Role Of Technology In Optimizing Pharmaceutical Distribution

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Abstract : This study is mainly to understand the pharmaceutical supply chain and to deeply study the concepts of supply chain and how it can be effectively restructured to improve the current operations of the industry and to augment with technology for the same. Today, every major player from any industry has same type of molecules, SKU's, etc. and still some excel in their business and operations while some fail to perform. Why does it happen so, even though most of them have almost identical product lines and similar strategies? Sure the marketing plays a major role. But apart from that the key distinguishing factor is the supply chain followed. It is usually said that, the competition is not among company's products but among its supply chain. Every company follows a unique supply chain which distinguishes them from the other players. It is only through an effective supply chain a product can penetrate into deepest and remote markets. Hence an effective and efficient supply chain is very much required. This paper focuses on the study of pharmaceutical supply chain focusing on distribution element and how it is altered to achieve business excellence by different players of the industry. The paper also summarizes on how the integration of technology into the existing supply chain can further improve the operation and also overcome the current limitations and challenges to get optimum results.

IndexTerms **– Pharmaceutical, supply chain, technology, distribution.**

I. EXECUTIVE SUMMARY

The pharmaceutical industry is experiencing major upheavals in this century and there is an urgent need to address these issues to thrive and prosper in the sector, as everyday a new opportunity and the scope is being widened. Many companies have responded by trying to discover, develop, market and distribute medicines more efficiently. But these firms have invested relatively little effort in reconfiguring their supply chain and distribution operations to date and to meet the competition.

Most pharmaceutical companies have complex supply chains that are mostly under-utilized and inefficient and also some are ill-equipped to cope with the products and changing requirements that are coming up. Therefore, the pharmaceutical supply chain needs a radical overhaul.

This paper studies the challenges, scope and various issues existing in the current pharmaceutical supply chain. The study analyzes the prevalent supply chain of the sector and crucially points out the hitches that can be effectively managed to achieve superior operations mainly in the depots and distribution warehouses.

Towards the end, the study concludes by suggesting some implications of these technologies in improvising the pharmaceutical distribution and efficiently counteracting certain problems like counterfeit of drugs, forecasting issues and other operational hurdles commonly occurring in the warehouses and depots. The study incorporates RFID, EPC, predictive analysis, wireless sensor networks, PML and other management software to eradicate the existing predicaments of pharmaceutical sector. This paper also summarizes various potential initiatives taken by some of the leading pharma firms to improve their supply chain operations.

II. LITERATURE REVIEW

Pharmaceuticals are higher in India as in other areas of the world, amounting to 13% of India's GDP (Adhikary & Bora, 2014). The purpose of this qualitative research is to explore the pharmaceutical SCM and to understand various problems associated with it. A total of 60 research papers and various other articles were referred and analyzed.

Kaushika Madhavan, Amit Saharia and Abhishek Malhotra (2018) in their paper describe about the pharmaceutical supply chain and the key hurdles related to the same. The paper focuses on both internal as well as external factors of SCM restraining the growth of the pharmaceutical sector. The authors constantly alarms for the need of an agile supply chain and also the requirement to collaborate the chain with various techs to improve the efficiency. Their findings also state that Indian pharmaceutical sector has a great opportunity in the near future and this scope can be drastically widened by implementing smart amendments using existing resources.

Nirmal Kumar and Ajeya Jha (2018) stated the importance of quality of medicines in a pharmaceutical supply chain in their "Quality risk management during pharmaceutical 'good distribution practices' – A plausible solution." According to them, quality risk management is an unavoidable element of quality management system for manufacturers and other stakeholders in SCM. Their study shows a dearth of research on quality risk management during supply chain operation. They also address the gap in literature on quality risk management during supply chain operations. A corollary of manufacturing quality risk management has to be drawn to the distribution of pharmaceutical products. The quality risk management during pharmaceutical distribution is useful to avoid market complaints, drug recalls, and regulatory actions. This study also proposes a unique solution model for the industry professionals and policymakers thus opening a scope to reduce the product rejection.

Murray Aitken (2016) briefly describes the importance to value chain requirement in a pharmaceutical SCM. He states that understanding the pharmaceutical value chain requires the identification of each component from manufacturer to end consumer of medicines, and also it is crucial to understand their interactions. The papers talks about the pricing of pharmaceutical products, the manufacturer's selling price represents only a fraction of the retail price of a drug, more than half of the end consumer price

resulted due to insurance, freight charges (CIF), import tariffs and charges, importer margin, distributor margin, retailer margin and taxes. The report also briefly describes about the elements of the medicine value chain, outlines factors and differences between the net price a pharmaceutical manufacturer receives for a drug and the final amount paid for the drug by the end user.

