging counterfeit product market. This paper will elaborate the application of radio frequency identification (RFID) in pharmaceutical industry and to identify its key benefits for patient's care. The benefits are: help to co-ordinate the stream of supplies, accuracy in chains of supplies, maintaining trustworthy information, to manage the operations in appropriate and timely manners and finally deliver the genuine drug to patient. It is discussed that how RFID supported supply chain information sharing (SCIS) helps to combat against counterfeit drugs. And a solution how to tag pharmaceutical products; since, some products prevent RFID implementation in this industry. In this paper, a proposed model for pharma industry distribution suggested to combat against the counterfeit drugs when they are in supply chain.

Keywords**—**Supply chain, RFID, pharmaceutical industry, counterfeit drugs, patients care.

I. Introduction

PHARMACEUTICAL industry operates for the sake to provide healthcare facilities to human beings and animals. It produces and market drugs and it is one of the major industry, playing vital role globally. This industry is different from any other industry, since in this industry a product with little defect, cannot be sold. The authorised company has to meet certain quality parameters to produce drug. This paper focuses on how to prevent counterfeit drugs in pharmaceutical industry, mainly when drug moves in pharma supply chain.

In order to make pharmaceutical chain of supplies more secure, the most influential technology worldwide Radio Frequency Identification (RFID) has been selected to elaborate its importance and contributions for the most sensitive industry. Further it will explain how much benefits can be derived from successful implementation of this technology.

Radio Frequency Identification (RFID) is an emerging technology, (see Figs. 1 and 2) and in shorter epoch it gained fame in Life Sciences Industry [1]. RFID is developed by the Auto-ID centre at the Massachusetts Institute of Technology to track and identify the objects with the assistance of radio waves [2]-[5]. RFID works with the combination of EPC (Electronic Product Code) (VeriSign, Inc. 2004). It has become an influential technology, which has a foremost impact on organizations. And it has designed more effective IT systems, which assist industry with an intention to achieve their results more accurately and rapidly than ever before. It detects, and detains data through wireless (AIDC), which is used to thwart hazards in industries [6].

A delve has proved that embracement of RFID technology improves the company's product availability, process control, inventory management, thwart hazards, and security [7]-[10]. Insofar, professionals from industry and researchers concentrated on it, since it has abundant paybacks for industry globally. World's well-known organizations the Wal-Mart, U.S. Food and Drugs Administration, U.S Department of Defence have recommended this technology to be implemented in supply chain, especially to thwart the counterfeit drugs worldwide [11]-[13].

This study aims to expand the discussion mentioned above. First the importance of RFID will be explained and its use in pharmaceutical industry. Second, issues related to counterfeit drugs, role of pharmaceutical industry and negative impact of counterfeit drugs will be explained. Third, counterfeit drugs detection through RFID will be discussed. Finally a proposed model will guide to supply chain managers/directors how RFID enabled supply chain delivers a genuine drug to patient. Last but not least the systematic review of literature will help researchers and also the proposed model can be further attested in the pharmaceutical industry

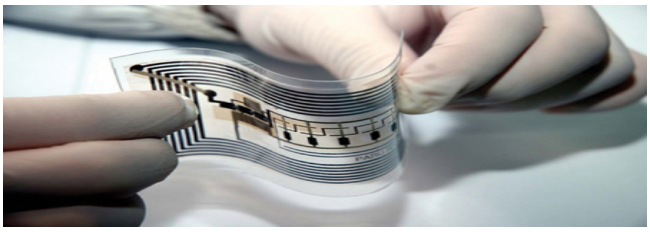

Fig. 1 Flexible RFID Tag using Nanotechnology

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Fig. 2 RFID Tag for Pharmaceutical Industry

Research Question: How can we combat against counterfeit drugs in Pharmaceutical Industry with RFID?

II. Literature Review

The RFID technology brought a revolutionary change in the field of supply chain management i.e. 1. Prevent the risks in industries (especially counterfeit drugs in pharmaceutical industry), 2. Warehousing efficiencies, 3. The ability to locate every product, 4. Ability to stop theft. The RFID tags work perfectly with the combination of EPC (Electronic Product Code).

EPC (Electronic Product Code) is a product of EPCglobal. It is a method, which is used to identify the physical objects globally via RFID tags [14].

EPC is used to identify the objects in specific chain of supplies, because of its unique numbers given to each product. It allows users to exchange data, between partners in the chain of supplies through its EPCglobal Network [15].

