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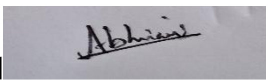
Signed  **& dated: 12-05-2025**

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LEVERAGING AI AND GENOMICS IN DRUG DISCOVERY AND IDENTIFICATION IN INDIA

A dissertation submitted to Griffith College Dublin, in partial fulfilment for the award of Master’s in Digital Transformation (Life Science)

By

ABHIRAMI KRISHNA

Innopharma Education, Faculty of Science

May 2025

CANDIDATE DECLARATION

I hereby declare that this dissertation, titled "Leveraging AI And Genomics In Drug Discovery And Identification In India "submitted in partial fulfilment of MSc. Digital Transformation is the result of my own work. I properly cited and acknowledged all sources and materials used in this study.

I confirm that I did not copy or plagiarize any part of this work from any other source, including the work of other students.

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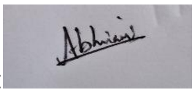
Signature: 

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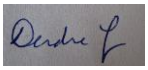
Supervisor Name: Deirdre Finn

Signature: 

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With heartfelt gratitude,
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LIST OF ABBREVIATION

ADME	Absorption, Distribution, Metabolism, Excretion
AI	Artificial Intelligence
CAGR	Compound Annual Growth Rate
CD	Crohn's Diseases
CDSCO	Central Drugs Standard Control Organization
CVDs	Cardiovascular Diseases
Da	Daltons
DL	Deep Learning
FDA	Food and Drug Administration
GANs	Generative Adversarial Networks
GD	Grave's Diseases
GWAS	Genome Wide Association Studies
ICMR	Indian Council of Medical Research
IFRS	International Financial Reporting Standards
ML	Machine Learning
MS	Multiple Sclerosis
NCD	Non-Communicable Diseases
NLP	Natural Language Processing
RA	Rheumatoid Diseases
T1D	Type 1 Diabetes
VAEs	Variational Autoencoders

ABSTRACT

Drug development and personalized treatment are changing as a result of the combination of genomics and artificial intelligence (AI), which holds promise for resolving India's complicated healthcare system. Given that more than 60% of deaths in India are caused by chronic diseases including diabetes, cancer, and cardiovascular ailments, the country urgently needs accurate and affordable medical treatments. This study investigates how AI may be used to drive population-specific drug development and targeted therapy by leveraging India's enormous genetic diversity, as demonstrated by programs like the IndiGen program. Important phases of the drug development pipeline are being accelerated by AI technologies, such as generative models, deep learning, and machine learning. These include of lead optimization, virtual screening, target discovery, and drug toxicity and efficacy prediction. In order to find new biomarkers, disease pathways, and drug resistance mechanisms, AI also makes it easier to analyze complicated genomic, transcriptomic, and proteomic information. Therefore, by providing individualized treatment based on a person's genetic composition, AI facilitates the shift from generic to precision medicine. Even with the quick developments, AI is still not widely used in the biotech and pharmaceutical industries in India. Widespread optimism over AI's revolutionary potential was emphasized by a national survey of 207 stakeholders, but it also identified obstacles such a lack of technical competence, fragmented data ecosystems, high implementation costs, and inadequate infrastructure. Concerns over ethical justice, data privacy, and the opaque "black-box" character of many AI models were also mentioned by respondents as issues that impede clinical trust and regulatory acceptance.

The study highlights the necessity of making strategic investments in infrastructure, education, and interdisciplinary cooperation in order to fully reap the benefits of AI-driven genomics. To guarantee fair access and responsible innovation, it also urges the implementation of flexible legal frameworks, standardized data standards, and moral protections. AI's impact can be further increased through public-private partnerships, targeted rare disease research, and the incorporation of digital health tools. By tackling these issues, India can fully utilize AI and genomics to transform drug discovery, enhance diagnostics, and provide individualized, reasonably priced treatments that are suited to its heterogeneous populace. The study emphasizes that India is in a strong position to lead the world in precision medicine and AI-powered pharmaceutical development with focused efforts.

CHAPTER ONE: INTRODUCTION

1.1 OVERVIEW

Drug development and identification in India are being revolutionized by the combination of artificial intelligence (AI) and genomics, which presents previously unheard-of options to address the nation's particular healthcare issues. India's diverse genetic environment, which presents both opportunities and difficulties for specific treatment, is a result of its rich cultural heritage (Panda *et al.*, 2022). The emergence of AI-powered tools is speeding up the drug discovery and development process by helping researchers better explore this complicated genomic landscape (Blanco-González *et al.*, 2023). With programs like the IndiGen program designed to gather sequencing data from various ethnic groups around the nation, India has made tremendous progress in genomic research in recent years (Panda *et al.*, 2022). When paired with cutting-edge AI algorithms, this abundance of genomic data is improving our comprehension of population-specific differences that affect medication responses and side effects (Sahana *et al.*, 2022).

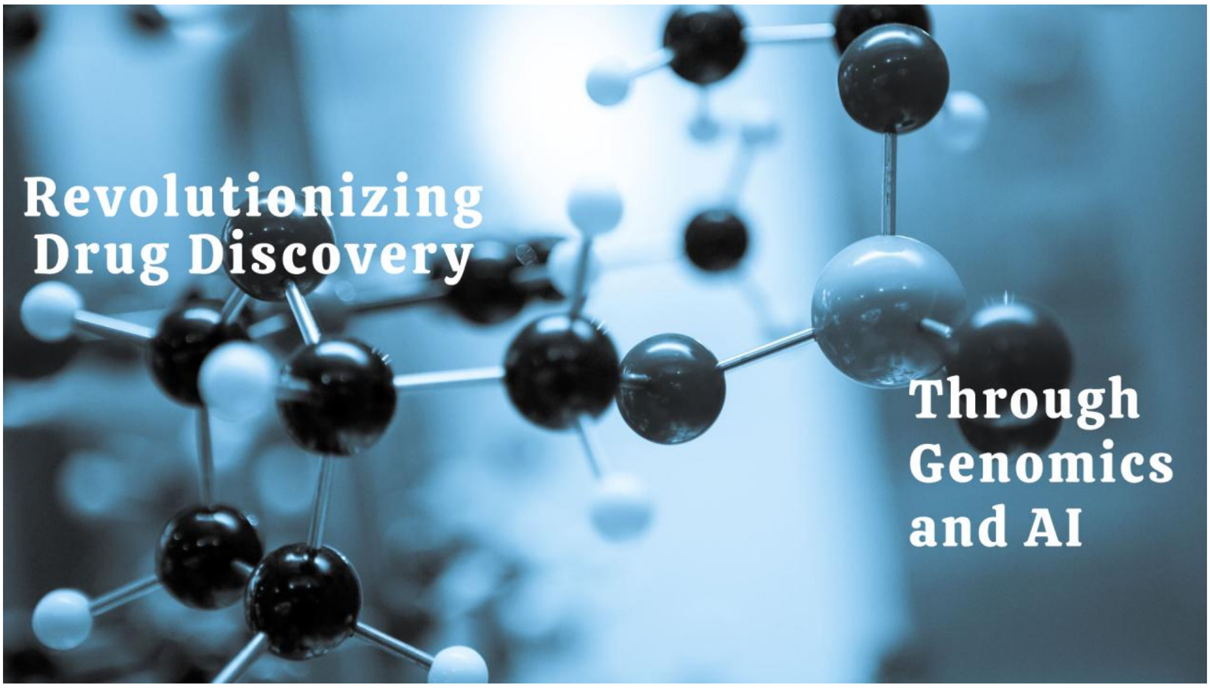


Figure 1Advancements in Drug Discovery Through Genomics and AI: Unveiling Novel Treatments For Old Diseases (Tena, 2024)

Drug development and discovery are being revolutionized by artificial intelligence (AI), which improves precision, lowers costs, and streamlines procedures. Since the therapeutic use of genomics is always changing as new information and technologies are developed, artificial intelligence (AI) techniques such as machine learning and deep learning provide new computational methods for analyzing large, heterogeneous, and high-dimensional datasets (Raza, 2020). By utilizing data analytics, natural language processing, and machine learning algorithms, artificial intelligence (AI) lowers cost, streamlines preclinical and clinical testing, and speeds up the identification of possible drug candidates.

Virtual screening of chemical libraries using AI algorithms can find compounds that have the best chance of attaching to particular targets, saving time and money compared to experimental screening (Colwell, MD, 2024). Additionally, AI models can forecast a compound's pharmacokinetic and pharmacodynamic characteristics, assisting researchers in ranking the most promising candidates for additional investigation (Kokudeva *et al.*, 2024). Large datasets, such as omics datasets, phenotypic and expression data, disease associations, patents, publications, clinical trials, research grants, and more, are being used to train AI in order to better understand the biological mechanisms underlying diseases and to find new proteins and/or genes that can be targeted to prevent or treat them (Billauer, 2023).By enabling high-fidelity molecular simulations that can be conducted entirely on computers (i.e., in silico) without costing as much as traditional chemistry methods, artificial intelligence (AI) can predict the three-dimensional structures of targets, speed up the design of suitable drugs that bind to them, and eliminate the need for physical testing of candidate drug compounds. Certain AI systems are able to predict important properties like toxicity, bioactivity, and the physicochemical characteristics of molecules; create novel and promising drug molecules from scratch; rank and prioritize lead drug compounds for additional evaluation; and create synthesis pathways for the production of hypothetical drug compounds, sometimes suggesting changes to compounds to facilitate their manufacturing (Billauer, 2023).

Diabetes, hypertension, heart disease, cancer, respiratory problems, arthritis, and neurological conditions are among the chronic illnesses that cause more than 60% of deaths in India each year (Rashmi and Mohanty, 2023). By improving diagnosis, therapy, and prevention, AI and genomics are revolutionizing the management of disease. By using genomic data to forecast medication responses and disease susceptibility, personalized medicine makes it possible to create individualized medicines to increase effectiveness and minimize negative effects (Goyal et al., 2024). Predictive analytics powered by AI finds genetic indicators for diseases like diabetes and heart disease, allowing for early interventions through lifestyle modifications or preventative treatments (Goyal et al., 2024). AI finds patterns in large datasets that clinicians miss, enabling proactive management of chronic diseases and real-time monitoring through smartphone apps that provide patients individualized advice for disorders like diabetes (Pan et al., 2025). Furthermore, by quickly evaluating data to create population-specific treatments, AI speeds up drug research and fills in gaps in traditional methods in India (Mohapatra et al., 2024). In order to reduce the burden of chronic diseases in the area, AI and genomics work together to provide a revolutionary framework for early detection, customized care, and cutting-edge treatments.

The burden of chronic diseases, especially non-communicable diseases (NCDs), is largely borne by India. Chronic illnesses that cannot be spread from one person to another are known as non-communicable diseases (NCDs). They frequently arise from a confluence of behavioural, physiological, environmental, and hereditary variables. These include cancer, chronic kidney disease, chronic respiratory diseases, and cardiovascular diseases, among others. The majority of the nation's premature deaths are caused by NCDs, with cardiovascular diseases accounting for the largest share. Additionally, treating the growing burden of NCDs presents difficulties for India's healthcare system, especially in low- and middle-income areas where resources are frequently scarce. Despite these obstacles, India is an important participant in worldwide efforts to tackle chronic diseases because its approaches to managing these conditions can have a big impact on global health activities. The research focuses on drug discovery and identification through AI, while many studies in India concentrate on the more general uses of AI and genomics in healthcare. This emphasis enables a more thorough investigation of how AI might hasten the creation of innovative medications suited to India's diverse genetic landscape. This research will also focus a lot on using AI and genetics to develop individualized treatment plans for chronic conditions like diabetes and cardiovascular disease, which are common in India (Pan *et al.*, 2025).

Given the genetic diversity of India, AI-powered tools are speeding up the development of personalized treatments by analyzing vast genomic datasets, predicting drug responses, and optimizing therapeutic interventions. This approach is especially important in managing chronic diseases like diabetes, cardiovascular disorders, and cancer, which account for a significant portion of India's healthcare burden. With the help of machine learning, predictive analytics, and computational simulations, AI is revolutionizing drug discovery and identification in India and providing previously unheard-of opportunities to address the nation's unique healthcare challenges. India is at the forefront of global healthcare innovation thanks to its advances in AI-driven genomics, despite obstacles including differences in infrastructure and a lack of finances. Further funding in this area will open the door to more efficient, population-specific therapies, which will enhance health outcomes and establish new standards for precision medicine (Rashmi and Mohanty, 2023).

1.2 WITH RESPECT TO ADVANCED MANUFACTURING IN SMART FACTORY

To maximize output, advanced manufacturing in smart factories uses digital twins, AI-driven automation, and predictive analytics. Likewise, AI and genomics transform medication discovery by facilitating tailored medicine and accurate drug identification. The manufacturing of pharmaceuticals is made more efficient, scalable, and customizable by the confluence of various domains. While guaranteeing superior, patient-specific medicines, this integration expedites medication development.

1. AI-Driven Process Optimization: Just as AI is used in drug research to analyze massive genetic databases and forecast medication efficacy, smart factories employ AI to improve manufacturing processes.
2. Robotics and Automation: AI-driven robotic platforms in drug development speed up compound synthesis and high-throughput screening, just like automated systems in smart factories speed up production.
3. Manufacturing of personalized Medicine: AI-driven genetic analysis and personalized production lines are supported by smart factories, allowing for the customization of medication formulas for specific patients.

1.3 PURPOSE OF THE STUDY

The purpose of this study is to explore and assess the possibilities of integrating genomics and artificial intelligence (AI) to transform drug identification and discovery procedures in India. This study intends to tackle India's distinct healthcare issues by utilizing the nation's diverse genetic landscape and cutting-edge AI algorithms to expedite and enhance medication development effectiveness. The study likely focuses on how AI can evaluate enormous volumes of genomic data from India's heterogeneous population in order to find new therapeutic targets, forecast the toxicity and efficacy of drugs, and create individualized treatment plans. By combining AI and genomics, the study aims to get beyond the drawbacks of conventional drug development techniques, which might save time and money when introducing new drugs to the market while meeting the health demands of India's population.