Marc Herlant, Simon Bauwens, Hugues Bocquet (2018) in their 'The intelligent pharmaceutical supply chain', studied the need for an intelligent supply chain by the use of AI and various other software. They proposed combination of new drugs, new treatments and advanced data analytics solutions, creating superior opportunities for patients, making treatments more effective, more affordable and less intrusive, with a positive impact on their quality of life. They have also studied various challenges for companies develop these new capabilities by identifying useful and necessary initiatives, without putting the ongoing operations at risk by building service models on the basis of correlations that will not be sustainable in the future. The authors have also developed a model to evaluate the current situation and development priorities in the supply chain.

Christian L. Rossetti, Robert Handfield and Kevin J. Dooley (2010) in their 'Forces, trends, and decisions in pharmaceutical supply chain management', studies the changing nature of purchase and distribution of biopharmaceutical medications in the supply chain and various forces associated with it. They also examine the impact of the same in logistics and other stakeholders of the chain. The paper also gives some insights of the major forces that are changing the way of biopharmaceutical supply chain.

Xuan Yua, Cheng Li, Yuhua Shib, Min Yua (2010) studied the pharmaceutical supply chain problems and their implications in the health system in China. The article briefly discusses about the performance and distortions of pharmaceutical market in China and even provides some insights and policy implications for currently implemented reform. The article sheds light on ineffective supervision, higher price equals greater profit, distortion of the price schedule, lack of authoritative drug formulary. The authors argue that new drug pricing mechanism is the key to the current pharmaceutical reform.

Dinar Kale (2017) discusses about the strategies followed by various firm in his paper, 'Internationalization Strategies of Indian Pharmaceutical firms'. The paper mainly focuses on new and emerging MNEs in the pharmaceutical sectors and their strategies followed in their supply chain. The article also explores these patterns and motives for internationalization by Indian pharmaceutical firms. The author also investigates different strategies adopted by Indian firms to internationalize their operations in this sector. He finds out that Indian pharmaceutical companies are acquiring small firms as well as setting up their subsidiaries, in order to access resources, move up value chain and enter new markets and to remain ahead in the competition.

Meghana Vyas (2018) briefly studies the scope, challenges and issues with Indian pharmaceutical logistics management in his work. He studies the various effects of increasing globalization and supply chain complexity have imposed greater risks to pharmaceutical safety, ultimately impacting businesses and most importantly, patients. In today's world, the raw materials is collected from multiple locations around the world, manufactured elsewhere, packaged in an another country and distributed and sold globally, hence to successfully operate and protect against risks, this supply chain should be highly secured and each member of the chain should be well equipped and informed and actionable intelligence that should be undertaken for the same. The supply chain management is also recognized as the management of key business processes across the network of organizations. The paper attempts to study and describe the pharmaceutical distribution system in India, challenges faced by pharmaceutical supply chain and also addresses some critical issues in managing pharmaceuticals. The study concludes by stating an example of Indian pharmaceutical distribution company and its way of performing effective operations.

III. PHARMACEUTICAL SUPPLY CHAIN ANALYSIS

As any supply chain, the pharmaceutical supply chain starts right from the raw materials then it continues as, procurement-to testing of materials, getting it manufactured in facilities, storing it rightly at the manufacturing sites at the right temperature, at the right conditions, and finally delivering it to the end user. Pharmaceutical supply chain is responsive as far as the material delivery is concerned from logistics point of view i.e. moving them from warehousing to distributors to stockists, to hospitals or the retailer and finally to the patient.

Ultimately, we are interested in delivering the right quality of a product at the right time for the patient who needs the medicine and that is a key issue which is present in the pharmaceutical industry.

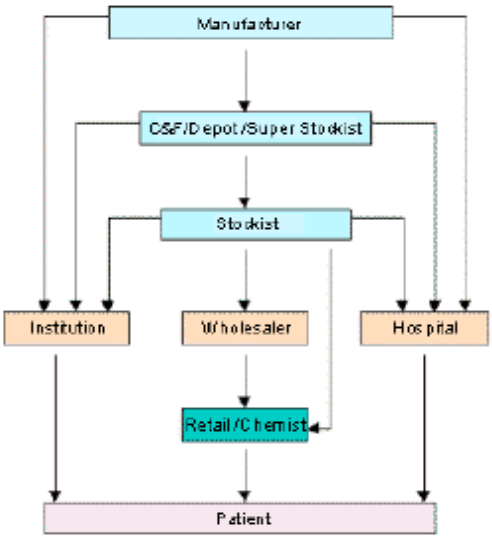

Figure - Basic pharmaceutical supply chain

The figure demonstrated above is the basic pharmaceutical distribution chain followed by almost all the players in the country. The Indian drug distribution chain have a small system, mostly limited to four or five layers, namely; the pharmaceutical manufacturers, factory or company depots, clearing or carrying and forwarding agents (CFAs), stockists, wholesalers and retailers. But however there exist a complex structure of distribution behind this simple chain.

