

Managing the Pharmaceutical Supply Chain: ‘By Wire’ “The next big thing”

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Abstract— *The emergence of computers in the 20th century has enabled the evolution of new age technology. Today, advances in information technology, the globalization of markets, and the push toward efficiency and sustainability continue to create challenges and opportunities that did not exist few years ago. In recent years, the ever-increasing technical complexity of standard consumer goods, combined with the ever-increasing size and depth of the global market, indicate that the connection between vendors and consumers is usually the link in the supply chain. The stampede to acquire new technologies, scientific innovations and managing technology are an imperative in every sector for which the health care industry is not an exception. In the healthcare industry, there could be added risk and complexity in the supply chain that can have adverse effect on patient safety and health outcomes. Hospitals and health systems are beginning to tap into the ignored opportunity: “pharmaceutical supply chain optimization”. Businesses such as healthcare will have to reorganize and continue to modify their business-model to capture potential benefits on emerging technological innovation that can positively affect patient care and costs.*

Keywords— *Information Technology, Radio Frequency Identification (RFID), Electronic Product Code (EPC), Sense-and-Response, Pharmaceutical supply/Value Chain, Drug Supply Chain Security Act. (DSCSA) Blockchain, and Cloud Based software solution.*

I. INTRODUCTION

Technology represents new ways of doing things, and, once mastered, creates lasting change, which businesses and cultures do not “unlearn.” Adopted technology becomes embodied in capital, whether physical or human, and it allows economies to create more value with less input. At the same time, technology often disrupts, supplanting older ways of doing things and rendering old skills and organizational approaches irrelevant. When IT is adopted or implemented correctly, in supporting the supply chain processes, it provides some potential benefit. Firms and or organizations that integrated some IT enablers have enjoyed the benefits of the integration with other supply chain partners, therefore gaining competitive advantages over those who have not incorporated such integration. For the globally connected and competitive market, such as healthcare, the use of information technology (IT) is becoming an effective paradigm. Therefore, to coordinate and synchronize supply chain, firms need information and communication technology as an enabler to achieve a higher level of supply chain

efficiency. Briggs, C.A, (2015). In today’s globally connected and dynamic markets, companies are making every effort to improve their organizational competitiveness to achieve a sustainable competitive advantage while meeting the changing global market requirement. Improvements in information technology have continuously facilitated business processes by enabling physical, information, and monetary (financial) flows across business organizations and with business partners. Bozarth& Handfield, (2008).

Digital transformation is no longer an option – it is an imperative. Billions of people are using social and digital communities to provide services, share insights, and engage in commerce. All the while, new channels for engaging with customers are created, and new ways for making better use of resources are emerging. These communities allow companies not only give customers what they want, but also align efforts across the business network to maximize value potential. To seize the opportunities ahead, businesses must go beyond sensors, Big Data analytics, and social media. More importantly, they need to reinvent themselves in a

manner that is compatible with an increasingly digital world and its inhabitants (a.k.a. your consumers). For example, the American Society of Clinical Oncologists (ASCO): Nonprofit organizations is transforming cancer patients care digitally worldwide, by consolidating patient information with its Cancer LIN. By unlocking knowledge and value from the 97% of cancer patients who are not involved in clinical trials, healthcare providers can drive better, more data-driven decision making and outcomes. Feldman and Suppal (2015).

Indeed, implementing new technology requires strong structure, retraining and attention to details such as installing and accommodating of the physical components as well as integrating any associated software applications with existing systems. However, integrating all these areas in the IT implementation will minimize user anxiety, make the process easier to manage and enable the organization to achieve its desired goals. Several technological innovations are pushing the healthcare and pharmaceutical industries into new realm that dictates the need for different healthcare supply chain model. Companies today, consider information technology (IT) as an effective tool to control and manage the complex supply chains as well as improving efficiency and logistic operations, while remaining responsive to changing customer demands and market situations, for which the health care industry is not an exception. In today's Information Age, more and more knowledge, and more and more ways of creating economic value are being abstracted into symbols that can be combined, transformed, and sent around the world at an electronic speed. The ability to manipulate this dematerialized reality drives both wealth creation and the discontinuous change that makes sense-and -response organizations necessary. Haeckel S. (1999). These emerging technologies are enabling greater efficiency to manufacture and distribution operations while speeding up the interface to the patient. Today, there is more focus on patient outcomes and access to information on patients is becoming as critical as the drug products. As the United States adds more stringent regulations and environmental controls, pharmaceutical and healthcare industry are struggling to comply. While these factors affect different aspects of the pharmaceutical and healthcare realms, companies are evaluating their options and taking a strategic look at their current supply chain approach. Datexcorp.com (nd).

Despite the widely accepted use and acknowledgement of the importance of IT for efficient

supply chain management (SCM), the actual benefits and nature of IT in specific functions in the pharmaceutical industry supply chain is still not fully explored. Most of this study is confined to published reviews of relevant literature on information technology and operations of the pharmaceutical industry across the globe. Indeed, the concepts of information technology in supply chain keep changing due to advances/innovations in technology. The advent and acceptance of costlier, more condition-sensitive medications and drug therapies, the growing, disparate range of product types and therapies which have shorter product lifecycles and other factors, has produced new complexities for the pharmaceutical supply chain that is in the process of shifting from the established version to a digital supply chain. Datexcorp.com (nd). Changes in technology will continue to update business models that will lead to truly **"THE NEXT BIG THING"** with a new mantra **"ADAPT OR PERISH."** Briggs, C. A (2017).

II. COMPOSITION OF THE PHARMACUTICAL INDUSTRY

The pharmaceutical industry consists of drug manufacturers, biotechnology companies, distribution, and wholesale companies. The primary focused of the industry is on medicinal and veterinary chemical and biological compounds. Global Edge (2019). The pharmaceutical industry is defined as the discovery, development, and manufacture of drugs and medications. It is widespread, including research, chemicals, and the regulation and involvement of government agencies. However, the characteristics of the pharmaceutical industry differ by region.

The European pharmaceuticals industry: Is regulated by the European Medicines Agency and European Union-wide legislation, which target packaging, safety, transparency, and authorization procedures. The biggest pharmaceutical company in Europe is Bayer.

The pharmaceuticals in Africa. African pharmaceuticals are growing and expected to be worth \$40 billion to \$65 billion by 2020. This growth is caused by urbanization, healthcare capacity, and better business environment. Urban households can adopt modern medicines. Indeed, healthcare is becoming more efficient, which lead to the introduction of price controls and import restrictions by governments throughout the continent. Furthermore, some governments

are considering promoting more local production of drugs to reduce the need for imports.

The Latin America Pharmaceuticals: There is expected growth in this pharmaceutical industry, but the market is difficult to predict, due to weaker data points available than some other regions. The growth is most likely in Brazil, Argentina, Mexico, and Colombia. Brazil and Mexico are key countries in pharmaceuticals around the world. With a recovering economy, Argentina's pharmaceutical industry tend to be growing, while Colombia has the potential to be at the top of the pharmaceutical industry in Latin America.

The United States Pharmaceuticals. A large segment of the United States population uses prescription drugs. The pharmaceutical industry holds 45% of the pharmaceutical market. The top pharmaceutical company in the United States is Pfizer, with total revenues of 53.6 billion dollars. In terms of government regulation, the United States Food and Drug Administration is responsible for regulating drugs before sale to citizens. Pharmaceuticals are a major industry, and, clearly, one that has immense potential, and an expected worth of \$1,170.00 billion in 2021. VanDyke E. (2019).

To sustain growth the pharmaceuticals industry requires large capital investment and therefore, spends relatively high percentage of its funds on extensive Research & Development (R&D). The pharmaceutical industry is one of the most heavily regulated sectors in the world. Drugs are evaluated for safety, efficacy, manufacturing quality, misleading product claims and illicit inducements to choose a particular drug although prices are regulated in many countries through their respective healthcare and insurance systems. Evidently, the increase cost of R&D in pharmaceuticals and biotechnology further increase the prices of medicines. The rapid increase in price in the United States, lead to some speculation that, unless there is regulation at some point, only the wealthy will be able to afford medicine. While product success in the U.S. market is largely determined by open competition based on quality, safety, and price, internationally, companies face a patchwork of uneven regulations, protectionist policies and price controls. These obstacles are increasingly being instituted in both developing and developed countries.

Regulatory complexity and efforts to contain accelerating health costs are key challenges the U.S. industry needs to overcome. According to the Census Bureau the pharmaceutical industry is comprised of companies engaged in researching, developing, manufacturing, and distributing

drugs for human or veterinary use. New drugs have an enormous positive influence on global health, prosperity, and economic productivity by saving lives, increasing life spans, reducing suffering, preventing surgeries and shortening hospital stays. Advances in medicine have eliminated deadly diseases and have brought other life-threatening conditions under control. ITA Pharmaceuticals Top Markets Report (2016). The leading companies in the pharmaceutical industry are characterized as "Big Pharma" and they generate more than fifty percent of the industry's sales with headquarters located in the United States, United Kingdom, Switzerland, Germany, and France. Pharmaceutical leaders include diversified companies such as Johnson & Johnson and Abbott Laboratories in the United States; Bayer in Germany; GlaxoSmithKline in the United Kingdom; and non-diversified companies such as Pfizer and Merck in the United States; Novartis in Switzerland; and Sanofi in France. Amgen and Genentech are the biggest sellers among biotech companies. The remainder of the industry is very fragmented, with many specialty companies such as small biotech companies that are often bought up by the "Big Pharma" before they can become a threat. The Pharmaceutical industry is Highly Concentrated, and production is dominated by a small number of large firms that are able to shape the industry's direction and price levels. European countries, and other countries with existing pharmaceutical industries, have governmental regulations in place, although, it is still a challenge. Global EDGE (2019).