Whether we are talking about the pharmaceutical industry supply chain risks, diabetes patient's tests, shipping documentations, passport control at the airports, library of a University or point of sale data collection, RFID is the best technology to implement in order to gain the desired outcomes. RFID technology has five primary abilities, which make it different from the bar codes [16]: 1. No line of sight requirement; 2. Each drug has a unique code; 3. It allows the immediate reading; 4. It is more durable; and 5. It has ability to store more data than the bar codes.

RFID enhances the efficiency in healthcare and pharmaceutical industry's supply chain management activities by securing and safety of products. In pharmaceutical and healthcare industry it was often mistreated activity [17]. RFID technology has become an important business utility after E-commerce and ERP, which were considered to be an advanced information management systems. It also contributes to the organizational capabilities [18].

The technology was implemented in hospitals and pharmaceutical industry specially to thwart the potential hazards. The hazard involves, but not limited to patients care, mobile assets tracking, preclusion of babies kidnapping, counterfeit drugs, and cold chains [19]. The technological solutions anticipated to increase the life sciences industry's efficiency are latest technologies like Radio Frequency Identification (RFID) [20]. In the healthcare sector spending on RFID was expected an increase in 2013 approximately 3.1 billon US dollars, which is about 6.5 times larger as compared to 474 million dollars in 2008 [21]. According to a research conducted by ABI in 2009 the generated revenue from the RFID services, readers, software, and transponders was approximately around 5.6 billion dollars. Another report presents the amount of entire RFID market 5.56 billion dollars [22]. In many countries almost half of the proportion of spending in healthcare industry is wasted.

For instance, in the U.S healthcare industry 30% to 40% of whole spending is wasted, since it is spent on worthless activities. The fact is U.S proportion of GDP (Gross Domestic Product), which is dedicated to healthcare industry is larger as compared to other countries in the world, which is around 50% and it is still increasing. A report in 2009 of Joint Commission Public Policy Initiatives, there is still no evidence that the healthcare industry in the country is improving. When counterfeit drugs are in question; this technology would bring the desired outcomes in U.S after its implementation throughout the pharmaceuticals supply chain. This technology contributes for the accurate tracking of products, when it is in chain of supplies.

This emerging technology helps to co-ordinate the stream of materials, accuracy in chain of supplies, maintaining trustworthy information, and to manage the operations in appropriate and timely manner. The worlds influential and authoritative departments U.S Department of Defence and FDA (Food and Drug Administration), life sciences industry [23], the multinational, multicultural, and multimillion dollar companies, [24], automotive companies [25], [26] and Information Technology [27] are engaged in taking sturdy actions for embracement of this tool. When RFID is utilized with ERP system, it facilitates the information sharing within the whole supply chain. Supply Chain Information Sharing (SCIS), which is supported by the RFID technology, develops the performance of the chains of supplies on the whole. This paper focuses on the counterfeit drugs in the pharmaceuticals supply chain, and to prevent it with implementation of RFID technology.

III. Issues Related to Counterfeit Drugs

A medicine that is fraudulently and intentionally labeled of a company's name and logo (which has the patent rights) by some other company is called counterfeit drug. The medication counterfeiting means products with fewer ingredients, devoid of dynamic ingredients, inaccurate ingredients, insufficient ingredients, or fake packaging WHO (World Health Organization).

A drug made by other than genuine manufacturer, imitating the original product without having the rights and authority, copied and marketing the imitating product to deceive and defraud (Black's Law Dictionary).

Counterfeit drug is a fake drug. Which may contain, wrong or no active ingredients or right ingredients with wrong dose. These drugs are illegal and may be harmful FDA (Food and Drugs Administration) U.S.

A counterfeit drug (fake or reduced-dose drug) is produced by a manufacturer with an intention to sale and target to those

areas, where the information about healthcare is almost not available. These areas are the rural areas and remote areas. Those companies produce such drugs; neither have the patent rights nor a qualified team, to produce the drugs with the right ingredients. This is very harmful for a patient to take such drugs, which may lead to death due to non genuine or less ingredients of dose. We will take a look on studies of RFID technology implementation.

However, not much literature is available on RFID implementations in the pharmaceutical industry. The available literature is by [20], [28]-[30]. These are useful literatures, however, provide a practical picture of the RFID implementation. These four (4) literatures are focused on the technical issues, organizational and social influences on RFID.

