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**BACHELOR OF PHARMACY**

***to***

**Lokmanya Tilak Institute of Pharmaceutical Sciences**

***by***

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**DR. BABASAHEB AMBEDAKAR TECHNOLOGICAL UNIVERSITY**

**TILAK MAHARASHTRA VIDYAPEETH’S**

**LOKMANYA TILAK INSTITUTE OF PHARMACETICAL SCIENCES PUNE**

**2023-2024**

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***CERTIFICATE***

*This is to certify that the work presented in the dissertation “****AI in channels of Pharmaceutical distribution”*** *for the degree of* ***Bachelor of Pharmacy****has been carried out by* ***Mr. Sajal Mohakar,*** *in the premises of* ***TMV’S Lokmanya Tilak Institute of Pharmaceutical Sciences Pune*** *and under the guidance of* ***Ms. Shraddha Dingare and Ms. Priyanka Todkari.***

***Date:***

***Place: Pune***

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***CERTIFICATE***

*This is to certify that the work presented in the report entitled* ***AI in channels of pharmaceutical distribution*** *for the degree of* ***Bachelor of Pharmacy*** *has been carried out by* ***Mr. Sajal Mohakar,*** *in the premises of* ***TMV’S Lokmanya Tilak Institute of Pharmaceutical Sciences Pune,*** *under my guidance and to my satisfaction. This report is now ready for examination. Such materials, as obtained from other sources have been duly acknowledged in the report.*

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***Place: Pune***

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***DECLARATION BY THE CANDIDATE***

*This is to state that the research work entitled,* ***“AI in channels of Pharmaceutical distribution”*** *for the degree of* ***Bachelor of Pharmacy*** *has not been submitted in parts or full to any other university by me. This is the original work carried out under the guidance of* ***Ms. Shraddha Dingare and Ms. Priyanka Todkari Assistant Professor TMV’S Lokmanya Tilak Institute of Pharmaceutical Sciences Pune,*** *Such materials, as obtained from other sources, have been duly acknowledged in the report.*

***Date:***

***Place: Pune Mr. Sajal Mohakar***

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**Aim:** To analyse the channel of pharmaceutical distribution

**1. Introduction:**

**1.1 What is Pharmaceutical Marketing?**

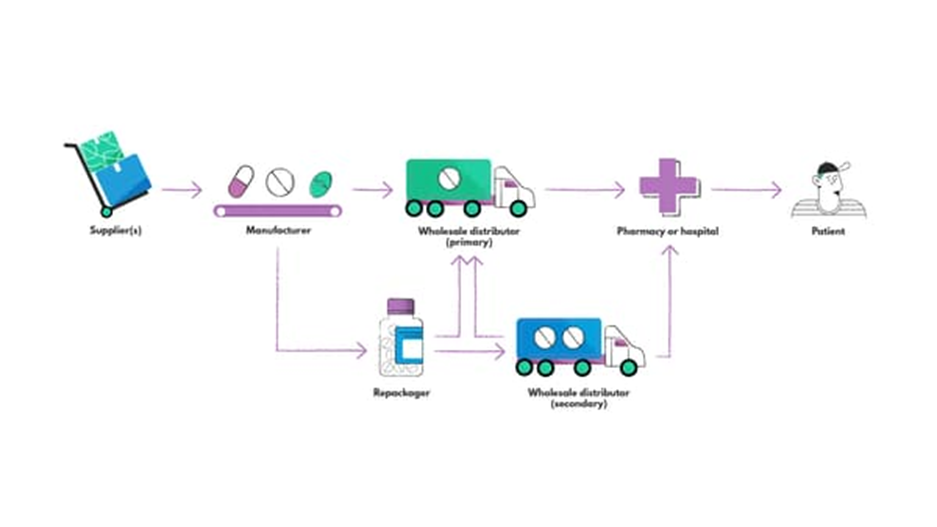
A subfield of marketing study and practice known as "pharmaceutical marketing" is devoted to the promotion, communication, and unique positioning of pharmaceutical products, including over-the-counter, specialty, and biotech medications. Consequently, marketing strategies for nutraceuticals and medical devices are occasionally included in this description.

**1.2 How Pharmaceutical distribution works?**

The distribution of pharmaceuticals is a complicated process that calls for careful planning and collaboration. Companies are searching for methods to reduce expenses without sacrificing their high standards of quality in order to have an advantage over rivals as the market grows more these savings in the form of cheaper prescription pricing.

The process of distributing pharmaceutical items from producers to final consumers, including patients, hospitals, pharmacies, and healthcare organizations, is referred to as pharmaceutical distribution.

Then, how are medications supplied? Precise planning and collaboration are necessary in the distribution of pharmaceuticals. The distribution ecosystem's players engage in extremely complex information, financial, and physical interactions with one another.



Here's a brief description of pharmaceutical distribution:

1. Manufacturing: Pharmaceutical companies use facilities that strictly comply with standards to manufacture pharmaceutical items in large quantities.

2. Packaging: Medication is packaged in proper containers following production, frequently with labels and instructions that are appropriate.

3. Warehousing: Following packaging, pharmaceutical items are kept in warehouses. The manufacturers themselves may own these warehouses, or third-party logistics firms that focus on pharmaceutical distribution may own them.

4. Distribution Centers: Medication is moved from warehouses to local or regional distribution centers, which are positioned carefully to cater to particular regions.

