

Leveraging RFID and 2D Barcodes: ePedigree and Beyond

This paper highlights the challenges of drug counterfeiting and discusses the approaches to handle “serialization” through the tracking and tracing of drugs in the supply chain. It provides an approach to deploy mass serialization using EPC and carrier technologies like 2D-barcodes and Radio Frequency Identification (RFID), and the option to implement a solution that meets the ePedigree requirement and leverages industry standards such as EPCIS and DPMS.

With a growing increase in the counterfeiting of drugs, the pharmaceutical industry and regulatory agencies are adopting multiple anti-counterfeit strategies such as new regulations, securing the drug supply chain and widening the awareness about counterfeiting of drugs among the stakeholders. Counterfeit drugs have a direct impact on patient safety, revenue, profitability and brand. It also increases the potential risk to pharmaceutical companies with regard to litigation and related penalties.

To develop a secure supply chain, one of the key requirements is the ability to trace, validate and verify the authenticity of the drug at any stage in the supply chain. Hence, new regulations like ePedigree and new technologies like EPC/RFID and 2D Barcodes have been introduced to counter the incidence of counterfeit drugs..

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Acknowledgements

We would like to thank Dr. Babu S. Nema, Murali V. , Bhargava Vangapally and Y. Vinesh Balakrishnan for their insights and suggestions.

Table of contents

1.	Introduction	4
2.	What are counterfeit drugs?	5
3.	Counterfeit drugs - challenges and issues	6
4.	Spread and impact of drug counterfeiting and drug recall	6
5.	Counter measures	10
6.	Approach to secured electronic track and trace	14
7.	Working model	15
8.	Mass serialization with rfid and 2d barcodes	15
9.	Epedigree with dpms and epcis	16
10.	Conclusion	18
11.	References	19

Introduction

In the Pharmaceutical industry, the core focus is on patient safety and in the recent past, the industry has been facing several challenges in this regard. These challenges are in addition to other challenges, such as the continuous increase in the cost of bringing drugs to market and shrinking revenues because of factors such as patent expiry, thin pipeline, penetration of generics, declining R&D productivity, reducing healthcare spending among others.

Some of the key challenges related to the drug supply chain are the management of drug expiration, drug returns/recalls and counterfeit drugs. One of the main reasons for drug return is the drug's expiration prior to dispensing. Also as per the current system, the drug recall process (using the batch number) is complex and expensive, where all to-be-recalled products must be tracked and then shipped back. Hence managing the administration of the drug recall is crucial both from the angle of patient safety as well as from the perspective of cost effectiveness of the whole process.

In the pharmaceutical industry, drug counterfeiting poses a serious threat and challenge to patient safety. Drug counterfeiting severely impacts the cost of the drug, as well as the revenues, profitability and brand of the drug manufacturer. Counterfeit drugs include drugs that have expired or have been adulterated or those that fake the brand name of pharmaceutical companies.

To combat drug counterfeiting, the secure distribution of drugs must be ensured and the pedigree of drugs must be captured. Secured distribution is ensured by using mass serialization, where each product is assigned a unique identifier such as an Electronic Product Code (EPC). The use of 2D barcode and Radio Frequency Identifier (RFID) addresses the challenge of serialization. Mass serialization also enables the traceability of products using the track-and-trace process. This process traces the entire lifecycle of the product in the supply chain market. The EPC Information Service (EPCIS) addresses the challenge of capturing information such as location, time, disposition, business transaction and other details of the product in the supply chain.

In this paper, we discuss the mass serialization through RFID and 2D barcodes, and the implementation of an electronic Pedigree (ePedigree) through various options, while leveraging industry DPMS and EPCIS standards.

What are Counterfeit Drugs?

The World Health Organization (WHO) International Medical Products Anti-Counterfeiting Taskforce (IMPACT) defines a counterfeit medical product as follows:

“A medical product is counterfeit when there is a false representation in relation to its identity or source. This applies to the product, its container or other packaging or labeling information. Counterfeiting can apply to both branded and generic products and counterfeit products may include products with the correct components or with the wrong components, without active ingredients, with insufficient active ingredients or with fake packaging.”

There are several factors that encourage the production of counterfeit drugs, apart from the monetary benefits. They are: the high cost of the drugs, lack of awareness/ignorance about the counterfeit products, inadequate regulations and enforcement, corruption, inadequate control on contract manufacturing and outsourcing and the complex logistics such as the involvement of multiple intermediaries.

Counterfeit drugs can include lifestyle drugs, life-saving drugs, patents/generic drugs and even medical devices. Hence, the patient safety is at risk as counterfeiting allows sub-standard drug delivery to patients. Counterfeit drugs are fraudulently manufactured, and also include cases where drug identity or its source is misrepresented, to wrongly influence the judgment of patients and healthcare professionals. Counterfeit drugs can be introduced at any of the following stages:

- During manufacturing of the product by using the fake Active Pharmaceutical Ingredient [API]
- During packaging by inserting incorrect dosage
- During recycling by re-packaging used or expired drugs
- Through the Internet by concealing address and other details

In addition to these entry points, there is the issue of diverted drugs, where drugs meant for a specific purpose or a market are diverted to other market(s) for monetary benefits. Illegal diversion usually happens when discounted drugs meant for specific market(s) or consumer group(s), are diverted to the open market to get higher profit margins.

Counterfeit Drugs - Challenges and Issues

Counterfeit drugs have a severe and direct impact on patient safety as well as on the profitability and reputation of the pharmaceutical companies. From the consumer's point of view, counterfeit drugs have an adverse impact on the patient's health and can cause severe side effects. For the patient this may be fatal or may lead to high cost of treatment because of prolonged illness. In addition, the pharmaceutical company may lose both direct and in-direct sale revenue because of damage to its reputation. Companies may also have to face penalty charges because of litigation and may need to recall their drugs from the market, which is usually a very complex and expensive process.