The study how information technology can bring the change and can help the healthcare industry to improve was conducted by [28]. The study was conducted by the researchers in Tennessee at Regional Shelby Country Medical Centre, Memphis, USA. The data for research was collected through documented analysis, observations from the participants, and the interviews. The results of study found that the implementation of RFID in the industry could help in controlling, measuring and workflow processes. It suggested that the habitual and non-habitual Information System (IS) exercises are necessary for thriving functioning of this technology.

Reference [29] conducted a study on RFID implementation in Taiwan Medical University Hospital. This study opted investigatory approach, in which contributors were requested to share their experiences. It explained the growth, planning and implementation strategy of the project. This study focused on how long term benefits can be derived from the implementation of RFID as a tool.

Another study by [20] was purposeful, in which the technology implementation impact was studied on the society and how it effects on the staff of the hospital. For this study, qualitative method of data collection was used. The research data was collected from healthcare industry, consultants and three hospitals staff members from the United States. In this study, findings show that the qualms were found, especially in nursing staff at hospital, regarding scrutiny and supervision feature of this tool. It proves that this technology influence on organizational factors as well as on social factors and this either will make it successful or show it the door of failure.

Reference [30] conducted a study focused on the RFID value in the businesses. This study was generated, and values were identified, from the case studies of five (5) hospitals, who implemented the technology, specifically to confront, the hazard of Severe Acute Respiratory Syndrome (SARS) in the year 2003. A number of intentions were identified, to measure the value of this technology at execution stage. Those intentions included; process enhancement of patients care, to enlarge the utilization of assets, and effectiveness in communication. The researchers concluded that, successful implementation of RFID technology, is only possible, when it has been included, in the whole business framework. Furthermore taking into account, the importance of RFID, the pharmaceutical sector needed such a technology, which can prevent the risks in pharma supply chain, when their product moves universally.

FDA (November, 2004) has published a compliance policy guide, for implementation of the RFID technology in the pharmaceutical industry. FDA believes that the compliance guide, will clear regarding tagging the packaging, specifically for those products, which are high likely to be counterfeited. The goal defined by the acting Commissioner FDA Dr. Lester M. Crawford as: "Creating the ability of tracking the drugs from the producer to the pharmacy would increase the security and safety of the drug that patient's consume."

The implementation of RFID in the pharmaceutical and healthcare businesses worldwide is an organizational push from Food and Drug Administration (FDA), to combat against sales of the imitate drugs. The research has also reported that, the revenue from RFID will rise in the future dramatically. RFID tags using by the pharmaceutical manufacturing companies, is because of FDA interest to combat against counterfeiting drugs (Jeff Woods, Research Vice President at Gartner). FDA made efforts to make possible the safety, and security of the drugs by implementing, the state of the art technology Radio Frequency Identification (RFID). This technology allows the manufacturers, distributors, and retailers to track the drugs accurately throughout the supply chain. However, in Pakistan the counterfeit drugs are also a major issue, which need to be addressed.

IV. Role of Pharmaceutical Industry

Pharmaceutical industry is playing a vital role, since it is the most organized business in Pakistan. The multinationals are playing major role in Pakistani pharma sector, and it holds 55% of the market [31]. Pakistan has nearly 400 hundred pharmaceutical companies, out of them 100 companies handle the 90% pharmaceutical business. Top 100 companies includes 30 multinational companies, holds the 50% of countries pharmaceutical industry (South Asian Journal of Management Sciences, Vol. 3, No. 1, (Spring 2009). Top 50 pharmaceutical companies' hold 80% of the market, however, the top 100 companies holds 90% of the pharmaceutical business [32]. Almost no raw material is produced locally so the pharmaceutical industry in Pakistan, imports the raw material as well as 20% of the medicines are also imported, since the production units in Pakistan only meets the 80% need of the country with in-house production [32].

It became a major risk in the pharma industry, however, in the Pakistan this risk exits and it is of severe kind. According to an estimate 50% of the marketed drugs are counterfeit in Pakistan [33]. However, according to the Pakistan Pharmaceutical Manufacturing Association (PPMA) the provided figures are overstated, and the proportion of counterfeits drugs is not more than 0.4% in Pakistan. Counterfeit drug is a major risk, which is not only being faced in Pakistan, but globally.

One of the major risks to life sciences and healthcare industry worldwide is counterfeit drugs. Pfizer has reported, for 200,000 bottles of their cholesterol pills Lipitor (see Fig. 3)

from outside the U.S continent, as fake drugs (total market value 55 million dollars). The counterfeit drugs have increased by 9% worldwide over the past year (Pharmaceutical Security Institute, 2010). The survey identified around 808 types of counterfeit drugs in 2009, which was a 36% increase from 2008 (detected in 118 countries in 2008). Food and Drug Administration (FDA) has taken this matter seriously in order to fight against such producers, and to prevent it from selling in the market. It is also working with the government, public sector, and private sector agencies in order to protect the humans from the hazard of counterfeiting.