5. Pharmaceutical Wholesalers and Distributors: They are in charge of supplying pharmacies, clinics, hospitals, and other healthcare facilities with pharmaceuticals. They buy pharmaceuticals in large quantities from producers or other distributors, and subsequently resell them to pharmacies and other clients.   
6. Pharmacy Dispensing: Pharmacies keep prescription drugs that they purchase from wholesalers in order to dispense them to customers. In order to guarantee that patients are prescribed the appropriate drugs and are aware of how to use them properly, pharmacists are essential.

7. Direct Distribution: Drug producers occasionally choose to ship their goods straight to pharmacies or medical facilities rather than through wholesalers. This method is frequently applied to expensive or specialized drugs.

8. Regulatory Compliance: To guarantee the safety, efficacy, and quality of pharmaceutical items, stringent regulatory guidelines must be adhered to during the distribution process. This involves following the Good Distribution Practices (GDP) guidelines for handling, storing, and traveling with pharmaceuticals.

9. Cold Chain Management: To preserve their stability and efficacy, many pharmaceutical products—particularly biologics, vaccines, and some medications—need to be kept at precise temperatures during storage and transit. To make sure that these products stay within the necessary temperature range, cold chain logistics are crucial.

10. monitoring and Traceability: As technology develops, monitoring and traceability across the supply chain for pharmaceuticals are becoming more and more important. Drugs can be tracked from production to dispensing thanks to barcoding, serialization, and computerized systems, which helps to thwart supply chain problems including diversion and counterfeiting.

**1.3 Information:**

A Medical professional access is directly facilitated by three patient-facing entities in a manner that is apparent to the patient:   
 • Providers: These professionals employ a variety of techniques to treat patients, frequently recommending medications to assist control illnesses or symptoms.   
 • Pharmacies: they disperse prescription medications and sometimes associated medical care as well. The pharmacy and the provider run their own businesses, although they might be a part of a bigger system.   
 • Payors: These are people or governments that receive payments from patients and utilize that money to pay for unexpected medical expenses.

Other ecosystem stakeholders have an important role in providing health care to patients that they are not directly aware of:   
• Pharmaceutical Manufacturer: offers a variety of treatments that are all patient-centered in their design. You can rely on quality and safety for your personal care because they provide supply continuity and operate in highly regulated environments.

• Distributor: By acquiring prescription medications from several manufacturers and making sure they are transported and stored properly, distributors give patients timely access to safe medications.

The three unseen parties in charge of discussions are last but certainly not least:   
Group partnering organizations, or GPOs, enable pharmacists and providers to save costs by pooling their purchasing power to bargain with manufacturers and other ecosystem players for reduced drug prices.

• PBMs negotiate formularies with doctors and pharmacies to determine which pharmaceuticals patients can access and at what price.

• Pharmacy services administration organizations (PSAOs): their goal is to make medications more inexpensive while serving the pharmacy community. By providing small independent pharmacies with tools, systems, and consultation support, as well as by mediating contracts between PBMs and payors, PSAO guarantees that these pharmacies may obtain prescription pharmaceuticals at reasonable prices. As a result, they are able to provide reasonable costs without sacrificing the level of care they provide

**2. Introduction to Artificial Intelligence (AI):**

Artificial Intelligence (AI) emerged as an intervention for data and number-related problems. This breakthrough has led to several technological advancements in virtually all fields from engineering to architecture, education, accounting, business, health, and so on. AI has come a long way in healthcare, having played significant roles in data and information storage and management – such as patient medical histories, medicine stocks, sale records, and so on; automated machines; software and computer applications like diagnostic tools such as MRI radiation technology, CT diagnosis and many more have all been created to aid and simplify healthcare measures. Inarguably, AI has revolutionized healthcare to be more effective and efficient and the pharmacy sector is not left out. During the past few years, a considerable amount of increasing interest in the uses of AI technology has been identified for analyzing as well as interpreting some important fields of pharmacy like drug discovery, dosage form designing, polypharmacology, and hospital pharmacy. Given the growing importance of AI, we wanted to create a comprehensive report which helps every practicing pharmacist understand the biggest breakthroughs which are assisted by the deployment of this field.

AI is a stream of science related to intelligent machine learning, mainly intelligent computer programs, which provides results in a similar way to the human attention process. This process generally comprises obtaining data, developing efficient systems for the uses of obtained data, illustrating definite or approximate conclusions, self-corrections, and adjustments. In general, AI is used for analysing machine learning to imitate the cognitive tasks of individuals. AI technology is exercised to perform more accurate analyses as well as to attain useful interpretation. In this perspective, various useful statistical models, as well as computational intelligence, are combined in AI technology.

Recently, AI technology becomes a very fundamental part of the industry for useful applications in many technical and research fields. Reflecting on the past 25 years, pharmacy has done a great job of addressing the growing demand for prescriptions, even when faced with pharmacist shortages, growing operating costs, and lower reimbursements. Pharmacy has also done a great job of leveraging enabling technology automation to improve workflow efficiency and lower operating costs while promoting safety, accuracy, and efficiency in every pharmacy setting. Automated dispensing gives pharmacists more time to engage with a greater volume of patients while also enhancing their health outcomes.

**3. Definition and types of AI relevant to supply chain management**

interchangeably with robotics and automation. While robotics is simply the creation of machines that can carry out difficult repetitive tasks, AI refers to the exhibition of human-like behaviors or intelligence by any computer or machine[7]. Traditionally, robots were not built to possess these “intelligent capabilities” even though they may be able to move or carry objects independently using a designed program and surface sensors in a process known as automation. AI, in essence, is the field of computer science that specializes in the creation of intelligent machines, developed with the ability to perform tasks that will ordinarily be associated with a human being

AI is frequently applied to the development of digital computers or computer-controlled robots with the capacity to autonomously execute intellectual and cognitive human-like processes. Such intellectual and cognitive processes include learning, reasoning, problem-solving, perception, and language. The form of AI currently in use today is referred to as narrow AI or weak AI because it is only designed to perform narrow tasks like internet search, facial and voice recognition, controlling and driving cars, and so on. However, the long-term goal of the AI community is to have machines that can autonomously outperform humans’ at all cognitive tasks. The AI that involves creating machines that can perform all human cognitive tasks will be the general AI or Strong AI (ADI)[9].

