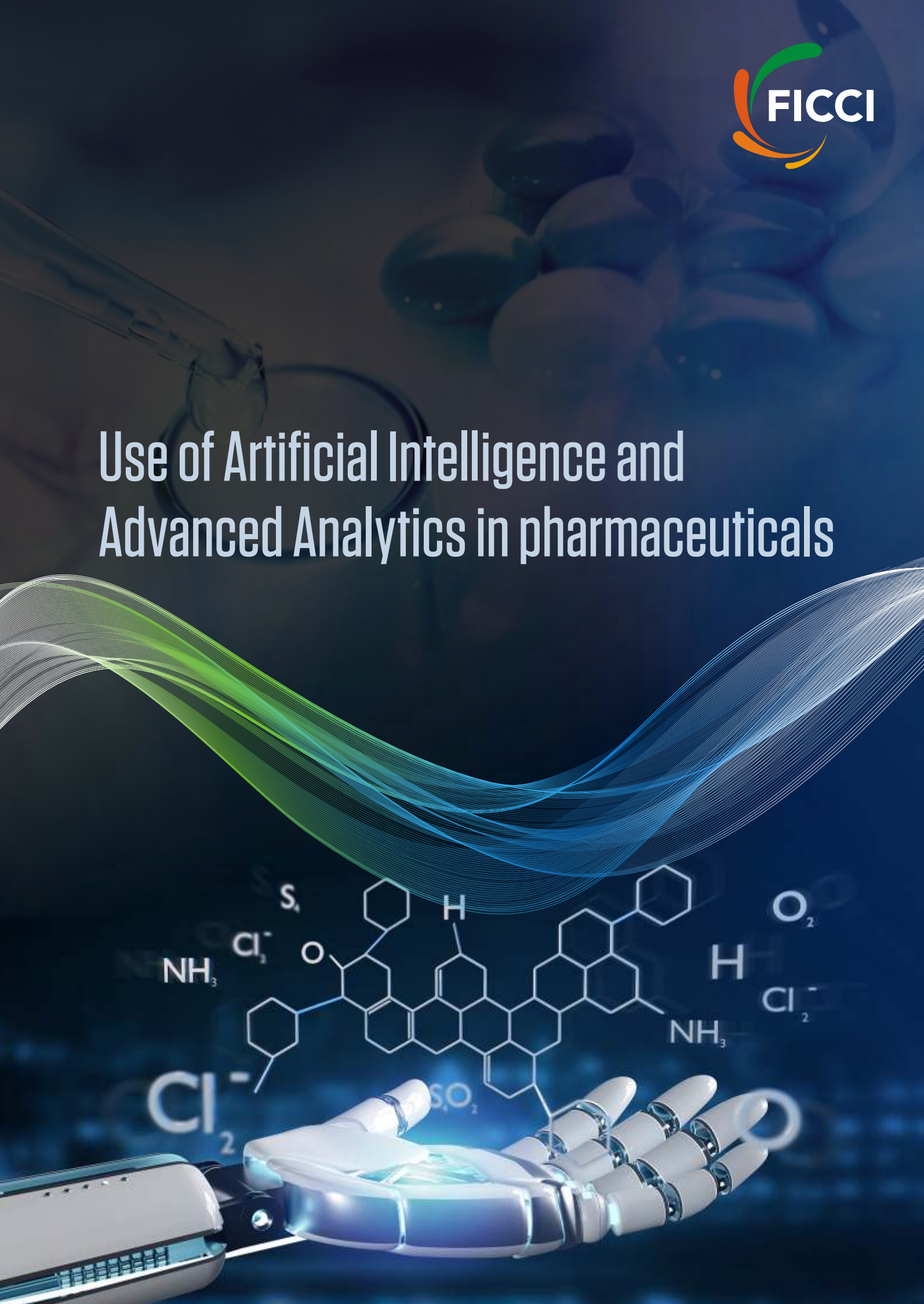
Use of Artificial Intelligence and Advanced Analytics in pharmaceuticals