There are various entry points for counterfeit drugs to infiltrate the supply chain. One such entry is through wholesaler route, where counterfeit drugs produced in other countries are brought in as part of the legal supply chain. In addition to this, the industry faces the challenge of diverted and re-imported drugs, where drugs meant for discounted/low price market are diverted to other markets where drugs are sold at a higher price.

The incidence of counterfeit drugs has increased in the market due to the following factors:

- Complexity of the existing drug supply chain (which involves multiple parties and countries)
- Difference in drug prices in various markets
- Lack of comprehensive laws and their enforcement
- Lack of customer awareness
- High cost of drugs
- Ease of manufacture and packaging of duplicate drugs

Pharmaceutical companies, governments and regulatory agencies are adopting multiple anti-counterfeit strategies such as new regulations, and better delivery mechanisms and technologies to combat the spread of counterfeit drugs.

The Spread and Impact of Drug Counterfeiting and Recall

As per the WHO (2006 report), "10% of medicines around the world could be counterfeit" and "in most developed countries with effective regulatory systems and market control (e.g. USA, EU, Australia, Canada, Japan, New Zealand) currently have a very low proportion, i.e. less than 1% of market value." On the other hand, in Africa and in some parts of Asia, the percentage of counterfeit drugs is nearly 30% and rises to about 50% for internet transactions, where the physical address is concealed deliberately. Thus, though the percentage of counterfeit drugs varies in different countries, the problem exists in all countries and is therefore a global challenge.

As per WHO (2006 report) estimations, the counterfeit drug business is worth US \$35 billion and is expected to grow at a rate of 13%, with sales reaching \$75 billion in 2010. Even in mature market like the

USA, there has been a sharp increase in counterfeit activities. In 2004, the FDA had 58 new counterfeit drug cases, whereas there were only 30 cases in 2003 and only 6 cases in 2000. The following graph represents the increase in counterfeit drug cases through the years.

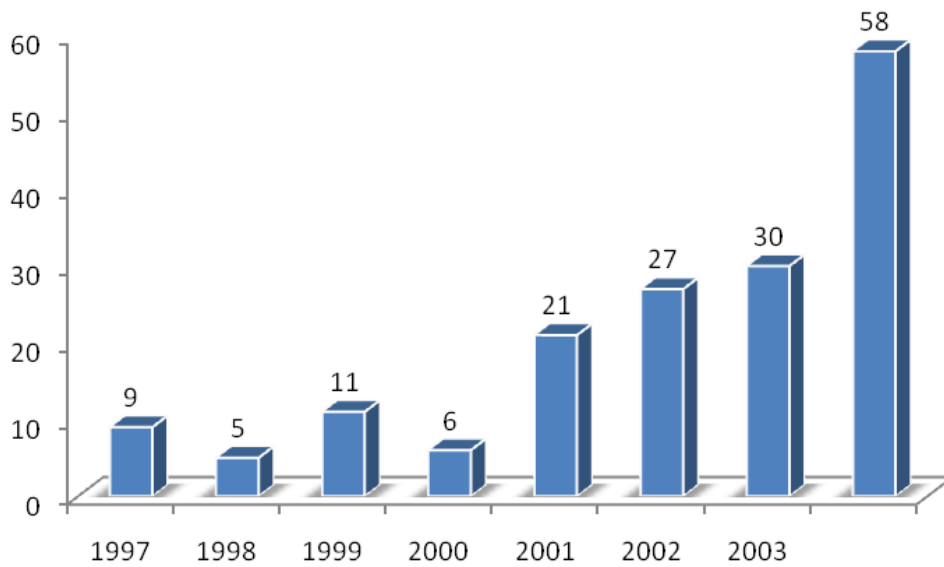


Figure 1: Counterfeit Drug cases

[Source: "Combating Counterfeit Drugs: A Report of the Food and Drug Administration," FDA Annual Update -May 2005]

In addition, the data collected on the counterfeiting, illegal diversion and theft incidents for eight consecutive years by the Pharmaceutical Security Institute (PSI) study (2010) shows a clear indication of increase of such incidents.

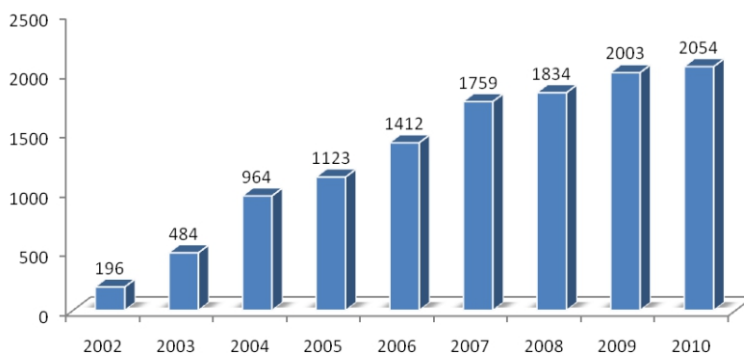


Figure 2: Total Number of Incidents by Year

[Source: Counterfeit Drugs – Incident Trends: www.pci-inc.org]

Earlier, counterfeit drugs were available only for high-value and high-demand drugs. Now, due to the high demand for high-value life-saving drugs, there is an increasing incidence in counterfeit drugs for life-saving purposes. As per the PSI data analysis (2010), the maximum increase in counterfeit drugs incidents were observed in therapeutic areas such as Metabolism (182%) and Cytostatics (20%). For pharmaceutical