In simple terms, AI refers to the ability of machines and computers to think, act, behave and function as human beings. Familiar examples of AI-controlled systems include Apple’s SIRI (in iPhone)[10], Amazon’s Alexa[11], and the self-driving cars of Google, Mercedes, BMW, and Tesla to name a few[12]. The core of AI can be Knowledge Engineering, in which machines are assembled with access to abundant data and information relating to the human world, which enables them to be able to mimic human behaviour. Machine Learning is another type of AI, which involves the use of algorithms and statistical models to improve the accuracy of software applications in predicting outcomes without being distinctly programmed. It was established based on the idea that machines can learn from data, identify problems and make decisions with minimum human help or intervention. Applications of machine learning include self-driven Google cars, fraud detection, and online recommendation offers like those on Amazon and Netflix. Machine perception is another aspect of AI and it involves designing and building machines with the ability to use sensory inputs to deduce information about the different aspects of the world. Computer vision is the ability of machines to process visual inputs such as facial information, objects, and gestures.

There have been various skepticism, criticism, and myths towards AI mostly concerning safety and the dangers that may be potentiated by the creation of machines that could match human cognitive capabilities. One of the five predictions made by Forbes for AI in 2019[15] is that it may become an issue of national politics. Aside from concerns that AIs may be used as weapons for war and mass destruction, certain people have expressed concerns that the creation of AI systems that are smarter than humans, through general AI could be more fatal and be the end of the human race itself. They believe we may not be able to predict how AI systems that are more intelligent than us will behave and that humans may end up being controlled by these super-intelligent machines. Scientists believe most of the safety concerns about future super-intelligent AI systems may be resolved if the “goals” of these machines can be made to align with our own goals.

**3.1 AI classification:**

AI can be classified in two different ways:

a) according to Caliber

b) according to the presence

Classification of AI:

Based on the Caliber:

1. Weak intelligence / Artificial narrow intelligence
2. Artificial general intelligence
3. Artificial super intelligence

Based on presence:

Type 1 reactive machine

Type 2 limited memory system

Type 3 is based on the theory of mind

Type 4 self-awareness

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Based on their Caliber, AI system is classified as follows:

1. Weak intelligence or Artificial narrow intelligence (ANI): This system is designed and trained to perform a narrow task, such as facial recognition, driving a car, playing chess, and traffic signaling. E.g.: Apple SIRI virtual personal assistance, tagging in social media.
2. Artificial General Intelligence (AGI) or Strong AI: It is also called Human-Level AI. It can simplify human intellectual abilities. Due to this, when it is exposed to an unfamiliar task, it can find the solution. AGI can perform all the things as humans.
3. Artificial Super Intelligence (ASI): It is brainpower, which is more active than smart humans in drawing, mathematics, space, etc; in every field from science to art. It ranges from the computer just little than the human to a trillion times smarter than humans.

Arend Hintze[18], an AI scientist classified the AI technology based on its presence and not yet present. They are as follows:

Type 1: This type of AI system is called a Reactive machine. E.g. Deep Blue, the IBM chess program which hit the chess champion, Garry Kasparov, in the 1990s. It can identify checkers on the chessboard and can make predictions; it does not have the memory to use past experiences. It was designed for narrow purposes use and is not useful in other situations. Another example is Google’s AlphaGo.

Type 2: This type of AI system is called a Limited memory system. This system can use past experiences for present and future problems. In autonomous vehicles, some of the decision-making functions are designed by this method only. The recorded observations are used to record the actions happening in the future, such as changing the lanes by car. The observations are not in the memory permanently.

Type 3: This type of AI system is called as “theory of mind”. It means that all humans have their thinking, intentions, and desires which impact the decisions they make. This is a non-exist AI.

Type 4: These are called self-awareness. The AI systems have a sense of self and consciousness. If the machine has self-awareness, it understands the condition and uses the ideas present in others’ brains. This is a non-existing AI

**4. AI technologies in distribution**

**4.1 AI Technologies Applied in Pharmaceutical Supply Chains**

Predictive Analytics: AI-driven predictive models help pharmaceutical companies anticipate demand variations and optimize production accordingly. This leads to reduced overproduction, minimized lead times, and increased supply chain responsiveness.

Natural Language Processing (NLP): NLP enables AI systems to understand and analyse unstructured data from various sources, such as customer reviews, social media, and market reports. This information aids in forecasting customer preferences and fine-tuning marketing strategies.

Blockchain Technology: AI combined with blockchain offers enhanced traceability and transparency across the supply chain. It enables real-time monitoring of product movements, ensuring the authenticity and integrity of pharmaceutical products while combating counterfeit drugs.

Robotics Process Automation (RPA): RPA automates repetitive tasks, such as order processing and invoice handling, reducing human error and processing time. This streamlines supply chain operations and frees up resources for more strategic activities.

**4.2 Enhancing Demand Forecasting and Inventory Management**

Demand forecasting is a critical aspect of pharmaceutical supply chain management, yet it comes with its fair share of challenges. Inaccurate predictions can have far-reaching implications, leading to excess inventory or stock outs. The consequences of these discrepancies are substantial, with excess inventory tying up working capital and increasing carrying costs, while stock outs result in lost sales and compromised customer trust.