1.4 SIGNIFICANCE AND JUSTIFICATION OF STUDY

The study's potential to revolutionize India's drug research scene makes it noteworthy and warranted. Researchers can improve lead compound searches, find new therapeutic targets more quickly, and make more precise predictions about the toxicity and efficacy of drugs by combining AI and genomics.

The country's increasing chronic disease rate calls for more efficient, focused treatments, which can be created by combining genetics and artificial intelligence. By allowing researchers to evaluate enormous volumes of genetic data, find new therapeutic targets, and forecast medication efficacy and toxicity with unprecedented speed and precision, this method has the potential to completely transform drug discovery.

Because it may address population-specific health requirements, the integration of AI and genomics in drug discovery is especially important for India. It may also shorten the time and expense required to bring novel pharmaceuticals to market. Additionally, the study can establish India as a major participant in the global clinical trial scene by utilizing its genetic variety to create more potent therapies.

The justification for this study is further strengthened by the potential for AI-powered analysis to improve genomics diagnostic capabilities, assisting in the detection of genetic predispositions and disease-causing mutations. Improved patient care and quicker interventions may result from this. Furthermore, the combination of AI and genomics can have a big influence on medication development and discovery by making it easier to find genetic markers linked to particular illnesses and by helping to identify and validate targets. In the end, this research could boost personalized medicine in India, speed up medication discovery, enhance treatment results, and target particular healthcare issues while enhancing population health generally.

1.5 AIM AND OBJECTIVES

The aim of using AI and genomics in drug development and identification is to increase process speed, accuracy, and efficiency while lowering costs and enhancing therapeutic results.

- To use AI to identify therapeutic targets, to examine how this makes the process faster and more efficient.
- To examine how AI and genomics can be used to find new drug targets, and to develop drug interactions more accurately.
- To use AI for effective drug design and repurposing and to accelerate the drug discovery process.
- To integrate artificial intelligence with genomics to advance personalized medicine by enabling precise diagnosis, tailored treatments, and improved health outcomes.

1.6 RESEARCH QUESTIONS

- How can artificial intelligence be used to identify therapeutic targets, and in what ways does it improve the speed and efficiency of the drug discovery process?

- How can artificial intelligence and genomics be integrated to identify novel drug targets and improve the accuracy of drug interaction predictions?

- "How can artificial intelligence be utilized to enhance drug design and repurposing, and accelerate the overall drug discovery process?

- How can the integration of artificial intelligence with genomics enhance personalized medicine by improving diagnostic accuracy, enabling tailored treatments, and optimizing health outcomes?

1.7 HYPOTHESIS

Integrating AI with genomics can accelerate drug discovery by enhancing target identification, drug interaction predictions, and drug design/repurposing, while enabling personalized medicine through precision diagnostics and tailored therapies to improve health outcomes.

1.8 THESIS STRUCTURE

The remainder of the dissertation is structured as Chapter 2 identifies knowledge gaps and combines previous study findings by carefully reviewing the relevant research. Additionally, it develops a conceptual framework by integrating appropriate theories. By defining further analyses and guiding the study inquiry, this framework acts as a compass. The study's research methodology will be covered in Chapter 3, which has the function of both explaining and justifying the methodological strategy used to carry out the research. The study's results and analysis, including the data gathered, the analysis carried out, and the conclusions drawn from it, are then presented in Chapter 4. The conclusion and recommendations are covered in Chapter 5, along with potential directions for further study. In addition to offering useful insights for all individuals concerned, this study will add to the body of information on the advancement of AI and genomics in drug discovery and identification in the medical sector.

CHAPTER TWO: LITERATURE REVIEW

2.1 OVERVIEW

In India, where conventional approaches have long predominated, the use of artificial intelligence (AI) into drug research signifies a revolutionary change in the pharmaceutical industry. Drug development has traditionally depended on empirical methods, which are frequently typified by high throughput screening and trial and error testing. This procedure is not only expensive but also time consuming; estimates indicate that bringing a novel medication to market can cost billions of dollars and take more than ten years. Although they can be effective in certain situations, traditional approaches are constrained by their dependence on discrete datasets and their incapacity to precisely forecast the behaviour of new compounds (Kimta, 2024).

On the other hand, artificial intelligence (AI) tools like deep learning (DL), machine learning (ML), and natural language processing (NLP) are transforming this discipline by making it possible to analyze enormous volumes of biological data more quickly and effectively (Blanco-González *et al.*, 2023). AI's capacity to improve several phases of the research process highlights its potential in medication discovery. For example, by evaluating complex biological systems and more accurately forecasting drug-target interactions than conventional techniques, AI can greatly speed up target discovery. This skill enables researchers to find new treatment targets that traditional methods would have missed. Additionally, by simulating interactions between medications and their targets, AI-driven platforms can expedite the candidate selection process, hence cutting down on the time and expenses related to early stage drug development. AI's ability to quickly find viable therapeutic options can be seen by the use of deep learning algorithms to find new drugs for the treatment of cancer (Singh Saini *et al.*, 2025).

Chronic diseases now account for 61.8% of all fatalities in India, up from 37.9% in 1990, making them a serious health concern. The main causes of this load include diabetes, cancer, heart disease, and chronic respiratory conditions. For example, with over 21.2 crore diabetics, India has the highest number of diabetics worldwide, and cardiovascular illnesses account for one-fourth of all fatalities. This problem is made worse by the aging population, which is predicted to reach 158.7 million by 2025 and of whom 21% have at least one chronic illness. By 2025, chronic illnesses are expected to be responsible for 75% of healthcare spending, indicating a significant economic impact (Maniyara and Kodali, 2025).

By improving early diagnosis and management of certain disorders, artificial intelligence (AI) presents a viable remedy. By offering predictive analytics and individualized care, AI-driven platforms like those created by Lillia have demonstrated success in controlling chronic illnesses, improving outcomes for thousands of people Lillia, a health tech firm based in Qatar, develops individualized treatments for diabetes and metabolic disorders using AI and professional human coaching from doctors, psychiatrists, and nutritionists. Their platform creates durable habits that have been shown to enhance long term health results by customizing interventions to each person's metabolism and lifestyle. India can improve patient outcomes and address the growing illness burden more successfully by utilizing AI to transform its healthcare system from one that is reactive to one that is proactive Lillia is an AI health tech business based in Qatar that focuses on using AI to manage chronic illnesses. The goal of Lillia's platform is to enable public sector organizations, businesses, insurers, and healthcare professionals to efficiently manage chronic illnesses. It uses AI in conjunction with knowledgeable human coaches such as doctors, psychologists, and dietitians to develop individualized treatment plans based on a person's metabolism and way of life (Iqbal, 2023).

AI can help bridge the healthcare gap by enabling remote monitoring and personalized care, which is especially helpful in regions with limited access to healthcare services. In summary, the rising tide of chronic diseases in India presents a formidable challenge, but AI offers a promising solution by improving early detection, improving management, and making healthcare more accessible and affordable for millions of Indians. AI can also predict disease risks, optimize treatment strategies, and improve patient outcomes by leveraging large datasets and advanced analytics (Park *et al.*, 2023).

The growing need for early diagnostics and the lack of qualified healthcare workers are driving India's rapid adoption of AI in medical diagnostics, which is growing at a compound annual growth rate (CAGR) of 23.10%. AI-powered diagnostic tools are proving invaluable in managing chronic conditions like diabetes and cardiovascular diseases, where early detection and timely intervention are crucial. For example, AI-driven platforms can analyze patient data and medical images to predict complications and guide treatment decisions. By lowering the need for lengthy hospital stays and treatments, this not only enhances patient outcomes but also lowers healthcare expenses. By offering individualized treatment and encouraging long-term lifestyle adjustments, the combination of AI and human expertise exemplified by platforms such as Lillia further improves the efficacy of managing chronic diseases (Ms. Sama Beg, 2024).

Companies like Biocon and Sun Pharma are leading the way in India when it comes to using AI into their drug discovery procedures. These companies use AI to find new applications for current drugs and improve the effectiveness of drug screening (Nagappan *et al.*, 2024). Combining artificial intelligence (AI) and molecular biology has made it easier to create personalized medicine that is based on each patient's unique genetic profile, increasing treatment effectiveness and reducing side effects. AI, for example, may discover disease signs by analyzing genetic data and clinical records. This allows medical professionals to choose the best course of treatment for diseases like cancer and uncommon genetic illnesses. The rare diseases like the Wilson’s disease, which is a hereditary condition that causes the body to accumulate copper, which damages the liver and nervous system. The Gaucher’s Disease is caused by organ damage caused by a genetic disorder that affects how fats are metabolized. Sickle Cell Disease which isa genetic disorder affecting haemoglobin, leading to anaemia and increased risk of infections (Ravishankar, 2025). AI's use goes beyond the early stages of discovery; it is also essential to the planning and conduct of clinical trials. AI can improve patient recruitment tactics by using predictive analytics, which takes into account genetic profiles and past treatment results. This increases the chance of favourable outcomes by accelerating trial durations and improving patient stratification. Additionally, throughout trials, real-time patient data monitoring enables adaptive modifications depending on new patterns, guaranteeing that trials stay successful and relevant (Paul *et al.*, 2021).

Despite these developments, India still confronts a number of obstacles when it comes to integrating AI into drug discovery. The consistency and quality of the data required to train AI models is a major challenge. The efficiency of AI-driven insights may be jeopardized by potential biases and mistakes resulting from the fact that a large portion of the biological data created is not gathered with machine learning applications in mind. Furthermore, India's regulatory frameworks for AI applications in healthcare are still developing. Researchers and businesses aiming to apply AI technologies in clinical settings may get uncertain due to the absence of clear rules (Zoccoli, Carlos N Velez, Remco Jan Geukes Foppen,, *et al.*, 2025). India must give priority to education and training initiatives that raise researchers' and healthcare professionals' AI literacy if it is to fully capitalize on the advantages of AI in drug discovery. Future generations will be better prepared to handle this quickly changing environment if pharmacy and biotechnology schools incorporate AI-focused curricula (Jain *et al.*, 2024).

2.2 AI IN DRUG DISCOVERY

From target identification to lead optimization, artificial intelligence has become more and more important for drug discovery. Large datasets are analyzed by machine learning algorithms, especially deep learning, to forecast molecular characteristics, find possible therapeutic options, and optimize chemical structures. These strategies drastically cut down on the expenses and development schedules related to conventional experimental techniques (Askr *et al.*, 2023).

The discovery of new drugs is essential to the healthcare industry. In order to improve patient well-being, address unmet medical needs, and combat a variety of illnesses, including both common and uncommon diseases, it is essential that new medical treatments be investigated and developed. However, the traditional approach to drug development is usually described as being costly, time-consuming, and filled with challenges, including lengthy regulatory approval processes and high failure rates. This makes the application of machine learning (ML) and artificial intelligence (AI) in pharmaceutical research very promising. The pharmaceutical business faces pressing challenges that these technologies offer innovative solutions for, from accelerating drug discovery to enhancing patient selection and clinical trial design. Researchers can use AI and ML to speed up the process of finding promising drug candidates, predict likely side effects, and tailor treatments based on individual patient characteristics (Ahmed Hussien A Al Rammadan *et al.*, n.d.).

Figure 2AI-Driven Drug Discovery and Development (Mattei, 2024)

Large volumes of genetic data can be analyzed by AI algorithms, which can then spot details in patterns and relationships that humans might overlook or find difficult to spot with conventional techniques. In addition to facilitating faster and more precise diagnosis, these patterns can uncover biomarkers, driver mutations, and drug resistance mechanisms, paving the way for targeted therapeutics that can overcome resistance. By examining genetic mutations, gene expression, protein function, and epigenetic modifications, genomics plays a critical role in determining cancer risk. New avenues for the investigation of novel treatment targets are made possible by the capacity to profile every patient for a whole range of therapeutically relevant genetic changes (Frasca *et al.*, 2024).

AI makes it possible to analyze vast amounts of clinical and genomic data on patients in order to find particular patterns and biomarkers that inform therapy choices. This would maximize effectiveness and reduce negative effects by allowing patients to get tailored treatments based on the unique genetic features of their tumour. AI models can examine genomic data to find early indications of cancer or genetic abnormalities, leading to more precise and timely diagnosis. Early in the course of the disease, more effective therapeutic measures may be made possible by this improved diagnostic skill. Finding intricate and non-linear correlations in data yields fresh perspectives that conventional methods might not have been able to provide. Therefore, incorporating AI into clinical decision-making procedures can enhance medical practice's accuracy and efficiency (Shreve *et al.*, 2022).

2.3 GENOMICS AND TARGET IDENTIFICATION

A crucial step in drug discovery is identifying viable drug targets. Artificial intelligence (AI) algorithms use genomic data to identify genes or proteins linked to diseases; for example, machine learning models have been used to predict gene disease associations by combining transcriptomic, proteomic, and genomic data. This method improves target identification accuracy and results in more effective therapeutic interventions (Jia *et al.*, 2024).