A company's value chain sits behind its web page. Indeed, what is common among the industries is the power of the web-based technologies that significantly change the status quo by providing a mechanism that further integrates the value chain by delivering products and services more efficiently and effectively to the end users. Norris, G. et.al (2000). Innovations in information technology are radically changing the way people around the globe live, communicate and work. The effective use of Information Technology in the supply chain is its ability to share information within the supply chain partners. Briggs, C.A.(2015). The economic, social, and political benefits of new wireless information and telecommunications are changing the relative competitiveness of nations as access to those technologies' spreads rapidly around the globe. Gaspar et.al (2017). The emergence of information and communication technology (ICT), such as Electronic Data Interchange (EDI), Radio Frequency Identification (RFID), the Internet, World Wide Web (WWW) and other range of related e-business

technologies, has created new opportunities and threats to logistics and supply chain performance. Briggs, C.A.(2015).

III. TOPOLOGY OF THE PHARMACEUTICAL SUPPLY CHAIN

The emergence of the global corporation and the global supply chain has brought about parallel changes in today’s global economy; however, supply chain management has become ever more complex. Peter Trkman et al (2005). The phrase “supply chain” is always used to describe the logistics activities. In an individual firm’s manufacturing, transportation, distribution, or retail network, it represents an integrated view across process. It is a critical concept to drive coherent strategies and to manage an organization around common (end-to-end) performance objectives (Lasschuit & Thijssen, 2004). Modern supply chain networks are not simple linear chains or processes; they are a set of complex networks of products and information flows that travel between the nodes of different networks. Indeed, supply chains are extremely complex, and every industry’s chain has its own different quirks and characteristics. Supply chain is a

link of resources and processes that begins with the sourcing of raw materials and extends through the delivery of the end products to the final consumer. This explains the concept that, a company’s supply chain links its upstream suppliers and downstream distributors. For example, Walmart is part of the supply chain for hardware, clothing, electronics, and various other products. Mentzer T. et al. (2001). Christopher M. (1992), assert that, supply chain is a network of organizations that links the upstream and downstream processes and activities that creates value in the form of goods and services in the hands of the final consumers. As shown, in Figure. 1, a Traditional supply chain is viewed as an integrated process where the flow of finance and information is a two directional process while the flow of goods and services is one directional. Coyle et.al (2009), assert that, supply Chain management can be viewed as a pipeline or conduit for the efficient and effective flow of products/materials, services, information, and financials from the suppliers through the various intermediate organizations/companies out to retailers or consumers or the system of connected networks between the original vendors and the ultimate final consumers.

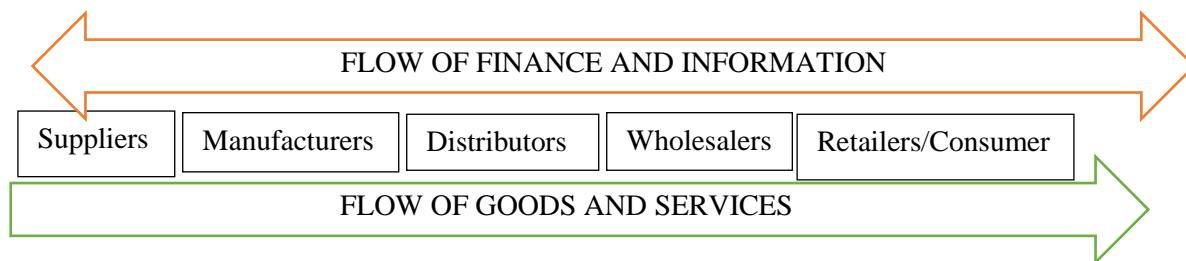


Fig. 1: Integrated Supply Chain

‘Pharmaceuticals’ (or ‘drugs’, ‘medicines’) in this study refers to innovative and generic products, chemically, and biologically-derived products, and prescription-based and over-the-counter products. Pharmaceuticals originate from the manufacturing sites and are transferred to wholesale distributors who distributes it to the retail outlets and mail order, pharmacies; healthcare facilities, hospitals, nursing homes and other healthcare providers and finally dispensed by pharmacies; and ultimately delivered to patients or consumers. The pharmacy supply chain is the means through which prescription medicines are delivered to patients. The Kaiser Family Foundation (2005). Supply chain integrations are usually complex regardless of the industry; however, the

pharmaceutical supply chain integration is more challenging and difficult. The pharmaceutical supply chain seems to appear or look simply, but with closer look reveals other supply chain members who have significant influence over the ultimate distribution of pharmaceuticals to healthcare consumer. Example of such supply chain members are health insurance payers, pharmacy benefit managers (PBMs), group-purchasing organization (GPOs), and pharmacy services administrative organizations (PSAOs). Manufacturers of prescription drugs, both brand and generic, ship their products to primary distributors (e.g. traditional wholesalers), for distribution to pharmacies and other healthcare providers.

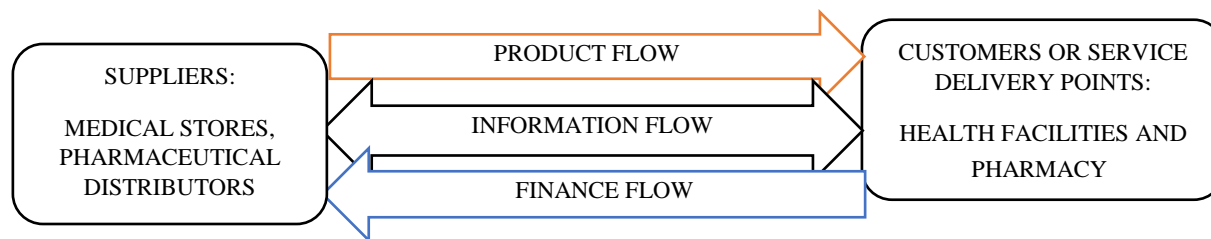


Fig.2: Three Basic Elements of the Pharmaceutical Supply Chain

The role of supply chain management is to manage and optimize these three flows.

The Three Basic Elements of the Pharmaceutical Supply Chain Management (Shown in Fig. 2: There are three basic element of supply chain management: the product flow, the information flow, and the finances flow.

- ✚ **The Product Flow** – The product flow involves the movement of pharmaceuticals from a supplier to a customer or service delivery points, in this case, the health facilities and pharmacy. This flow also concerns customer returns and service needs.
- ✚ **The Information Flow** – The information flow centers on transmitting orders and updating the status of delivery.
- ✚ **The Financial Flow** – The financial flow involves credit terms, payment schedules, and consignment and title ownership arrangements. Camcode (2020).

The United States Department of Commerce (2016) distinguished the segment of pharmaceuticals as follows:

Generic Pharmaceuticals: Produces copies of innovative pharmaceuticals with the same active ingredient, strength, dosage form, and route of administration. In the United States for example, upon either patent expiration or a successful challenge of relevant patents, a manufacturer can produce a generic drug if it meets FDA approval and bio-equivalence standards. Generic companies typically focus on high volumes to earn profits, requiring efficient production methods and distribution chains.

Biopharmaceuticals: Are biological or cell-based drugs. Pharmaceuticals (biopharmaceuticals, drugs, medicines) are defined as any substance intended for use in the diagnosis, cure, mitigation, treatment or prevention of disease or any substance (other than food) intended to affect the structure or function of the body.

Innovative Pharmaceuticals: Are chemically derived drugs developed by an innovator (originator), following extensive R&D efforts in clinical trials in both humans and animals. The innovator relies on patents, regulatory data protection and other forms of intellectual property rights (IPR) to justify the investment required to bring a product to market. The pharmaceutical industry is heavily dependent on the development of new molecules to replace the revenue stream of older drugs that are approaching the expiration of their patent terms. (U.S. Department of Commerce 2016). Enyinda C. and Briggs C. (2009) identified two sources of supply chain risk drivers as: internal and external. They described the internal risk as the risk under the direct control of the organization and while the external risks are risks beyond a firm's control, including demand and supply risk, counterfeits, regulation and legislation, third-party relationship. These external risks can disrupt the reliability and continuity of the smooth flow of pharmaceuticals and/or active pharmaceutical ingredients. A breach at any point in this continuum could lead to dangerous and even deadly outcomes for patients.

Participants in the Pharmaceutical Supply Chain

A manufacturer produces the drug product and is usually the entity that submits the application to FDA for approval to market the product or that holds the approval.

A wholesale distributor sells the drug to “persons other than a consumer or patient”. (21 CFR 203.3)(2011). The pharmacy supply chain shows the steps a finished drug product may take on its way from the manufacturer to the dispenser who will give the drug to the individual patient. This segment of the supply path is called downstream. The upstream segment ends with the manufacturer and involves the sources of materials that the manufacturer uses to produce the finished drug product, such as active pharmaceutical ingredients and inactive ingredients (e.g.,

fillers, binders, and colors). The increasingly complex drug supply chain, from raw source materials to finished products for consumers, presents multiple opportunities for the product to be contaminated, diverted, or otherwise adulterated. Therefore, securing the supply chain will require minimizing risks that will arise anywhere along the supply chain: from sourcing a product's ingredients through the overseeing of a product's manufacture, storage, transit, sale, and distribution.

A primary wholesale distributor gets the drug products directly from the manufacturer and sells them to other wholesalers or dispensers. Three large primary wholesale distributors accounted for 85% of U.S. pharmaceutical wholesaling revenue; these are McKesson Corp., Cardinal Health Inc., and AmerisourceBergen Corp. Pew Health Group (2011) and Adam Fein, (2012).