The advent of AI algorithms and machine learning models has revolutionized demand forecasting, significantly improving accuracy and mitigating the challenges faced by traditional methods. AI can analyse vast amounts of historical and real-time data, including sales figures, market trends, social media sentiments, and even weather patterns, to identify complex patterns and factors that influence demand.

AI-driven demand forecasting enables pharmaceutical companies to anticipate fluctuations in customer demands more precisely. By understanding the intricate interplay of variables affecting demand, such as seasonality, promotions, and economic indicators, AI models provide invaluable insights for optimizing inventory levels and production schedules.

Several pharmaceutical companies have already reaped substantial savings and benefits from AI-powered demand forecasting and inventory management.

Example 1: Novo Nordisk adopted AI-driven demand forecasting to improve its supply chain. The company achieved a 50% reduction in forecast errors and significantly reduced overstock, leading to estimated cost savings of $20 million annually.

Example 2: AstraZeneca implemented AI and machine learning models to optimize its inventory management. By accurately predicting demand variations and streamlining inventory levels, AstraZeneca reported a 40% reduction in inventory carrying costs.

Example 3: Pfizer harnessed AI algorithms to optimize its supply chain. Through more accurate demand forecasting and improved inventory management, Pfizer achieved a 25% increase in supply chain efficiency and substantial cost savings.

**4.3 Streamlining Manufacturing and Production Processes**

Inefficiencies in manufacturing can exert a significant toll on pharmaceutical companies’ overall costs. The complexities of drug production, coupled with the need for strict adherence to quality standards and regulatory requirements, can lead to various challenges. These challenges include prolonged production cycles, excessive downtime, suboptimal resource utilization, and significant waste generation. Such inefficiencies not only escalate operational expenses but also delay time-to-market for critical medications, affecting patients and healthcare providers alike.

Fortunately, AI offers innovative solutions to optimize manufacturing and production processes, improving efficiency and reducing costs. AI algorithms can analyse vast amounts of data from various sources, including equipment sensors, production metrics, and historical records, to identify bottlenecks, optimize production schedules, and minimize downtime.

By leveraging AI, pharmaceutical companies can implement predictive maintenance programs that use real-time data to identify potential equipment failures and proactively schedule maintenance, minimizing unplanned downtime. AI-powered systems can also analyse production data to identify areas of waste and inefficiency, enabling process improvements that reduce material waste and optimize resource utilization.

Several pharma companies have successfully implemented AI technologies to streamline their manufacturing processes, resulting in substantial cost savings and improved productivity.

Example 1: Sanofi implemented AI-based predictive analytics to optimize its manufacturing operations. The company achieved a 30% reduction in production cycle times and a 20% decrease in equipment downtime, resulting in significant cost savings.

Example 2: Merck utilized AI algorithms to optimize its production scheduling. By considering various factors such as demand fluctuations, equipment availability, and regulatory requirements, Merck improved its production efficiency by 25% and reduced costs associated with overtime and underutilized resources.

Example 3: Johnson & Johnson integrated AI-powered quality control systems into its manufacturing processes. By identifying quality issues in real-time and enabling timely interventions, Johnson & Johnson reduced product defects, minimized waste, and achieved cost savings of approximately $60 million per year.

These case studies highlight the transformative impact of AI in streamlining manufacturing and production processes within the pharmaceutical industry. By harnessing AI technologies, companies can optimize resource allocation, reduce downtime, minimize waste, and improve overall operational efficiency

**4.4 Revolutionizing Logistics and Distribution**

Pharmaceutical logistics and distribution networks are complex and challenging due to various factors. The transportation of temperature-sensitive medications, stringent regulatory compliance, and the need for timely and secure deliveries pose significant hurdles. With a global supply chain and the demand for faster order fulfillment, traditional logistics methods struggle to keep up with the industry’s evolving demands.

AI-powered route optimization algorithms analyse vast amounts of data, including traffic patterns, weather conditions, and road closures, to devise the most efficient delivery routes. This not only reduces transportation costs but also ensures that medications reach their destinations faster and fresher.

Real-time tracking powered by AI ensures end-to-end visibility of pharmaceutical shipments. Companies can monitor product movements, temperatures, and storage conditions throughout the supply chain. AI-driven sensors and IoT devices enable immediate alerts in case of temperature deviations or potential security breaches, safeguarding the integrity of the medications.

Numerous success stories illustrate how AI has transformed pharmaceutical logistics and distribution, leading to cost savings and enhanced efficiency.

Example 1: Moderna utilized AI-driven real-time tracking to ensure the swift and secure distribution of its COVID-19 vaccines. This streamlined process minimized delays and enabled efficient distribution to vaccination centres worldwide, contributing to the rapid vaccination drive.

Example 2: AstraZeneca utilized AI-based temperature control systems to transport sensitive biologic medications. With precise temperature monitoring and adjustments, the company achieved a 30% reduction in product wastage during transportation, leading to substantial cost savings and increased availability of critical medications.

As AI continues to advance, logistics processes become increasingly efficient, cost-effective, and reliable. The synergy between AI-powered intelligence and human expertise in managing pharmaceutical supply chains is the key to meeting patient needs promptly, ensuring medication accessibility, and driving sustainable growth in the pharmaceutical industry. By embracing AI-driven logistics solutions, pharmaceutical companies can usher in a new era of precision and excellence in delivering life-saving medications to those who rely on them.