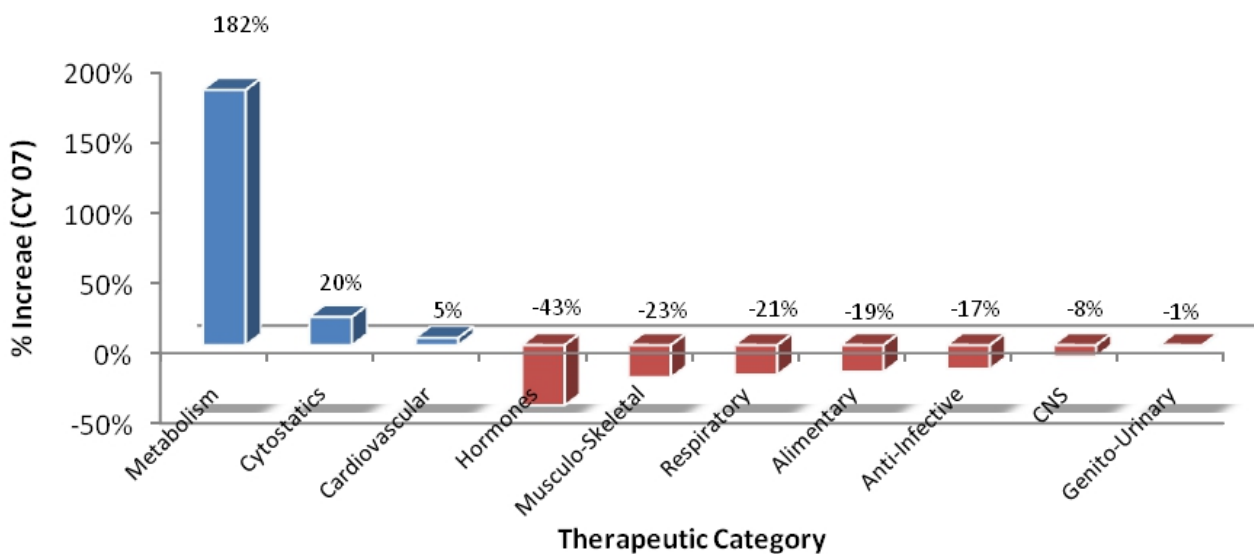


Figure 3: Percentage Increase in therapeutic categories Counterfeit's Incidents
 [Source: www.pci-inc.org]

companies, the impact of counterfeit drugs is multifold (refer to the chart below). They lose revenue either due to reduced direct drug sale (as counterfeit products are sold instead of genuine products) or because of indirect revenue loss (as the reputation of the company is affected and healthcare professional/patients stop using the drugs of the company). Additionally, the company's revenue is also affected as the pharmaceutical companies are subject to various law suits arising out of the use of the counterfeit drugs and the potential additional litigation burden and penalties impact the company's brand.

The other impact is on the governmental agencies and healthcare payers as there is an increase in healthcare costs. The impact arises as the counterfeit drugs take longer time to cure or have less impact or an adverse impact, and so the patient has to spend more money on drugs and treatment.