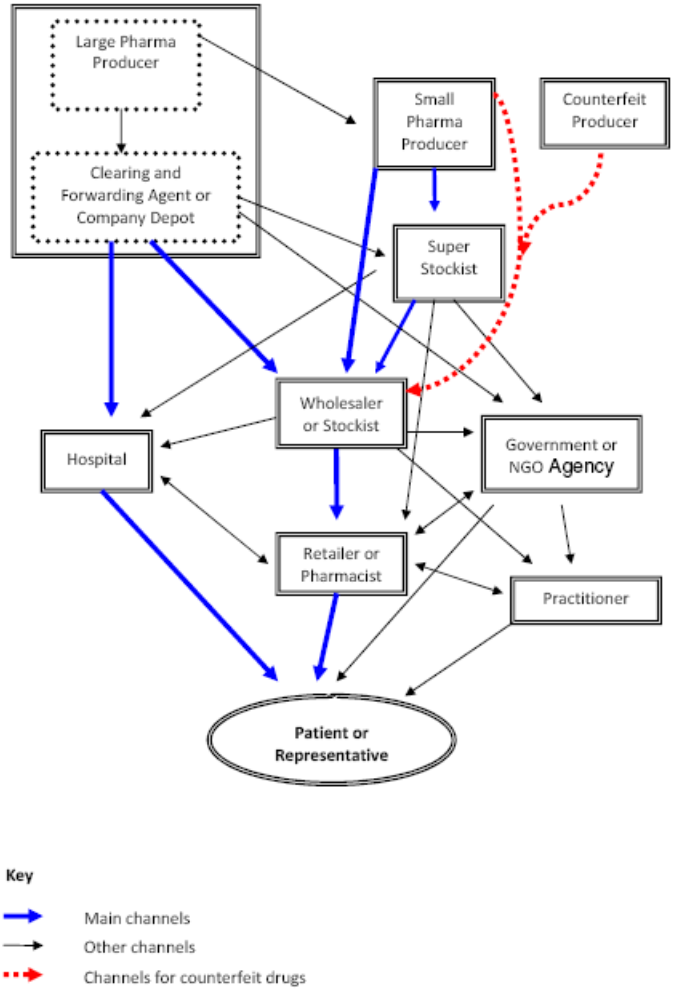

Figure - Complex illustration of pharmaceutical distribution cycle

The stockists supply wholesalers as well as hospitals and other kinds of medical institution such as Government and other procurement agencies. The distribution of drugs in most cases is taken over by importers and wholesalers, which act as a main link between the manufacturers and the retailers to ensure the ceaseless supply of medicine, under any circumstances and also regardless of the geographical location and portfolio of medicine required. For imported medicines an additional step is taken from the importer's side who arranges the logistics (CFAs) of bringing the medicine into the country which are then transferred to the wholesaler for domestic distribution based on the import license and adhering to the countries regulations. In some special cases the two entities are vertically integrated, decreasing the number of steps in the distribution stage of the value chain. But however, in many instances, particularly when supplying to rural regions, wholesalers may engage sub-wholesalers, thereby increasing the distribution complexity.

The position of CFAs is one of the weakest in the Indian pharmaceutical supply chain. They exist only because of India's particular taxation systems, and some new retail chains are attempting to by-pass the CFA and deal directly with manufacturers.

The Indian pharma industry's distribution set-up is highly fragmented and has evolved on the basis of the two tier sales tax structure, i.e. the central sales tax (CST) and the local sales tax. Hence to avoid CST, most of the firms have a Carrying and Forwarding Agent or a company depot in each state and transfer goods as interstate stock transfer. The smaller companies however adopt the super stockist model due to the unbearable cost of infrastructure for depots or CFAs. These agents are primarily responsible for maintaining storage or stock of the company's products and forwarding SKUs to the stockist on request. Most companies keep 1 to 3 CFAs in each state, this depends on the size and ability of the companies, demand or geography and network. On an average, a company may work with a total of 25 to 35 CFAs. Unlike the CFA that handle the stock for a single company, a stockist or distributor can simultaneously handle more than one company, usually 5 to 15, depending on the city area, and may go up to even 30 to 50 different manufacturers. The stockist, in turn, after 30 to 45 days, which is a typical credit offered, pays for the products directly in the name of the pharmaceutical company. The CFAs are paid by the company yearly, once or twice, on a basis of the percentage of total turnover of products (mostly between 2 and 4 percent of the turnover) and according to the company's policies, this varies from company to company. From the CFA the stocks are forwarded either to the stockist, substockist or to the hospitals. The retail pharmacy or chemists obtains the products from the stockist or substockist and hence it finally reaches the consumers.