An authorized distributor of record (ADR) is a wholesale distributor that has a relationship with a manufacturer that is ongoing, defined in regulations as including a written agreement specifying which products it will distribute and for which period. Not all primary wholesalers are ADRs. Pew Health Group (2011)

The term secondary wholesale distributor generally applies to wholesale distributors that acquire drug products from a wholesale distributor, not directly from the manufacturer. Some wholesale distributors focus on a region of the United States; others focus on a specialty market, such as cancer drugs, or on the discounted drug market. FDA (2001).

A re-packager removes a drug from its container and places it in another, usually smaller container for sale to a distributor or dispenser.

A third-party logistics provider may take temporary physical possession of the drug, such as during transport or warehousing, under contract with a manufacturer, distributor, or dispenser, but does not assume ownership of the drug.

A dispenser provides the drug to the consumer/patient. A dispenser may be an independent, community pharmacy; a retail chain pharmacy; a hospital or health care facility; a doctor's office; etc. as depicted in figure 3. Indeed, the generic pharmaceutical supply chain, surmise that, the pharmaceutical manufacturers manage the distribution of drug products from the point of production to the drug wholesalers and in some instances, directly to retail pharmacy chains, specialty pharmacies, hospital chains as well as to some health plans. While wholesale distributors are the manufacturers' largest purchasers, in some cases, drug manufacturers also distribute products directly to government purchasers including the AIDS Drug Assistance Program (ADaPs), Veterans Administration and Vaccines for Children (VFC) program. Datexcorp.com(nd)

In addition to the members of the supply chain, other entities also have interest in its functioning. The primary federal regulator of drug safety, and drug supply chain, is the Food and Drug Administration (FDA), joined by others, such as the Centers for Disease Control and Prevention (CDC) and the Federal Trade Commission (FTC), as warranted. A state regulator can be a board of pharmacy, often placed within a state department of health. Professional and industry organizations with interest in pharmaceutical supply chain security include those representing pharmacists, pharmacies, health care institutions, manufacturers, distributors and wholesalers and data-and-code-based technology (hardware and software) developers and maintainers. Congressional Research Service (2013).

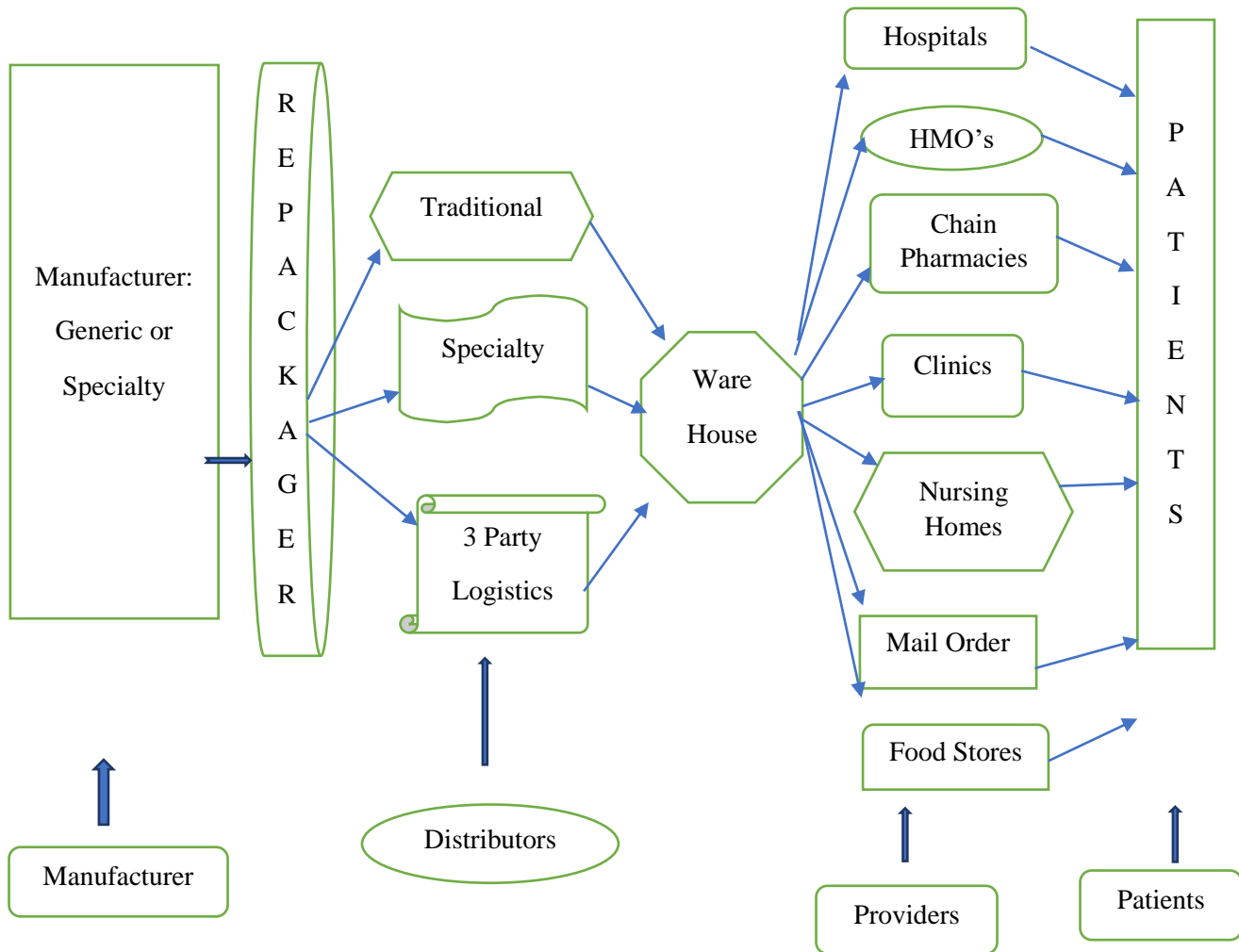


Fig.3: A Generic Pharmaceutical Industry Supply Chain

This flow ensure that drugs are readily available from the manufacturers and distributed through the providers to the patients.

The production planning and inventory control process is comprised of the manufacturing and storage processes which includes the design and management of the entire manufacturing process. The distribution and logistics process determine how products are retrieved and transported from the warehouse or storage facility to the retailer. These processes interact with each other to form an integrated supply chain. (Benita M. B,(1998).

Three major components of the pharmaceutical value chain according to Murray Aitken, (2016) includes:

1. Manufacturing of the medicine: Starts the initial research and development phase, to getting regulatory approval that allows the medicine to be available for sale in a market, to the final phase of commercialization. The process and requirements may differ based on the specific medicine, manufacturers, and the country of manufacture.

2. Distribution to the dispensing point: This includes the transportation and handling of the medicine from the manufacturer to the end user. (e.g. retail pharmacy (retailer), hospital or dispensing doctor. The complexity of the distribution depends on the manufacturer’s location, nature of special handling requirements, if medicine need to be imported due to geographic location of the end user.

Transportation is an essential part in the execution of the supply chain. It provides the link between nodes. Therefore, transportation capabilities must be integrated with their enabling supply chain structures (Morash & Clinton, 1997). Important decision making in transportation includes modal selections, shipment size, and routing which are all directly related to the location of warehouses, customers, and plants (Webster, 2008). Therefore effective management of a firm's transportation system will ultimately ensure adequate visibility of the firm's orders and shipments along the supply chain.

3. Dispensing to the end user: Providing the correct medicine dosage and form, to the right patient, in a convenient and timely manner is the final step in the value chain. This step can also involve several additional activities, including checking for potential interactions, providing advice, and processing reimbursement claims. Indeed, all these activities are to ensure the patient receives the full benefit and value from the medicines they receive.

In each of these components of the value chain, there are range of costs incurred and value added, as summarized in Fig: 4; Murray Aitken (2016).