It has become an intense need of the pharma industry, to enhance the detailed safety and security of their products, particularly in today's technological business world; where the customer can order product online. To bring out customers from endanger of counterfeit drugs is the absolute tracking of drug's packaging. RFID technology also provides the transparency in pharmaceutical logistics. However, this technology is not yet implemented in the small and medium sized industry at all. The main reasons are the high fixed costs, and the difficult technical implementations. Thus in this industry, the hazard is not only for those products available online, but also at hospitals and pharmacies. It not only causes endanger to human's health, but also sales losses and damages the drugs manufacturers reputation.

An estimated report submitted by National Crime Prevention Council (NCPC), showed that 10% pharmaceutical products in global chain of supplies are counterfeited. World Health Organization (WHO) reported that in some of the developing countries the potential hazard of counterfeit drugs is about 70%, another estimation of countries (Australia, Canada, European Union, Japan, New Zealand, and United States) tells that 1% drugs are fake in these countries. However, the biggest problems were found in Latin America, and Africa where the fake drugs percentage is about 30%. In one continent of former Soviet Union, 20% sold drugs were estimated as fake.

The pharmacists and physicians are involved in the manufacturing of counterfeit drugs. These criminals are supported by the scoundrel pharmaceutical businesses, rebel groups, and dishonest national as well as international officials. This dilemma is of extreme kind, because the criminals are simply everywhere in the global supply chain.

Counterfeiting of drug is a criminal act and it is premeditated and coldblooded murder said Nicholas White, a malaria expert at Mahidol University Bangkok, Thailand. Further he added, "You are killing people with counterfeit drugs", a message to the counterfeit drugs mafia. The full knowledge about this crime is out of our sight. The population, which is most effected due to the counterfeit drugs are living in the countryside, since they do not have full but limited access to the healthcare facilities. None, of the countries go safe from this fraudulent activity. Most of such drugs are available for sale online. These medicines are cheaper, but are not for healing, because of the lack of information the companies have for production. If drugs are checked for their quality and controlled strictly, then a millions of human's lives could be saved annually. Though, the business of bogus and imitated drug is a money-spinning and lucrative. This business has lofty margins and little hazard, which make it attractive for mafia, who are involved in counterfeiting. This kind of business is not even considered as illegal in some of the countries, and their government has no law for this specific crime. As said, "Where there is no opportunity, there is a thief."

The negative impact of counterfeit drugs on human lives can be seen, from an example of disease called "Malaria." The death rate with malaria: around 20% children died before their fifth birthday [34].

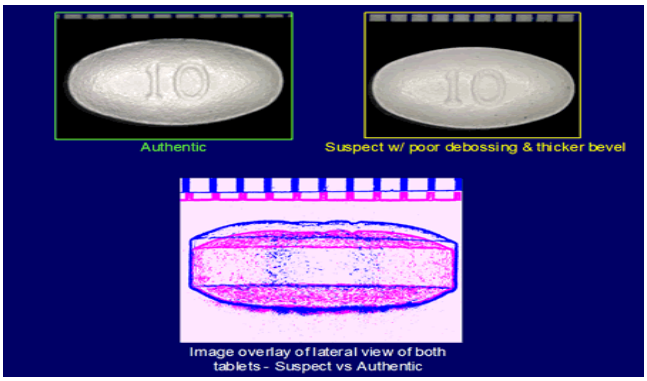

Fig. 3 Counterfeit Drug: Lipitor

A disease spread by the Anopheles mosquito, following by its bite can cause fever, vomiting, headache, and sweating to humans. The estimated killings with malaria worldwide are more than 660,000 per year (FDA to Test Detection Device for Fake Drugs, April 25, 2013). International Policy Network (IPN) in 2009 estimated that killings because of fake malaria and tuberculosis drugs are 700,000 per year. According to an estimated report, 3.3 billion people live in the malarial areas in 106 countries and territories (Centers for Diseases and Prevention). Food and Drug Administration (FDA) U.S is intended to block the flood of fake and reduced dose (counterfeit medicines) medicines that are available worldwide. According to a report of FDA, fake malaria medicines are common in Africa and the parts of South Asia. The report added that the 35% anti-malarial drugs were substandard and 36% were counterfeit in southwest Asia, in Africa 35% of anti-malarial drugs were substandard and 20% were counterfeited. According to the commissioner of FDA Margaret A. Hamburg, "Fake or substantial drugs cause double damages". Counterfeit drugs trafficking that contribute, to the health dangers are estimated 75 billion dollars annually (IPN, International Policy Network). According to another report of International Policy Network (IPN) in 2009 the World Health Organization (WHO) estimated 25% counterfeit medicines of the whole in medical supplies in the less developed countries (LDC's).