Stockists or distributors typically market products of 6 to 8 pharmaceutical companies, a very few distribute products of more than 50 companies. Mergers and acquisitions of pharmaceutical companies have approximately doubled the number of stockists per company and created a tough competition at the distribution level in the market. The competition between these distributors has heavily strengthened the bargaining position of retailers. Stockists have their own salesmen who contact and stock retailers on a frequent basis. They are paid 8 to 10% their sale price to the retailer. However, some stockists apparently pass up to 6% to retailers, leaving themselves with margins of around 2-2.5%.

Stockists are basically paid on a regulated margin basis set as a fixed percentage of the price. In markets with regulated margins, discounts from the manufacturers are given, in other countries and for some categories of products, discounts may not be allowed. These vary from 5-10% from manufacturers in the form of free packs, some of which they may pass on as a discount to retailers.

The distributor invests in inventory for proving better services to its customers. The distributor might typically hold one to two months inventory and the cost to carry inventory includes warehousing cost, capital cost, and obsolescence. In India, under the Drugs Price Control Order, both the wholesaler and retailer margins are differentially regulated based on essential drug classification, with maximum margin for distributors at 8% for scheduled drugs and 10% for non-scheduled drugs.

Figure - Illustration of distributor margin

The remainder of the market is made up of a large number of small-scale suppliers, who often act as referred as well as retailers. From a study, it is estimated that around 70-80% of the pharmaceuticals sales in the country, with the remainder being sold directly through hospital pharmacies. The retailers comprises of a wide variety of very different kinds of operation, ranging from small shops to retail chains.

Retailers are entitled to a margin of 16% for controlled formulations and 20% for decontrolled formulations on the Maximum Retail Price. The magnitude of retail margins vastly vary between the therapy area and product types depending on the level of regulation or negotiation that retailers has with the wholesalers and manufacturers.

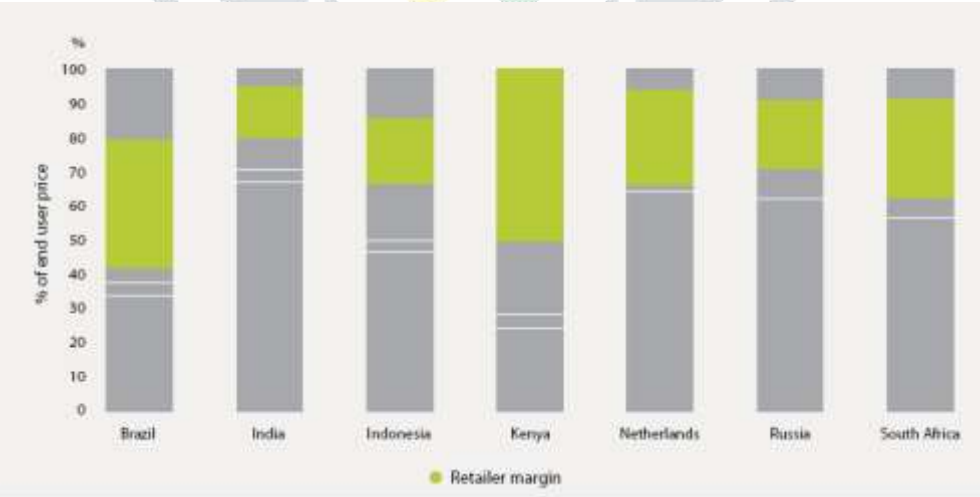

Figure - Illustration of retailer margin

IV. KEY PHARMACEUTICAL SUPPLY CHAIN PROBLEMS

If we look at the overall the supply chain in the pharmaceutical industry, it starts at the procurement and manufacturing industry so whatever issues we are facing today in the industry, at least a part of it is related to the input material. So, we have to work hard on ensuring that we have a control on the availability of these raw materials and also active pharmaceutical ingredients which are basic drugs to ensure that we have full control on the availability. Recently we've seen a large focus at the government level and also at the industry level to change what has been the forte of the Chinese industry to supply API's to India. A lot of

work has been done and a lot of it is in progress by various stakeholders to ensure that large clusters of API industry are created in India so that the reliance on imports is reduced.

Right quality at the right time is the first point, the second point is that in the labs we need to create automation. We need to create first time right situation so that we do not have failures. A lot of supply chain cost is built up into these areas because if we have failures at the raw material stage or the finished product stage there is a lot of waste and scrap which is getting generated into the system.

The top global players are now building and ensuring more stress in the inputs and less on the output and that is what we need to do now because we need to be a mature country as far as the pharmaceuticals are concerned.

The next stage is warehousing. Whether it is a warehouse within the pharmaceutical industry or external warehouses, these are created to ensure that the materials are distributed from these large warehouses across India, we need to ensure that we create automation, good storage practices, good distribution practices, and to ensure this we use various technologies.