**5. Applications of AI**

**5.1 AI in diagnosis and targeted genomic treatments**

There are several applications of AI in hospital-based health care systems[19, 20] in organizing dosage forms for individualized patients and selecting suitable or available administration routes or treatment policies.

Maintaining of medical records: Maintenance of the medical records of patients is a complicated task. The collection, storage normalizing, and tracing of data are made easy by implementing the AI system. Google Deep Mind health project (developed by Google) assists to excavate the medical records in a short period. Hence, this project is a useful one for better and faster health care. The Moor fields Eye hospital NHS is assisted by this project for the improvement of eye treatment.

Treatment plan designing: The designing of effective treatment plans is possible with the help of AI technology. When any critical condition of a patient arises and the selection of a suitable treatment plan becomes difficult, then the AI system is necessary to control the situation. All the previous data and reports, clinical expertise, etc., are considered in the designing of the treatment plan as suggested by this technology. IBM Watson for Oncology, the software as a service, is a cognitive computing decision support system that analyzes patient data against thousands of historical cases and insights gleaned from working thousands of hours with Memorial Sloan Kettering Cancer Center physicians and provides treatment options to help oncology clinicians make informed decisions. These treatment options are supported by literature curated by Memorial Sloan Kettering, and over 300 medical journals and 200 textbooks, resulting in almost 15 million pages of text.

Assisting in repetitive tasks: AI technology also assists in some repetitive tasks, such as examining the X-ray imaging, radiology, ECHO, ECG, etc., for the detection and identification of diseases or disorders. Medical Sieve (an algorithm launched by IBM) is a “cognitive assistant” having good analytical and reasoning abilities. A medical start-up is necessary for the improvement of the patient’s condition by combining deep learning with medical data. A specialized computer program is available for each body part and used in specific disease conditions. Deep learning can be employed for almost all types of imaging analyses, such as X-ray, CT scan, ECHO, ECG, etc.

Health support and medication assistance: In recent years, the uses of AI technology are recognized as efficient in health support services and also, for medication assistance. Molly(a start-up-designed virtual nurse) receives a pleasant voice along with a cordial face. Its aim of it is for helping patients to guide the treatment of patients as well as support them with their chronic conditions during doctor’s visits. Ai Cure is an app existing in a Smartphone webcam, which monitors patients and assists them to control their conditions. This app is useful to patients with severe medication situations and for patients who participate in clinical trials.

Accuracy of medicine: AI shows a good impact on genomics and genetic development. Deep Genomics, an AI system is useful for observing patterns in the genetic information and medical records to identify the mutations and linkages to diseases. This system informs doctors about the events happening within a cell when DNA is altered by genetic variation. An algorithm is designed by the father of the human genome project, Craig Venter that gives information on patients’ physical characteristics based on their DNA. “Human Longevity” AI technology is useful to identify the exact location of cancer and vascular diseases in their early stage.

Drug creation: The development or creation of pharmaceuticals takes more than a decade and consumes billions of rupees. “Atomwise”, an AI technology that uses supercomputers, is useful to find out the therapies from the database of molecular structure. It hurled a virtual search program for safe and effective therapy for the Ebola virus with the existing drugs. The technology identified two drugs that caused Ebola infection. This analysis was completed within one day compared to months to years with manual analysis. A Biopharma company in Boston developed big data for the management of patients. It reserves data to find the reasons why some patients survive diseases. They used patients’ biological data and AI technology to find out the difference between healthy and disease-friendly atmospheric conditions. It helps in the discovery and design of drugs, healthcare, and problem-solving applications.

AI helps people in the health care system: The “open AI ecosystem” was one of the top 10 promising technologies in 2016. It is useful to collect and compare the data from social awareness algorithms. In the healthcare system, vast information is recorded which includes patient medical history and treatment data from childhood to that age. This enormous data can be analyzed by the ecosystems and gives suggestions about the lifestyle and habits of the patient.

Healthcare system analysis: In the healthcare system, if all the data is computerized then retrieval of data is easy. Netherland maintains 97% of invoices in digital format, which contain treatment data, physician names, and hospital names. Hence, these can be retrieved easily. Zorgprisma Publiek, a local company analyses the invoices with the help of IBM Watson cloud technology. If any mishap occurs, it recognizes it immediately and takes the correct action. Because of this, it improves and avoids patient hospitalization.

**5.2 AI and development of pharmaceuticals**

Top pharmaceutical companies are collaborating with AI vendors and leveraging AI technology in their manufacturing processes for research and development and overall drug discovery. Reports show nearly 62 percent of healthcare organizations are thinking of investing in AI shortly, and 72 percent of companies believe AI will be crucial to how they do business in the future. To get a better sense of the future of AI in the sector, Pharma News Intelligence dives into current AI use cases, the best uses for the technology, and the future of AI and machine learning. The McKinsey Global Institute estimates that AI and machine learning in the pharmaceutical industry could generate nearly $100B annually across the US healthcare system. According to researchers, the use of these technologies improves decision-making, optimizes innovation, improves the efficiency of research/clinical trials, and creates beneficial new tools for physicians, consumers, insurers, and regulators. Top pharmaceutical companies, including Roche, Pfizer, Merck, AstraZeneca, GSK, Sanofi, AbbVie, Bristol-Myers Squibb, and Johnson & Johnson have already collaborated with or acquired AI technologies. In 2018, the Massachusetts Institute of Technology (MIT) partnered with Novartis and Pfizer to transform the process of drug design and manufacturing with its Machine Learning for Pharmaceutical Discovery and Synthesis Consortium

Research works are carried out daily to find new active principles for the currently incurable diseases and conditions; increase the safety profile of already existing drugs; combat drug resistance and minimize therapeutic failure. Hence, there is an increase in the size and variety of biomedical data sets involved in drug design and discovery. This factor and many more contributed to the advancement of AI in the pharmaceutical industry. Today, some companies offer software with much relevance in drug design and data processing, as well as in predicting treatment outcomes.