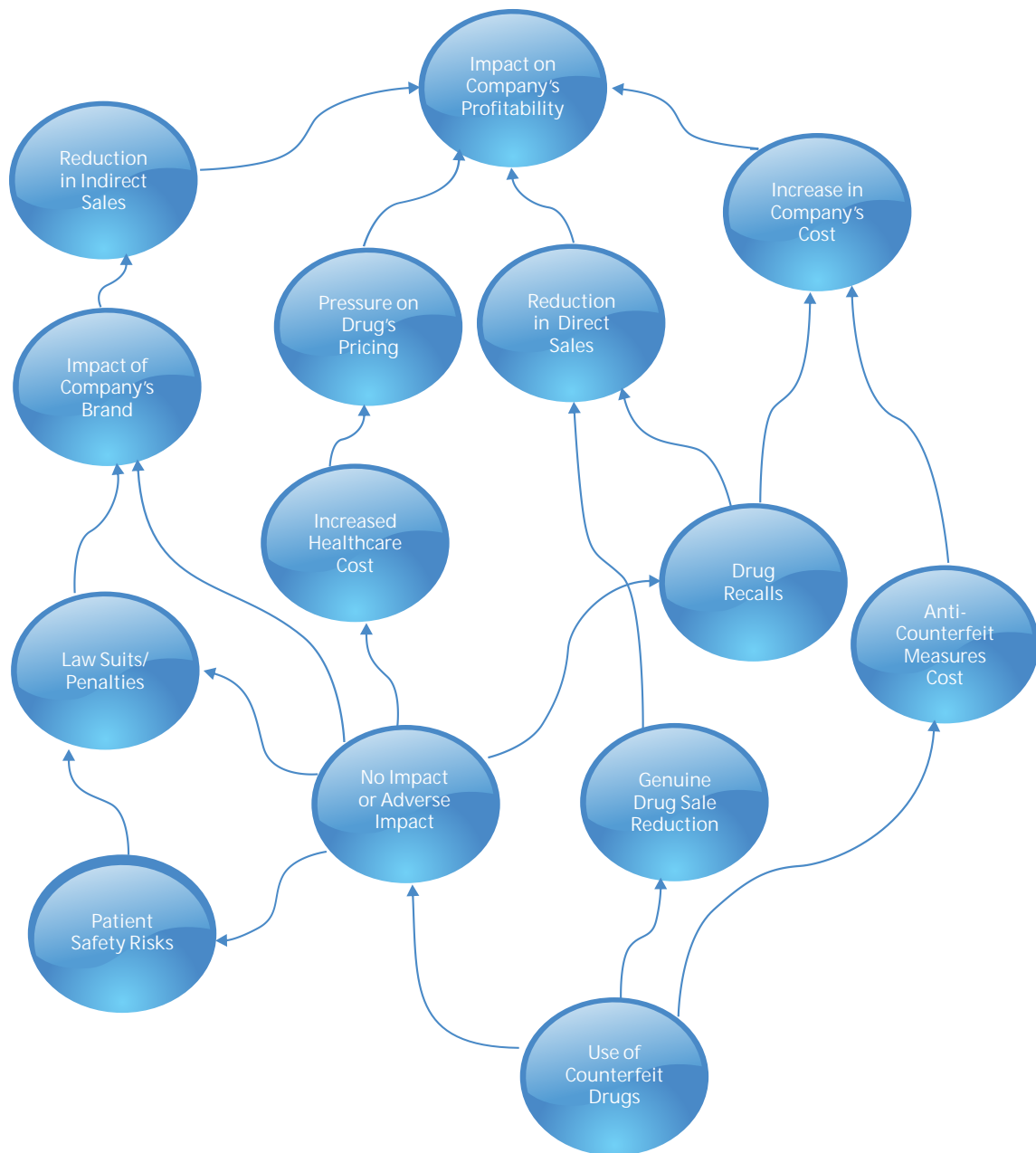


Figure 3: Percentage Increase in therapeutic categories Counterfeit's Incidents
 [Source: www.pci-inc.org]

Product recall is another major concern in the pharmaceutical industry. The following chart depicts the number of drug recall cases in the USA, where a drug is tracked and returned. This chart consists of drug recall cases including cases for drug counterfeits, correctly labeled products in incorrect packages, illegible labeling, lack of assurance of sterility and other such reasons.

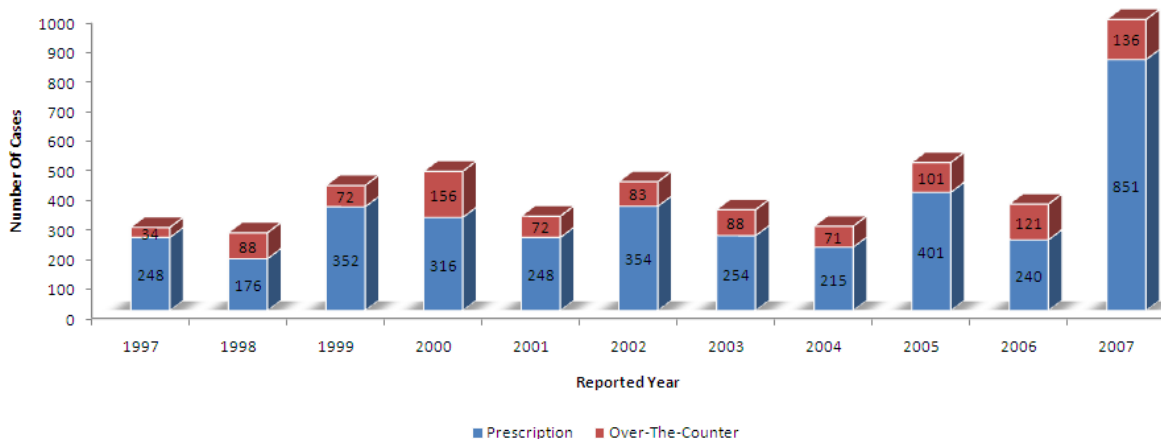


Figure 5: Number of drug recall cases
 Source: Center for Drug Evaluation and Research (CDER) 2007 Update Drug Recalls and Safety-Based Withdrawals. http://www.fda.gov/cder/reports/rtn/2007/14_recalls.htm

Counter Measures

To address the challenge of counterfeit drugs in the market, pharmaceutical companies, governments, regulatory agencies and non-government organizations are taking several steps. These steps include measures such as new regulations, better control on the drug distribution network, adopting new technological solutions, bringing awareness along with the better collaboration across agencies, governments and other stakeholders.

One such measure is the taking of joint action against counterfeit drugs, and in February 2006, the World Health Organization created a global initiative known as the International Medical Products Anti-Counterfeiting Taskforce (IMPACT). This taskforce seeks international collaboration among the several stakeholders and tries to increase awareness of the impact of counterfeit drugs in the market. This taskforce aims to improve coordination and harmonization across countries to eventually cease the production, trading and selling of counterfeit drugs.

Information sharing across stakeholders is one of the key methods to address this challenge; hence many pharmaceutical companies together formed The Pharmaceutical Security Institute – “PSI.” PSI is a non-profit organization dedicated to protecting public health, sharing information on the counterfeiting of drugs and initiating enforcement action through the appropriate authorities. Also in 2004, the FDA created the Counterfeit Alert Network, a coalition of health professionals and consumer groups to disseminate information to various stakeholders.

To tackle this, different countries are adopting different approaches and roadmaps – for example, in Europe some countries have already adopted the Serialization program and the European Union (EU) is working on developing standards for its member countries. The European Federation of Pharmaceutical Industries and Associations (EFPIA) supports the principle of mass serialization. This serialization assigns unique product

identification codes on the secondary packaging of all pharmaceutical products sold in the EU. The EFPIA proposes this system to verify the product while dispensing medicine to ensure the authenticity of the dispensed product. A common controlled data source called Pharmaceutical Interchange Logistic Link (PILL) verifies the dispensing product. PILL also helps in product recall and gives any new warnings or advisory notices.