Another stage from the distributor onwards is when the material reaches the stockist and the retailers, whether it is stored well at the prescribed storage conditions or not. We have to increase the monitoring and enforcement to ensure that the right quality reaches the patient.

In using this, we need to ensure that we use a right network of good suppliers, good vendors, good partners in the good distribution practices and good ERP solutions. Also there is transparency in operations, transparency in manufacturing, material management, supply chain and also at the retailers and the stockist level. From this we would able to recall the last product which is there in the market so that if there is a risk because of any reason, we can control, we can mitigate that risk so the patient is not affected.

Now on one side the industry, as well as the government, is focusing a lot in ensuring that the right quality is available to the patients but it is not easy. It's a challenging task because today there is a gap between what a global regulatory agency demands and what the regulatory agency in India demands.

With a lot of discussions going on, India is going to adopt WHO based GMP practices and the next stage is the participation in pharmaceutical inspection convention program PIC and ICH. So the next stage is the best in the class stringent system. This gap creates a lot of complexity in the system because companies have to follow schedule M on one side, WHO requirements and global regulations on the other side.

But the real opportunity is how do we really harmonize this and come to one platform so whatever the system requires we follow only one system. That's something which is a huge challenge.

Another great challenge is the complexity due to large product proliferation and also there exists lot of supply chain fragmentation in the market. There also exists a huge complexity in the distribution front.

Considering the infrastructure, we have a large gap between what is our requirement and what is available today. We need to work on creating the best in class warehousing and distribution centers to ensure that right across India and also good infrastructure availability for not only logistics but storage, control of various parameters including temperature. In case something goes wrong, the use of various parameters like artificial intelligence or other electronic systems to ensure that the right person is informed that something is going wrong in the system here. Hence a lot of work has to be done on the infrastructure to create this excellence in the distribution chain.

Infrastructure is not only these areas but infrastructure would also be required in areas related to automation and software to ensure there are large visibility and the data capability of analytics and then management of that. So overall, these are the areas that we need to work on to ensure an excellence in the pharmaceutical supply chain.

Hence the key issues analyzed in the Indian pharmaceutical supply chain can be quoted as;

- Managing of perishable products.
- Degradation of the medicines when they move through the supply chain results in poor quality substandard products to be dispensed to the patients.
- Maintaining temperature control.
- More focus on R&D.
- Shipping of expiry products.
- In case of an epidemic break-out, global demand for certain medicines overshoots the demand suddenly, therefore agility in supply chain is very much required.
- Product withdrawal during sales due to side-effects and expiry or due to any other reasons. (Reverse Logistic).
- Complex Network Design.
- Controlling of wide and complex supply chain due to huge SKUs becomes very difficult.
- Improper forecasting software and distorted information storage system.
- Majority of hospitals seems to use outdated information systems with poor inter-organizational connectivity.
- Determining the optimal inventory levels has been a serious issue due to ineffective and outdated software and also due to the involvement of various stochastic variables.

V. SMART PHARMACEUTICAL SUPPLY CHAIN

As we have learned, pharmaceuticals industry is facing an era of transformation, from the supply chain to the distribution channel. The supply chain is overstressed by SKU proliferation, demand variability and lower margins. All these factors have compelled the pharma companies to rethink their supply chains and IT strategies and develop more collaborative models that enable them to be more agile, flexible and compliant.

The pharma industry has begun to build collaborative networks that connected stakeholders across the value chain, as seen in other industries. These networks will effectively help the industry to manage drug supplies in the face of increasingly unpredictable demand, gain better visibility into inventory across the value chain and service diverse markets. It is estimated that,

supply chain collaborated with smart technologies and networks shall boost the current operating profit margins of pharmaceutical firms by 9-11%.

5.1 Smart Forecasting

The current forecasting approach prevalent in the pharmaceutical supply chain is based on correlations. This technique builds a heavy bullwhip effect in the entire system and instead of reducing it, the method usually magnifies the effect thus increasing unnecessary operational cost.

The correlations approach is backward-looking and only describes what had happened in the past. However, this technique has no predictive value as it doesn't establish any causality i.e. one cannot be sure that because an event occurred in the past, it will happen again in the future.

More specifically, this approach does not analyze the situation but rather it only understands the current situation and sets a similar result in the future. A similar issue has been discussed below which shall deliver a detailed understanding of the problem about this approach.

The failure of Google Flu Trends in 2013 illustrates the logical fallacy between correlation and causality. Google aimed to predict the number of people with flu symptoms based on the number of Google search queries for flu-related topics. However, its results have proved to be wrong, it is estimated that 11% of the US population had had influenza in winter 2012–2013, which was approximately 2 times about 6% more than actual official statistics. This was mainly due to the use of inappropriate backward-looking statistical patterns in the data. This demonstrates the occurrence of thousands of incidental correlations, which would result in catastrophically wrong forecasts if used for predictions.