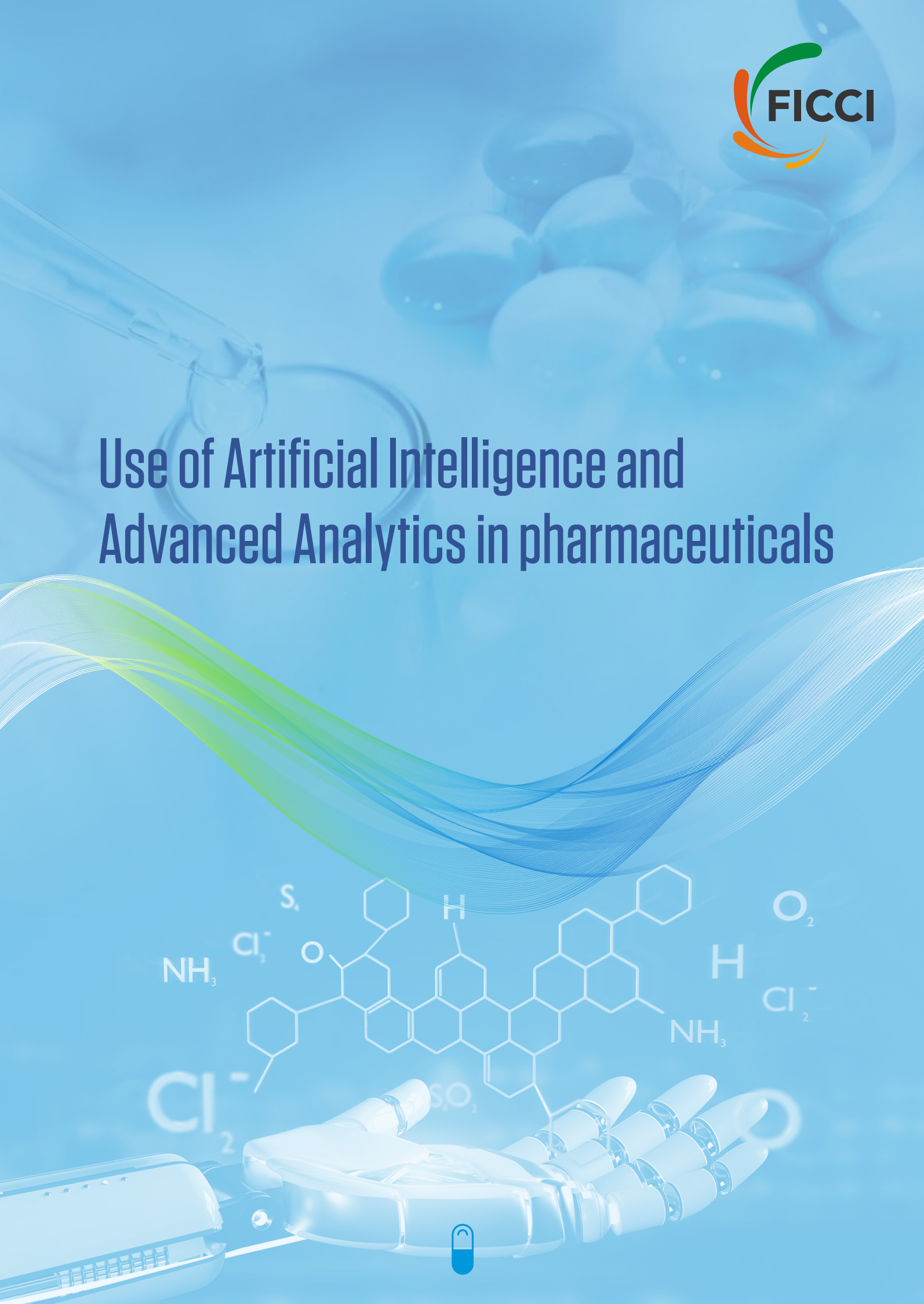


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Use of Artificial Intelligence and Advanced Analytics in pharmaceuticals



Use of Artificial Intelligence and Advanced Analytics in pharmaceuticals

Ministers' Message

Use of Artificial Intelligence and Advanced Analytics in pharmaceuticals



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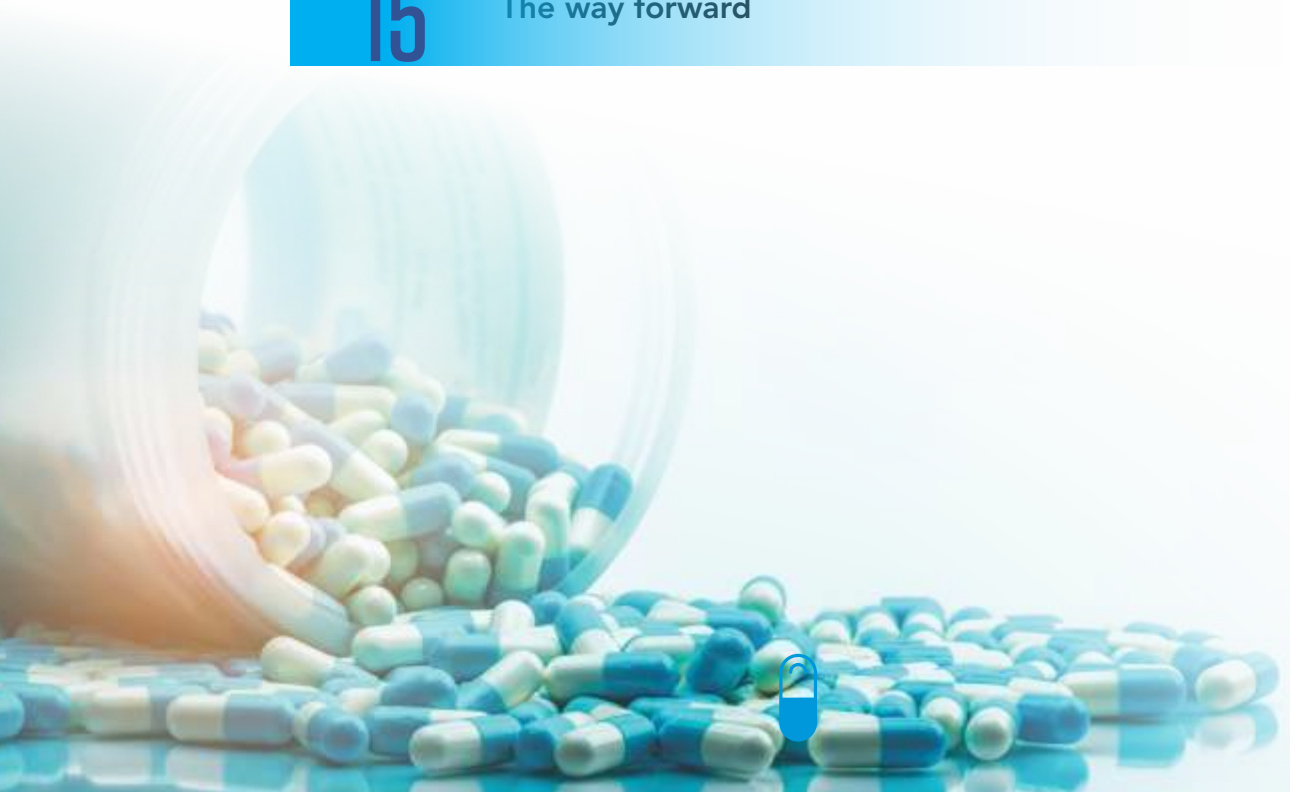
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Use of Artificial Intelligence and Advanced Analytics in pharmaceuticals



Executive summary

Catalyzed by an exciting range of new, disruptive technologies, the pharmaceutical industry needs to reimagine its future. And the need to reimagine is being driven by shifts which are disturbing the industry's status quo – pressure to reduce costs and demonstrate greater value, swing from treatment to prevention, and personalized treatments. These shifts are challenging the overall business model of the pharmaceutical companies.