In the USA, PDMA (Prescription Drug Marketing Act) was enacted in 1998, to ensure that drug products purchased by consumers are safe and effective. This legislation requires the need of increasing the number of safeguards in the drug supply chain, to prevent the introduction and sale of ineffective, sub-standard, or counterfeit drugs. FDA started (in December, 2006) to enforce the clauses of PDMA that required the creation and maintenance of a detailed chain of custody records (Drug Pedigree) for medication products. To address this challenge, the FDA suggested a framework with a multi-layer approach in its report “FDA Counterfeit Drug Task Force Report, 2006” and included the following measures:

- Secure the product and packaging
- Secure the movement of drugs through the supply chain
- Secure business transactions
- Ensure appropriate regulatory oversight and enforcement
- Increase penalties and heighten vigilance and awareness
- International cooperation

“Widespread use of electronic track and trace technology would help secure the integrity of the drug supply chain by providing an accurate drug pedigree, which is a record of the chain of custody of the product as it moves through the supply chain from manufacturer to pharmacy”.

- Suggestions in FDA Counterfeit Drug Task Force Report, 2006

As per the current status, many pharmaceutical manufacturers are working towards the compliance to e-Pedigree regulations. For example, the regulation implementation timelines of California's e-Pedigree law have been extended till 2015 from the last deadlines of 2011. The following diagram provides the status of ePedigree adoption in various states of the USA in 2011.

Distributor Licensing and Pedigree Requirements by State

Current as of 5/05/11

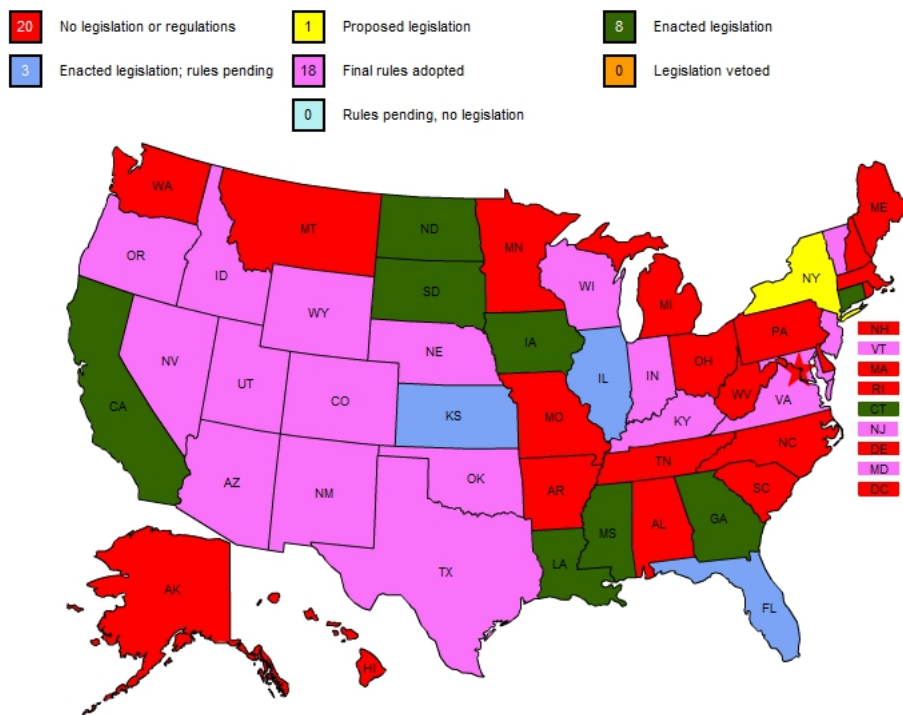


Figure 6: Pedigree Requirement by US States as May, 2011 (Source HDMA)

There are several control measures to combat counterfeit drugs. Stakeholders can also take many actions in communication, vigilance, regulations, supply chain, packaging and others to combat counterfeit drugs. Among these, the serialization of the product and the secured supply chain are key components.

Serialization not only provides a way to uniquely identify the product, but also enables process automation for greater operational efficiency and brings the much needed visibility into product movement and availability across the product supply chain. For example, serialization technology makes it easy to implement first-in, first-out policies for products on-shelf. This helps to track-and-trace the expiry dates of products that are still on the shelf and adjust the ship dates for those that need to be moved quickly or removed from distribution.

To ensure secured distribution of authentic drugs through the supply chain, a few regulators now mandate a pedigree of the drug delivered. The objective of the pedigree regulation is to reduce the incidence of both counterfeit drugs and diverted drug supplies. In the US, different states have different requirements for the following: Pedigree Initiator (Manufacturer or the first wholesaler), Electronic and/or paper-based pedigree, level of information needed in a pedigree, etc. US States such as California, Florida and Indiana have different requirements related to pedigree laws. For example, all states (except California) accept paper as well as ePedigree because exchanging and managing huge volume of pedigree electronically is more efficient.

As per the definition ePedigree “means a record, in electronic form, containing information regarding each transaction, resulting in a change of ownership of a given dangerous drug, from sale by a manufacturer, through acquisition and sale by one or more wholesalers, manufacturers, or pharmacies, until final sale to a pharmacy or other person furnishing, administering or dispensing the dangerous drugs. The pedigree shall be created and maintained in an interoperable electronic system, ensuring compatibility throughout all stages of distribution.”

- As per California Business and Professions Code section 4034(a)

The pedigree includes information about the manufacturer, distributor and any wholesaler who previously handled the product. The pedigrees must be complete from the stage of manufacture through delivery of a product to a pharmacy or other dispenser.

To ensure a secured supply chain, i.e., to ensure that the genuine drug gets delivered to the patient and to all intermediaries, various approaches like mass serialization of products through track-and-trace and product authentication techniques may be adopted.