The multiplication of consumption and distribution patterns having small volumes and high variations, forecasting tools based on extrapolation of past demand are malfunctioning. This causes problems and misinterpretation in on-time product delivery. The main challenge, when applying predictive analytics to supply chain, is to distinguish and distinctively understand the random correlations from the ones that result from causal determinism.

Today we can use an AI-generated prediction which is based on probability and not causality. This would work well in a number of situations with much less errors and with higher effectiveness. An intelligent supply chain based on predictive analytics and machine learning would be better at demand anticipation, forecasting and characterization by identifying and understanding the patterns influencing it, rather than simply projecting the past demand.

However, seeing patterns is not sufficient. Understanding the 'why' behind them is the key and today's need. These anticipation tools allow pharmaceutical companies to ensure fluid and fast access to their treatments to clinicians. Furthermore, the companies need to build these skills to adapt their factory and personnel planning to demand in real time, and industrialize the approaches.

Figure - Smart forecasting anticipation

Leading pharmaceutical companies have already started piloting data analytics solutions in different functional domains, essentially starting with R&D. For instance, GlaxoSmithKline is using a machine learning based platform to improve pre-clinical candidates' discovery, in partnership with Exscientia. This have enabled them in designing new molecules, assessing them for their potency, selectivity and ability to bind to specific targets and uses a rapid 'design-make-test' cycle to modify drug candidates according to the desired criteria.

Similarly, Pfizer and IBM have collaborated to accelerate the drug discovery in immuno-oncology. Their collaboration aims to quickly analyze and test hypotheses extracted from large and broad data sources such as laboratory and data reports.

The use of predictive analytics therefore will improve production quality management, predicting from the external factors of the production chain which batches will be likely to deviate from the quality requirements and, consequently, significantly improving planning in the downstream part of production.

The below figure illustrates the use of these new technologies to gain an operational edge in supply chain.

	Descriptive statistics	Statistic Forecasting	Pattern Matching	Predictive Analytics	Machine Learning	Prescriptive Analytics
Key question	What has happened (why, where, how many times, …) ?	What will happen if past demand equals the future demand while considering market insights ?	What are the additional parameters/ simulation patterns that impacted the demand in the past by identifying correlations?	What is likely to happen, considering probabilities?	How to improve probability-based prediction by constantly integrating additional relevant patterns	What should we do to anticipate properly what will happen?
What it is	Analyze data so as to describe the situation as it is	Extrapolate historic demand and include human sensing factor to define a forecast	Identification of recurring patterns and behaviors in internal and external datasets	Predict potential future states, based on the probabilities	Makes a computer perform a task without explicitly programming it. Can compute decisions	Prescription of the recommended choice of action among a complex web of options, and showing likely outcome
How it works	Gather data on past activities in a purely descriptive mindset (standard & ad hoc reporting, alerts…)	Using statistics technique, extrapolation of historic data	Primarily driven by broad data sets more than longitudinal data sets	Deep analysis of data sets to identify recurring relationships between data points	Prescriptive data combined with learning models to create new algorithms	Define supply chain management rules that leverages machine learning
Comments	Crucial step in data analytics to collect large amount of data & develop a data-friendly mindset	Backward looking strategy, that can include insights, leveraging correlations but without clear identification	Correlations are clearly identified as datasets are further looked into	If possible identification of causal factors drives success, next to data quality, interpretation capabilities, statistical analysis	Still mainly experimental	Still in early development phase for complex decision making situations
	Low		Degree of complexity			Very High

Figure - Data analytics maturity model

Some other examples of leading pharmaceutical companies adapting predictive analytics is illustrated in the figure below.

Demand Solutions	■ **Enables** the use of **predictive analytics** in **pharma supply chain management** by making use of relevant (causal) data and supporting forecast management, requirements planning, retail, and sales & operations planning	■ Demand Solutions' DSX allows companies to use relevant sales-forecast data to **predict real expected demand** (not based on historic data) ■ Customizable **dashboards** allow for easy decision-making, and presentation of sales-forecasting information in a **variety of formats** ■ Demand Solutions' DSX Offers a **"Lead Time module"** which tracks every line item of every transaction and runs the data through a forecasting engine to inform purchasing decisions
splice MACHINE	■ Offers **machine-learning solutions** that, while working with numerous suppliers, **improve inventory management**	■ Working with a major pharma company in the US to help **predict delays in inbound shipment orders** ■ The client pharma company has complex formulations and works with hundreds of global suppliers; using **machine learning** enables it to better assess ATP* dates from suppliers and make sure to **balance inventory** appropriately
MERCK Aera	■ Merck KGaA intends to **deploy sensors**, coupled with a **machine-learning** program, to **improve demand forecasts** and **agility** in its inventory and distribution processes	■ The objective is to have computers make more decisions and create an **autonomous supply chain operation** (implementation 2017) ■ The technology allows users to **change forecasts immediately** based on far-off events, such as hospital fires or natural disasters, that impact demand ■ The company considers an Aera (formerly FusionOps) software-based system able **to react quickly and effectively** to market changes ■ Pilot runs show the **technology is 80% more effective than humans** in demand-planning processes