Finding novel therapeutic targets is significantly impacted by the way AI has transformed scientists' comprehension of the genetic foundations of diseases. In the past, finding medicinal targets required tedious, time-consuming laboratory work that involved trial and error. But because to the quick processing of enormous volumes of genetic data by AI algorithms, possible therapeutic targets that could have gone unnoticed with traditional techniques can now be found.AI can find links between genetic alterations and disease pathways by examining large-scale genomic datasets, such as those from genome-wide association studies (GWAS), which investigate the relationship between genetic variants and diseases. Genetic risk factors and new pathways have been found by GWAS in Crohn's disease (CD), an inflammatory bowel illness. The inflammatory condition known as rheumatoid arthritis (RA) has been linked by GWAS to pathways such as the influenza-A pathway. GWAS has also connected the phagosome and toxoplasmosis pathways to type 1 diabetes (T1D), an autoimmune disease. Genetic risk factors for multiple sclerosis (MS), an autoimmune illness, have been found via GWAS. GWAS is also being used to study celiac disease, an autoimmune condition that affects the small intestine. Genetic connections have been found by GWAS for Grave's Disease (GD), an autoimmune thyroid condition. This enables the discovery of previously unidentified biomarkers or genetic changes that may be new targets for treatment (Wenteler *et al.*, 2024). By forecasting how targets and possible drug candidates will interact, AI not only finds possible targets but also helps validate them. As a result, there is less need for repeated laboratory testing during the target validation phase. Moreover, AI can create chemical hits and leads that attach to new targets, improving the search for potent medicinal substances. In instance, generative AI can produce a variety of binding structures that have never been investigated before, avoiding the biases present in traditional chemical libraries (Colwell, MD, 2024).

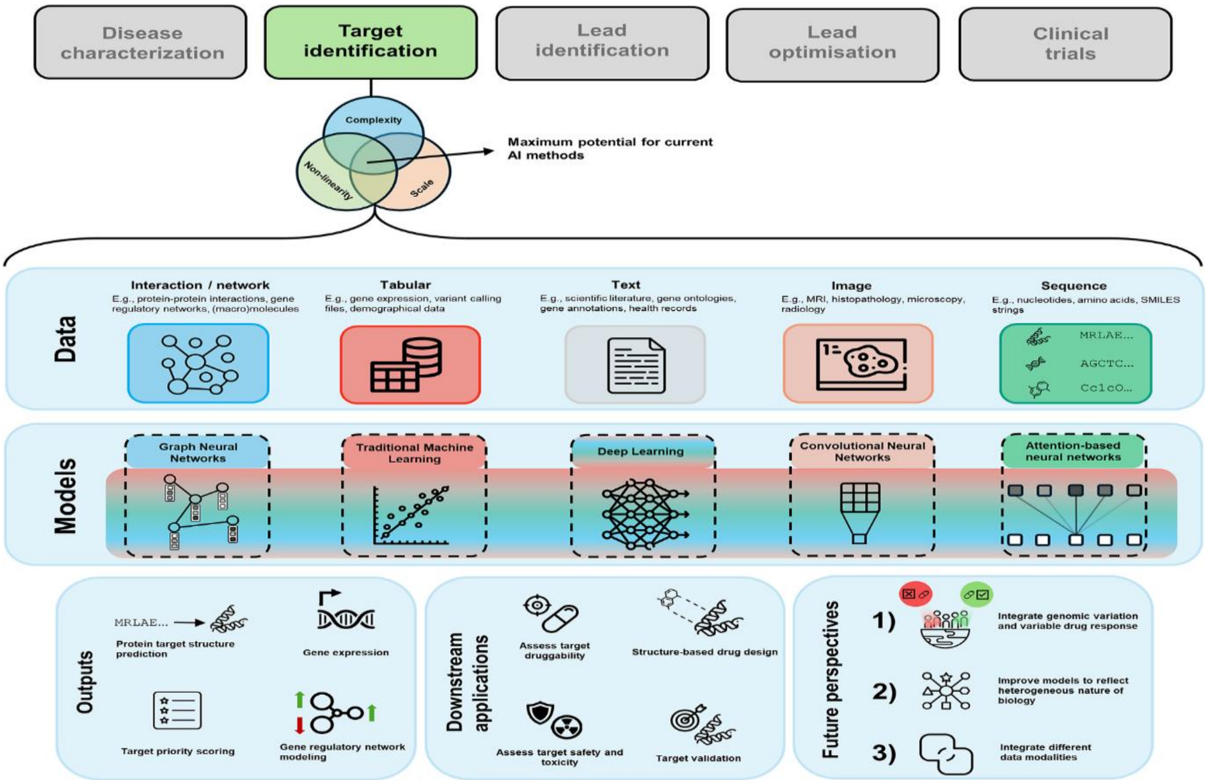


Figure 3 Target Identification (Wenteler et al., 2024)

Since AI trained on genomic data can quantify target effects and find successful targets for rare diseases such as mitochondrial disorders which is a condition affecting the mitochondria, which are essential for cells to produce energy. AI-powered methods are assisting in the detection of disease-related patterns in cellular imaging. Rare Cancers were AI-driven drug discovery tools are using genetic data to find new treatment targets for a variety of uncommon cancer forms. Wilson's disease is a hereditary condition that causes the body to accumulate copper. AI can assist in determining the genetic variations linked to this illness and creating individualized therapies. Gaucher's disease is a hereditary condition that affects how fats are metabolized. Using genomic profiles, AI can help forecast the severity of diseases and optimize treatment plans. Tyrosinemia Type I is a hereditary condition that affects how the amino acid tyrosine is metabolized. AI-powered methods can assist in locating genetic targets for treatment. It can help overcome the biases present in genomic data, which leans toward prevalent diseases. Additionally, AI improves sequencing precision and speeds up genomic analysis, enabling the quick investigation of genetic variants. All things considered, drug discovery has greatly expedited due to AI's capacity to quickly evaluate genetic data and find new targets, which has decreased expenses and increased process efficiency (Liao *et al.*, 2025).

2.4 AI-DRIVEN DRUG DESIGN AND REPURPOSING

The process of creating novel medicinal compounds has been completely transformed by AI algorithms, especially generative models. These models allow for the quick creation of molecules with desired qualities including potency, selectivity, and pharmacokinetic profiles by forecasting the effects of chemical alterations on biological activity. Pharmacokinetic profiles are the study of a drug's absorption, distribution, metabolism, and excretion (ADME) as it passes through the body. This data is essential for drug research since it helps forecast a drug's human behaviour, ensuring that it achieves therapeutic levels with the fewest possible side effects. By automating the exploration of large chemical spaces, generative AI has expedited the drug design process. This allows researchers to concentrate on improving effective concepts instead of manually synthesizing and testing a large number of molecules. Small to medium-sized compounds are usually the focus of generative AI in drug creation since they are more likely to be synthesizable and drug-like. Typically, these molecules have molecular weights between 200 and 500 Da (daltons), which is a typical range for pharmacological substances. Because it influences their pharmacokinetic characteristics, including absorption, distribution, metabolism, and excretion, the size of these molecules is crucial.

But while though AI has demonstrated potential in improving medication candidates for known targets, its capacity to produce new compounds with unique inhibitory patterns is still restricted. To create new chemical structures from preexisting substances, methods such as Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs) are employed. These models can generate novel compounds with comparable characteristics after learning patterns from big datasets of well-known medications. Predictive Modelling: By examining the molecular characteristics and interactions of drug candidates with biological targets, artificial intelligence models are able to forecast the safety and effectiveness of these prospects. This involves forecasting solubility, metabolic stability, and binding affinity. High-Throughput Virtual Screening: AI is able to quickly analyze vast virtual chemical libraries against particular targets, finding interesting candidates for additional experimental verification (Crucitti *et al.*, 2024).

Drug repurposing is the process of finding new therapeutic uses for already-approved medications, providing a quick and economical way to treat newly emerging illnesses. Artificial intelligence (AI) algorithms, like as machine learning and natural language processing, are essential to this procedure because they analyze vast amounts of data to forecast how well-suited current medications will be to new targets. For instance, by recognizing adalimumab, an FDA-approved monoclonal antibody, as a possible treatment, AI algorithms have successfully repurposed medications for uncommon disorders like idiopathic multicentric Castleman's disease. In addition to speeding up research, this strategy gives patients with few treatment options new hope (Crucitti *et al.*, 2024).

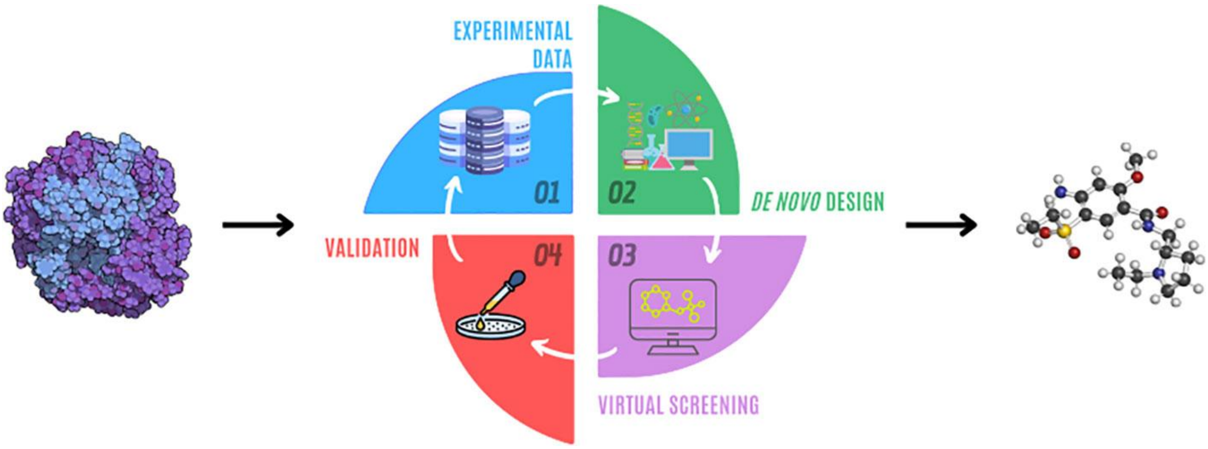


Figure 4 Drug Design Process(Crucitti* et al.*, 2024)

Machine Learning algorithms: To forecast possible novel applications for currently available medications, these algorithms examine enormous databases of drug-target interactions, illness processes, and clinical outcomes. Natural Language Processing (NLP): NLP technologies are used to search clinical records and scholarly literature for information about drug-disease relationships, frequently revealing unexplored repurposing opportunities. Biological Network Analysis: By modelling intricate biological networks, artificial intelligence (AI) can determine how medications may interact with illness processes, indicating new therapeutic uses. Scientists are combining AI models with biomedical knowledge graphs to improve the efficiency of AI in drug design and repurposing. These graphs provide more insightful hidden representations for variables implicated in drug-disease interactions and serve as a guide for AI-driven hypothesis creation by illustrating verified links between genes, proteins, and medications. Through this integration, AI is able to thoroughly synthesize literature and decipher insightful information on new therapeutic applications for currently available medications (poojaallawadhi, 2023).

The pharmaceutical sector is undergoing a transformation because to AI-driven medication discovery, which drastically cuts prices and time. AI shortens conventional timetables from years to months by automating and using predictive analytics to find promising drug candidates. By enhancing patient recruiting, site selection, and dosage procedures, artificial intelligence (AI) optimizes clinical trials and potentially save millions of dollars every day by minimizing trial delays. By anticipating drug-target interactions and toxicity early on and eliminating unsuitable candidates before expensive lab testing, artificial intelligence reduces experimental redundancy and saves money. All things considered, the effectiveness of AI is anticipated to propel the expansion of the AI drug discovery market in India, which is anticipated to rise quickly over the next several years and might save the country's pharmaceutical sector billions of dollars (Buntz, 2023).

Future developments will depend on overcoming present constraints, even if AI has demonstrated considerable promise in medication design and repurposing. This includes widening the chemical space available to generative algorithms and creating measurements to contrast AI approaches with conventional techniques. It will also be essential to combine AI with other technologies, such as high-throughput screening and synthetic biology, in order to convert computer forecasts into potent medicinal drugs. In conclusion, the pharmaceutical industry is changing due to AI-driven medication design and repurposing, which speeds up the development of new treatments and optimizes those that already exist for other uses. With its potential to transform healthcare by offering more individualized and efficient therapies for a variety of illnesses, artificial intelligence (AI) will play an ever more important role in bridging the gap between clinical efficacy and computational predictions (Crucitti *et al.*, 2024).

2.5 INTEGRATION OF AI AND GENOMICS IN PERSONALIZED MEDICINE

Traditional medicine frequently takes a "one-size-fits-all" approach, treating patients according to their symptoms rather than their unique genetic makeup. However, because patients differ genetically in how they react to the same medication, this approach may result in inconsistent treatment outcomes. For example, some people may have decreased efficacy or greater toxicity due to genetic variations that impact drug metabolism. In order to overcome these constraints, AI-driven personalized medicine combines clinical and genomic data to forecast a patient's reaction to particular therapies. When it comes to processing large-scale genomic datasets, AI systems excel at finding patterns and connections that manual analysis can miss. These algorithms are capable of predicting drug responses and possible adverse effects by analyzing genomic data such as DNA methylation patterns and gene expression levels. AI is able to recognize genetic markers linked to negative drug reactions, for instance. Clinicians can select safer and more efficient treatments with the aid of AI by comparing these markers to known side effects (Anon, 2024).