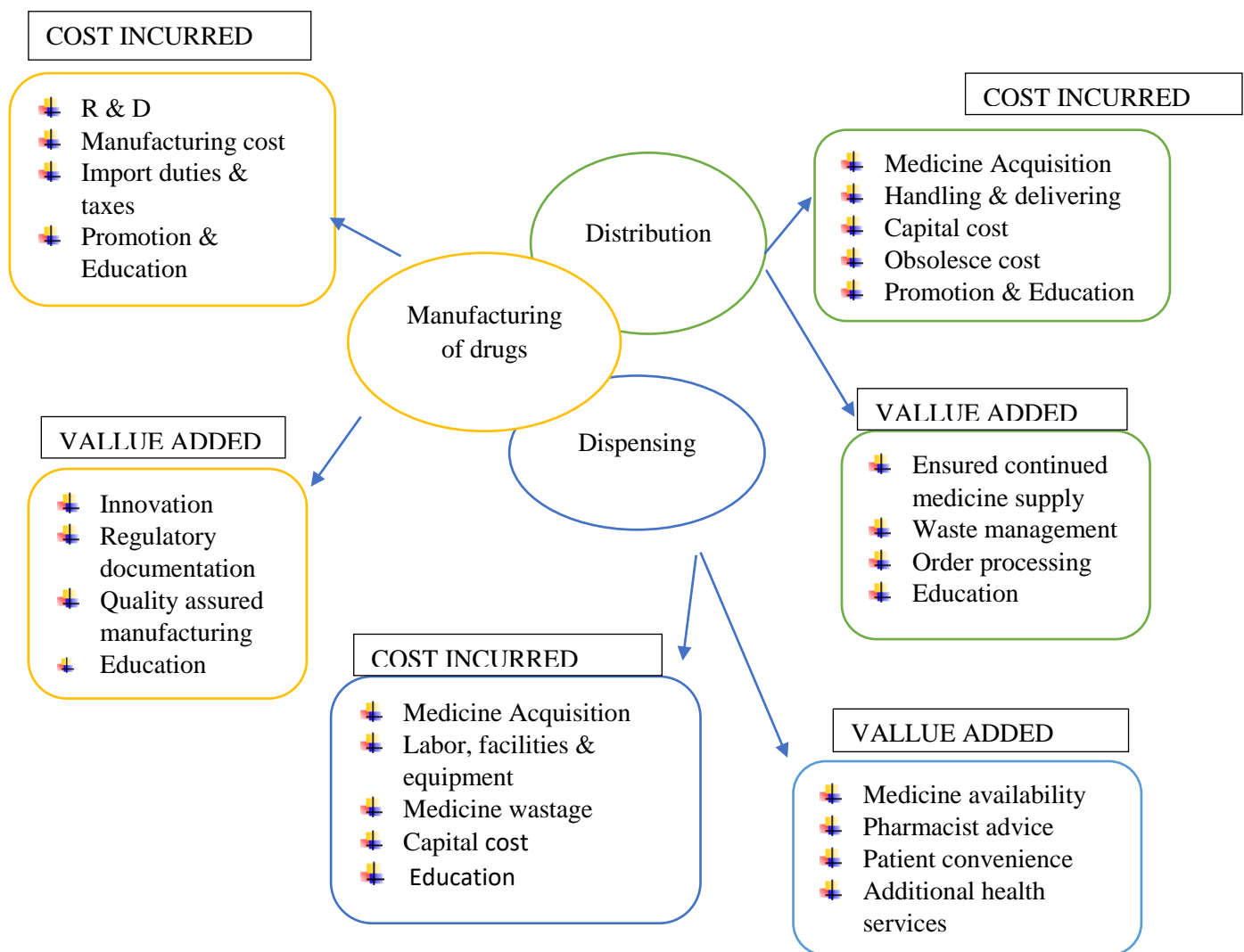


Fig.3: A Generic Pharmaceutical Industry Supply Chain

Pharmaceutical Value Chain (Adopted from Murray Aitken (2016). (ifpma.org).

With the ever-increasing complexity in the global marketplace, a higher level of supply chain performance is being pursued to deliver better value to both consumers and businesses. However, to reach the proverbial pot of gold, a fully integrated and synchronized supply chain is required (Ian Sewell 1999).

IV. THE PHARMACEUTICAL SUPPLY CHAIN “ON THE WIRE”

The internet has transformed many aspects of the global marketplace, from consumer behaviour to new business models. Mobility, cloud computing, business intelligence and social media underpin how the internet has changed our world. Industries are undergoing digital transformation. While new firms can embrace the digital marketplace straight away, established firms will need to transform how they sell, price, produce and deliver products and services. Real time business intelligence and predictive analysis is required not only for faster decision-making, but to cope with unexpected market risks and opportunities. Banomyong, R (2018). The value of information can be calculated based on the relative value of alternative response strategies and the likelihood that acquiring the information would result in a change in response. Only information that leads to a change in response strategy has any value, and its value is a function of the difference in the values of the alternative strategies. Once the organization knows how to determine what information is valuable, its investments in information gathering become more focus and productive (Haeckel, 1999).

In recent years, social media have transformed the way people communicate by reducing barriers to the exchange of information, increasing both the amount of communication and the number of people who can participate. Health care organizations (e.g. hospitals, health systems, patient associations) have chosen to use social media for both communication and marketing. As health care systems continue to work toward meeting meaningful-use requirements of the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009, pharmacy practitioners struggle to provide meaningful and coordinated database exchanges (interoperability features) that would allow seamless information additions and subtractions among medication-related technology, devices,

and related electronic health care systems that rely on accuracy for the safe provision of medicine to patients. Volpe G. et al (2014). Hospital pharmacy services, community pharmacies and clinical pharmacists tend to have several amount of twitter accounts. Helena Esteban-Cartelle, et al (2017).

One study conducted with pharmacists from nine countries revealed that the most used social media among consulted pharmacists were Wikipedia, YouTube and Facebook. Benetoli A, et.al (2016). A posterior publication by the same authors stated that the pharmacists interviewed did not provide individualized services to consumers via social media, despite most of them working in a pharmacy with a Facebook page. They occasionally provided advice and general health information on social media to friends and followers, and more commonly corrected misleading health information spread on Facebook. Also, short YouTube videos were used to support patient counseling in community pharmacy. Benetoli A, et al (2017). Twitter is the second most used social media platform by hospitals in the United States and has been used by organizations to promote health and detect poor-quality health care. One study recently found 672 accounts belonging to emergency physicians; another study aslo found that just 13 pharmacy preceptors acknowledged creating a Twitter account. Another study identified 12% of pharmacists from a single state as having a Twitter account. More broadly, American Society of Health-System Pharmacists (ASHP) surveys suggest that 25% of pharmacy students regularly use Twitter, 22% of new practitioners have an account, and only about 12% of pharmacists who have been in practice keep an active Twitter account, compared with 13% of the general population. Hajar z et al. (2014).

Pharmacists are in a great position to counsel patients about digital options that can help them make better health decisions. Notable among these options are digital applications. From monitoring a patient's diabetes to reminding individuals about their immunization status, there is, as Apple would tell you, “an app for that.” According to Mobile fact sheet 2013, 77% of US adults own a smartphone, while Kaltwasser J. 2019 stipulate that as major mobile carriers now race to 5G, it is time to embrace this technology as a health care tool. Hennessy M. (2019). These apps can not only save pharmacists and physicians counseling time, as patients turn to their phones for reminders about what vaccines they need, but also provide critical information

during emergencies. Now is the time to embrace this technology as a health care tool.

These apps can not only save pharmacists and physicians counseling time, as patients turn to their phones for reminders about what vaccines they need, but also provide critical information during emergencies. According to the latest measles number from the Centers for Disease Control and Prevention, from January 1 to December 31, 2019, 1,282 individual cases of measles were confirmed in 31 states. Of these cases, 128 were hospitalized and 61 reported having complications, including pneumonia and encephalitis. However, in May 7, 2020, there have been 12 confirmed cases in 7 jurisdictions. The Jurisdictions here refers to any of the 50 states, New York City, and the District of Columbia. Measles cases and outbreaks. (2019).

In instances like these, apps have the potential, in the future, to deliver up-to-the-minute immunization recommendation. Although social media is important, the pharmacy's commercials are the most successful marketing tool. Mike H. Sr (2019). This improvement in information technology (IT) has reduced the cost and time required for business processes, creating competitive advantages for businesses that know how to use it. The increasing scope of business diversification (facilitated by IT) has led to globalization issues such that businesses now must deal with highly diversified customer groups with different preferences, living within different cultural contexts. Briggs C. (2015). Automated dispensing machines—decentralized medication distribution systems that provide computer-controlled storage, dispensing, and tracking of medications—have been recommended as one potential mechanism to improve efficiency and patient safety, and they are now widely used in many hospitals (Fung E. and Leung B. (2008). Indeed, re-engineering of pharmacy inventory management is long overdue. Technological innovation and better workflow design are improving processes traditionally

characterized by manual, error-prone practices, and lack of visibility into existing inventory.

Ultimately, empowered with the right information at the right time, directors of pharmacy can maximize purchases and enhance patient safety through faster and better decision-making. Evidently today, this enterprise-wide medication management model is transforming how health systems view the pharmaceutical supply chain. Advanced Staff, (2016). Improving patient safety is always a key focus in the hospital setting, and pharmacists have been exploring a variety of strategies and technologies to achieve this goal.

Sensing and Responding at the Pharmaceutical Industry

Information technology (IT) capabilities is an imperative for logistics and supply chain sustainability and an important tool for cost containment/reduction, better customer service, increase on returns on asset (ROA) and increase in sense and response to customer and market needs. Haeckel, (1999) emphasized that, adapting organizational context is the key to keeping a business viable in discontinuous change. As with many industries, technology is a major driver as well as, for pharmaceuticals, technology is just about everything.

Recently, the newest technological trends have been with the research and use of stem cells, and the introduction of nanotechnology as a complement to drugs in healing patients. The chemicals and drugs industry have a promising but challenging future. With an aging population consuming three times as many drugs as younger population, worldwide demand is expected to rise. Drug expenditure is expected to triple from 2000 to 2050 and the market value is estimated to be worth \$1.6 trillion by 2020. As demand rises, especially in emerging markets, Pharmaceutical companies are increasingly reliant on major technological advances and sharing resources among each other to develop revolutionary medicines. Global Edge. (2019).

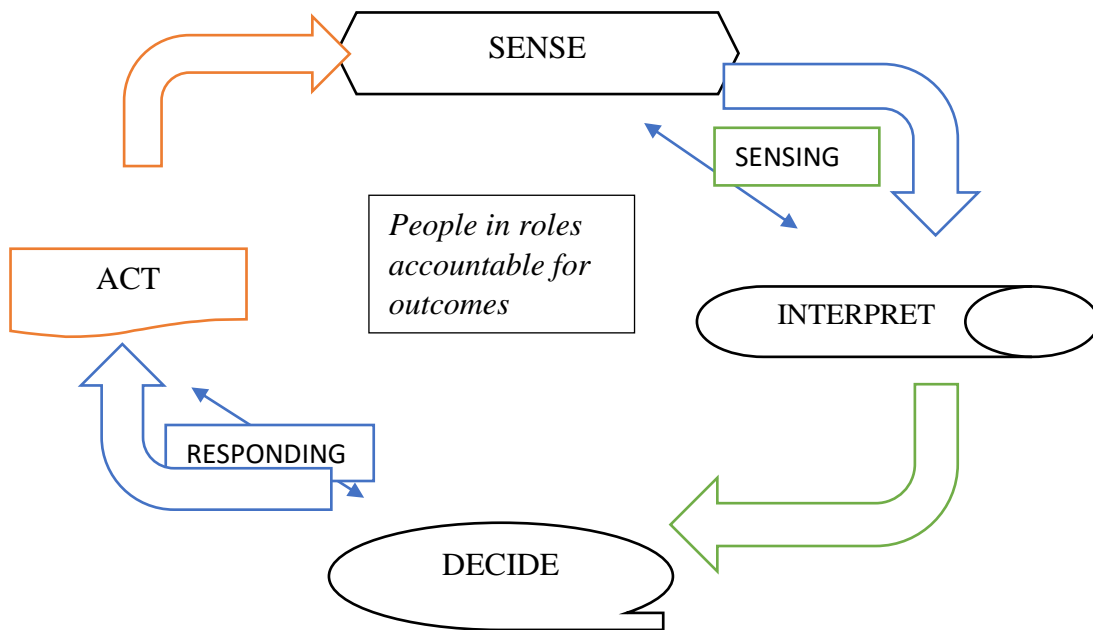


Fig.5: The Adaptive Loop

Adopted from Haeckel, (1999).