Figure - Illustrative examples of predictive analytics used by leading in pharma companies

5.2 Optimizing Pharmaceutical Depot

The current mode of operation in pharmaceutical depots are based on an order which is entered into the system, which in turn gets assigned one or more totes that begin to travel on a conveyor belt to the collection stations. The presence of the tote is checked with a set of sensors, mostly proximity optical sensors, placed on the band. Operators store the required landmarks in the order attached to the tote when they arrive at the collection centers, picking up the products on the shelves where they are stored. These totes continue to a check area, where they are weighed and all the necessary items are checked. Upon successful

completion, they proceed to the sealing and delivery area, where they are taken over by other operators and shipped to their final destinations.

Figure - Illustration of picking line in a pharmaceutical depot

Some of the significant deficiencies and issues with the current mode of operation in pharmaceutical depots are;

- High occurrence and repetitive sequence of errors during processing due to the lack of correlation between the operator processing the order and the cart to be processed.
- Outdated and ineffective method for checking the integrity of a processed order.
- Non-effective method for tracking the cart along the belt.

With proper understanding of the conveyor belt, sensors, actuators, electromagnetic transducer elements and along with information systems such as DBMS, IoT and artificial intelligence in collaboration with Deep Neural Networks these operations can be effectively optimized. By effectively implementing these at depots auto adaptability can be achieved which can eliminate human intervention errors.

These benefits can be achieved by;

- Placing a custom built beacon for the human operator, in the form of a bracelet which can give the system information about the position in space and the interaction with the carts.
- Camera modules capable of autonomous information processing shall be installed for checking cart integrity.
- These carts can be equipped with RFID sensors to ensure multiple methods for tracking the position and interaction with the human operator.

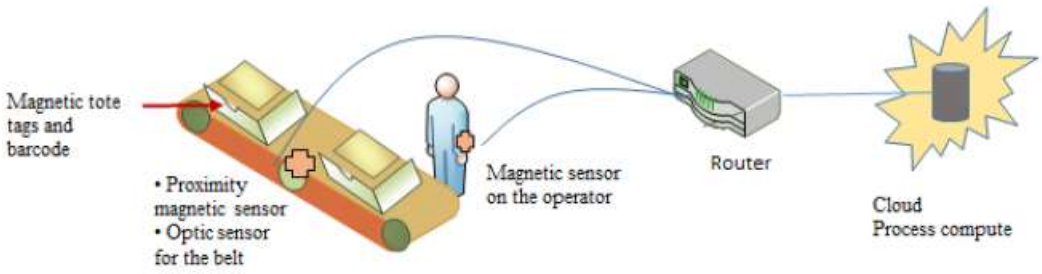

Figure - Illustration of a simple proposed method to optimize operations in a pharmaceutical depot

Further the depot shall be equipped with Industrial Wireless Sensor Network (iWSN) that allows the signal to be retrieved from any point. These will largely expand the coverage and offer several channels for communicating the collected information within the depot. The installed wireless sensors are based on the SensorTag platform, interfacing with the RFID modules which will enhance the effectiveness of the centre and will significantly reduce the error rate in the field especially on the picking line, which transports the carts containing the medicines.

5.3 Improved Anti-Counterfeit System

The complexity of the pharmaceutical supply chain is increasing rapidly day by day. High R&D, discovery of new drugs, large SKUs are causing greater volumes of raw materials and finished products to move through the pharmaceutical supply chain. A greater problem prevalent in the industry is the counterfeit of drugs and medicines at various levels of supply chain.

The WHO interprets counterfeit as "A medicine that is deliberately and fraudulently mislabeled with respect to identity and/or source. Counterfeiting can be seen in both branded and generic products and counterfeit products may include products with the correct ingredients or with the wrong ingredients, without active ingredients, with insufficient active ingredients or with fake packaging."

According to WHO, the intentional nature of the mislabeling and adulteration of a drug is what makes a drug/medicine counterfeit. This type of illegal behavior leads to compromises of patient safety, economic loss to established drug manufacturers, and a threat to the national security of sovereign countries. The WHO estimates that between roughly eight percent of the worldwide trade in pharmaceuticals is counterfeit. In a study conducted simultaneously at Dulles and Oakland International Airports, U.S. Customs and FDA agents had found about 10% of the drugs they analyzed contained no active ingredients.