From within the realm of these emerging technologies, AI and advanced analytics are being increasingly adopted by the industry in many diverse and interesting ways. The value of these technologies come from their ability to process large amount of complex, both structured and unstructured data, at a rapid pace to generate actionable insights and thereby reduce costs, improve time to market and gain competitive strength in the market place. While lot of interesting applications are in areas related to drug discovery, applications in other areas such as drug dosage and safety, manufacturing and supply chain and commercialization is being further explored.

Interestingly as far as these technologies are concerned, pharmaceutical companies are choosing their fields of play and also who they play with, with a growing emphasis on collaboration and partnership. Accordingly, the industry is witnessing many such partnerships and quite often with technology start-ups.

Going forward, the industry is likely to witness a rapid adoption, driven firstly by demonstrated high return for the front-runners thereby leading to competitive pressures on others to adopt, and secondly the breadth of ways in which these technologies are finding application, especially fueled by drive of the start-ups. At the same time, the regulators will need to update their traditional approaches for medical device approvals and equip themselves sufficiently with knowledge and people required to evaluate and approve these emerging technologies faster.


ai

1 Introduction

1.1 Overview

The global pharmaceutical industry has been witnessing two seismic shifts which are disturbing the industry status quo. The first shift is in the balance of power across the healthcare value chain, as governments and insurers take center stage, pressuring pharmaceutical companies to reduce prices and demonstrate greater value from their therapies. Secondly, a swing from treatment to prevention, diagnostics and cure, is growing stronger in time, attracting a host of new entrants from within and outside of the sector. This shift is driven by three underlying developments: groundbreaking new therapies, advances in technology and the consumerization of health through increased access to data by patients.

Advances in technology is making things possible in many different ways, which till not long time back were considered difficult. Digital technologies including mobile communications, cloud computing, advanced analytics and the Internet of Things (IoT) are amongst the few innovations that aim to transform the pharmaceutical industry in the ways they have transformed other industries including industrial manufacturing, retail, telecom and banking. Various drivers are accelerating the digital transformation in the pharmaceutical landscape:



From within the realm of emerging technologies, AI and advanced analytics are challenging the overall business model of the pharmaceutical companies. Some of the technology companies in this space may outplay the traditional pharmaceutical companies and come up with new business models that will leave the traditional pharmaceutical companies with no alternative but to adopt. The amount of data generated in the pharmaceutical industry is exponentially high and leveraging this data to drive value is emerging as the utmost priority for companies with the objective of streamlining pharmaceutical value chain, improving drug approval rates, deliver efficiencies and lower the high level of associated costs[1].

To realize the benefits of these technologies, prominent companies have announced heavy investments and have entered into strategic alliances with various AI-driven companies to integrate AI within their value chain. Some of the key alliances include:

[1]Artificial Intelligence in Life Sciences: The Formula for Pharma Success Across the Drug Lifecycle, LEK, December 2018

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Top pharmaceutical company partnerships or acquisitions within AI space[2]

Pharma company	AI-driven companies			
Roche	Owkin	GNS Healthcare	Flatiron	Syapse
Johnson & Johnson	Benevolent AI	Winter Light		
Novartis	IBM Watson	MIT	Intel	Quantum Black
Pfizer	IBM Watson	MIT	XtalPi	
Merck	Atomwise	Numerate		
Sanofi	Berg	Exscientia	Recursion	
AstraZeneca	Berg			
GSK	Berg	Exscientia	Cloud Pharmaceuticals	Insilico Medicine
AbbVie	Atomwise	AiCure		
Bristol-Myers Squibb	Path AI			

Development | Target discovery | Drug discovery

Most of these companies are leveraging AI for drug discovery and the most preferred strategy seems to be strategic alliances with AI-driven companies. Since these partnerships are in the areas which are core to a pharmaceutical company, some pharmaceutical companies are also of the view that they need to develop these capabilities internally. Drug dosage and safety

With AI, the dosages are customized for each patient depending on the patient's stage of illness and characteristics; AI is implemented at each stage of safety value chain to improve the overall quality and complianceIncreasingly AI in pharmaceutical industry is transforming processes from the initial R&D level to the after-consumption stage. Some of the prevailing trends in the industry include

1 **Pharmaceutical R&D**
Major companies are either developing their own AI capabilities or are partnering with AI-driven start-ups to accelerate the **drug discovery process and personalization of medicines**

2 **Drug dosage and safety**
With AI, the dosages are customized for each patient depending on the patient's stage of illness and characteristics; AI is implemented at each stage of safety value chain to improve the overall quality and compliance

3 **Manufacturing and supply chain**
AI is being used to optimize drug identification and verification across the manufacturing process along with identification of counterfeit drugs

4 **Commercialization**
Growing use of AI for patient segmentation, drug efficacy, understanding adverse events

5 **Regulatory approvals**
Streamlining of clinical drug approval process to make it more transparent and quick

At India level, it is only recently that pharmaceutical companies have started to demonstrate significant interest in AI application for various R&D and supply chain needs. Drug discovery remains the most common area of digitalization in the industry where AI is leveraged to scan through the available database on a particular molecule for a medicine[3].