GNS healthcare uses AI machine software known as Reverse Engineering and Forward Simulation (REFS). REFS determines the cause and effect relationships between various types of data, that are unforeseen ordinarily by direct data evaluation. GNS claims that REFS can transfer millions of data points ranging from clinical to genetics, laboratory, imaging, drug, consumer, geographic, pharmacy, mobile, proteomic, and so on. In drug design, a company known as Atomwise developed the first deep learning neural network for structure-based drug design and discovery that they called AtomNet. AtomNet makes use of a statistical approach to extract information from millions of experimental affinity measurements and thousands of protein structures to predict the binding properties of small molecules with proteins. By presenting 3-dimensional images of the protein and ligand pair showing channels for carbon, oxygen, nitrogen, and other types of atoms, AtomNet technology enables the pharmaceutical chemists to perform core processes of drug discovery and design like hit discovery, lead optimization, and prediction of toxicity with high precision and accuracy in weeks as against years.

Insilico Medicine announced an AI project by the company called Pharm AI. Insilico Medicine claims they applied Generative Adversarial Networks (GAN) and reinforcement learning algorithms. The GAN is a type of generative model that can generate samples and also learn from training samples. They are made up of two neural networks, the generator, and the discriminator. The relationship between the generator and the discriminator is referred to as “adversarial”. The generator tries to create and learns to create new samples and sends them to the discriminator, which classifies the sample as real or fake where real denotes the examples that belong to the data set, and the examples generated by the generator are denoted “fake”. Through continuous training, the generator begins to create samples that are similar to the real ones while the discriminator gets better at the identification process. With Pharm AI, through GAN and reinforcement learning, Insilico Medicine claims that it can generate new molecular structures and ideate the biological origin of a disease.

**5.3 AI in pharmacy practice in hospital and community pharmacies**

Machine learning models allow e-mails to be personalized at a speed and accuracy greater than that of any human being. Chatbots can be used to increase the efficiency of service delivery. Chatbots are capable of mimicking interactions between customers and customer care of sale staffs. Chatbots are capable of automatically resolving customer complaints and queries and the difficult questions are transferred to human staff. In retail pharmacy, this principle can be applied. The chatbots can be programmed to mimic pharmacist-patient interaction.

Walgreen made a partnership with Medline, a telehealth firm to create an avenue to help patients interact with healthcare professionals through video chat. AI can also be useful in inventory management. As a retail pharmacist, imagine being able to predict what your patients will need in the nearest future, stocking them, and using personalized software to deliver e-mails to remind the patient of drug needs. With the use of AI-powered data analytics, a patient’s future drug purchase can be predicted. Predicting the patient’s drug purchase through AI will help the pharmacist to make proper stock procurement decisions.

Although, there are existing inventory management software and application that are used in retail pharmacy stock management like Mckessons; Liberty; Winpharm; PrimeRx; and WinRx, not all of them utilize AI or machine learning. For example, an AI company, Blue Yonder developed software for Otto group, a German online and catalog retailer. This software can predict with 90% accuracy what will be sold by Otto in 30 days. This reduced the delivery schedule for purchased products from one week or more to one of two days by enabling direct delivery of the product from the supplier to the consumer without having to pass through the warehouse.

Intending to improve the safety of patients, the University of California San Francisco (UCSF) Medical Center uses robotic technology for the preparation and tracking of medications. According to them, the technology has prepared 3, 50, 000 medication doses without any error. The robot has proved to be far better than humans both in size as well as its ability to deliver accurate medications. The abilities of the robotic technology include the preparation of oral as well as injectable medicines which include toxic chemotherapy drugs. This has given the freedom to the pharmacists and nurses of UCSF so that they can utilize their expertise by focusing on direct patient care and working with the physicians. Within the automated system of the pharmacy, the computers first receive medication orders electronically from the physicians and pharmacists of UCSF. After this, individual doses of pills are picked, packaged, and dispensed by the robotics. This is followed by machines assembling the doses onto a bar-coded plastic ring. The thin plastic ring contains all medications that have to take by a patient within a period of 12h. Adding to the capabilities of the automated system is their ability to prepare sterile preparations that are meant for chemotherapy along with filling intravascular syringes with the right medications

**5.4 Use AI for predictive analytics**

Now that machine learning and AI are more accessible than ever, you can use them to anticipate market trends, drug demand patterns, and customer engagement opportunities. This proactive approach enables you to allocate resources effectively and adapt your strategies accordingly.

Pharma companies can also use AI to gain valuable insights into healthcare professional (HCP) behavior to fine-tune their omnichannel marketing strategies and build useful pharma and healthcare web apps and HCP portals. For instance, predictive analytics can help identify HCPs who are more inclined to engage with specific content types and help with delivering personalized marketing messages.

**5.5 Make better decisions with the help of AI**

AI can extract valuable industry insights from vast datasets, uncovering hidden patterns not readily discernible to humans. AI models can assist in strategic planning and decision-making processes like forecasting, risk analysis, and customer segmentation. This accelerates informed decision-making and helps you achieve better outcomes.

**5.6 Greater integration between sales reps and marketing**

AI models can help bring together data from various sources and score and prioritize your audience based on their progress in the customer journey and their customer profiles. This automated lead scoring system can be the basis for deciding on the best possible path forward for all teams involved.