It estimated that the 10% of medicines are fake, and this figure could go up to 50% in the coming years especially in poor countries. "A global effort needed to combat this threat"

(Interpol). The livings of millions of humans are in danger; because of this act, the agency added. According to the Christopher Viehbacher the chief executive of French drugs maker Sanofi Aventis said; "counterfeiting drug means the difference between life and death of a patient." The online sale of medicines where the physical presence is concealed, are 50% fake [35]. Twenty nine of the world's biggest drug companies will provide 5.9 million dollars (4.5 million euro) in the next three years to solve the problem of counterfeit drugs. The funds would be used to support those countries where the counterfeit drugs are a massive issue. For instance, in Pakistan more than a hundred heart patients died due to the counterfeit drugs. In Kenya 30% of drugs are counterfeited (National Quality Control Laboratories, Kenya). However, 30% counterfeit drugs survey claim of Kenya is seven (7) years older. The deaths because of fake cough syrup contaminated with antifreeze (chemical names: ethan-1,2-diol or diethylerie glycol), including 339 children in Bangladesh in 1990, 100 children in Panama in 2007, 85 children in Haiti in 1995 and in march 2009 around 80 children were reported dead in Nigeria after ingesting a teeth mixture [36]. However, in this scenario the researchers and professionals are continuously seeking for an opportunity to avoid any harm for human beings. Since, the initiative has been taken by the FDA for pharmaceutical industry; so, the researchers have provided the solutions in order to combat with counterfeit drugs. Though, we can see from the example of, "diabetes patient's care" that how this technology brought a positive impact in healthcare industry.

A silent killer global disease called "Diabetes." According to the American Diabetes Association in 2009 the numbers of people diagnosed from this silent killer disease are increasing every year. To test the blood sugar level, patients have to prick their finger in order to give their blood sample, which is then transferred to a computer, where it is being tested. To assure that the sugar level in blood is accurate, a regular test is required, which is greatly disturbing. Children are being diagnosed from this disease are increasing every year, and they hesitate to prick themselves every day. Due to the fear of needles kids and grown-ups are not found motivated to test the level of sugar in their blood, which leads to a health risk. If patient do not constantly check and take counteractive actions to regulate the level of blood sugar it may cause heart attack, due to drastically increase or decrease sugar level in blood. Companies are in search to develop a new product, which would help patients to check their sugar level in blood without being pricking themselves for each test. The popular technology globally is now focused, to be utilized for testing of blood sugar level [37]. An embedded RFID chip would help to eliminate the need of any needles to take patient's blood. Digital Angel, a branch of RFID giant VeriChip, invented a syringe-implementation glucose detecting RFID chip (see Fig. 4) [37]. A onetime RFID chip injection with a glucose monitor inside the bloodstream, will allow patient to check their blood sugar level by using reader to get information available on the tag [38]-[40]. Not only focusing on the positive impact for the diabetes patients care but also there is a wider positive impact of the implementation of RFID technology in pharmaceutical and healthcare industry. This technology implementation gives a sustained competitive advantage to industry, in order to combat against the fake drugs available in the market.