The adaptive loop presented in fig. 5 begins with and is fueled by data, and that the system must transform into information and knowledge before it acts.

According to, Bozarth and Handfield, (2008), Information System (IS) is a set of interrelated components that collect or retrieve, process, store and distribute information to support decision making, in an organization. Coyle, et.al (2009), assert that information must be accessible, relevant, accurate, timely and transferable across the supply chain and further described supply chain information system (SCIS) as a system that automate the flow of information between a firm and its suppliers to optimize planning, sourcing, manufacturing and delivery of goods and services. While Sanders, (2012), concludes that information technology is the tool that has broken down the barrier of distance between companies and geographic regions.

The Adaptive Decision Process (ADP)

The Adaptive Decision Process (ADP) provides a powerful way to think about the relevance and value of information-gathering activities. Its logical framework can be best described as decision pull, as distinguished from information push. Indeed, an adaptive organization must

sense what information can contribute to the development of value-creating strategies. Sense-and-response logistics (S&RL) is a principal tenet of focused logistics that fuses operations, intelligence, and logistics information with the goal of managing logistics events in near real time. The goal is to maximize the readiness and logistics effectiveness and enabling logisticians to accurately observe, orient, decide and act faster than the supported customer. Indeed, the S&RL requires a network-centric enterprise and mandates collaboration within and across communities of interest. In today's information age, to be adaptive, organizations must meet an essential criterion for processing information from an environment, they must be able to translate apparent noise into meaning faster than it arrives. As both noise and potentially meaningful data arrive faster and faster, complex organizations in complex environments need help to sense and interpret event quickly (Haeckel, 1999). For the globally connected and competitive market, the use of information technology (IT) is becoming an effective paradigm. Therefore, to coordinate and synchronize supply chain, firms need information and communication technology as an enabler to achieve a higher level of supply chain efficiency. The absence of coordination and synchronization across supply chain members could lead to inadequate performance, therefore adopting information and communication technology (ICT) as an enabler will reduce the inadequacies and inefficiencies that relates to poor

information processing and sharing. To become more competitive, innovative, and adaptive, it is imperative that organizations embrace information technology for improved performance.

There are several functional roles of IT in supply chain management (SCM) such as: Customer relationship management, Firm, Procurement, Operation, Logistics and Vendor relationship management. Improvement on customer satisfaction can lead to better service and lower cost. Logistics information systems create and manage the informational flows in the network. Order management systems, warehouse storage and retrieval systems, transportation scheduling and package routing systems, and even tracking systems like the one UPS uses to track shipments are all part of the logistics information system, Bozarth & Handfield, (2008). Indeed, an efficient and effective use of IT can reduce cycle time, reduce parts inventory, work in progress and finish goods in the pipeline, increase the accuracy and competitiveness of filling a customer's order (Mehdi, et al 2008). Bakos and Brynjolfsson, (1993) posit that, the development of IT in supply chain could lead to closer buyer-supplier relationship. Studies has shown that, successful supplier-buyer relationships are due to efficient and successful information sharing. Stump and Sriram (1997), stipulate that the use of IT is associated with the overall closeness of buyer-supplier relationship. Grover, et al. (2002), argue that the decision to use IT within the firm encourage the commitment to establishing relational behavior. They further conclude that IT decreases transactional costs between buyers and suppliers and creates a more relational/cooperative governance structure.

The utilization of ICT is one of the most important modes for improving the quality of healthcare services in both developed and developing countries. However, since 2006, the Malawian Ministry of Health for example; in collaboration with Baobab Health Trust and Luke International, two non-governmental organizations (NGOs) operating locally, have begun investing in ICT solutions by

installing electronic health record (EHR) systems in health facilities throughout Malawi. World Health Organization (WHO) (2013), and Centers for Disease Control and Prevention (CDCP), (2014). Mastellos, Nikolaos, et al (2018). These EHR systems intend to improve patient outcomes by supporting the management of supplies, helping clinicians in the delivery of care, also providing robust patient-level data for stakeholders. David Bell, et al., (2018), explores the future of computerized clinical decision support systems (CDSSs) for primary health care in low-resource settings. They stipulate that advances of CDSSs in various settings, using the growing availability of big data in clinical decision-making, open a radical technological approach that could enable countries with poor health infrastructure to capitalize on the information revolution transforming other sectors of society (Celi LA, 2014). By integrating clinical and local epidemiologic data, with improved medical record systems, and improving digital linkages within and between clinics, a system that employs dynamic clinical algorithms (DCAs) could optimize the clinical care of patients, incorporating relevant data from all levels of the health system into decision-making in primary care consultation (David B, et al., 2018).

Moore et.al (2005), in their research on "trends and issues in supply chain management" identified six drivers of excellence as represented in fig. 6:

- 1). Collaboration, 2). Visibility, 3) Connectivity, 4) Optimization, 5) Execution and 6) Speed, in adaptive enterprises and recognized the link between information technology and excellence. They stated that: firms that have real-time or near real-time information about a products, customers, and order fulfillment across the supply chain are more effective and deliver customer service that surpasses their competition. Then went further to confirm that these technology-assisted drivers of excellence when executed properly, generates adaptive capabilities, help synchronize high-velocity supply chains, and serve as valuable weapons in the ongoing battle for competitive advantage. Coyle et.al (2009).

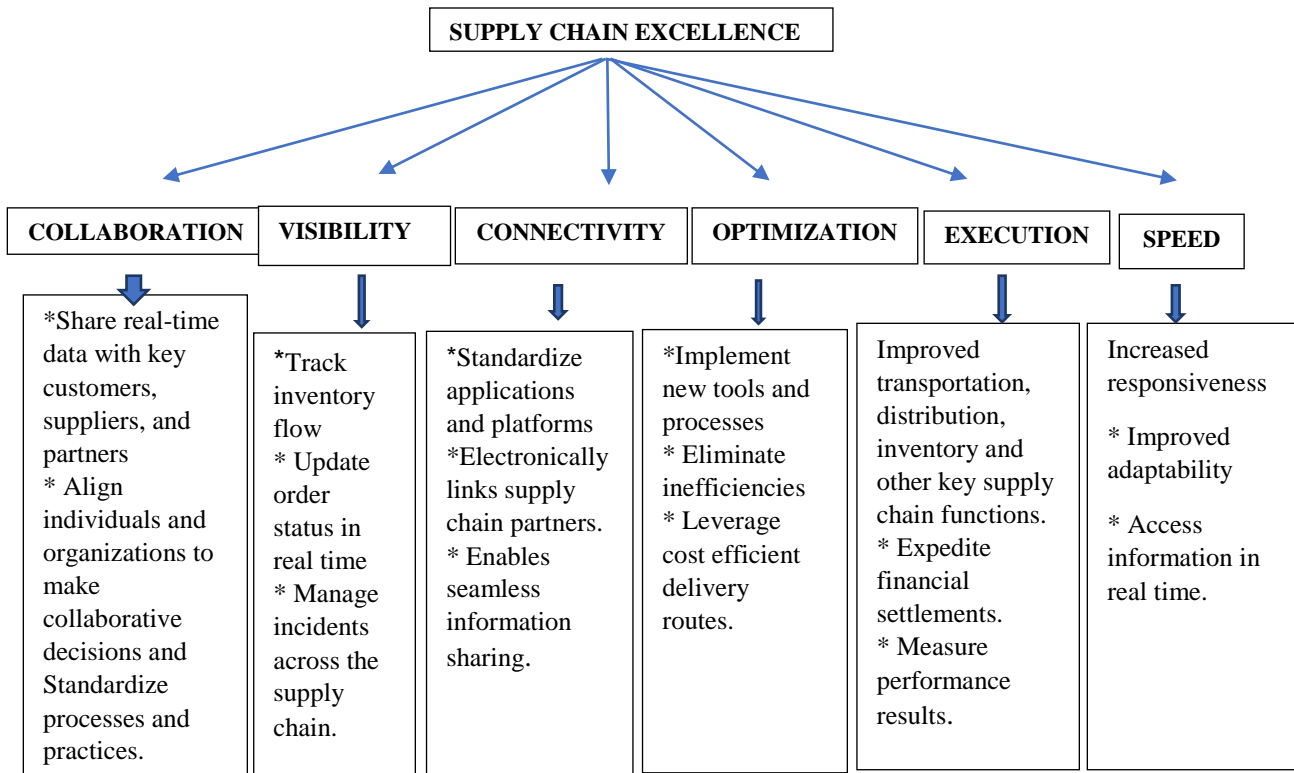


Fig.6: Six Drivers of Supply Chain Excellence

(Adopted from Moore et.al (2005) Information Technology supports the pursuit of these drivers, facilitating the evolution to highly coordinated, dynamically responsive supply chains.