- (a) Track and Trace – Here, the products are uniquely identified (through “Serialization”) and tracked across the supply chain. The “Track” feature helps to determine where the product is, and the “Trace” feature helps to determine where the product is at any point in the supply chain, from its source till its destination. From the perspective of pedigree regulation, “Tracing” the product movement and capturing the change of the product’s “ownership” is a key requirement.
- (b) Product Authentication: This methodology helps to prevent or reduce the chances of product replication and helps verify the authenticity of the product. Some methods of product authentication are tamper-proof packaging, and authentication techniques like Holograms, Color Shifting Inks, Forensic modes, Bar Codes, 3D Chips and Magnetic threads.

The next section provides information about how “Secured Electronic Track & Trace” may be used to keep track of drug movement electronically and in a secure manner and how it helps meet the ePedigree requirements.

An Approach to Secured Electronic Track and Trace

In a typical pharmacy supply chain, the key supply chain stakeholders are:

- The Primary Manufacturer
- The Wholesaler/Distributor/Third Party logistics
- The Pharmacy/Hospitals/Retail

The following figure represents the drug supply chain and the key entities (such as manufacturers, distributors, wholesalers, Pharmacy and Hospitals) who participate in the movement of the drug in the supply chain.

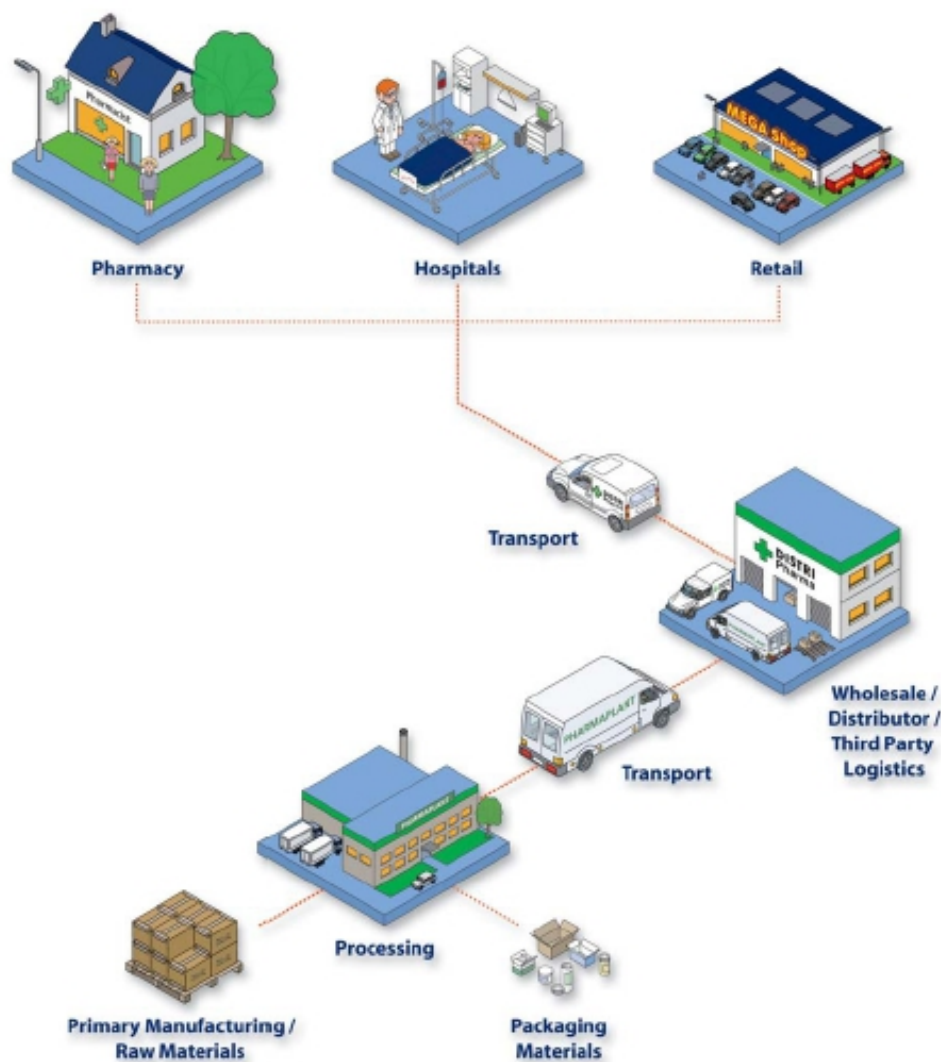


Figure 7: Typical Drug Supply Chain and its key entities (Source: www.gs1.org)

To create a secure supply chain, one of the key requirements is the ability to trace, validate and verify the authenticity of the drug at any stage of the supply chain (as shown in the figure). Thus each saleable unit (item and case) must have a unique identifier (through “Serialization”). This “serialization” helps to trace the product’s movement in the supply chain and captures the change of the product’s ownership and thus helps to build the drug’s pedigree. Further, serialization helps address other related business problems such as drug recalls, optimized inventory management, expiry date management, financial reimbursements (claims for chargeback, returns and rebates) and on-shelf availability. At present, within the USA, California’s pedigree law is the only law that requires each of the saleable unit transacted to have a unique serial number. The most suitable carrier technologies for serial numbers on products are RFID and 2D barcodes.

As part of the supply chain, a recipient is required to receive the prescription drugs from the originating party along with its certification of authentication. As per various US pedigree laws, recipients should authenticate the received pedigree as well as add their own certification of receipt and authentication. The US state laws specify the data that is required in the ePedigree, but not the data format. Some challenges of an ePedigree are the handling and managing of a large volume of data in a secure manner, and providing a reliable system with high data availability to various stakeholders within the supply chain.