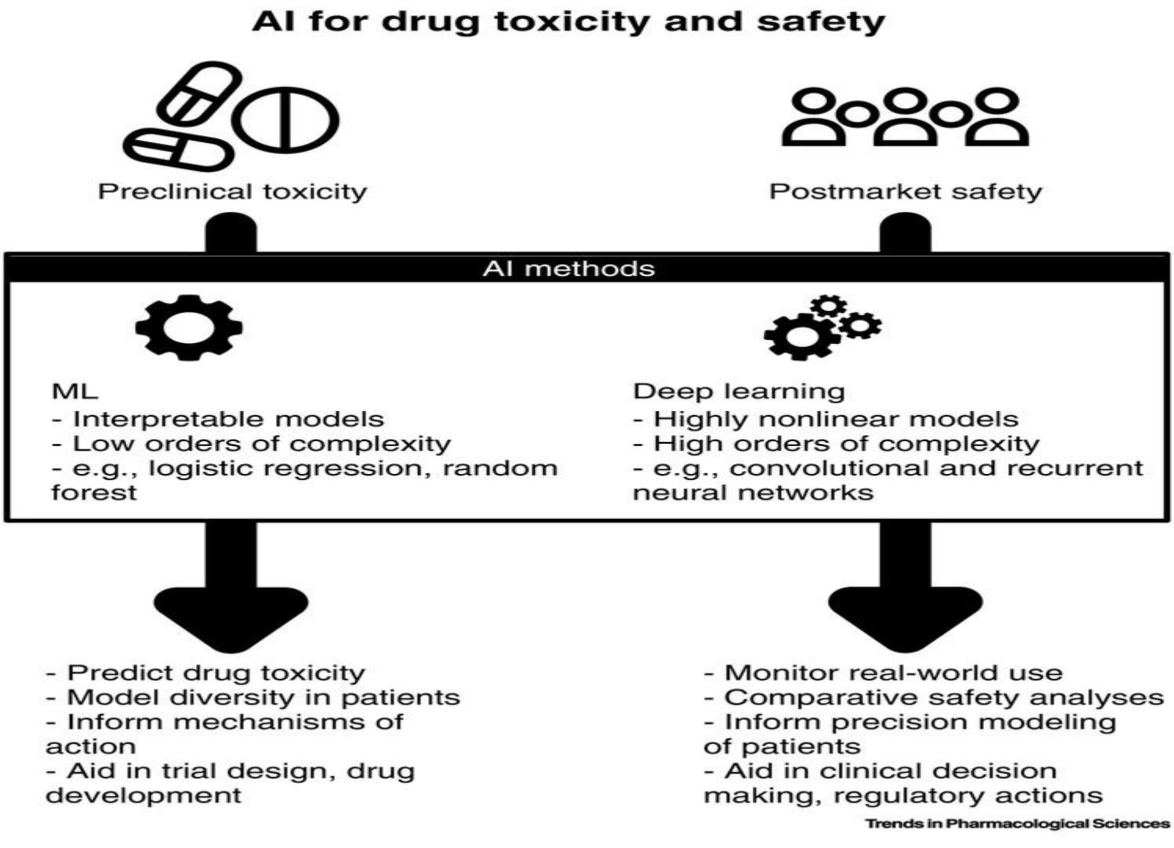


Figure 5 AI for Drug Toxicity and Safety(Basile et al., 2019)

The danger of late-stage therapeutic failures is greatly decreased by using AI to forecast the toxicity and effectiveness of new medicinal substances. Reliance on animal testing can be decreased by using deep learning algorithms that have been trained on big datasets to accurately predict negative effects. By examining past data, AI systems may also categorize cardiac toxicity concerns and detect drug-drug interactions, allowing for safer combination treatments. By spotting any problems early on, this predictive power not only increases drug safety but also speeds up the development process (Basile *et al.*, 2019).Since drug response prediction enables medical professionals to customize therapies according to a patient's genetic profile, it is an essential component of personalized medicine. AI algorithms, like as machine learning and deep learning, are used to evaluate clinical and genomic data in order to forecast how patients will react to particular medications. Key genomic traits that impact medication sensitivity can be identified by these models by integrating a variety of information, including gene expression profiles, mutation data, and clinical outcomes (Park *et al.*, 2023).

AI may combine multi-omics data, such as proteomics and metabolomics, in addition to genomes to offer a thorough understanding of biological systems. Protein interactions and biomarkers can be better understood with proteomic analysis, and drug-affected metabolic pathways can be better understood with metabolomics. Combining these datasets enables AI models to forecast the impact of drug interactions on molecular networks, improving the precision of drug response predictions and aiding in the identification of new therapeutic targets (Abdelhalim *et al.*, 2022). From managing rare diseases to cancer treatment, the combination of AI and genomics has several therapeutic uses. AI-driven models have been used, for instance, to uncover important genomic traits that affect the effectiveness of treatment and anticipate how patients would react to anticancer medications. Because AI can analyze genomic profiles and forecast potential therapeutic benefits, it can assist in repurposing existing medications in rare disorders. But in order to make progress in the future, issues including data heterogeneity, patient privacy, and the creation of standardized frameworks for incorporating multi-omics data into clinical practice must be resolved (Zhang *et al.*, 2021).

Because AI can examine large datasets, doctors can make more accurate diagnosis and forecast how a disease will progress. Clinical records, lifestyle data, and genomic profiles can all be integrated by AI to find subtle trends and relationships that can guide individualized treatment plans. This method, which focuses on focused medicines and minimizes trial-and-error methods, not only improves treatment efficacy but also lowers healthcare expenditures (Rane *et al.*, 2023). Customized treatment plans based on each patient's unique genetic profile are made possible by the combination of AI and genomics, revolutionizing personalized medicine. By improving diagnostic precision and treatment effectiveness, AI's ability to evaluate enormous genetic datasets and forecast medication reactions has created new opportunities for precision medicine. AI promises to transform healthcare by offering more efficient and individualized therapies for a variety of ailments, and as it develops further, its role in bridging the gap between computational forecasts and clinical outcomes will become more significant (Park *et al.*, 2023).

2.6 CHALLENGES AND FUTURE DIRECTIONS

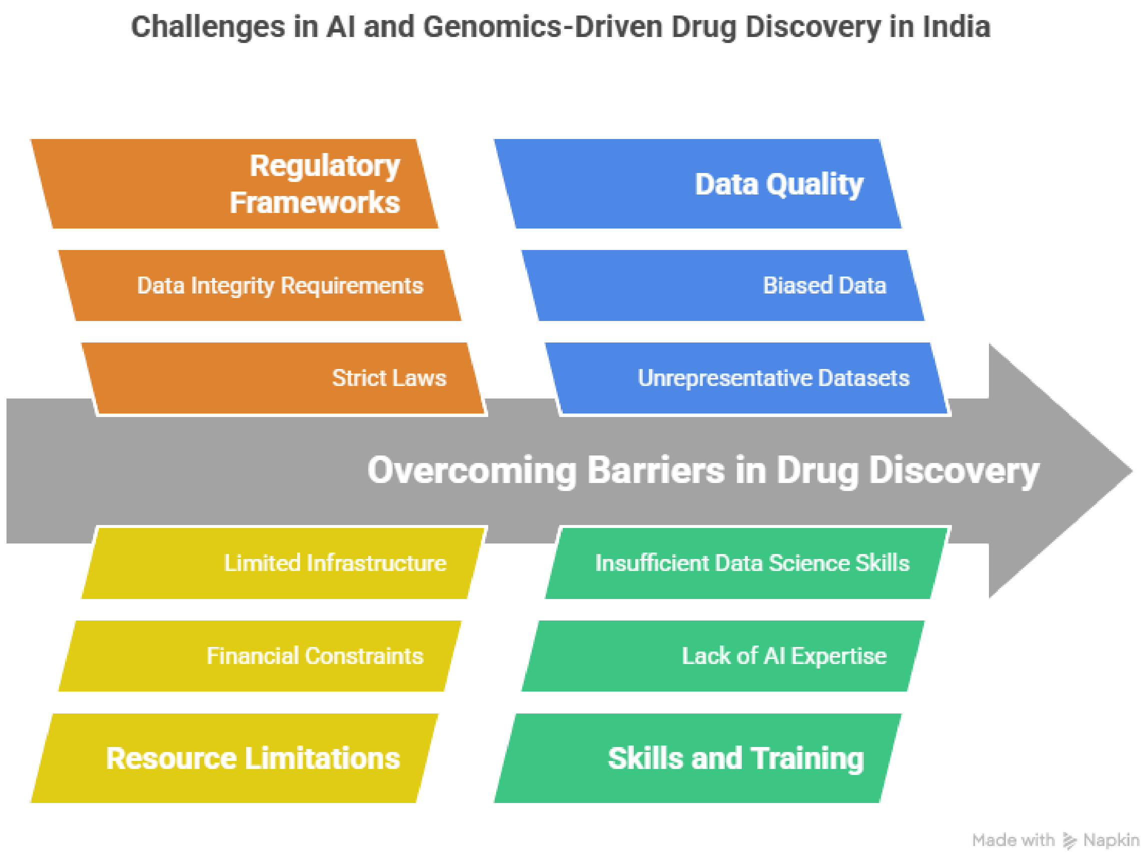


Figure 6 Challenges in AI and Genomics (By author)

Drug development using the combination of genomics and artificial intelligence (AI) is a quickly developing discipline that has the potential to revolutionize the pharmaceutical sector. The integration of heterogeneous data sources, model interpretability, and data quality are among the issues that still need to be resolved despite tremendous progress. Future research must concentrate on creating strong AI models that can handle a variety of datasets and produce results that can be interpreted in light of these difficulties, as these factors are essential for their usage in therapeutic contexts. AI is rapidly being used in India's drug research environment to speed up different phases of medication development. Deciphering complex biological data, streamlining target identification, and improving lead compound searches are all made possible by AI. Large-scale datasets can be analyzed through the use of machine learning, deep learning, and natural language processing, which makes predictive modelling for medication interactions, personalized medicine, and biomarker discovery easier. But strict rules and restrictions make it difficult for AI to be seamlessly integrated into India's drug discovery sector. Even while these legal frameworks are crucial for patient safety and data integrity, they frequently don't keep up with the quickly changing AI technology field (Bhattacharjee and Bhadra, 2025).

Globally, drug discovery is being revolutionized by the combination of biotechnology and artificial intelligence. To investigate disease mechanisms and find possible therapeutic targets, biotechnology offers methods such as transcriptomics, proteomics and genomics. By evaluating and interpreting the enormous volumes of data produced, AI supports these initiatives and improves the effectiveness and precision of drug discovery. Given the increased incidence of chronic illnesses including cancer which is a major contributor to Non communicable Disease related death which is 61.8%, diabetes is diagnosed by approximately 18% Indian adults, cardiovascular diseases (CVDs) are responsible for one-fourth of all deaths in India, and neurological problems in India, this combination is especially crucial. By effectively analyzing large datasets that include genomes, proteomics, and clinical data, the combination of AI and genomics can aid in the discovery of effective treatments for these disorders (Waghmare *et al.*, 2024).

Technological developments and ongoing interdisciplinary cooperation are necessary to properly reap the rewards of combining AI and genomics in drug discovery. This involves creating AI models that can efficiently combine many data sources and produce findings that are easy to understand. These models would guarantee that the knowledge acquired is applicable in clinical situations and expedite the drug discovery process. In order for India to successfully utilize these developments in its drug discovery market, it will also be essential to remove regulatory obstacles with more precise regulations that take AI technology into account (Bhattacharjee and Bhadra, 2025).

2.7 KEY DEBATES

Although genomics and artificial intelligence (AI) have great potential to speed up drug discovery and cut costs, there is discussion on the regulatory barriers that could stand in the way of advancement. While vital for patient safety and data integrity, India's strict laws and regulations could not be compatible with the quickly changing AI technology landscape (Anon, 2024). There's a debate about India's ability to compete globally in drug discovery. While AI and genomics present opportunities for innovation, Indian pharmaceutical companies face limitations in resources compared to major companies in the United States and Europe. This raises questions about India's capacity to progress drugs beyond Phase 2 clinical research (Nagappan *et al.*, 2024). The representativeness and quality of the data used to train AI algorithms are hotly debated topics. In drug discovery, biased or unrepresentative data may result in unfair or erroneous predictions. This connects to more general ethical worries regarding the application of AI to the creation of medicinal substances. There is disagreement in the literature regarding India's preparedness to use genomics and AI to their full potential in drug research (Nagappan *et al.*, 2024).

Specialized AI and data science capabilities are reportedly in scarce supply in the sector. The speed and efficiency with which India can embrace and apply new technologies is called into doubt by this (Harne *et al.*, n.d.). Future directions for AI and genomics-driven drug discovery in India are being discussed. While some call for more strategic partnerships, including those between Indian businesses and foreign partners, others stress the importance of developing autonomous capacities (Harne *et al.*, n.d.). Although genomics and AI have the potential to lower drug discovery costs in the long run, there is disagreement concerning the significant initial outlay of funds needed. In the Indian environment, where financial resources for research and development activities are limited by venture capital and private equity firms' limited funding, this is particularly relevant (Harne *et al.*, n.d.).

To overcome these challenges, interdisciplinary collaboration and technological innovation must focus on robust AI models, Interdisciplinary Collaboration, Regulatory Frameworks, Data Infrastructure, Education and Training. It's critical to create AI models that can process a variety of datasets and yield findings that can be understood. This entails boosting model explainability, enhancing data quality, and making sure models can successfully incorporate data from several sources (Blanco-González *et al.*, 2023). More precise regulations that take AI technology into account are required. These frameworks should strike a balance between the necessity of innovation and the requirements of data integrity and patient safety (Waghmare *et al.*, 2024). To support AI-driven drug development, it is essential to invest in a strong data infrastructure. Creating databases that can efficiently store and handle massive amounts of clinical and genetic data is part of this (Blanco-González *et al.*, 2023). It is critical to inform researchers and doctors about the capabilities and constraints of artificial intelligence in drug discovery. This will make it easier to guarantee that AI technologies are applied across the drug development process in an efficient and responsible manner (Waghmare *et al.*, 2024).

In conclusion, there is a great deal of potential for revolutionizing medication development and discovery through the combination of AI and genomics. Even so, there are obstacles to overcome, and further research and cooperation will open the door to more effective, precise, and customized medication development procedures. For India to fully realize its potential and make a substantial contribution to international drug development efforts, regulatory complexity must be addressed and an environment that is favourable for AI integration must be created (Waghmare *et al.*, 2024).