Tracking and tracing of pharmaceutical products can build the foundation for patient safety by manufacturers, distributors and pharmacies as a systemic method to detect and control counterfeiting. These can be considered as crucial and important aspects of supply chain security. But unfortunately, the current system is cumbersome because of a dependence on manual procedures and improper storage of information. This state can be improved by implementing technology to take over tracking in the supply chain.

Auto-ID technology can be employed in the pharmaceutical supply chain to deal with counterfeit drugs. The Auto-ID technology enables instant verification of any drug, at any location. This verification process can be possible through an information technology infrastructure that spans over the complete supply chain. This also delivers true pedigree information about drugs, which can be accessed by supply chain partners at any level.

RFID tags, containing an EPC (Electronic Product Code), applied to each unit of dosage would provide this capability. The figure illustrated below outlines a conceptual framework for an Auto-ID implementation in a typical pharmaceutical supply chain. It also demonstrates how each elements of Auto-ID technology, RFID tags, readers, ONS and the PML server can be integrated together to form an integrated solution that achieves unique identification of individual drugs.

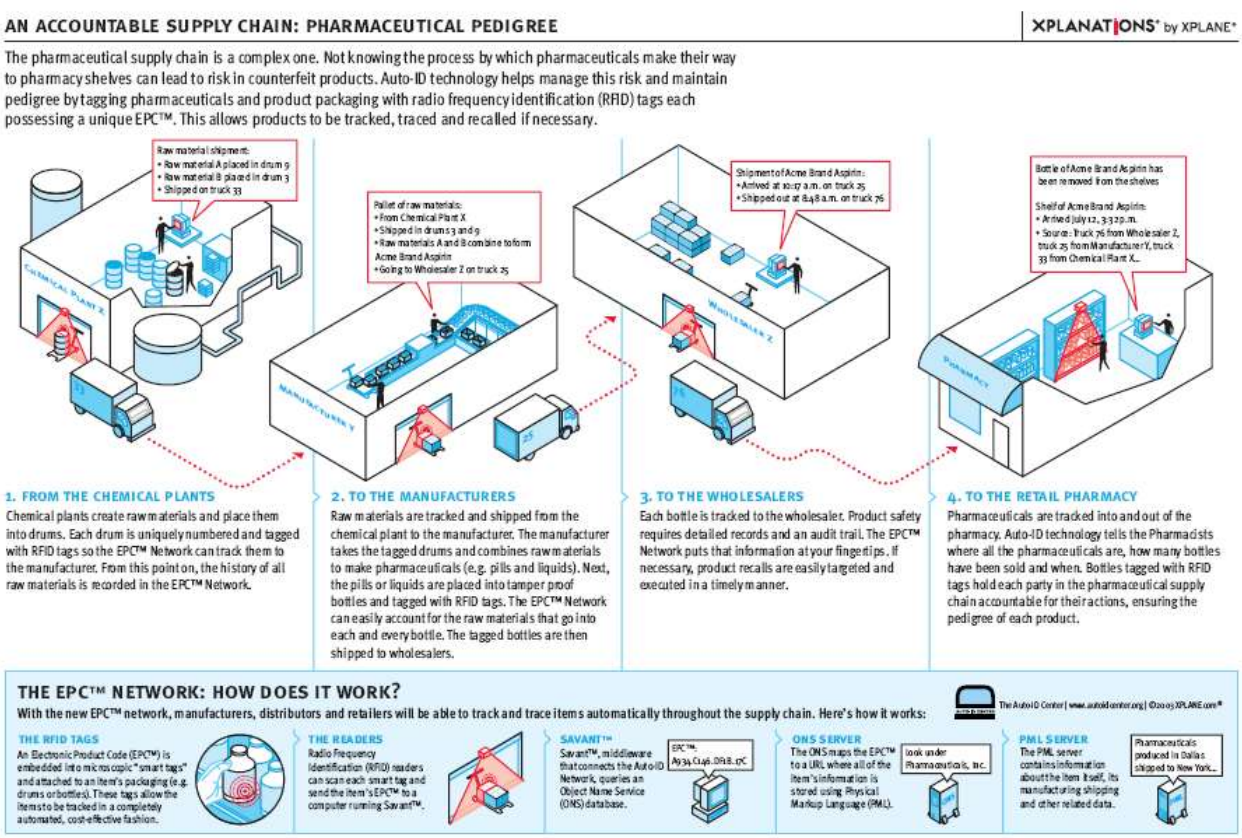

Figure - Illustration of Auto-ID technology achieving unique identification of drugs.

This Auto-ID technology appeal requires the internet or dedicated computer networks to provide a strong communication link through EPC to look up important information about a drug contained in a remote database. This ability to link physical objects to information provides a powerful capability for track and trace drug authenticity.

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