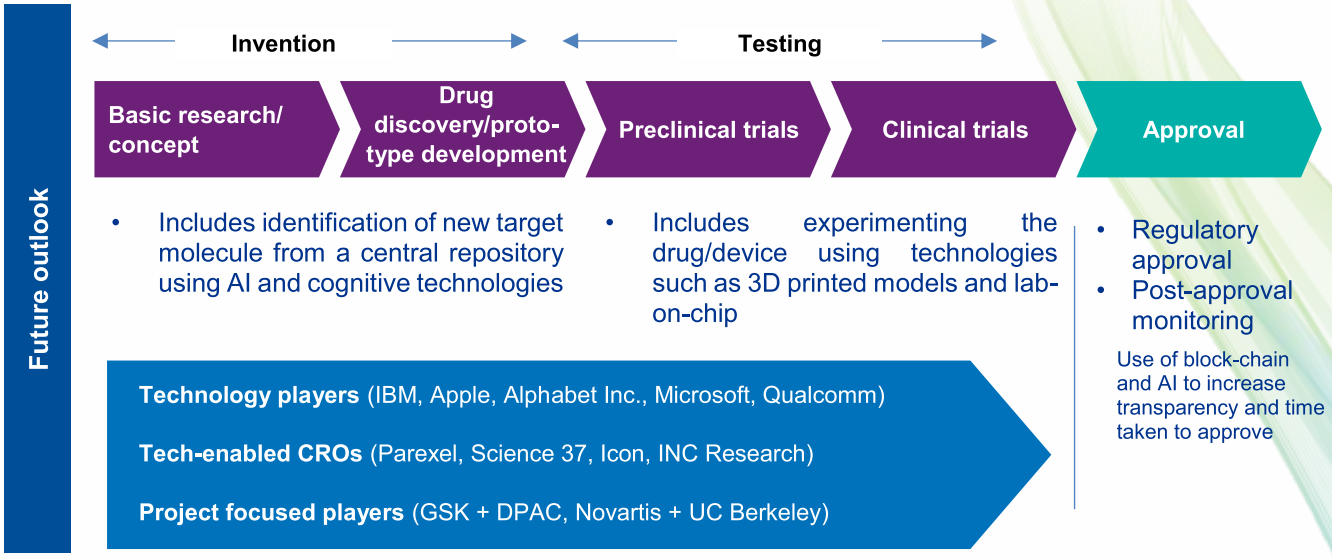
[2]Artificial Intelligence in Life Sciences: The Formula for Pharma Success Across the Drug Lifecycle, LEK, December 2018
[3]Artificial Intelligence in the Healthcare Industry in India, CIS India, January 2018

2 Role of AI in pharmaceutical value chain

2.1 Pharmaceutical research and development (R&D)

In the coming years, it is expected that the pharmaceutical ecosystem would move away from traditional stakeholders performing R&D to more diverse technology-enabled partnerships. The emerging business model is expected to have technology companies playing a crucial role at each stage of pharmaceutical value chain. In future, there could be emergence of project-focused players which would include teams of various stakeholders such as pharmaceutical and biotech players, members of academia and healthcare startups brought together for a common purpose.

Future outlook of pharmaceutical R&D value chain[4]



[4]R&D 2030: Reinvent innovation and become an R&D front-runner by 2030, KPMG, accessed on 28 January 2019

Use of Artificial Intelligence and Advanced Analytics in pharmaceuticals

AI in drug discovery

AI has the potential to radically transform core drug discovery and development models. The fact that AI and machine learning could help reduce the time it takes to discover new drugs which amounts to real cost savings is one of the key drivers for pharmaceutical companies to invest in this technology at a holistic level.

Drug discovery is becoming highly competitive as well as expensive. In spite of technological progress, the cost of developing a new drug doubles every nine year. For pharmaceutical companies that have launched more than four drugs, the median cost stands closer to a USD5.3 billion. This high cost has prompted the leading pharmaceuticals companies to search for new methods to reduce their R&D costs[5].

Use of AI in drug discovery and development[6]:

Organic synthesis and design	Scoring synthetic complexity	Automation of molecule design	Predicting organic reaction outcomes	Computer-aided synthesis
Computer-assisted retrosynthesis	Predict drug performance in testing	Discover off-label use	Predict toxicity prior to clinical trials outcomes	Personalized medicine

With the growing demand of AI in pharmaceuticals, the industry has witnessed huge number of fundraising deals among AI-driven drug discovery startups. For instance, Atomwise, a start-up which established the use of deep neural networks for drug design, raised USD45 million investment to develop its AI-driven drug discovery technology[7]. Pharmaceutical companies are increasingly entering into strategic alliances with the AI-startups to explore opportunities and are equally active in growing internal AI capabilities

Drug developers are relying on AI for multiple uses-to develop better biomarkers; to identify drug targets; to design new drugs as well as for re-purposing drugs i.e. finding new uses for existing drugs or late-stage drug candidates. An increasing need is also being felt for pharmaceutical companies to explore coming together to share data and look for patterns for precision medicines

Novartis invested heavily on its big data, digital infrastructure and artificial intelligence. It has recently announced the completion of its first phase:

- The first phase included launch of various IT infrastructure systems for document management, internal investigation, clinical trial management, etc.
- The next phase involves implementation of a predictive analytics platform, driven by machine learning algorithms, to support clinical trial operations.
- Lastly, Novartis plans to bring all the of company's data sets together in a centralized manner. Thus it is aiming to develop its internal capabilities significantly to respond to changing market scenario.