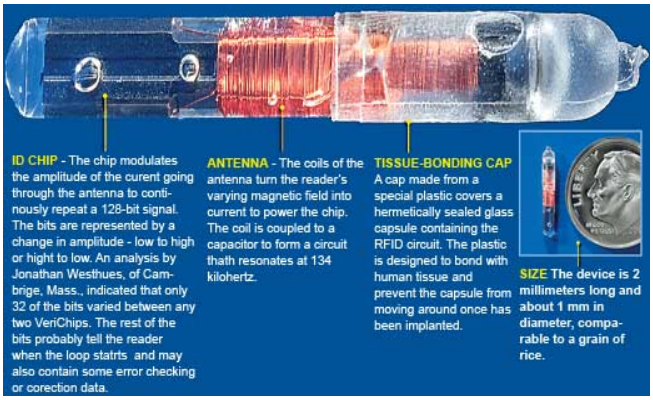

Fig. 4 VeriChip

V. Counterfeit Drugs Detection through RFID

RFID implementation in the pharmaceutical industry makes it easier to guarantee, that drugs are genuine. This technological tool helps to maintain the records of raw material; or finished products from the point of production, to the point of sale. There are some barriers in-between the implementation of this technology in the pharma industry. According to the researchers from the Stuttgart University's Institute of Mechanical Handling and Logistics (IFT), Germany "the RFID technology is rarely implemented or not at all." The reasons they found metallic packaging (tubes or blister pack foils), and liquid pharmaceutical products interferes with the RFID readings. Researchers noted that, "after the successful implementation of RFID in pharma industry will enable advanced defence against counterfeiting of drugs and consumers will have secured and safe products to buy." The work of researchers was supported by the Federal Ministry of Economics & Technology (BMWi), and German Foundation of Industrial Research Association (AIF) with assistance of German Logistics Academy (BVL). Although, it's successful implementation has a great value for industry as well as for the patients. This technology works in a systematic way to track and identify, whether the drugs are genuine or not.

RFID tagged products are assigned the unique number for each product, which makes it easier to track, and identify the product throughout the supply chain. In the first line, drug ingredients authorised producers carefully tag at each item level, prior to its supply to pharmaceutical companies. So, the data of ingredients is stored by the manufacturer in their system. After a drug is manufactured the data of tags is scanned and reported for the further action. Information regarding the ingredients in drug serial number, manufacturing date, expiry date, components of ingredients and sources information is updated accordingly, which is then attached to the drug package. This way RFID chip placed on the

packaging will not only have the information of drug's own source, but source of ingredients as well as ingredients quantity in medicine and other data, which is an essential element for patients care. The information available on the RFID tag can be transferred to the e-Pedigree (Electronic Pedigree) and this e-Pedigree will be filled during the drug's journey though the supply chain with an information at every level of actions. This way the drug will move from the manufacturer, to distributor, to wholesaler, finally to pharmacy or hospital. Thus, the tracing and scanning of the drug specific information like weight, shape, size, colour of the pills can help in order to identify the counterfeit drug. Analyzing the e-Pedigree and scanning the RFID tag allows the distributors, wholesalers, pharmacies, hospitals and the pharmacists to find out the identity, exact quantity of ingredients in the drug, and also the route it had to reach at the end point from the manufacturer/producer. How does RFID works? Once the product is tagged with RFID, reader uses the radio signals to communicate with tags, a middleware system which takes information and roots it to host system, and a host system, which receives and manages the relevant information generated by the RFID infrastructure. The role of middleware system is; it acts as bridge between the reader, and host systems [6]. The systems where information is being stored in this process are Ingredients Management Information System (IMIS), Pharmaceutical Management Information System (PMIS), Distributor Management Information System (DMIS), Wholesaler Management Information System (WMIS), Pharmacy Management Information System (PMIS), and Hospital Management Information System (HMIS). This is how, data is stored in the system and on the chip i.e. manufacturing and expiration data, which prevent any modifications in the future. The RFID reader will alert as soon as the drug is expired. Hence, implementation of this technology makes the chains of supply secure, protected and ensures the delivery of accurate drug with genuine ingredients for patients. Last but not least, the usage of RFID against counterfeit drugs in the pharma industry makes it an effective weapon to protect the theft in supply chain, from its first origin to at the end destination. In this whole process the drug e-Pedigree would help for identification. A drug pedigree is a statement of origin, that identifies each prior sale, purchase, or trade of a drug, including the date of those transactions, name and addresses of all parties to them [41]. The e-Pedigree is an electronic version of above detailed "Pedigree". As we discussed above, regarding the Stuttgart University's Institute of Mechanical Handling and Logistics (IFT) Germany students research, who stated the reason, why drugs are not being tagged with RFID were metallic packaging (blister pack foils or tubes), and liquid pharmaceutical products, which interferes with the RFID readings. In this context, we will be further looking for a solution related to tagging the products in pharma industry.

The packing of drugs is often of plastic cans. On such cans the RFID chips have two possible options to position; either on the lid or under the label of product, which is placed on side of the can. If drug cans are not of smaller size (smaller size of cans cause the tag get packed tightly), then the performance of reading ought to be 100% or at least near to it, since the RFID tags perfectly works with the plastic materials. The problem with RFID tagging arises, when the drugs packaging are of metal (i.e. tubes or blister packets) or if the drug is in form of syrup. However, there are the ways to overcome these barriers.