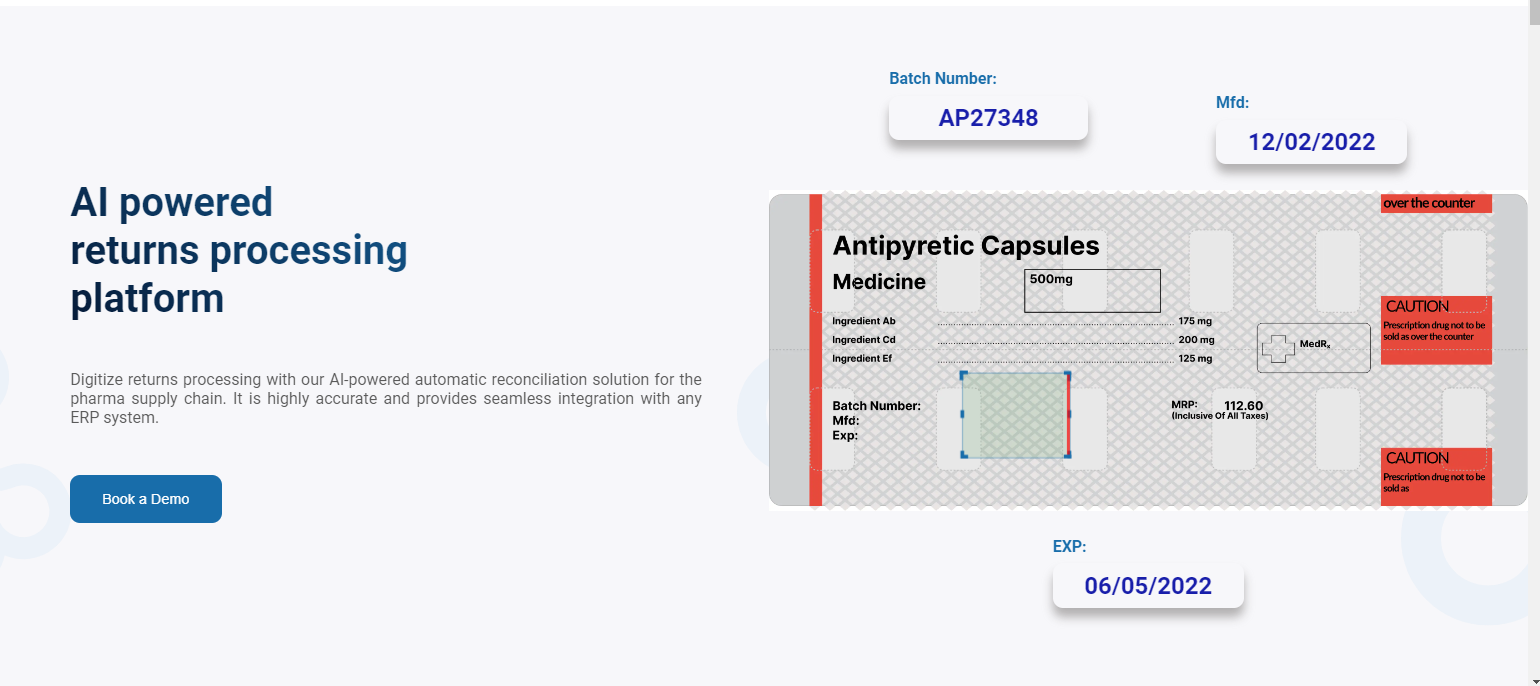
Applying AI can lead to uncovering audiences ready for certain commercial actions by typing in simple inputs and letting the AI put the data together. This will, for example, reduce the time needed to find and sort the audiences ready for a field representative visit.

**5.7 Automate internal tasks and processes**

The first step is identifying repetitive and rule-based activities. Then, you must choose appropriate AI tools, integrate data sources, and create a clear process map. AI technology, such as RPA (Robotic Process Automation), works great for automating mundane tasks as soon as you integrate them with existing systems.

**6. Software for inventory data and returned data**

**Ausadh AI software/machines**

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**More software:**

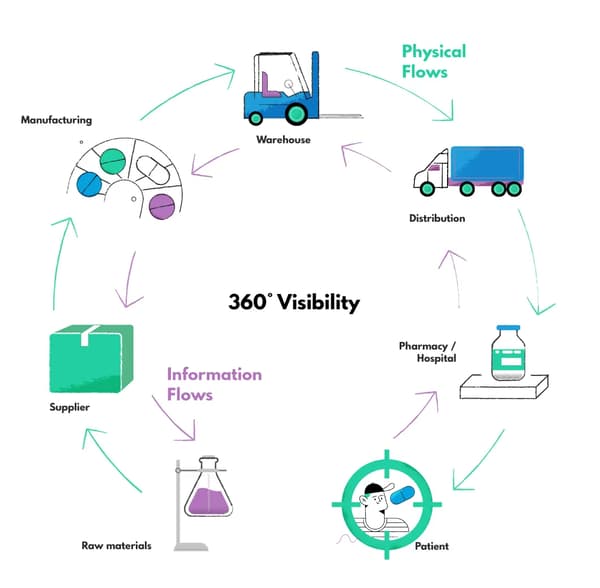
1. [EMedStore](https://www.techimply.com/profile/emedstore)
2. [Medico Sales & Distribution](https://www.techimply.com/profile/medico-sales-distribution)
3. [Unisolve](https://www.techimply.com/profile/unisolve) UNISOLVE is a premier software solution for pharmaceutical wholesale and distribution businesses. The software streamlines business operations by offering digital solutions for billing, stock auditing, product inflow, stock selection, online order taking, delivery optimization, real-time reporting, and decision-making. The software reduces the operating costs involved in inventory management, product delivery, and other organizational operations. Pharmaceutical Wholesale and Distribution businesses can use UNISOLVE software to run their businesses with minimal resources. It is a 100% accurate and dependable solution for all their needs.