V. RADIO FREQUENCY IDENTIFICATION (RFID) AND SENSOR TECHNOLOGY

Faced with a rising tide of counterfeit and mispriced drugs, pharmaceutical companies are turning to technologies such as RFID to better track medications through the convoluted supply chain. To fix this problem, pharmaceutical companies are under increasing pressure to plug holes in their supply chain, particularly in the distribution network that runs from manufacturer to customer. For instance, several US states are now mandating that companies confirm the authenticity of their product by creating a "pedigree" that vouches for a medication's origin and who else has handled it. The FDA has recommended that pharmaceutical companies start using radio frequency identification technology (RFID) as a means of better tracking drugs. As a

result, most pharmaceutical companies are experimenting with RFID, or at least using bar codes or other technologies such as Web portals that can help track and authenticate the drugs. Patton S. (2007).

Some of the IT tools commonly used include: Electronic data interchange (EDI), Electronic Fund Transfer (EFT), and Electronic Product Code (EPC), which defines the RFID tag data structure and allows unique identification of manufacturer, the products and individual items that belongs to that product. barcode and radio frequency identification (RFID). Indeed, technologies such as RFID is increasingly in use in pharmaceutical and healthcare systems. Radio Frequency Identification (RFID), infrastructure describes the IT infrastructure which is necessary to collect, filter and enrich raw RFID data before being processed by the backend systems (i.e., business intelligence systems like

ERP) Floerkemeier C, and Lampe M, (2005). The basic RFID system is composed of three main elements: the RFID Tag which contains data that uniquely identifies an object, a RFID Reader which reads and writes the data on the tags and finally, a backend database which is used to record the data collected by the tag readers. Potdar M, et al (2006). The RFID Reader in turn send radio waves to the RFID tags, to enquire about their data contents while the tags respond by sending back the requested data. The readers having some processing and storage capabilities is linked via the RFID middleware

with the backend database, to do any other computationally intensive data processing. However, the RFID middleware, is designed to provide the messaging, routing, and connectivity for reliable data integration with existing backend systems such as Enterprise Resource Planning (ERP) Systems and Warehouse Management Systems (WMS). Finally, the backend database, stores the complete record of RFID items. It maintains the detailed item information as well as tag data, which shall be consistent with the one read from the RFID. Leaver S. (2004).

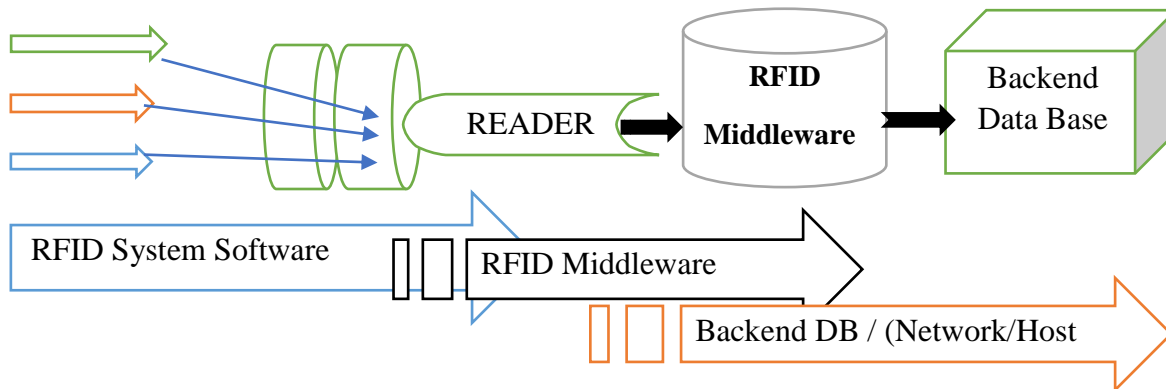


Fig.7: RFID Tag

FIG. 7. Shows the Relationship between RFID Tag, RFID Reader, RFID Middleware, and Backend Database. The phases of RFID Processing include: 1. Collecting data through the RFID reader, 2. Using the collected data for further use, 3. Finally exchanging data with backend systems.

The technical characteristics of RFID whether Passive or Active are distinct technology substantially different capabilities but often considered and evaluated together. Passive RFID is most appropriate where the movement of tagged assets is highly consistent and controlled, and little or no sensing capability or data storage is required. Active RFID is best suited where business processes are dynamic or unconstrained, movement of tagged assets is variable, and more sophisticated security, sensing, and/or data storage capabilities are required. Savi Technologies (nd). Although slowly adopted, the RFID technology seem to a more reliable, however, the use of two-dimensional bar coding has been a widely form of electronic identification used in the pharmaceutical industry. Ajami S and Rajabzadeh A. (2013). Indeed, the implementation of RFID technology in the pharma industry has some noted

advantages: accuracy, scalability, productivity, increased customer satisfaction and potential for higher return on investment (ROI). Alberto C. et al (2016).

Several uses of RFID in the Pharmaceutical Industry include but not limited to:

- 1) Used to create electronic drug pedigrees (e-pedigrees) instead of the current manual ones. E-pedigrees are auditable electronic documents that provide the distribution history of a drug, including the dates of sales, purchases, or trades as well as the parties associated with each transaction and helps to ensure authenticity of the medication through the supply chain. Tailor D.(2014).
- 2) RFID technology, through automatic identification, can detect and avert errors during medication administration and has penetrated through the healthcare system. Ajami S., Rajabzadeh A. (2013).
- 3) Use of RFID has been estimated to decrease risk across the healthcare continuum in a variety of ways. Tribble D (2010).

- 4) RFID tags in the pharmaceutical industry have helped to reduce the adverse effects associated with patient noncompliance. Alberto C. et al (2016).
- 5) RFID can track the location of recalled medication within the supply chain. Kavilanz P (2010).
- 6) RFID tags combined with “smart shelves,” automated cabinet or robotic dispensing, and other inventory management tools help to identify drugs that have been recalled by reading lot numbers. Violino B. (2005).
- 7) Using RFID technologies to improve patient safety and satisfaction can help to decrease malpractice claims, reduce the number of dispensing errors, and help to control the rising costs of healthcare. Mello M. et al. (2010).

Advances in RFID and sensor technologies’ ability to communicate with each other in a network environment are redefining the concept of visibility throughout the supply chain. These “sense and respond” networks can help improve the security, quality, and integrity of products moving through the supply chain. Information Communication Technology (ICT) applications in healthcare is as important as advances in diagnosis and treatment. ICT enables access to clinical knowledge which leads to better quality healthcare. Indeed, disseminating information and knowledge management with ICT empowers all stakeholders. This ultimately improve outcome and more cost effective, than only developing better drugs, better surgical procedures, or improved diagnostics. K. Ganapathy (2011). In July 2019, the U.S. Food and Drug Administration signed a six-month project with a technology firm, as well as drug companies and hospitals, to study the value of data captured from UHF RFID-tagged injectable drugs as they move from the manufacturer to a patient. The study is to measure the effectiveness of using RFID technology to improve drug traceability and verification in the supply chain. The six-month pilot will test an alternative technology for meeting the requirements of the FDA’s Drug Supply Chain Security Act (DSCSA)—namely, RFID—with UHF tags applied to the packaging of drugs, which are read as they move through the supply chain and are compared against traditional 2D barcodes. The pilot will leverage both the 2D barcode monitoring technology commonly in use, as well as RFID, so both methods can be evaluated, compared, and analyzed. The goal is to identify whether RFID could provide use cases for greater drug supply chain visibility. The Pharmaceutical traceability technology firm “Kit Check” recommended the

pilot to the FDA and is providing the testing of UHF RFID tag reader, as well as related data, in partnership with the Hackensack University Medical Center, Coral Gables Hospital, Nephron Pharmaceuticals and Novartis. It is stated that the pilot will show that RFID, a non-line-of-sight technology, can reduce aggregation errors in the supply chain for serialization, provide efficiency on the product flow in the supply chain, and assist hospitals with utilizing DSCSA-required data in recall situations. Swedberg, C (2019). Also, in April 2020 Pharmaceutical label company Schreiner MediPharm teamed up with Kit Check to release a technology-based solution that includes Schreiner MediPharm’s customizable UHF RFID-enabled labels, known as RFID-Labels, and Kit Check’s reader stations and management software. The system is intended to help drug companies, hospital pharmacists and healthcare providers automatically track injectable drugs from manufacture to administering and thereby improve drug safety. Swedberg C. (2020).

Pharmaceutical Supply Chain Security

Schumpeter first introduced the phrase disruptive technology in 1942 as “creative destruction, a process where radical innovations create major disruptive changes in a market or in a whole industry. There are two distinct categories of technology: sustaining and disruptive technologies. According to business dictionary, disruptive technology is the “new ways of doing things that disrupt or overturn the traditional business methods and practices. Disruptive technology is expressed as a completely new technology or new ways of doing things that replaces or disrupts an existing technology or overturns a business traditional methods and practices. While sustaining technologies are technologies that enhance the performance of a product. Bower, J. L., & Christensen, C. M. (1996). Indeed, Bower & Christensen, further posit that, although disruptive technologies, are the problems of large companies, most large companies are familiar with sustaining technologies and are inclined in turning sustaining technologies into accomplishments. The real threat and opportunity in technology’s disruption lies in the evolution of customer and employee behavior, values, and expectations.

“A disruptive technology is one that displaces an established technology and shakes up the industry or a ground-breaking product that creates a completely new industry”. Solas B. (2014). Technology represents new ways of doing things, and, once mastered, creates lasting change,

which businesses and cultures do not “unlearn.” Adopted technology becomes embodied in capital, whether physical or human, and it allows economies to create more value with less input. At the same time, technology often disrupts, supplanting older ways of doing things and rendering old skills and organizational approaches irrelevant.