2.8 RESEARCH GAP

The increasing use of artificial intelligence (AI) in drug discovery, especially in India, is highlighted by a number of publications, which also point out the field's prospects and difficulties. When these sources are examined, a research gap regarding the successful application of AI in drug development within the particular framework of India's data and regulatory environment is revealed. Specific areas of the research gap include: Regulatory alignment, Data Availability and Quality, Model Interpretability, Target Validation, AI-Guided Drug Repositioning, Focus on Specific Diseases, Interdisciplinary collaboration.

- Regulatory alignment: Even though AI is known to speed up drug research, India's strict restrictions present a problem. Examining how these legal frameworks may be modified to accept AI technologies without jeopardizing data integrity and patient safety is necessary. For a smoother incorporation of AI in the drug discovery pipeline, research should concentrate on pinpointing regulatory obstacles and suggesting fixes (Kimta, 2024).
- Data Availability and Quality: Large, varied, and high-quality datasets are necessary for AI algorithms to function effectively. However, it might be costly and difficult to obtain such data from different Indian sources. The investigation of methods to improve the quality and accessibility of data for AI-driven drug development is severely lacking.

This entails looking for ways to integrate, share, and standardize data while abiding by privacy and ethical standards.

- Model Interpretability: Drug toxicity and efficacy can be predicted by AI models, however deciphering these models and comprehending the underlying mechanisms is still difficult. To create AI models that offer interpretable insights into drug-target interactions and disease biology in addition to precise predictions, more research is required. This is essential for increasing confidence in AI-driven outcomes and promoting their use in medical settings (Paul *et al.*, 2021).
- Target Validation: AI can help find possible targets for drugs. Further study is necessary to determine the best ways to use AI-driven methods to validate these aims. This involves investigating techniques for combining genomic data, locating genes linked to disease, and utilizing causal AI to forecast clinical efficacy.
- AI-Guided Drug Repositioning: Deep learning algorithms and network-based techniques are used in AI-guided medication repositioning. To increase the effectiveness and success rate of drug repositioning, more research might examine and refine these techniques, possibly finding new applications for already approved medications (Paul *et al.*, 2021).
- Focus on Specific Diseases: Targeted research on AI applications is necessary to find treatments for these particular problems, as the prevalence of chronic diseases like cancer, diabetes, heart disease, and neurological disorders is on the rise in India. In order to find effective medicines, this involves using AI to examine large datasets that contain proteomics, genomes, and clinical data.
- Interdisciplinary collaboration: Collaboration between biotechnologists, doctors, and AI researchers is necessary for the successful integration of AI in drug discovery. There is a lack of understanding regarding how to promote and maintain these kinds of interdisciplinary partnerships in the Indian setting. This entails determining the obstacles to cooperation and creating plans to encourage information exchange and cooperative research projects (Kimta, 2024).

In order to fully realize AI's promise to revolutionize drug discovery and development in India, improve patient outcomes, and enhance global healthcare, these research gaps must be filled.

2.9 CONCLUSION

By improving speed, accuracy, and affordability, artificial intelligence (AI) is revolutionizing drug discovery and the management of chronic diseases in India's pharmaceutical and healthcare industries. AI improves diagnostics (increasing at a 23.10% CAGR) and treats diseases like diabetes and cancer while speeding up target selection, clinical trials, and personalized medicines. Despite obstacles including incomplete data, regulatory gaps, and a lack of skilled workers, government, academia, and industry can work together strategically to promote ethical policies, standardized frameworks, and skill development. India can become a global leader in AI-powered, equitable healthcare by removing these obstacles and providing creative, patient-centered solutions to address regional and global health issues.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 OVERVIEW

In order to overcome obstacles including high expenses, prolonged development schedules, and population-specific health requirements, this research investigates the combination of artificial intelligence (AI) and genomics to enhance drug discovery in India. The approach uses computational biology and machine learning (ML) to find new therapeutic targets and repurpose existing medications for common diseases (such as cancer, diabetes, and tuberculosis) while utilizing India's genomic diversity and new AI technologies. The study also discusses the scalability, ethical, and legal issues surrounding the use of AI-driven solutions in India's healthcare system. This strategy seeks to establish a scalable framework for precision medicine by combining state-of-the-art technology with regional genetic and clinical resources, thereby promoting pharmaceutical innovation and achieving fair healthcare outcomes in India (Nagappan *et al.*, 2024).

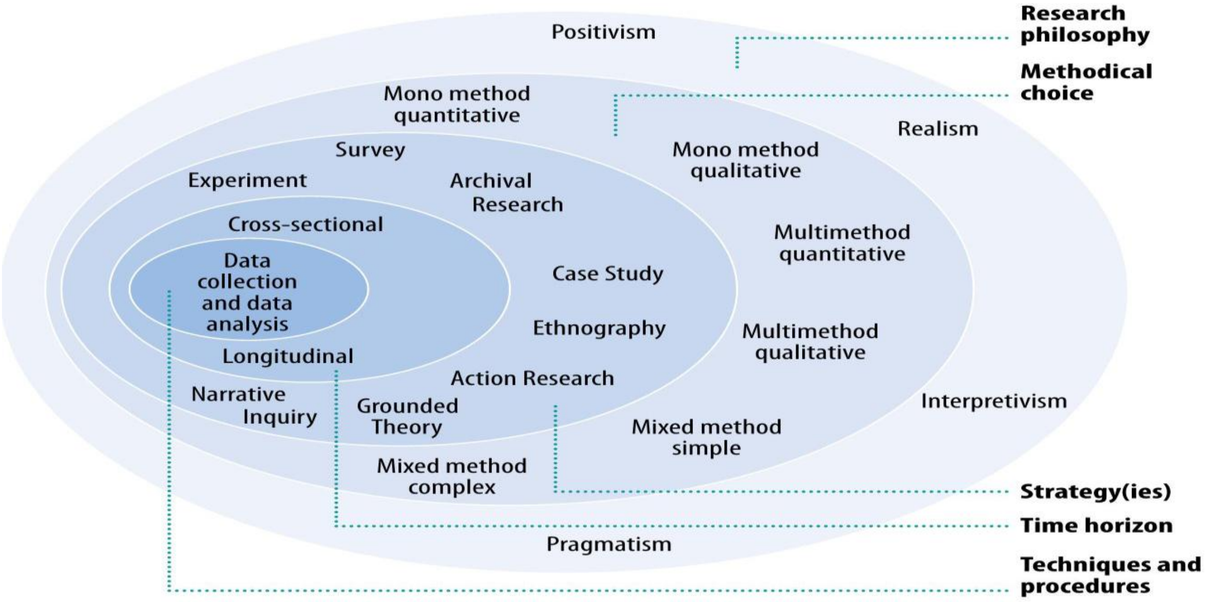


Figure 7Research Onion (Saunders et al 2012)

3.2 RESEARCH PHILOSOPHY

Given the objective, empirical, and scientific nature of the subject, research on the topic of "Leveraging AI and Genomics in Drug Discovery and Identification" necessitates a positivist research perspective. In order to determine patterns, correlations, or causal relationships exactly what is needed when assessing the efficacy of AI and genomics technologies in medication development—positivism places a strong emphasis on observation and measurement of events through methodical data gathering and analysis.

In line with the quantitative results of drug discovery, such as success rates, time-to-market, cost reduction, and target identification accuracy, this method makes the assumption that reality is external and measurable. Researchers who employ positivism mainly use quantitative techniques, including experiments, statistical analysis, and structured surveys, to test theories regarding how AI enhances the interpretation of genomic data and drives pharmaceutical innovation.

Furthermore, in nations like India, where the biotech and healthcare industries are developing quickly, the positivist method enables researchers to assess the reproducibility and scalability of integrating AI-genomics in a variety of regulatory and infrastructure contexts. Researchers may impartially assess how much these tools boost productivity and creativity in drug development by gathering standardized data from biotech companies, academic labs, and governmental organizations.

In conclusion, positivism is crucial to this study because it offers a rigorous, empirical framework for measuring the contribution and efficacy of AI and genomics in drug discovery, guaranteeing that results are legitimate, trustworthy, and applicable in real-world contexts.

3.3 RESEARCH APPROACH

Because the topic is organized and theory-driven, a deductive research technique is the most effective way to conduct research on using AI and genomics in drug development and identification in India. In order to find drug targets and speed up research, this method starts with well-established theories that show how artificial intelligence improves the efficacy, precision, and affordability of evaluating complicated genetic data. These theories serve as the basis for the development of particular, testable hypotheses relevant to the Indian environment, such as whether AI-integrated genomics may shorten the time it takes for medications to reach the market or increase the success rate of clinical trials conducted by Indian biotech companies. Researchers may verify whether globally recognized trends apply to India's distinct healthcare and biotechnology sector by using a deductive method, which makes it especially appropriate. With its enormous genetic diversity, expanding biotech sector, and obstacles with infrastructure, finance, and regulations, India offers a unique setting. By beginning with broad concepts and focusing on particular findings, researchers can gradually evaluate the usefulness and efficacy of integrating AI and genomics in regional contexts.

In the end, the deductive method guarantees contextual relevance and scientific integrity, allowing researchers to provide practical insights suited to India's changing healthcare environment. It promotes the creation of focused policies, the distribution of resources, and scalable solutions that complement national agendas and enhance precision medicine and drug discovery worldwide.

3.4 RESEARCH STRATEGY

The research strategy in Saunders' model helps structure the investigation of how AI and genomics can be leveraged in drug discovery by guiding the selection of appropriate methods, data sources, and analytical techniques tailored to the Indian biomedical context. This systematic layering ensures that the study is methodologically sound and capable of addressing the complex, interdisciplinary nature of AI-driven genomics research in drug discovery.

Effective study on using AI and genomics in drug development and identification in India can be carried out by employing a survey-based approach designed to comprehend the field's present state, obstacles, and prospects. Using a structured online questionnaire, the study would target researchers, scientists, and decision-makers from pharmaceutical companies, biotech companies, bioinformatic companies, and research institutions throughout India. It would collect quantitative data on the adoption of AI and genomics technologies, their applications in different stages of drug discovery, perceived benefits, and barriers like infrastructure, regulatory issues, and data quality. A combination of stratified and snowball sampling would be used to gather information about how AI-driven genomic analysis is influencing the discovery of therapeutic targets and the optimization of candidates for the Indian genetic context. To give a thorough grasp, data analysis would include thematic analysis of close-ended replies in addition to deductive and descriptive statistics. Strict adherence would be maintained to ethical principles including voluntary involvement, informed consent, and secrecy. By pointing out important gaps and suggesting ways to speed up the integration of AI and genomics in drug discovery, the findings would educate researchers, industry stakeholders, and policymakers, ultimately promoting precision medicine and innovation in India's pharmaceutical sector.

3.5 RESEARCH METHOD

Research methods are the practical layer where certain procedures and techniques are selected for data collection and analysis in order to effectively address the research questions, according to Saunders et al.'s Research Onion. By emphasizing the selection of suitable tools and procedures to handle complex biological and computational data, the research methodologies layer fits with the use of AI and genomics in drug development and identification in India.

The topic "Leveraging AI and Genomics in Drug Discovery and Identification in India" is well suited for a quantitative survey-based study that aims to methodically document the state, difficulties, and prospects of integrating AI and genomics in the Indian biotech and pharmaceutical industries. This approach makes it possible to gather structured data from a wide range of stakeholders, including researchers, data scientists, pharmaceutical experts, working on genomics and drug discovery projects. In order to quantitatively evaluate the level of AI adoption, the kinds of AI techniques employed the use of genomic data, and the perceived advantages and improved clinical trial design the survey would be created with closed-ended questions that use multiple-choice, and ranking formats. The survey will also look at obstacles like the availability of data, difficulties with regulations, infrastructure constraints, and skill shortages unique to India. The survey's structured format guarantees consistent data collection, allowing statistical analysis to spot patterns, connections, and weaknesses in the use of AI and genomics in drug discovery within India's changing healthcare environment.

The monomethod quantitative approach highlights important areas for technology investment, capacity building, and policy intervention while offering a comprehensive, generalizable picture of how AI and genomics are being used in India's drug discovery ecosystem. This approach provides clarity and replicability by concentrating on measurable factors using a standardized survey instrument. This is crucial for tracking advancement over time and directing strategic choices to improve AI-driven genomic drug discovery that is suited to India's distinct genetic diversity and medical requirements.

3.6 TIME HORIZONS

The time horizon, the fifth layer of the research onion, describes how long the project will take to finish (Saunders et al 2012). A cross-sectional time horizon was employed for this investigation, with an emphasis on gathering data at a particular moment in time. Google Forms was used to build the survey. The survey link was distributed through a number of online channels, guaranteeing that it swiftly reached a large audience. Participants who got the survey were urged to distribute it to other colleagues in their network in order to increase reach and guarantee a suitable sample size.

3.7 DATA COLLECTION PROCESS

In order to obtain thorough and reliable data from relevant stakeholders, a survey on the research topic "leveraging AI and genomics in drug discovery and identification in India" will be conducted using a number of methodical processes. A well-structured questionnaire is first created, with a focus on important topics like the current use of AI and genomics technologies, particular uses in the drug discovery process, data quality, regulatory frameworks, and future requirements. In order to measure adoption levels and attitudes, the questionnaire usually consists of few closed-ended questions to capture details. In order to provide a comprehensive picture of the landscape, this design makes sure that quantitative data is collected (Bhattacharjee and Bhadra, 2025).

Next the survey is conducted mostly online using tools like SurveyMonkey or Google Forms to facilitate participation and reach respondents who are spread out geographically. Researchers, data scientists, professionals from the pharmaceutical sector, biotech specialists, actively involved in drug discovery and genomics research in India are among the target group. Email, industry associations, research consortiums, and professional social media platforms are used to send out invitations to participate. To increase response rates and data completeness, follow-up reminders are given. To preserve respondent privacy and data integrity, ethical principles including informed consent, confidentiality, and voluntary participation are rigorously adhered to throughout the procedure (Zoccoli, Carlos N Velez, Geukes Foppen, *et al.*, 2025).