A. Tagging the Liquid Bottles with RFID

The bottles, which contain liquid, should be tagged on the lids, to keep away the liquid from the tag, as a condition to let the tag be readable by the RFID reader. However, bottles should not be packed in the same sealed card board box on the top of each other, since it reduces the reading performance of tag.

B. Tagging the Blister Packs (Bubbles Pack) with RFID

To tag the blister pack (also called bubble packs) is not an easy task due to material it contains. Though, the best way to place a tag would be separately on surroundings of each card board box. Generally drugs are packed in the bigger boxes for the purpose of transportation. Thereby, the card board boxes shall be placed separately in bigger transportation boxes, which enable the readability of tags. While packing we need to focus that tags are well close to the readers. After the transportation box is well sealed, it is imperative to tag it as well, which contains the information of every single medicine packed inside the bigger box. This process makes it easier and abolishes the need to untie boxes time and again, due to non-readability of any single item packed inside.

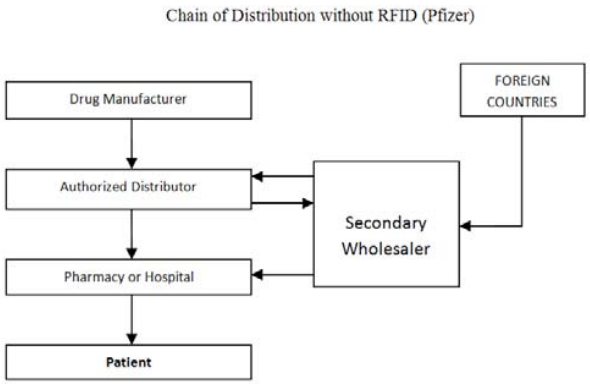

Fig. 5 A Serious Threat to Patient Safety: Counterfeit Pharmaceuticals (Pfizer)

C. Tagging Drug Container Tube Made of Metal with RFID

These kinds of containers are generally used to pack vitamin pills, that can be melt in water. The process of packing for these can be very same way as blister packs; however, these shall be packed separately in card board boxes. Occasionally, tags can be positioned inside the card board box on the plastic display plate. It is suggested that the tag must be attached on the lid of such containers; since, these are made of plastic. It also helps to keep it away from the metal surface, which can reduce the readability.

Metal is a barrier for the implementation of RFID on item level. However, there are hard tags available in the market, specially designed to place on the metal surface. The hard tags designed for metal surface are more expensive than the label tags. Since, hard tags are more expensive these can be placed on the most expensive drugs and the price of tag paid will be of benefit.

This study proposed a framework that can be implemented in pharmaceutical industries supply chain in order to combat against the counterfeit drugs.

Proposed Change Made in Drug Distribution for Dealing with Counterfeit Drugs through RFID