On November 27, 2013, President Obama signed into law the Drug Quality and Security Act (DQSA), P.L. 113-54 (27 Stat. 587). P.L. 113-54 contains two separate titles: Title I address drug compounding and is known as “the Compounding Quality Act,” and Title II is known as “the Drug Supply Chain Security Act” (DSCSA). The DSCSA enhances the security of the pharmaceutical supply chain by establishing a national system for tracking, tracing of prescription drugs, and serializing pharmaceutical products and for establishing national licensing standards for wholesale distributors and third-party logistics providers. The DSCSA is a huge step forward in reducing potential

threats to supply chain security and patient safety associated with pharmaceutical distribution. Public Law 113-54 (2013). These rules replace the previous differing state rules and regulations concerning the pharmaceutical supply chain and standardize the US market's track-and-trace rules. The DSCSA outlines critical steps to build an interoperable electronic system by November 27, 2023, which will identify and trace certain prescription drugs as they are distributed in the United States, facilitating the exchange of information at the individual package level about where the drug has been in the supply chain. US. FDA (2013).

With the example of DSCSA, according to Kevin A. Clauson et al (2020), each regulatory component should map to blockchain capabilities for it to be a viable solution. In the case of the pharmaceutical supply chain, possible DSCSA-blockchain policy and technology alignment is illustrated in Table 1. below:

Table 1. Blockchain applicability for DSCSA key requirements:

Key Requirement	Blockchain Applicability	Compatible
Product identification	Unique product identifier can be required with contributed information validated as a side chain	YES
Product tracing	Allows manufacturers, distributors and dispensers to provide tracing information in shared ledger with automatic verification of important information	YES
Product verification	Creates system and open solution to verify product identifier and other contributed information	YES
Detection and response	Allows public and private actors to report and detect drugs suspected as counterfeit, unapproved, or dangerous	YES
Notification	Creates shared system to notify FDA and other stakeholders if an illegitimate drug is found	YES
Information requirement	Can create shared ledger of product and transaction information including verification of licensure information	YES

Adopted from Blockchain in Healthcare Today.

This new system will enhance the FDA's ability to help protect US consumers by improving detection and removal of potentially dangerous products from the pharmaceutical distribution supply chain. Coustasse et al (2016). On Jun 2020, Systecha division of Market-Image specializing in serialization solutions, as announced a cloud-based software solution for the serialization of pharmaceutical products.

They indicated that the cloud-based system allows pharmaceutical products to be serialized according to a country's national requirements. However, the procedure is for collecting, storing and transmitting product data across the supply chain and that, the serialization will involve preventing counterfeiting and diversion of products, but it has not been enough to prevent criminals from taking action.

As a result, other technologies such as: fingerprinting, Systech’s UniSecure mobile solution, holograms, tamper-resistant seals, and special inks are added as extra protection to each product. They concluded that serialization affects all partners in the supply chain: brands, contract manufacturers, packers, logistics providers, distributors, hospitals, and pharmacies. Perin E. (2020). Various international and national health organizations, including the American Medical Informatics Association, expressed the urgent need for health organizations to have information systems that improve the quality, cost-effectiveness and safety in patient care. Leape L L, Berwick D M. (2005) and Kane-Gill S L. et al (2017).

Generation Y is a group that is extremely social, incessantly connected, and highly demanding. They want to get things done, and they want to use any device that will help them get it done. Bremmen, (2013). Organizations that have succeeded in engaging with Generation Y know that, as well as accelerating the take-up of new digital technology, they pose additional challenges due to their evolving expectations. Generation Y are best thought of as an evolving mindset and are today, the catalysts and the

incubators of change, but each day their influence is growing in consumer and corporate environments, meaning that organizations must learn to engage effectively now, or risk being shut out of the game. To attract these young people, both as consumers and as employees, a company cannot just look good – it must be good. The proliferation of digital channels, platforms and devices has produced a generation who are born ‘plugged-in’. This ‘Generation Y’ already plays a major role in accelerating the emergence of a new, digital world, and their impact is impossible to ignore. Briggs C. (2017).

Stages of the pharmaceutical value chain and IT applications

IT applications provides several benefits which include but not limited to improving customer services, human resources efficiency, total efficiency if more time are allocated to more value adding business activities, information quality and supporting collaborated planning and consequently improving the agility of the supply network.

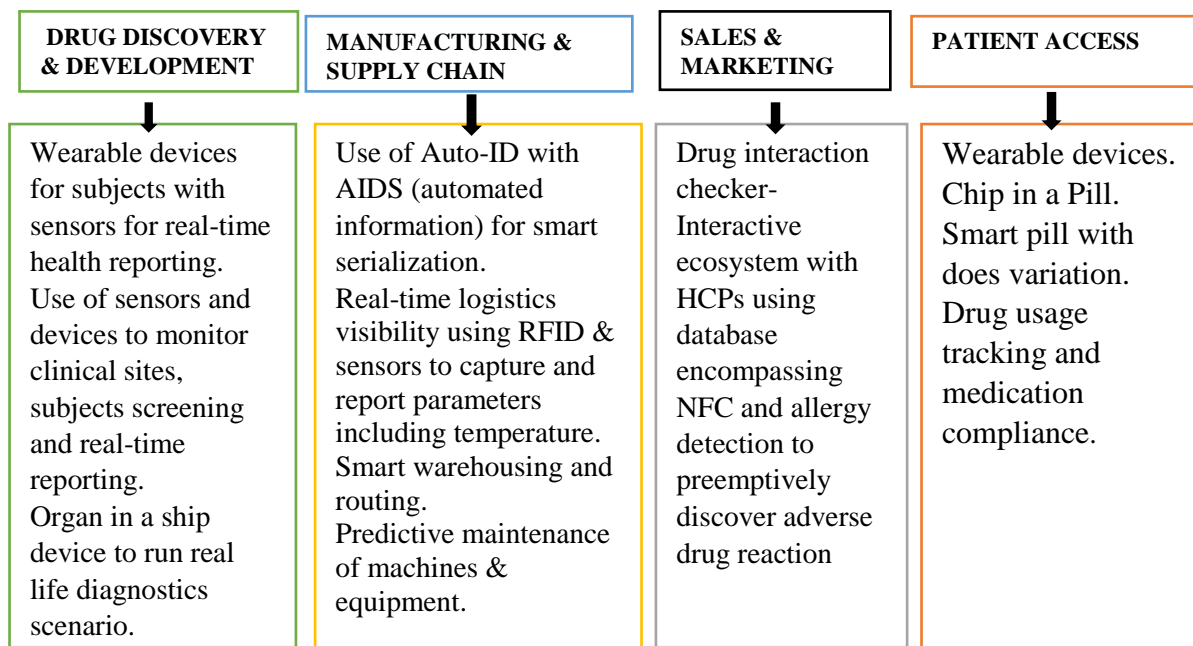


Fig.8: Pharmaceutical Value Chain and IT Applications

The major stages of the pharmaceutical value chain in figure 8 begin with drug discovery, drug development, manufacturing, distribution, sales, marketing, and patient

access. In addition, organizations face more risks in an electronic supply chain including delay, system breakdown, lack of information security etc. Rajab-Zadeh A, et al (2011).

Figure 9 selectively list applications and benefits of Information Technology to Pharmacy Supply Chain. Despite the benefits, there are still some difficulties in the IT

application, for example: changing the business processes and business relations to adapt to the new IT environment.