Working Model

This section describes how carrier technologies like RFID and 2D-barcodes are suitable for mass serialization requirement and how industry standards – EPCIS and DPMS — help in the exchange of information across the supply chain, fulfilling the requirements of electronic track-and-trace, as well as e-Pedigree.

Mass Serialization with RFID and 2D Barcodes

Mass serialization may be accomplished by assigning unique identifiers such as EPC for products. EPC is a globally recognized unique serial number that identifies an item in the supply chain. The 2D barcode and RFID are two carrier technologies that implement the unique serial numbers (as per the EPC coding scheme) for the products.

The table below highlights the key differences in adopting the 2D barcodes and RFID technology.

	2D Barcode	RFID
Direct line-of-sight requirement	Yes	No
Difficult to duplicate/alter tag content	No	Yes
Readability robustness (Interface with liquids/metals)	No	Yes
Cost of tags	Low	High
Support for high automation for logistics operations	Low	High
Tag data storage	Low	High
Patient data privacy concerns	No	Yes
Tag reading - Bulk tag reading	No	Yes
Tag reading - Product case dismantling requirement	Yes	No
Initial technology setup cost	Low	High
Eco-system and/or standards maturity	High	Medium
Tag feature's extendibility (e.g. Tag with sensors)	Low	High

2D barcode is most commonly used technology as it is easy to implement, with a lower cost of deployment. However, there are a few constraints with this technology, such as the requirement of line-of-sight to capture product details as well as the capturing each product detail individually. Hence in case product-level tracking is required, each product package/case must be dismantled and brought individually in line-of-sight of the bar code readers. This requires time and effort, and hence is more expensive

The line-of-sight constraint of the bar code technology may be circumvented by using RFID technology. RFID allows the reading of multiple product tags at the same time without dismantling the product. The RFID tag also allows the capture of more data as compared to bar code tags, and provides the option to use more advanced tags (such as writeable tags, tags with sensors) that help perform various complex business operations (like temperature monitoring, alerts). The tag used in RFID technology can be hidden in the product packaging, which further helps improve product security.

RFID is relatively a newer technology than bar codes, and is slowly maturing over time. At present, this technology has been deployed in a few industries and business scenarios to improve efficiency and compliance requirements. However, there are some known challenges with RFID-based solutions for electronic track-and-trace, which slows down its adoption. These are the high cost of tags/infrastructure, potential reliability issues of (UHF – Ultrahigh Frequency) tags with liquids/metals, evolving regulations and standards and patient privacy.

For ePedigree requirements, the RFID solution is an effective solution. The FDA also recommends RFID as a promising technology to achieve ePedigree. EFPIA recommends 2D barcodes because it is easy to implement and it is cost effective. However, a solution that not only supports the existing technology (Bar code, paper tracking and a framework for RFID) but is also extendable to provide support for other potential technical options and requirements in the future is the mandate.

ePedigree with DPMS and EPCIS

For capturing and sharing information across trading partners, EPCglobal standard EPCIS may be used. EPCIS captures key information regarding various business events such as location, time, disposition and business transactions in the life of the product movement along the supply chain. Thus, EPCIS provides new opportunities (such as optimized inventory management, expiry date, and on-shelf availability management) to improve efficiency, transparency and security. EPCIS is a standard that defines interfaces for representation and exchange of data between various entities. This framework is designed to work with serialized objects and includes data model, capture interface and query interface.

To meet the ePedigree regulatory requirements for the security and authenticity of drugs or medical products, EPCglobal has developed the Drug Pedigree Message Standard (DPMS). DPMS captures data when the ownership of the product changes across the supply chain and allows the partners to exchange the pedigree data in an interoperable and secure manner. Thus, it provides a standard uniform data format which may be exchanged between partners and also provides the varying data requirements at different state levels. At present, no law demands any specific data format to be adopted for this purpose; however, California law requires a uniform standardized nonproprietary data format to be used across the supply chain partners

The following diagram depicts the movement of drugs across the various entities and demonstrates how an e-Pedigree is created..