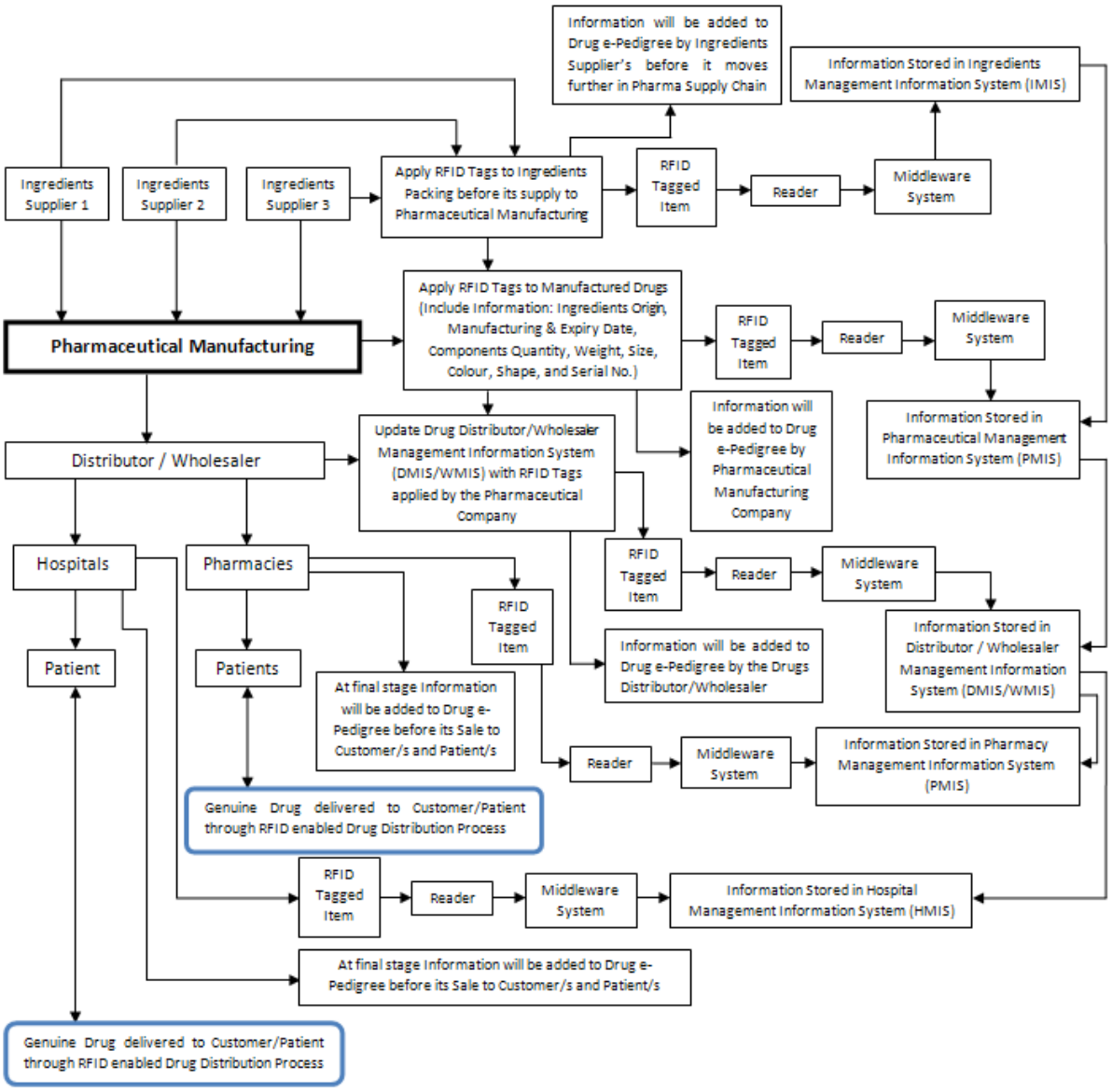

Fig. 6 Propose Model

VI. Discussion and Conclusion

The proposed model explains how RFID help to combat against counterfeit drugs in pharmaceutical industry, and help to deliver genuine drugs to patients. RFID enabled distribution process starts from drug ingredient suppliers. In the first phase of proposed model, ingredient suppliers apply RFID tags at packaging level, and through a process shown in model tag is read by readers, which transfer the information to host system (Ingredients Management Information System, IMIS), with the help of middleware system. Further the information available on tag is transferred to the e-pedigree. The e-pedigree will be updated at every level as shown.

In the second phase, ingredients start to move in supply chain, and delivered to pharmaceutical manufacturing for production of drugs. The same process is being followed by the pharmaceutical manufacturing for updating the host system, called Pharmaceutical Management Information System (PMIS) and information available on RFID tag is then transferred to drug e-pedigree, which will be updated at distributor, wholesaler, hospitals, and pharmacies-level respectively. The pharmaceutical manufacturing will add information on RFID tag, i.e. ingredients origin, manufacturing & expiry date, components quantity, weight, size, colour, shape, and serial number.

In the third phase, manufactured drug will move further for its supply to pharmaceutical distributors/wholesalers, where the information will be updated in Distributor Management Information System (DMIS), and Wholesaler Management Information System (WMIS). In the next step prior to its supply to hospitals and pharmacies drugs journey information will be updated on drug's e-pedigree as well.

In the fourth phase, distributor/wholesaler will deliver the products to hospitals or pharmacies. As soon the drugs are received at the hospitals or pharmacies, it will update their host systems called, Hospital Management Information System (HMIS), and Pharmacy Management Information System (PMIS). And the information will be updated on drug e-pedigree.

The fifth phase would be to sale genuine products to consumers (patients). This model provides a solution to combat against counterfeiting of drugs. As we can see in the proposed model, the right arrows tell that by following this procedure information stored in Ingredients Management Information System (IMIS), will be updated and stored in the Pharmaceutical Management Information System (PMIS), which then will be updated and stored in Distribution Management Information System (DMIS), Wholesaler Management Information System (WMIS), Pharmacy Management Information System (PMIS), and Hospital Management Information System (HMIS) respectively. It is concluded; that RFID enabled pharmaceutical distribution system will help to prevent the hazard of counterfeiting in this industry, and will make it possible to deliver the genuine drugs to patients.

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