[5]AI in Pharmaceuticals and Healthcare", Mind Titan, accessed on 25 January 2018
[6]"How Artificial Intelligence Is Accelerating Life Sciences", Psychology Today, 5 July 2018
[7]"2018: AI Is Surging In Drug Discovery Market", BioPharma Trend, 10 January 2019

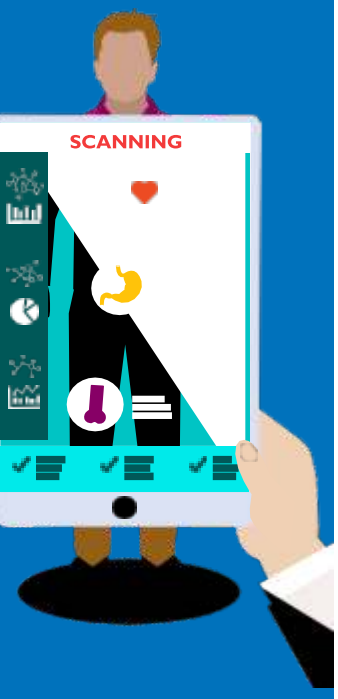
Use cases of AI in drug discovery

The last few years were marked by a wave of new R&D collaborations between key biopharma players and AI-driven companies, primarily startups

1 **Drug discovery process usually involves the identification of large number of compounds. Use of AI streamlines the development timelines by using algorithms to examine the chemical profiles of molecules and develop rules detailing the profile of a molecule that may make a suitable drug**[8]

Pharma companies such as GSK, Sanofi, Takeda Pharma and Merck have entered into various partnerships with AI start-ups

- **GlaxoSmithKline** signed a USD43 million drug discovery collaboration with Exscientia, a UK based AI-based start-up, to identify small molecules for ten selected targets across undisclosed therapeutic areas.
- **Sanofi and Exscientia** entered into USD283 million strategic research collaboration agreement aimed at developing new therapies for diabetes and other metabolic diseases



2 **Repurposing of drugs is another common use case. Various algorithm aims to identify new potential use cases for existing drugs or late-stage drug candidates**

Repurposing late-stage drug towards new therapeutic areas is a preferred strategy for many biopharmaceutical companies

- Sanofi and an AI-based start-up Recursion Pharmaceuticals entered into R&D partnership with the aim to identify new uses for Sanofi's clinical stage molecules across various genetic diseases.
- Astellas Pharma Inc. signed a research deal with NuMedii, a big data-driven bioinformatics company, to conduct drug repurposing projects using machine learning techniques[9].

3 **Development of biomarkers is an important component of drug discovery and development programs. AI has witnessed increasing usage in this area**

- Sanofi Pasteur, a vaccine company, announced that it would use Berg Health's platform and artificial intelligence tool to identify molecular signatures and potential biomarkers for assessing the Influenza vaccine immunological response.
- In addition, there is an increased focus on digital biomarkers, which present an opportunity to capture clinically meaningful, objective data in a cost-effective manner

[8] "GlaxoSmithKline signs $43m deal with AI start-up", The New economy, 03 July 2017
[9] "How Big Pharma Adopts AI To Boost Drug Discovery", BioPharma Trend, 08 October 2018

2.2 AI in drug dosage and safety

AI in drug dosage

In order to overcome the challenges of conventional combination therapy, pharmaceutical companies are developing AI platforms that use a patient's clinical data, primarily drug doses, to create a customized treatment course. This course is further processed to create an individual patient's profile that helps physicians recommend them the optimum drug dose plan[10].



The estimated potential annual benefits from application of AI in Drug dosage error reduction is forecasted to be USD16 billion in 2026[11]

Case example[12]

The National University of Singapore (NUS) has created an AI platform 'CURATE.AI' that uses a patient's clinical data including historical records to rapidly identify the drug doses and future modifications in dosage basis the tumor size or level of cancer biomarkers. The data is further used to generate a unique course of treatment customized to the patient's needs and requirements.

"A patient's clinical profile changes over time. The unique ability for CURATE.AI to rapidly identify the drug doses that result in the best possible treatment overcomes allows for actionable, and perpetually optimized personalized medicine. Using CURATE.AI to dynamically modify drug doses and successfully treat a metastatic cancer patient represents a landmark breakthrough for the use of AI to truly personalize patient care"

— Professor Dean Ho, Director Singapore Institute for Neurotechnology (SINAPSE), NUS

AI in drug safety

Drug safety issue has been one of the key concerns in the industry. These issues could appear from the initial lead candidate stage all throughout the preclinical and clinical development to post-marketing stage.

While the risk is inevitable, implementation of advanced AI technologies to analyze and transform the data can significantly enhance the chances of lowering the risk.

Application of AI in drug safety across the industry[13]

Clinical safety

Agios Pharmaceuticals uses NLP technologies to get fast and comprehensive decision support to their systems. It has been leveraging the technology to identify safety signals though its exploratory research, target discovery for drug pipeline and for pre-clinical development. NLP is used to study the patterns of symptoms amongst patients to help identify those patients at high risk.

Non-clinical safety

Merck MSD uses Natural Language Processing (NLP) technologies to automate workflow and extracts insights from unstructured data which is combined with structured data to create a visualized dashboard for the safety assessment team. This process of text mining enables the company to identify anomalies that are otherwise only identifiable in chronic testing.

Pharmacovigilance

The clinical safety team of GSK reviews its medical literature to constantly identify relevant safety signals. With an average product portfolio of nearly 200 products, GSK leverages NLP to enhance its research efficiencies and linguistic processing to advance search specifications to identifying relationships between a drug and an adverse event.

[10]A.I. Allows 'Dynamic Dosing' For Cancer Drugs, Futurity, October 2018
[11]Artificial Intelligence: Healthcare's New Nervous System, Accenture, 2017
[120]The opportunities for AI to revolutionize the pharmaceutical industry are clear, Outsourcing Pharma, October 2018
[13]AI Technologies Can Support Drug Safety Assessment, Pharma Exec, September 2018

At all stages, critical unstructured data is generated from internal safety reports and individual case safety reports[14]. In such instances, AI is the key tool that is used to synthesize this complex data to generate quantitative and qualitative insights. These insights could be implemented at every stage of drug safety process[15].