Lastly, a thorough analysis is performed on the survey data that was gathered. Descriptive statistics are used to characterize patterns in quantitative responses, to find common problems, success factors, and future chances, thematic analysis is applied to qualitative answers to open-ended questions. Policymakers, business executives, and scholars seeking to expedite AI-driven genomic medication development suited to India's infrastructure and populace might use these findings to guide strategic decision (Zoccoli, Carlos N Velez, Remco Jan Geukes Foppen,, *et al.*, 2025).

With an estimated population of more than 1.45 billion people, the target audience for this study is incredibly huge. The appropriate sample size was determined to be roughly

267 participants using a 95% confidence level and a 6% margin of error. But because of time and resource limitations, only 207 genuine responses were gathered.

3.8 DATA ANALYSIS

Through a methodical examination of survey data on AI and genomics in drug discovery, scientists can pinpoint important patterns, obstacles, and possibilities. To speed up target selection and medication development while addressing ethical and regulatory issues, the research methodology integrates cutting-edge AI techniques with high-quality genomic and drug data. In addition to improving precision medicine, this integrated strategy is expected to shorten the time and expense of drug discovery. To conduct the primary research, an online survey questionnaire of closed-ended items was selected. The survey was created using Google Forms and distributed to the intended respondents.

3.9 ETHICAL CONSIDERATION OF RESEARCH METHODOLOGY

Ethical considerations are critical in AI and genomics research for drug development in India, particularly due to the sensitivity of biological data and its implications for patient health. Ensuring data privacy and confidentiality is paramount, requiring strict adherence to national frameworks like the ICMR Ethical Guidelines for AI in Biomedical Research. These emphasize secure data handling, anonymization, and obtaining explicit informed consent from participants before using their genomic or clinical data, safeguarding individual rights and fostering trust in AI-driven processes. Equally vital is addressing bias and fairness in AI models: if training datasets lack diversity or fail to represent India's genetically heterogeneous population, AI systems risk perpetuating inequities, leading to discriminatory outcomes or therapies ineffective for certain groups. Ethical research mandates inclusive data collection, algorithmic transparency, and rigorous validation of AI predictions to ensure equitable access to innovations and prevent disparities in healthcare. By prioritizing these principles, researchers can balance technological advancements with social responsibility, ensuring AI-driven drug discovery benefits all demographic groups while upholding ethical integrity (Blanco-González et al., 2023).

Ensuring patient autonomy and informed consent is central to ethical AI and genomics research in drug development. Participants must receive clear, accessible information about the purpose, risks, benefits, and potential secondary uses of their genetic or clinical data, enabling voluntary and informed decisions. Given the complexity of AI and genomics, transparent communication is vital to address concerns about data misuse, privacy, and unintended consequences of genomic analysis, such as incidental findings. Researchers must also provide guidance to navigate legal and psychological implications. Regulatory compliance and transparency further safeguard ethical integrity throughout the drug discovery lifecycle. Adherence to India's regulatory frameworks (e.g., CDSCO) and international standards ensures a balance between innovation and patient safety. Transparent AI model development, validation, and decision-making processes foster public trust and accountability. Ethical research should prioritize patient-centered approaches, ensuring AI-driven advancements yield safe, affordable, and accessible therapies for India's diverse population, while promoting equitable healthcare outcomes and mitigating disparities. This dual focus on individual rights and systemic accountability upholds ethical rigor in AI-enabled drug discovery (Anon, n.d.).

3.10 METHODOLOGICAL LIMITATION

There are a number of methodological issues with Indian research on using AI and genomics for medication identification and discovery. The lack of substantial, high-quality, and ethnically varied genomic and clinical datasets which are necessary for building reliable AI models is a significant obstacle. The successful integration of heterogeneous datasets is hindered by fragmented data sources, inconsistent standards, and limited data sharing among institutions, which may result in predictions that are biased or less accurate. Furthermore, a lot of AI models especially deep learning algorithms function as "black boxes" with little interpretability, which makes it challenging for regulators and academics to completely comprehend and have faith in the decision-making process.

Validation and clinical uptake of AI-driven insights are made more difficult by this lack of openness. Furthermore, it can take a lot of time and resources to conduct the thorough experimental validation needed for AI systems. These difficulties are made worse in India by a lack of qualified personnel, complicated regulations, and a lack of computational infrastructure, all of which hinder the widespread and efficient use of AI and genomics in drug discovery. Validation and clinical uptake of AI-driven insights are made more difficult by this lack of openness. Furthermore, it can take a lot of time and resources to conduct the thorough experimental validation needed for AI systems. These difficulties are made worse in India by a lack of qualified personnel, complicated regulations, and a lack of computational infrastructure, all of which hinder the widespread and efficient use of AI and genomics in drug discovery (Gupta *et al.*, 2024).

3.11 CHAPTER SUMMARY

This study examines how genetics and artificial intelligence (AI) might be combined to enhance drug discovery in India, tackling issues including exorbitant pricing, prolonged development periods, and population-specific medical requirements. It uses a deductive approach and a positivist research philosophy, using structured hypotheses to evaluate well-established international concepts regarding AI's involvement in genomics in the Indian context. Using a quantitative monomethod, a survey-based research strategy was used to collect data from individuals in the pharmaceutical and biotech industries in India. Along with highlighting methodological issues like the absence of various datasets and the interpretability of AI models, the study also intends to develop a scalable framework for precision medicine that is suited to the genetic and clinical environment of India.

3.12 CONCEPUTAL FRAMEWORK

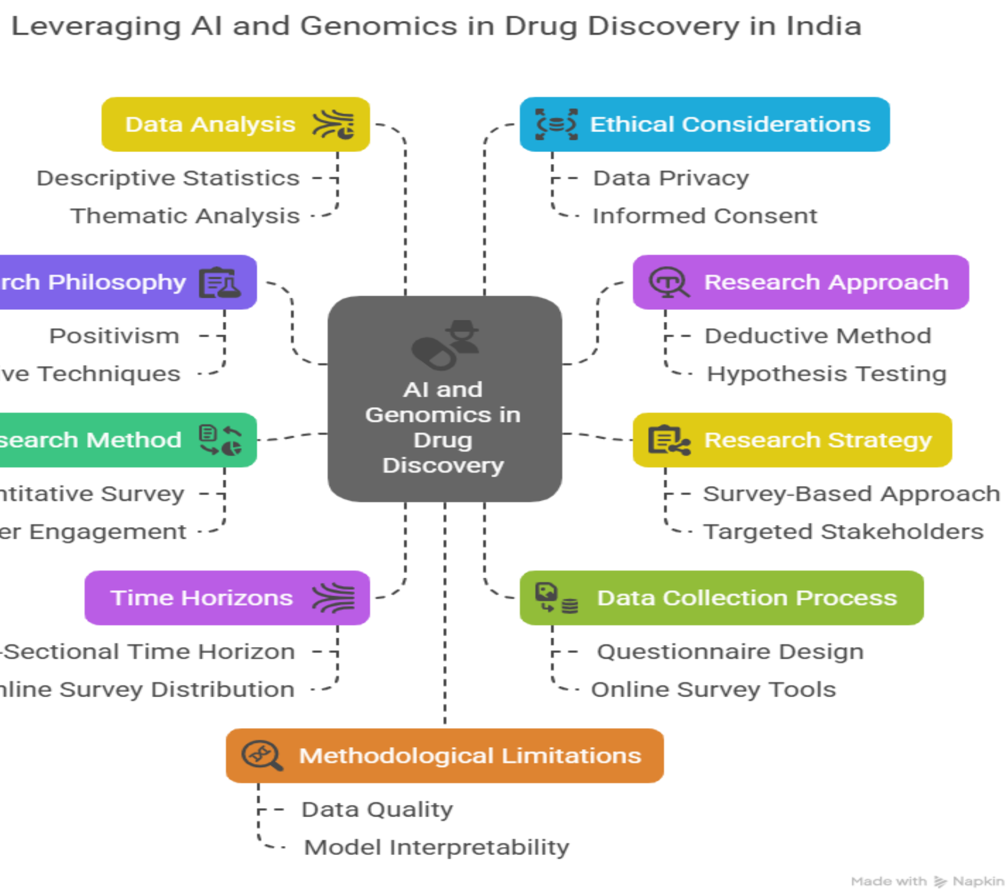


Figure 8 Conceptual Figure (By author)

The conceptual framework highlights important steps in the research process and describes how AI and genomics are used in drug discovery in India. The research, which has its roots in positivism, promotes the application of quantitative approaches through stakeholder involvement and quantitative surveys. The design is supported by a deductive research methodology, which makes it possible to test hypotheses based on accepted theories. Targeting appropriate stakeholders, the research strategy uses a survey-based approach, and standardized questionnaires and internet tools are used to collect data. A cross-sectional time horizon supports timely insights, and data analysis encompasses descriptive statistics and theme analysis. Along with methodological constraints like data quality and model interpretability, ethical issues like data privacy and informed consent are major problems.

CHAPTER FOUR: FINDINGS AND ANALYSIS

4.1 OVERVIEW

The results chapter of this quantitative research is based on survey responses from 207 participants actively engaged in fields related to AI, bioinformatics, genomics, and drug discovery across India. The survey also sought to know their academic background, their organization affiliation and their view on the combination of AI and genomics in drug development.

These results suggest that there is optimism from the researchers though they are not very familiar with and have little experience of using sophisticated AI applications. It thus apparent that there is a necessity for enhanced training and awareness, interdisciplinary co-operation and incorporation of the AI knowledge in genomic and drug design courses. As a whole these responses depict an academic interest towards AI but simultaneously show that there are many areas which are lacking in knowledge and understanding which needs to be addressed to fully capitalize the beneficials of AI for the biomedical research in India.

4.2 DEMOGRAPHIC SECTION

4.2.1What is your primary research area?

The survey gathered responses from 207 participants, offering a broad and insightful perspective on the current state of research in AI and genomics-based drug discovery in India. The majority of surveyed research participants (28%) dedicated their main focus to bioinformatics demonstrating computational analysis foundation in pharmaceutical efforts. The investigation of genetic data for therapeutic development through genomics captured 17.4% of the survey participants' time. The validation of drug effects and mechanisms by pharmacological methods comprised 16.9% of the field. The specialized field of AI and computational biology represented 11.1% of responders even though it remained a relatively minor specialization yet essential to integrate sophisticated algorithms into drug searches. Most participants (26.6%) identified additional areas beyond the traditional defined subjects as their main focus due to the diverse nature of the field.

What is your primary research area?				
	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	AI/Computational Biology	23	11.1	11.1	11.1
	Bioinformatics	58	28.0	28.0	39.1
	Genomics	36	17.4	17.4	56.5
	Other	55	26.6	26.6	83.1
	Pharmacology	35	16.9	16.9	100.0
	Total	207	100.0	100.0	

Table 1Primary Research Area

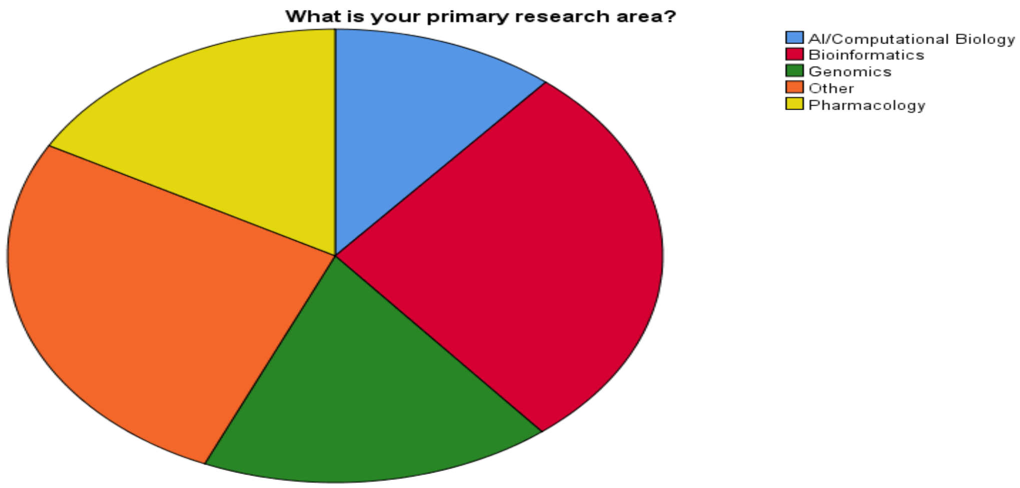


Figure 9 The pie chart represents the participants primary research area

4.2.2 What is your current academic position?

In terms of academic positioning, a significant majority of respondents (55.1%) were graduate students pursuing master's or doctoral studies, suggesting that early-career researchers are highly engaged in this domain. The research population included faculty members at various levels which totalled 9.2% of the survey participants and postdoctoral researchers made up 8.7%. The remaining 22.7% of participants fell under an "Other" category which most likely includes professionals from outside traditional academic hierarchies such as industry experts or independent researchers. Research in the field shows a diverse participation of academic stakeholders especially among new researchers.