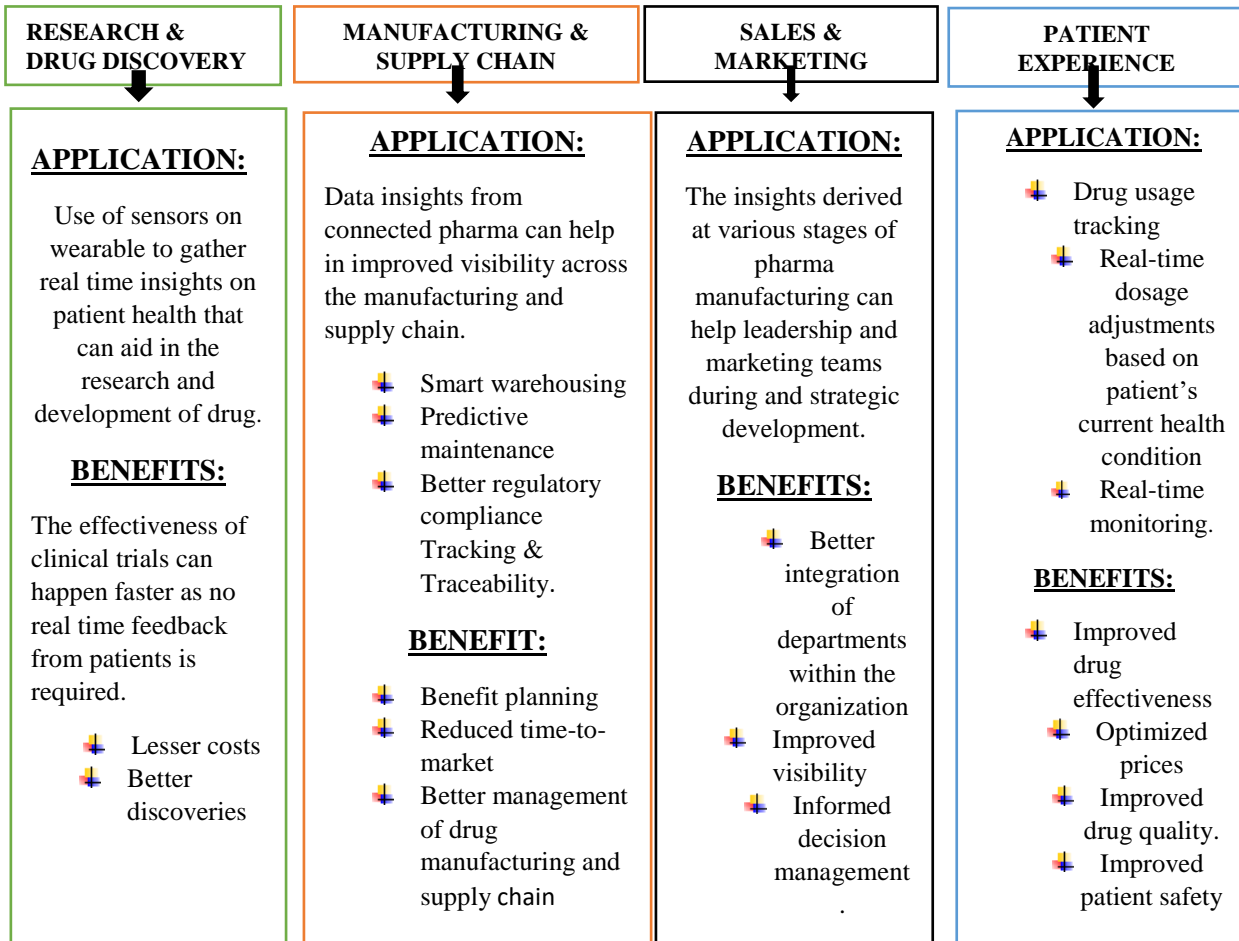


Fig.9: Applications and Benefits of Information Technology to Pharmacy Supply Chain

Electronic Prescribing Systems (EPS), automate prescribing, supply, and administration of medicines in hospitals. Barcode identification of medicines, are used in conjunction with the Electronic Prescribing System, this help to reduce errors in medication prescriptions, that lead to safety of patience while electronic ward cabinets provides benefits such as reducing number of missed doses, supply delays, stock outages, reduction of stockholding and wastage. However, a poorly implemented electronic prescribing system may create errors. The use of computerized physician order entry has significantly increased accurate medication dosage and decreased

medication errors. The use of clinical decision support systems has significantly increased physician adherence to guidelines, although there is little evidence that indicates any significant correlation to patient outcomes. Research shows that interoperability and usability are continuing challenges for implementation. Weigel F. K et al (2015). Falsified Medicines Directive (FMD), is used to combat counterfeiting at the point of dispensing. Automated dispensing: Although robots have been used in logistics, manufacturing, and distribution for several years, but adopted and used recently in pharmacy. Various technologies are now available to support approaches to adherence monitoring. Clinical

applications of e-Health include: Electronic Health Records, TeleConsultations, Clinical Decision Making Support Systems, Vital Signs Monitoring Services, TeleHomeCare, Ambulatory e-Health—smart clothing, e-Wear, e-Clothing, ePre-scribing, e-Nursing, e-dissemination of personalized healthcare and professional Continuing Education, using e-Learning tools such as: Health Information Systems, LifeTime Health Records/EMR, Pharmacy Information Systems, Electronic Claims Systems, Laboratory Information Systems, Interfacing with Diagnostic Equipments, ICT in Health Administration, and Identification and Tracking Solutions. Ganapathy K. (2011).

Today, patients have more power than ever before to review potential treatment plans, consult second opinions, and get into contact with patients similarly affected, without leaving the comfort of their home. Several free app such as DementiAssist (Baylor Scott and White Health, Dallas, Texas allows a patient to view list of triggers for several behavioral acts which will enable the family to select the best clinical treatment for the patient. Husain I.(2015). There are several useful diagnostic and treatment apps but not limited to: the new Apple Watch (Apple Inc, Cupertino in California) that utilizes data recorded from your wrist to monitor heart rate and blood pressure, blood glucose levels, sleep apnea, and even ABCD2., (*ABCD2 is a validated, seven-point, risk-stratification tool to identify patients at high risk of stroke following a transient ischemic attack (TIA) and Congestive heart failure, Hypertension, Age 75 years Diabetes mellitus, previous Stroke, transient ischemic attack, or thromboembolism, Vascular disease, Age 65 to 74 years, Sex category (CHA₂DS₂-VASc) scores (CHA₂DS₂-VASc is used to assess stroke risk in atrial fibrillation)*)—all synced to the Cloud to create an online, personal health profile, accessible on several devices. Husain I(2015).

Several vendors have developed “smart” packaging, where a microchip-containing tablet blister pack is able to monitor when doses are popped out (not necessarily taken) and prompt the patient to record side-effect monitoring information for the medicine in question. These data can then be transmitted to a mobile telephone or tablet device. A more invasive adherence monitoring technology is the “smart” pill. This consists of a sensor pill, ingested by the patient, which transmits data on doses taken, heart rate, body posture to a mobile telephone or tablet device, via a receiver patch on the patient’s skin. At present, this is available only as a dummy pill, but eventually it will be incorporated into medicines. Telecare also involves the use of digital communications

technology (audio and visual) to provide healthcare consultations and services to patients remotely at home. Telecare has various potential benefits: it puts patients at the center of their care and supports personalized medicine; it improves access to healthcare by reducing the need for hospital attendance. However, the exact benefits provided by telecare vary between different applications and care scenarios, and, at present, the literature suggests that more evidence of outcome benefits, and more cost-effectiveness data are required to justify further investment in telecare.

There are specific IT solutions for various stages of the pharmaceutical value chain. Solutions such as electronic data capture for drug development, enterprise resource planning for manufacturing and sales force automation for sales and marketing are few examples. Information Technology (IT) adoption in a pharmaceutical company can be characterized by four different levels. The level 1 companies have only department-specific solutions, which automate a single department and are not integrated. While the implementation of IT solutions in level 2 companies is integrated into multiple functional areas. Such as; an ERP solution which integrates the company’s financial, manufacturing, sales and human resources department, is a typical example of level 2 companies. Solutions such as business intelligence, data warehousing, data mining along with the enterprise-wide solutions for instance SCM, form the IT set up of the level 3 companies. These solutions assist the company to make informed decisions after extensive data analysis. Then the level 4 companies are totally automated with the help of solutions such as enterprise application integration. Sourabh K (nd).

One of the most important objectives companies need to focus on is building agile supply chains. In effect, this will give companies direct contact with patients. This new approach will allow greater commercialization as companies refocus their sale and marketing strategies that will support in creating valuable products. Advances in technology will allow pharmaceutical and medicine manufacturers to make time conscious innovations. In pharmacy, use of remote consultations, together with EPS release and an internet pharmacy supply service, could transform the way that pharmacy services are provided. Goundrey-Smith, S. (2014). However, companies must work together and share resources to increase research and development efficiency to mitigate cost. The future success and major profits lie within the hands of companies willing to make bold moves and alter traditional strategies. Hospitals

and health systems are beginning to tap into the ignored opportunity: “pharmacy supply chain optimization”.

VI. SUMMARY AND CONCLUSION

Business such as healthcare will have to reorganize and continue to modify their business-model to capture potential benefits on emerging technological innovation that can positively affect patient care and costs. Improving efficiency for a speedy ROI in every stage has become a critical factor to ensure the success of the company. Strategic adoption of Information Technology (IT) is also essential to speed up the process of research, development, and sales of drugs. Mounting focus on drug discovery has led to an exponential growth in creation of intellectual property (IP).

In such a scenario, pharmaceutical companies have come to realize the importance of IT solutions. They have started implementing knowledge management solutions for data management and security solutions to protect their IP. ERP solutions are also being implemented for optimizing the use of resources and maximizing returns. The pharmaceutical companies are using the Internet technology for web-based data capture, mining, reporting for clinical trials, eDetailing and eSampling for sales and marketing.

This new age of savvy healthcare consumerism has opened doors for a new stage of medicine, one in which patients play the leading role. It is no secret that educated patients are empowered patients, and with Google enabling the common public to research their diagnosed conditions and learn about potential treatment options, patients now have the tools to be more empowered than ever before. Studies have documented better clinical outcomes, and perhaps better decision making, in patients who are able to self-manage and incorporate lifestyle changes to accommodate their diseases. Adam R.J. (2010), and many of the latest apps are making it easy for patients to do just that. We can only imagine the potential of such broad-reaching health education for preventive medicine. But although it is easy to hear about the future of medicine that lies within the World Wide Web, it is often difficult to see the results of such advancements on a community scale, especially in underdeveloped and less educated areas. Amit Om Ms3(2015).

As the United States adds, more stringent regulations and environmental controls, pharmaceutical companies are struggling to comply. While these factors affect different aspects of the pharmaceutical and healthcare

realms, companies are evaluating their options and taking a strategic look at their current supply chain approach. Although considerable effort and expense has been expended to innovate, develop, and market medications more efficiently, there has been only minimal effort to reconfigure manufacturing and distribution operations or adjust the pharmaceutical supply chain network. Industry experts report that most pharmaceutical companies have complicated supply chains that are inefficient, under-utilized, and ill-equipped to deal with the products that are being introduced. Datexcorp (nd). Indeed, leading-edge technology will continue to rapidly advance and be incorporated into the pharmaceutical supply chain process. However, government policies on data management or governance, privacy, security, ethics, and human retraining are lagging and will need faster improvement. To efficiently manage the consequences of using information technology requires more knowledge of information technology. Technology knowledge must be coupled with improved critical thinking and communication skill integrated into strong ethical base to help the pharmaceutical industry continue to thrive in the “NEW WORLD ORDER” Rod K. (2020).

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