Genpact Pharmacovigilance Artificial Intelligence (PVAI) solution integrates optical character recognition, RPA and ML technologies to automatically extract insights from adverse events (AE) data from unstructured and semi-structured documents – eliminating redundant manual work, saving pharmaceutical companies significant time and resources.

2.3 AI in manufacturing and supply chain

AI in manufacturing

Unlike drug discovery, the penetration of AI in pharma manufacturing is at very nascent stage, however, companies are gradually exploring the usage of AI and advanced analytics in the manufacturing operations. Potential use of AI systems include reducing the drug production time, improving safety and quality, and identifying ways to repurpose existing drugs.

Recently, Amgen, a biopharmaceutical company, started using AI to identify manufacturing deviations. The company is piloting a process using AI to enhance its ability to identify patterns in manufacturing deviations and to prevent their recurrence. This tool would replace a labor-intensive process with one that can look across large data sets and find correlations between obscure signals and events which the previous system could have missed[16].

Similarly, Dr. Reddy's has leveraged AI in its manufacturing process and quality assessment. The company's manufacturing division is obligated to document every step as a part of regulatory compliance. The documentation had visible errors in terms of language. The company is also expected to create a standard operating procedure (SOP) for each process and sub process in the quality labs. SOPs are large complex documents and the chances of errors are high. To address these issues, the company created an AI-based solution on how to write a smart SOP. This context specific tool could read sentences and identify the intent, reducing the chances of human error significantly[17].

Additionally, quality and compliance is a major area of concern for pharmaceutical companies. Companies incur heavy loss in their revenue solely due to product recalls. To overcome this challenge, they are implementing end-to-end solutions that provides a realistic and holistic view of manufacturing, quality and compliance. These solutions enable them to deploy cost reduction methods while maintaining quality compliance and product safety[18].

AI in manufacturing

As compared to other industries, pharmaceutical industry stills lags in the sophistication and performance of its supply chain. The industry is plagued by rising complexity that comes with new drugs, complex production technologies, patent expiry and demand variability. The supply chain inefficiency is further under spotlight as prices of prescription drugs continue to climb. All of these factors, coupled with looming regulatory mandates are compelling pharmaceutical companies to transform their supply chains and develop more collaborative models. In order to achieve this objective,

[14] AI Technologies Can Support Drug Safety Assessment, Pharma Exec, September 2018
[15] Genpact Launches an Artificial Intelligence (AI)-Based Solution to Usher in a New Era of Drug Safety Automation, Genpact, June 2017
[16] "How Amgen Uses AI Tools To Improve Manufacturing Deviation Investigations", Life Science Leader, 26 October 2018
[17] "Using AI for documentation, R&D and drug manufacturing", Tech Circle, 24 September 2018
[18] Role of manufacturing analytics in pharma, Wipro, accessed on 30 January 2019

the pharmaceutical companies have started exploring the AI and advanced analytics tools in their supply chain.

The adoption of new technologies such as AI and machine learning could automate various processes including drugs logistics, tracking, packaging and processing, giving less room for human error. The companies are now realizing the benefits of integrated capabilities in streamlining their supply chain processes including warehouse management, performance tracking and labor management. Moreover, forecasting and replenishment solution in the supply chain suite assess the trends of markets and helps in making more informed decisions. Such reduced user interactions provides significant productivity improvements. The big pharmaceutical players are looking for collaborating with third party players to develop their AI capabilities.

Additionally, with the rising demand of technology, the industry is witnessing increasing number of third party players offering various supply chain solutions. For e.g.: a US based software solutions company, offers supply chain solution which enables the use of predictive analytics in pharmaceutical supply chain management by making use of relevant data and supporting forecast management, requirements planning, retail, sales and operations planning[19].

Big pharmaceutical companies are also introducing pilot projects around usage of AI and advanced analytics in automating their supply chain.

Merck KGaA announced a multi-year project in 2016 to deploy sensors, coupled with a machine-learning program with an aim to improve demand forecasts in its inventory and distribution processes

- The goal is to create an autonomous supply operation where computers make more decisions about allocating materials and distributing products
- The technology allows users to change forecasts immediately based on far-off events such as hospital fires, that may impact demand
- Pilot runs show the technology is 80 per cent more effective than humans in demand planning processes

Like the global market, Indian pharmaceutical industry is still embracing the application of AI or advanced analytics in their supply chain operations to its full potential. Recently, some startups have ventured into this space

Founded in 2015, **Pharmarack**, a Software-as-a-service (SaaS) based application company partnered with nearly 10,000 pharmaceutical retailers and 600 distributors across 35 locations in India. Their advanced analytics technologies provided a real time update of the supply chain processes to the pharmaceutical stakeholders.
The platform provides a clear visibility of the supply chain network to pharmaceutical manufacturers across all geographies, enabling them to keep a tab of the inventory within their warehouses. Manufacturers also leverage the platform for efficient marketing and sales initiatives and use the market information for inventory forecasting. Apart from benefitting manufacturers, the platform provides significant advantages to distributors and retailers as well. It helps distributors to optimize resources, reduce cost of sales, analyze business and take informed decisions. Further, it helps retailers gain product knowledge and efficiently manage stocks as per customer demand.

Another interesting emerging area is use of these emerging technologies to tackle issue of counterfeit drugs. In India, NITI Aayog has partnered with Oracle, Apollo Hospitals and Strides Pharma Sciences to deploy a blockchain-enabled drug supply chain model, to help track the drug through the entire value chain and bring out any discrepancy[20].