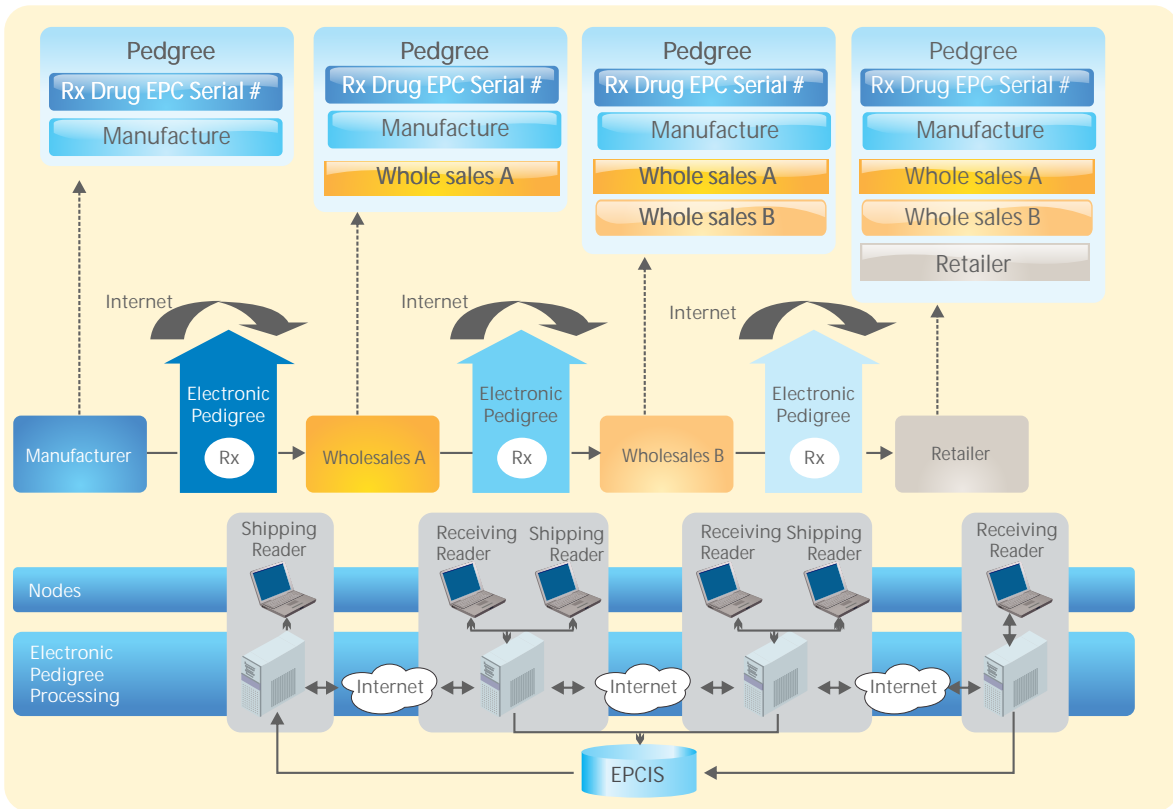


Figure 7: Typical Drug Supply Chain and its key entities (Source: www.gs1.org)

As not all regulations require the serialization of each saleable unit and also because the deployment of an ePedigree solution differs by entities, both serialized and non-serialized products will exist within the supply chain. DPMS can manage both serialized units and non-serialized units.

For pedigree authentication, digital certificates may be nested as part of the DPMS message to authenticate and certify electronically the information received as part of the pedigree. As there is no standard data format enforced (other than data content requirements), there may be alternate formats (for example, PDF or scanned files). However, auto-authentication is not feasible for these alternate formats.

While EPCIS helps in the product's track-and-trace by the trading partners, by sharing information on the product's visibility, DPMS ensures the product's security and authenticity. Hence EPCIS events are generated when a logistic event is completed (for example, change of custody or other product handling transactions) whereas pedigree events are generated when there is change in the ownership of the products.

Based on the available standards, some key models that implement the ePedigree requirements are as follows:

- Option-1: DPMS Only — This creates the ePedigree DPMS messages and exchanges between the trading partners
- Option-2: Interoperable DPMS and EPCIS—Both DPMS and EPCIS standards are implemented in a loosely coupled manner to leverage features of both
- Option-3: EPCIS only—This shares pedigree information using EPCIS messages. As event data is exchanged between partners, it is possible to provide product tracking information.

Option-2 allows companies to implement the combined features of DPMS and EPCIS and provides a framework for the product's track-and-trace along with security and authenticity within the supply chain. Option-1 and Option-2 meet the ePedigree requirements. Some of the drawbacks with Option-3 are: As part of EPCIS events, not capturing of few change-of-ownership events or non-availability of complete pedigree information at each step, as well as the inability to generate ePedigree messages from EPCIS events.

Currently, the industry along with EPCGlobal is also working on a new standard that utilizes both DPMS and EPCIS to address the ePedigree and track-and-trace requirements.

Conclusion

To create a secure supply chain, one of the key requirements is the implementation of serialization. This helps trace, validate and verify the authenticity of the drug at any stage of the supply chain. Hence the new regulations (Serialization, Pedigree and others) in countries like the USA, Belgium, Turkey and China have been introduced and technologies like EPC, RFID and/or 2-D Barcodes have evolved to support these.

In the near future, because of the staggered deployment approach, the combination of both paper and ePedigree will exist and will largely use technologies like RFID and 2D barcodes. Though these technologies have not been enforced, these two carrier technologies along with EPC will help the industry implement the required ePedigree regulations. Because of the ease of implementation and the low cost, it is expected that 2D barcodes will be more popular in Europe, but in the USA it is expected that a hybrid approach will be adopted (for example, using RFID at a case level and the 2D barcode at an item level) and a combination of technologies will be used.

Using the available industry standards—EPCIS and DPMS— multiple options are available to implement the ePedigree requirements (2D barcode and RFID). As multiple entities and scenarios are involved, a hybrid option (combination of 2D barcodes and RFID) where the deployment of both EPCIS and DPMS standards are loosely coupled will be more suitable. This allows companies to quickly implement serialization and hence meet the ePedigree requirement with DPMS standards, and provide the flexibility to implement EPCIS whenever they would like to leverage its product tracking abilities within the supply chain.

By adopting multiple anti-counterfeit measures and supply chain traceability, pharmaceutical companies will be able to contain current losses in their sales revenue, reduce their risk of an adverse impact on their brand and risk of potential penalty charges. Currently, companies are adopting different counterfeiting strategies based on the level of counterfeiting of the drug for the specific product type, volume of drug business, geography and other related factors. In future, these technologies will also help the supply chain partners to bring operational efficiencies in inventory and logistics management and provide a better ROI on investment in these technologies.

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Tata Consultancy Services is an IT services, consulting and business solutions organization that delivers real results to global business, ensuring a level of certainty no other firm can match. TCS offers a consulting-led, integrated portfolio of IT and IT-enabled infrastructure, engineering and assurance services. This is delivered through its unique Global Network Delivery Model™, recognized as the benchmark of excellence in software development. A part of the Tata Group, India's largest industrial conglomerate, TCS has a global footprint and is listed on the National Stock Exchange and Bombay Stock Exchange in India.

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