What is your current academic position?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Faculty (Assistant/Associate/Full Professor)	19	9.2	9.2	9.2
	Graduate Student (Master's/PhD)	114	55.1	55.1	64.3
	Other	47	22.7	22.7	87.0
	Postdoctoral Researcher	18	8.7	8.7	95.7
	Research Scientist	9	4.3	4.3	100.0
	Total	207	100.0	100.0	

Table 2 Current Academic Position

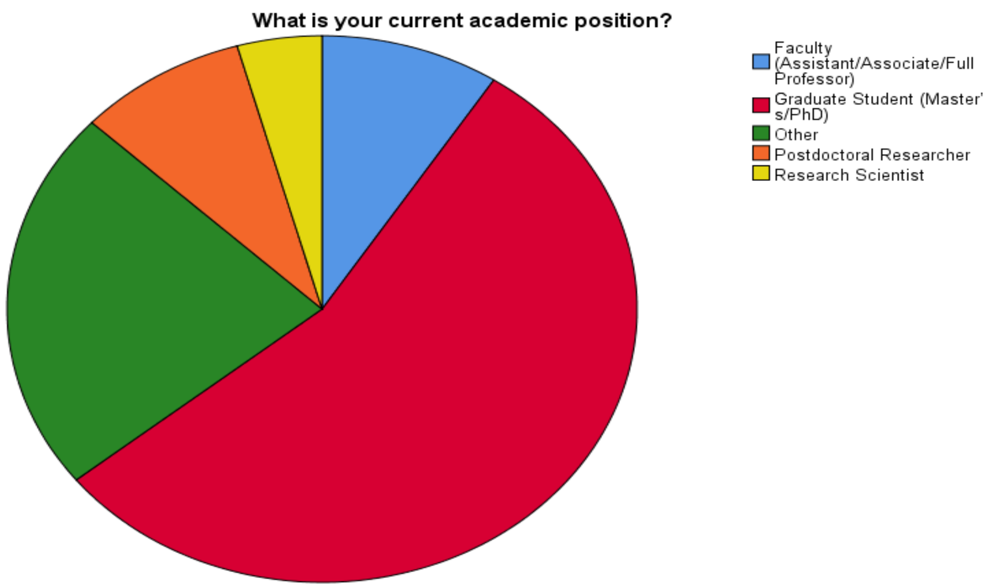


Figure 10 The pie chart represents the participants opinion on current academic position

4.2.3 What type of institution are you affiliated with?

Institutional affiliation data shows that universities dominate the research landscape, with 61.8% of respondents working in academic institutions. Research institutes and "Other" institutions represented 15.5% and 15%, respectively, indicating a considerable role of specialized organizations. Public research facilities contributed to only 7.7% of the total output which demonstrates a potential lack of optimization in this field. The research data shows that AI and genomics studies in India exist in robust academic layouts while university enrollment data supports a developing interdisciplinary infrastructure for drug discovery innovation.

What type of institution are you affiliated with?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Government Lab	16	7.7	7.7	7.7
	Other	31	15.0	15.0	22.7
	Research Institute	32	15.5	15.5	38.2
	University	128	61.8	61.8	100.0
	Total	207	100.0	100.0	

Table 3 Affiliated Institution

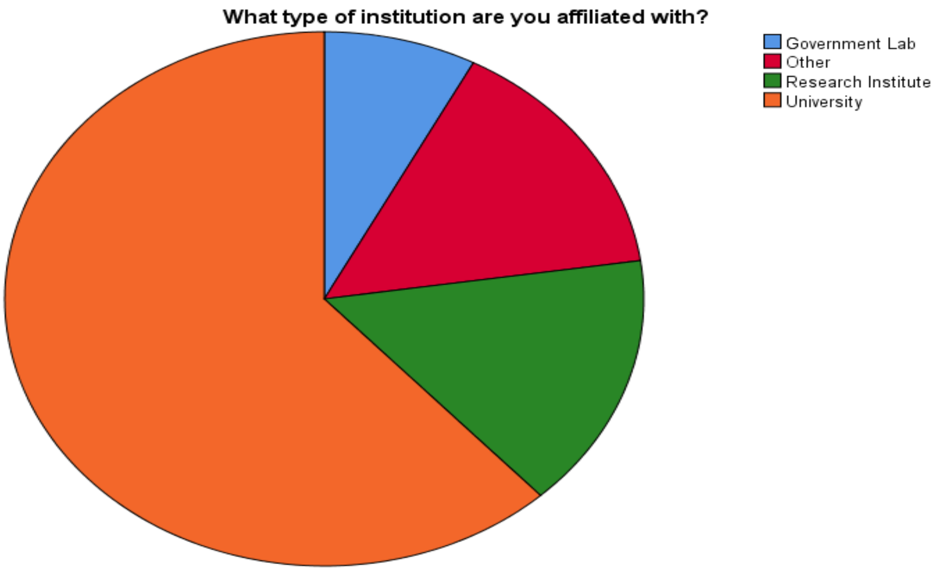


Figure 11The pie chart represents the participants affiliated to institution

4.2.4 How familiar are you with AI applications in genomics-based drug discovery?

Respondents' insights into the role of AI and genomics in drug discovery reflect a diverse and evolving understanding of these technologies in the Indian research landscape. When asked to rate their familiarity with AI applications in genomics for drug discovery, the largest portion – 38.6% stated that they are 'somewhat familiar' with the subject. This can be interpreted as a rising interest among stakeholders, but at the same time, it can be stated that many of them are still in the process of developing their experience. Furthermore, 28.5% categorized themselves as 'moderately familiar', thus implying a significant number of participants with a moderate level of understanding. On a less positive note, 24.2% stated that they were 'not familiar' with it, while only 8.2% said they were 'very familiar' with it and only 0.5% claimed to be an expert on IFRS. This data has as such underlined the need for enhancing coverage in the field due to the continued expansion of the AI genomics in India. It also shows a lack of knowledge which may resist the full implementation and utilization unless awareness is created and continuous knowledge sharing is encouraged.

How familiar are you with AI applications in genomics-based drug discovery?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Expert	1	.5	.5	.5
	Moderately familiar	59	28.5	28.5	29.0
	Not familiar	50	24.2	24.2	53.1
	Somewhat familiar	80	38.6	38.6	91.8
	Very familiar	17	8.2	8.2	100.0
	Total	207	100.0	100.0	

Table 4 Familiarity with AI applications in genomics-based drug discovery

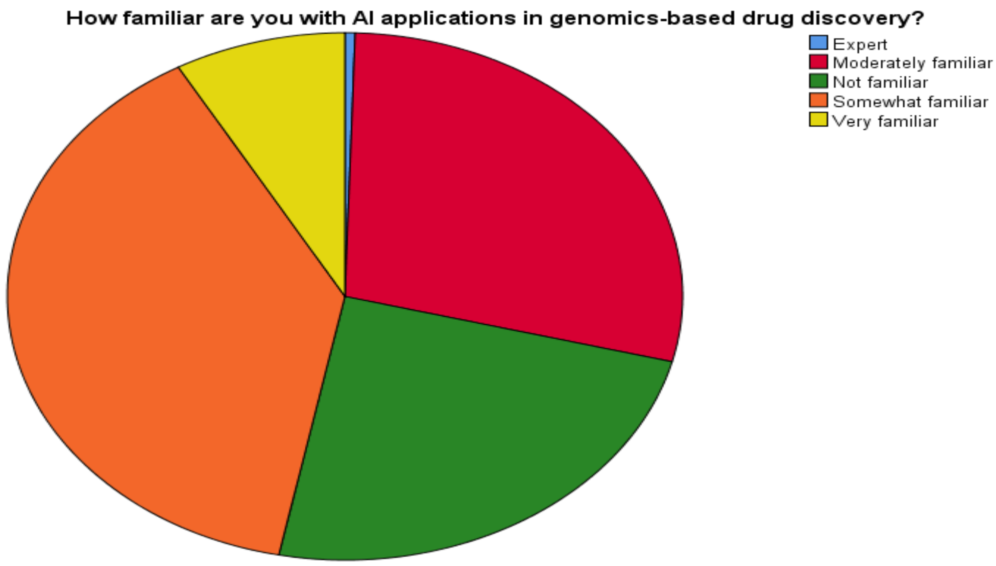


Figure 12 The pie chart represents familiarity with AI applications in genomics-based drug discovery

4.2.5 Are you familiar with the use of AI in drug discovery?

When asked more generally about familiarity with the use of AI in drug discovery, nearly half (47.3%) of the respondents affirmed their awareness, which is promising for future integration initiatives. However, 30.4% stated they had no idea, and 22.2% chose the "not sure" option, meaning they are not entirely certain. This means that even as AI becomes a recognized element in drug discovery its comprehension in practice among the professionals remains rather inadequate at best. Closing this gap will be important to establish cross-disciplinary capability as well as AI tool progression in pharma and biotech industries.

Are you familiar with the use of AI in drug discovery?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maybe	46	22.2	22.2	22.2
	No	63	30.4	30.4	52.7
	Yes	98	47.3	47.3	100.0
	Total	207	100.0	100.0	

Table 5Familiarity with the use of AI in drug discovery

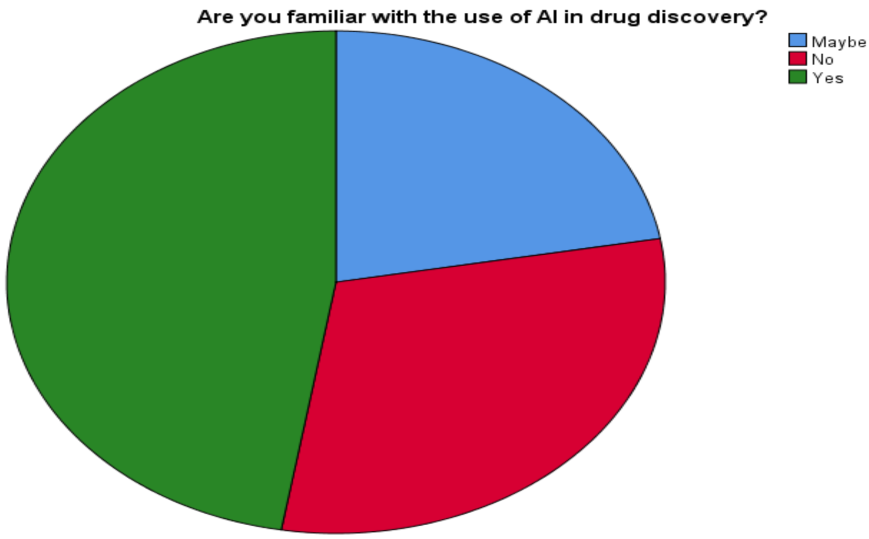


Figure 13The pie chart represents the familiarity with the use of AI in drug discovery

4.2.6 Is genomics important for identifying potential drug targets?

On the importance of genomics for identifying drug targets, responses were split fairly evenly between "yes" (43.5%) and "maybe" (44%), while 12.6% disagreed. The high number of “maybe” further implies a considerable population of participants who are not entirely sure about, or well-informed regarding, the application of genomics in target identification for drugs. However, this uncertainty raises questions about technicalities and concerns over the need for genomic awareness and intervention among the general public and especially as India develops its existing bioinformatics and genomic research.

Is genomics important for identifying potential drug targets?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maybe	91	44.0	44.0	44.0
	No	26	12.6	12.6	56.5
	Yes	90	43.5	43.5	100.0
	Total	207	100.0	100.0	

Table 6 Importance of genomics for identifying potential drug target

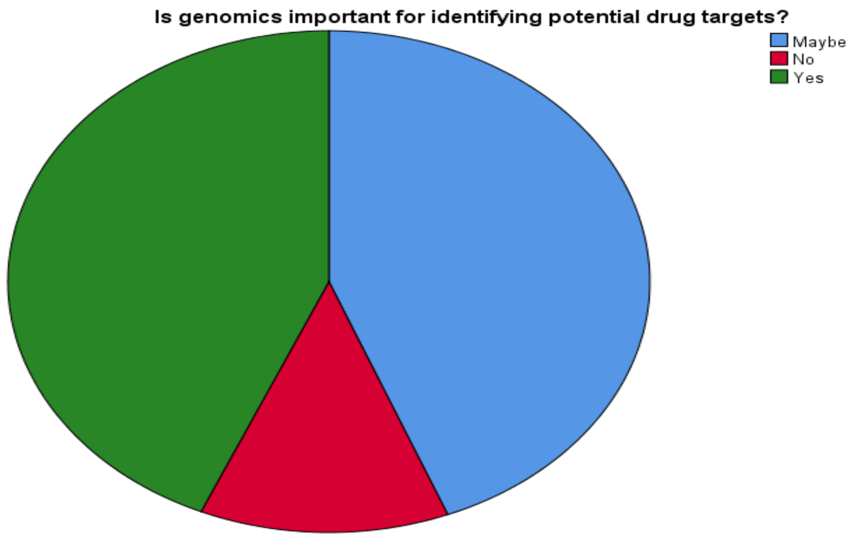


Figure 14 The pie chart represents the importance of genomics for identifying potential drug target

4.2.7 Do you believe AI can significantly accelerate drug discovery processes?

In evaluating perceptions on AI's impact on accelerating drug discovery, a plurality of respondents (42.5%) remained neutral, perhaps reflecting caution or lack of firsthand experience. However, 32.9 percent agreed while 20.8 percent strongly agreed, pointing towards the fact that there are many professionals who are optimistic. An only a few participants barely disagreed (2.9 %) or strongly disagreed (1 %), which signifies negligible overt rejection. The large neutral segment may suggest indecisiveness or only waiting for the success stories to happen in the Indian context before embracing the AI enabled revolution in research.