[19] The intelligent pharmaceutical supply chain", ADLittle, July 2018
[20] https://www.oracle.com/in/corporate/pressrelease/niti-aayog-oracle-pilot-real-drug-supply-chain-with-blockchain-iot-2018-09-28.html, accessed on 11 Feb 2019

Case example:

Veripad is an organization that is using machine learning to solve the issue of fake drugs in supply chain. The organization provides a chemical test card capable of identifying components of common medications in minutes, with no lab equipment. You just crush one tablet of the medication you want to test, rub it over the card, and soak the card in water. Veripad uses chemical testing paper and a mobile application to identify falsified medications. This card is similar to the Paper Analytical Device (PAD), a technology that has been in existence for some years. However, Veripad have developed their own testing cards that can perform several chemical tests on a medication in question by simply adding water. From there, they utilize their smartphone application to interpret the results of the chemical test card and indicate whether the medication is suspicious or authentic. Finally, they utilize data analytics technology to aggregate the results of every test in order to better understand the flow of counterfeits within affected regions with the ultimate goal to improve initiatives and policies.

But when a PAD has 12 chemical testing lanes and can detect up to 60 different types of medication, even trained human readers can only "eyeball" it with 80-85% accuracy. The Veripad founders set out to build a mobile app that anyone could use to photograph a PAD and get clear results. They applied machine learning algorithms to learn from a dataset of PAD images. Their first-generation app achieved 80% accurate classification of medication type, chomping at the heels of human experts. The latest model can "read" a PAD in a matter of seconds and report back with 90% confidence - 5-10% higher than human experts.

Another team of researchers led by New York University has developed a new mechanism that uses Machine Learning algorithms to distinguish between genuine and counterfeit versions of the same product.

The success of these solutions is as yet unknown, but the issues it solves, even if they only go a small way to solving the problem, are potentially lifesaving

Reference: How Machine Learning Will Transform The Pharmaceutical Supply Chain. Increasing Visibility, Transparency, and Efficiency. Innovation Enterprise, accessed online on 8 Feb 2019

2.4 AI in market access and commercialization

As pharmaceutical industry shifts to a more patient-centric model, companies are working towards strengthening their commercialization strategies. In the current scenario, it is imperative for life science companies to develop a digital strategy incorporating all business units and stakeholders.

To generate valuable insights, companies are deploying technologies such as Intelligent Automation, value-based pricing and predictive analytics[21]. Through advanced analytics, companies are better equipped to identify untapped markets by synthesizing details pertaining to demographics, EHRs etc. These tools help the companies build their value proposition by assessing the sales efficacy and client feedback on real time basis.

[21]Digitization in Life Science, KPMG, December 2017

Use of Artificial Intelligence and Advanced Analytics in pharmaceuticals

Application of AI and advanced analytics in the marketing and commercialization process[22]

Real-time monitoring	Bridging the knowledge gap and bias	Active customer segmentation for enhanced engagement	Industry benchmarking to enhance commercialization strategies
Data pertaining to personal medical information is shared online on social media through various medical forums. By tapping into such spaces, AI has the potential to monitor, identify and generate value around treatments and dosage intake on a real-time basis. AI can be programmed to proactively inform patients about the right time to consult a physician. Additionally, application of AI and analytics has the ability to capture information on aspects such as patient satisfaction, helping the marketing and R&D teams make informed decisions in a timely manner.	Accurate and timely diagnosis has long been an area of development for the industry. Inaccuracy is primarily due to gaps in clinical data or biases that focus on particular groups for various types of illnesses. Using AI to synthesize the information shared on various platforms, helps identify these gaps and biases in clinical data. It can be used to create groups of patients with similar symptoms, for enrollment in trials, significantly reducing time and associated costs. Overall, this opens up new avenues for traditionally underserved groups along with generating new R&D and marketing opportunities for pharmaceutical companies.	Currently customer segmentation is done on the basis of treatment/illness categories. AI enables a more specific segmentation process, allowing commercial teams to personalize their commercialization strategy. With analytics, marketing segmentations are equipped with better predictive capabilities, allowing them to forecast leads and optimize resource allocation. For instance, sales reps could efficiently plan their week by segmenting targeted physicians in clusters. This would maximize their coverage, improves their connectivity with customers and enhance their engagement experience.	Along with optimum resource utilization, AI has the capabilities to optimize marketing strategies by analyzing the trends prevailing in the market currently. As there is no reliable industry benchmarking database available, leading companies apply analytics to vast datasets to generate insights. Soon, pharmaceutical companies would be able to apply AI and advanced analytics to benchmark themselves against the industry and be better at implementing successful commercial campaigns.

Case example

A global pharmaceutical company partnered with Aktana, an AI and analytics company to streamline their Multi-channel Marketing (MCM) process. The company realized that physicians are three times more likely to open an email sent by a pharmaceutical representative than an automated message. Basis this information, the company decided to simplify its compliance and tracking channel activity with the help of Aktana's analytics. As these processes are quite complex and time consuming, the pharmaceutical company relied on Aktana to pre-synthesize data, deliver strategically timed emails and track interactions within the Customer Relationship Management (CRM). Post the implementation of Aktana's suggestions, the company witnessed a 23 times increased traction of mails sent to clients and a two-fold increase in email engagement.

[22] How AI Will Reshape the Pharma Industry and Make Marketing Easier Than Ever, PM 360 online, May 2018

3 Integrating patient pathway

3.1 Patient access in personalized medicine

Pharmaceutical companies are quickly realizing that the shift from a traditional to a patient-centric model is possible through integration of technologies such AI. These technologies are enabling significant progress in medical examinations, in the form of preventive monitoring, that includes drug dosage adjustment and customized treatment plans on the basis of the condition and requirements of the patient[23].