**7. Inefficiencies in Pharmaceutical Supply Chain Cost**

**7.1 Leveraging AI in Drug Supply Chain Management**Supply chain companies are adopting artificial intelligence at a great pace. Many companies are already on their way towards digital transformation across various industries that face supply chain management challenges. The AI applications in supply chain management include, among a host of other uses, process robotization, forecast demand, real-time visibility on shipments, and improved efficiencies in last-mile deliveries. According to Gartner’s report, the use of artificial intelligence (AI) and machine learning was one of the top 2020 trends in supply chain businesses and one of the top technologies giving companies a leg up over the competition.

The pharmaceutical industry is no different. Companies in various ways are applying AI in pharma to gain a competitive advantage. Slowly but steadily, the pharma sector is also becoming the next testing ground for companies looking to use AI to help digitalize and boost their global supply chains.

The pharmaceutical supply chain involves a complex network of steps required to produce a drug, from sourcing and supply of materials, warehousing, through manufacturing and distribution, to the drugs’ end delivery to the pharmacy and patient.



**7.2 Major challenges in the pharmaceutical supply chain**

For Big Data transformation in the pharma supply chain to succeed, organizations must transform to overcome the difficulties they face in an ever-changing technological environment.

AI in Pharma

Pharma’s biggest data challenge is its historical siloed structure resulting from decades-old legacy systems. These disparate data silos prevent access to drug manufacturers’ and distributors’ data in real-time. It is essential going forward that organizations strive for a data-centric and user-centric approach allowing visibility of the complete data across all channels - the right information at the right time in the right place.

As the operations are struggling to move forward, the drug discovery phase embraces new technologies like no other. Especially AI can have colossal impact for discover and development drug.The spectacular discoveries and a new wave of therapies based on complex biologic medicines and gene and cell therapies are becoming increasingly popular. Nevertheless, they throw up huge challenges for manufacturing and distribution networks due to their sensitivity, the need for temperature control and special handling, and short life cycle.

The biggest challenges pharmaceutical within the supply chain management include:

1. lack of end-to-end visibility
2. malfunctions at the manufacturing level
3. tight deadlines and costly expedites
4. fragmented multimodal networks
5. cold chain - temperature control and strict handling along the whole process
6. issues related to drug counterfeiting
7. keeping highest quality and repeatability of drug manufacturing personalized treatment production for individual patients (e.g., T-cell therapies)

**7.3 How AI in the drug supply chain can make a difference?**

Artificial Intelligence presents the pharmaceutical industry with the opportunity to solve problems previously unsolvable with simple data analysis. Looking at the pharmaceutical supply chain specifically, we’re seeing a growing number of AI-based solutions offering answers to many of the industry’s current challenges. As organizations look to improve their operational performance, productivity, efficiency, and cost-effectiveness leveraging artificial intelligence across the entire pharmaceutical supply chain seems to be the next move. What are the major [**benefits AI**](https://nexocode.com/blog/posts/artificial-intelligence-in-the-chemicals-how-ai-benefits-the-chemical-industry/) can bring to the drug supply chain?

### Process visibility



To compressively and accurately assess today’s complex supply chains, a 360-degree approach must be taken. Point-to-point visibility across the whole supply chain will enable companies to become more efficient by rapidly responding to and mitigating disruptions. AI solutions applied to the supply chain can provide an insightful and comparable benchmarking of pharmaceutical supply chains. As artificial intelligence relies heavily on data, a crucial first step must be considered to even think about AI solutions - digital transformation. Information flowing along the supply chain needs to be collected and normalized in real-time.

Digitalization is crucial for visibility, and it should be organized with the future AI implementation already in mind. Full visibility means coupled with AI for insights will reveal supply chain performance gaps, e.g., caused by low inventory enabled by low utilization and high unit cost, with a full profile of contextual information. Once this is in place, AI-augmented solutions for the pharma supply chain will provide advanced decision-making systems by efficiently collecting and managing data in real-time and generating actionable insights. Beyond these benefits, AI is capable of seeing patterns that even trained professionals might miss. Further, it supplies real-time actionable insights filling the potential knowledge gap between suppliers, drug manufacturers, and [**logistics**](https://nexocode.com/blog/categories/logistics/)providers.

**8. Conclusion:**

AI-based supply chain optimization offers a multitude of benefits for cost reduction in pharmaceutical companies. The potential for cost reduction is not just incremental; it is transformative, with examples of companies saving many millions of dollars annually through AI-driven optimization.

The urgency and opportunity for pharmaceutical companies to adopt AI solutions are paramount. In an industry grappling with mounting financial challenges, embracing AI-based supply chain optimization can be a game-changer. It enables companies to navigate complexities, streamline operations, enhance profitability, and stay ahead of the competition.

As we look to the future, the transformative potential of AI in the pharmaceutical supply chain is truly awe-inspiring. With advancements in AI technologies, the possibilities for cost savings, efficiency, and innovation are boundless. Imagine a future where personalized medicines are delivered with precision, where supply chains are optimized to perfection, and where patient care is elevated to new heights. The future of pharmaceutical supply chains lies in the hands of those who embrace the transformative power of AI and seize the opportunities it presents. So, let us embark on this journey together, where AI-driven optimization reshapes the landscape of the pharmaceutical industry, and the promise of cost reduction and improved patient outcomes becomes a tangible reality.

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