Case example

Oncology has been a prime area of research in the pharmaceutical industry with key focus on finding best possible treatments for tumors and cancer. To achieve this, clinicians are first trying to identify the suitable treatment basis the individual patient's etiopathology. Intelligent technology such as IBM's Watson, helps support clinicians in this process. With IBM Watson's capabilities in data analytics and ML, data in EHRs and relevant articles can be analyzed. It further examines treatment alternatives best suitable for an individual patient. Furthermore, AI is used to help match patients to clinical trials which helps improve outcomes in cancer care trials.

Recently, Novartis and IBM Watson have partnered to develop such solutions in the area of advanced breast cancer, with further plans to expand to the wider oncology field. In this partnership, real-time patient data with the aim to generate insights to improve patient outcomes.

Case example

Turbine, a Hungarian startup aims to virtually develop an effective combination of cancer therapies by deploying AI, in partnership with Bayer. With the help of gene sequencing, Turbine aims to create a simulated cancer cell. The software has the potential to create millions of simulations to develop the best combination of therapies. This concept offers several possible benefits for pharmaceutical companies some of which include high returns on investment through significant reduction in trial periods and in the case where no treatment plans exist, Turbine's AI platform tests millions of treatment combinations to find the closest possible treatment plan.

Genome testing is another field of medicine where AI is being leveraged to generate more predictive value for patients. With **genome testing**, pharmaceutical companies now have the capabilities to enhance personalized treatment. By applying direct-to-consumer tests, genetic testing has become easier and can be used to treat severe diseases such as cancer and can also be used for preventive purposes.

For instance, GRAIL, a US based medical research company has developed a blood test to detect cancer in its early stages. GRAIL leverages AI and data

[23]Digitization in Life Science, KPMG, December 2017

science and integrates it with population-scale clinical trials. Early detection of cancer would not only help the company raise significant investments for further research but also **improve cancer survival rates significantly.**

The potential that AI holds for personalized medicine is vast and presents opportunities for the industry that is strongly focusing on evolving patient-centricity. Pharmaceutical companies that are able to engage these technologies sooner into their value chain are expected to gain a significant competitive advantage.

3.2 Patient connectivity via telemedicine and mHealth

The increasing popularity of connected platforms indicates the growing need for patients and physicians to interact proactively. This connectivity is enabled through telemedicine and mHealth platforms. The advent of AI and advanced analytics in telemedicine and mHealth technologies is still at a very early stage, with implementation mainly in the fields of clinical trials and patient engagements.

Currently, the industry is integrating analytics with mHealth technology to generate opportunities for successes in clinical trials. For instance, the use of smartphone apps in clinical trials of Parkinson's disease treatment generates data that is further analyzed to derive insights. These insights have been found to be accurate enough to detect disease progression and medicine effects[24].

Using technology and AI in tandem, pharmaceutical companies aim to improve the patient care through online platforms. Chatbots are programmed to function as front line of care. These bots could be installed on specific sites and forums or programmed into websites of hospitals/clinics and insurance providers. They are programmed to conduct a basic exchange exploring a patient's condition and provide alternatives to treatment. In some cases, these can supplement the need to see clinical staff to a certain extent. Additionally, telemedicine is being used to create opportunities in patient engagement. Methods such as virtual visits are useful in case of patients with mobility issues, heart failures and other conditions affecting the geriatric population. Additionally, remote monitoring and virtual visits are helpful in the case of rare disease trials in which patients are usually widely scattered. Such level of conveniences enable greater patient participation in trials, thereby reducing recruitment and overall study costs.

Using technology and AI in tandem, pharmaceutical companies aim to improve the patient care through online platforms. Chatbots are programmed to function as front line of care. These bots could be installed on specific sites and forums or programmed into websites of hospitals/clinics and insurance providers. They are programmed to conduct a basic exchange exploring a patient's condition and provide alternatives to treatment. In some cases, these can supplement the need to see clinical staff to a certain extent.

Case example

London-based AI health app maker, Ada Health, has launched a telemedicine app. This app uses AI and NLP to generate relevant questions and suggestions for an individual's symptoms. The ideology behind this app is the company's realization of how the pharmaceutical and health industry is adopting a more patient-centric model. This app enables doctors and AI to work together and support patients. Additionally, the company has partnered with Karepack, a pharmacy, to enable users to get doctor prescribed medications delivered to their houses.

These connected platforms monitor patient symptoms on a real-time basis, enabling patients to adhere to or modify their treatment course. While the pharmaceutical industry is leveraging AI and analytics to monitor and analyze patient, the industry plans to further scale up these efforts from the current granular level.

[24] mHealth: Changing the Dynamics of the Healthcare Ecosystem, Pharma Exec, January 2018

4 The way forward

For pharmaceutical companies, it will not be enough to recognize the two seismic shifts -- reducing prices and demonstrate greater value from their therapies, and a swing from treatment to prevention, diagnostics and cure. The biggest challenge would be to translate the impact of these changes on business and operating models in a holistic way, to adapt swiftly and decisively to these shifts.

As a response, pharmaceutical companies have displayed increasing willingness to adopt different technologies such as AI and advanced analytics, to not only improve efficiencies and reduce costs, but adapting to a more patient centric business models. Several vital factors such as automation, efficiency and collaboration shall play a fundamental role in reshaping this patient-centricity of the pharmaceutical industry[25].

The integration of these technologies is expected to grow at a rapid rate and transform the overall outlook of the pharmaceutical value chain. The pharmaceutical companies are gradually loosening their reigns and are investing in AI-driven technologies, be it in terms of collaborating with AI-driven startups or developing their internal capabilities. While currently only a few of the pharmaceutical value chain elements have embraced these technologies in true sense, in next few years, the key differentiator for a pharmaceutical company would be the level of advancement in firm's processes in terms of technology.

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Notes