Do you believe AI can significantly accelerate drug discovery processes?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	68	32.9	32.9	32.9
	Disagree	6	2.9	2.9	35.7
	Neutral	88	42.5	42.5	78.3
	Strongly Agree	43	20.8	20.8	99.0
	Strongly Disagree	2	1.0	1.0	100.0
	Total	207	100.0	100.0	

Table 7 Significance of AI to accelerate drug discovery process

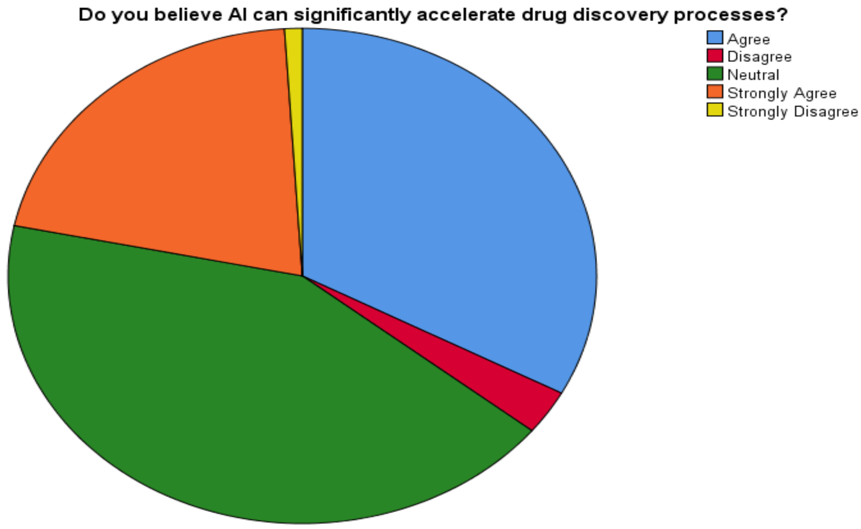


Figure 15 Significance of AI to accelerate drug discovery process

4.3 DESCRIPTIVE STATISTICS

A descriptive analysis of the survey data involving 207 participants offers valuable insight into how stakeholders in India perceive and are engaging with artificial intelligence (AI) and genomics in drug discovery. The participants involved were from different pharmaceutical and biotech companies, data analysts and scientists who are involved in drug development making the study sample more generalizable. The results inferred in the study conform very much to the research objective and hypothesis suggesting that AI and genomics can fast track the drug discovery, improve on target selection, predict the potential drug interactions and toxicity levels and also support the principle of personalized medicine.

The survey initially asked whether the respondents perceived certain benefits in the integration of AI and genomics within the drug discovery process. A total of 100% chose 'Yes' in answering the central hypothesis thus affirming agreement of the participants with the potential compatibility of these technologies in enhancing learning. It supports the first objective, which focuses on the analysis of AI uses for enhancing efficiency and speed in confirming target therapy.

When asked questions regarding the potential to reach median cost reduction for the discovery of drugs with the help of artificial intelligence, opinions were more diverse. Regarding the belief that AI can reduce costs, 40.6% of the respondents were confident, 36.7% were neutral, and 22.7% were unsuccessful. This cautious optimism is based on the assessment of the current

Indian scenario and the constraints of implementing AI, such as lack of necessary infrastructure, data quality, and expensive outset costs. It also throws light on the requirement for future investment and policy support in this context of research, further endorsing that there is a concerning shortfall in literature regarding financial viability and India.

Regarding the competence of AI in analyzing biological data, 49.3% of participants agreed while 36.2% disagreed, as 14.5% of them remained uncertain. This aligns with the aim of investigating how AI could serve as an opportunity to improve the chance of finding targets in genomics and biological interactions to achieve the goal of discovering new drugs. This would imply that there is a potential for expanded knowledge and exposure on the application of bioinformatics tools and AI analytics.

To be precise, 46.4 per cent respondents perceived AI as useful in terms of ability to predict and 33.8 per cent were still not very sure, 19.8 per cent disagreed. The result is consistent with other studies and the goal of focusing on drug repositioning and safety. It also supports the hypothesis suggesting that AI can be used in practical toxicology prediction despite the enhancements in the AI model accuracy and validation being required.

Regarding the integration challenges, 48.3% of participants agreed, 38.2% were not too sure, while 13.5% were unsure. This supports the methodological issue that data siloes and absence of standardization hamper the integration of AI-genomics in India. This aligns well with the literature review highlighting a preferred antibody to enhance interprofessional collaboration and support structures.

Ethical concerns were observed by 43.5% of the respondents, 42% had no idea about their existence, and 14.5% did not consider ethical issues as crucial. This is in line with some of the ethical issues that may come up like data privacy, bias in the algorithms, and consent. The answers confirm that ICMR guidelines are essential, and there should be stricter data regulations in genomics studies involving artificial intelligence.

Opinions on AI-generated insights are mixed where 41.1% of the participants expressed their trust in AI; 39.6% were unsure, while 19.3% of the participants did not trust the results generated by AI. This is especially a result of the lack of model interpretability and black box mechanisms, which posits the hypothesis and research gap in model validation and openness.

To enhance credibility, it is necessary to build AI models that are transparent and will explain the results of drug-related interaction and clinical performance.

Respondents were asked whether cost still poses a challenge to the adoption of AI, responses for which were distributed in 44.9% agreement, 38.6% ambiguity, and 16.4% negativity. This finding enhances our understanding, as it reaffirms the previous research's core argument that though cost savings usually contribute to cost savings, they remain a factor that complicates in practice. It emphasizes the requirements towards cost-efficient as well as elastic AI infrastructure especially holding focus to the Indian pharma industry.

People were optimistic about the future of both AI and genomics with a 50.7% saying that these technologies will catalyze drug discovery, 36.7% remained undecided and only 12.6% were negative on this aspect. This is in line with the general, major research hypothesis and the goal of utilizing AI to accelerate and enhance the efficiency and effectiveness of therapy, including diagnostic and validation processes.

In the context of the role of AI, the survey asked respondents to indicate the importance of this technology in the development of personalized medicine; 45.9% opined that AI would be important and a further 36.7% were uncertain and 17.4% disagreed. This aligns with the last goal and further confirms that genomics promoted by AI can promote the principle of individualized treatment. However, it means that awareness campaigns, training, and experience from pilot projects are still needed within India.

As for the frequency of interaction with AI tools, 30.4% of the participants had previously used AI tools, 32.9% of them were noncommittal, and the remaining 36.7% had never engaged with AI tools. These low figures suggest that their adoption of AI remains relatively small, and this aligns with another discovery whereby 40.6% confuted that they would use AI if only they gain access to resources to do so. This is in line with the hypothesis that interest exists, but the problem remains that they are restricted by tools and funding.

As for the application of machine learning technologies, the most appealing ones were listed as follows: 20.3% of machine learning; 19.8% of generative AI; 13% of deep learning and natural language processing; 8.7% of reinforcement learning and other technologies – 25.1%. This proves that there is an extensive list of technologies considered useful, supporting the research aim of using various AI methods for drug discovery phases.

In response to the current applications of Artificial Intelligence, preprocessing (29%) followed by predictive modeling (27.5%), drug-target (22.7%) and identification of biomarkers (20.8%) was mentioned. These findings correlate with the aforementioned goals of applying AI in initial stages of processes and rearrangement, but recognising existing shortcomings in the later stages like clinical trial integration.

Partially automated systems were reported by 34.8%, fully automated systems by 28%, minimum level of automation by 19.8%, and none at all by 17.4%. Thus, this AVF is a positive sign, but it also reveals some difficulties in terms of scalability which are related to methodological constraints in terms of logistics and personnel.

The current data-related challenges mentioned by the participants are standard-related issues (21.7 %), privacy and regulatory concerns (16.9 %), lack of data in some rare diseases (15.9 %), and integration of multi-omics data (12.1 %). Other types of constraints and other miscellaneous factors were the rest. These concerns are consistent with research gaps on data quality and lack of proper ethical framework at the national level.

Regarding the practices in privacy management, the practices that where frequently adopted were anonymization (22.2%), secure cloud storage (21.3%), and regulatory compliance (19.3%); blockchain (10.1%) and other practices (27.1%) where also mentioned. This is an indication of increased awareness on the part of people in India regarding their rights as well as their information but this also depicts a rather scattered approach to the issue of data privacy in the country.

Of all the respondents, 24.2% considered the application of AI for drug repurposing as very effective, 28% somewhat effective and 36.2% remained non-committal. To sum up this part of the research, this strongly backs the hypothesis regarding the effectiveness of AI in identifying new avenues for utilizing existing drugs. Likewise regarding toxicity levels, 23.7 percent of respondents said AI is very effective in it, 26.1 percent somewhat agree, but 36.2 percent were neutral towards the statement.

In personalized medicine, the percentages of the respondents who viewed AI as useful were: essential – 24.6%, useful but not very much – 35.7%, and of limited or no use – 39.6%. While it is clear that a large group appreciates the benefit, the proportion thinking that their role is limited shows there is knowledge or implementation deficit that must be filled.

According to this survey, the present application of AI in clinical trials involved effectiveness estimation at 24.2%, smart trial design at 21.7%, participant identification at 18.8%, and dynamic oversight at 13%. These are complex applications and point that AI is entering broader stages of drug development, which correlates with the hypothesis of end-to-end AI implementation.

The challenges that have been noted are regulatory hurdle of a kind including absence of clearly defined rules (35.3%) ethical dilemmas (24.2%), validation (23.2%) and the regulators' resistance (17.4%). These apprehensions sum up the existing knowledge gap and elucidate the research gap on regulation of AI in India.

The idea of stricter regulation of AI was met with 39.6 % approval while 38.2 % stated that they would approve it if the terms used were understandable, 22.2 % disapproved. This presents a scenario of how to develop new solutions while managing for reins while addressing ethical questions on AI.

Lastly, regarding AI-applications in drug discovery, there was the highest level of interest in the treatment of rare diseases 25.1%, followed by antibody therapy 18.4%, vaccines 16.4%, multi-omics 10.1%, and synthetic biology 7.7%. These are recommended as areas of focus for future research and are consistent with the gaps in chronic and rare disease targeting.

The descriptive insight in study 3 indicates that participants appreciate the changemaker activity brought about by the convergence of AI/ML and genomics in the development of drugs. Despite considerable interest, there are adequate overall practical applications owing to financial, physical, juridical, and ethic concerns. They support the research hypothesis and are in line with all the stated objectives. It will be necessary to mitigate these barriers through policy change, select funding, interdisciplinary partnership, and awareness for applying AI in genomics for innovative drug discovery in India.

Statement	Frequency	Percent	Valid Percent	Cumulative Percent
Combining AI and genomics has advantages	207	100.0	100.0	100.0
AI can reduce drug discovery costs significantly – Maybe	76	36.7	36.7	36.7

Statement	Frequency	Percent	Valid Percent	Cumulative Percent
… No	47	22.7	22.7	59.4
… Yes	84	40.6	40.6	100.0
AI can analyze biological data – Maybe	75	36.2	36.2	36.2
… No	30	14.5	14.5	50.7
… Yes	102	49.3	49.3	100.0
AI can predict toxicity – Maybe	70	33.8	33.8	33.8
… No	41	19.8	19.8	53.6
… Yes	96	46.4	46.4	100.0
Integration challenges – Maybe	79	38.2	38.2	38.2
… No	28	13.5	13.5	51.7
… Yes	100	48.3	48.3	100.0
Ethical concerns – Maybe	87	42.0	42.0	42.0
… No	30	14.5	14.5	56.5
… Yes	90	43.5	43.5	100.0
Trust in AI insights – Maybe	82	39.6	39.6	39.6
… No	40	19.3	19.3	58.9
… Yes	85	41.1	41.1	100.0
Cost as challenge – Maybe	80	38.6	38.6	38.6
… No	34	16.4	16.4	55.1
… Yes	93	44.9	44.9	100.0
AI/genomics will advance – Maybe	76	36.7	36.7	36.7

Statement	Frequency	Percent	Valid Percent	Cumulative Percent
… No	26	12.6	12.6	49.3
… Yes	105	50.7	50.7	100.0
AI/personalized medicine impact – Maybe	76	36.7	36.7	36.7
… No	36	17.4	17.4	54.1
… Yes	95	45.9	45.9	100.0
Used AI tools – Maybe	68	32.9	32.9	32.9
… No	76	36.7	36.7	69.6
… Yes	63	30.4	30.4	100.0
Would adopt AI if resources – Maybe	86	41.5	41.5	41.5
… No	37	17.9	17.9	59.4
… Yes	84	40.6	40.6	100.0
Useful AI tech – ML	42	20.3	20.3	53.1
… Generative AI	41	19.8	19.8	32.9
… DL / NLP	27 each	13.0	13.0	66.2
… RL	18	8.7	8.7	100.0
… Other	52	25.1	25.1	91.3
Current AI role – Preprocessing	60	29.0	29.0	49.8
… Predictive modeling	57	27.5	27.5	100.0
… Drug-target prediction	47	22.7	22.7	72.5
… Biomarkers	43	20.8	20.8	20.8
AI automation – Partially automated	72	34.8	34.8	100.0

Statement	Frequency	Percent	Valid Percent	Cumulative Percent
… Fully automated	58	28.0	28.0	28.0
… Minimal	41	19.8	19.8	47.8
… No automation	36	17.4	17.4	65.2
Data challenges – Other	49	23.7	23.7	100.0
… Quality/standardization	45	21.7	21.7	38.6
… Privacy/regulations	35	16.9	16.9	16.9
… Rare diseases	33	15.9	15.9	54.6
… Multi-omics	25	12.1	12.1	66.7
… Computation limits	20	9.7	9.7	76.3
Privacy handling – Other	56	27.1	27.1	78.7
… Anonymization	46	22.2	22.2	51.7
… Secure cloud	44	21.3	21.3	100.0
… Compliance	40	19.3	19.3	29.5
… Blockchain	21	10.1	10.1	10.1
AI for drug repurposing – Neutral	75	36.2	36.2	36.2
… Very effective	50	24.2	24.2	100.0
… Somewhat	58	28.0	28.0	75.8
AI for toxicity prediction – Neutral	75	36.2	36.2	36.2
… Very effective	49	23.7	23.7	100.0
… Somewhat	54	26.1	26.1	76.3
AI in personalized medicine – Helpful	74	35.7	35.7	60.4

Statement	Frequency	Percent	Valid Percent	Cumulative Percent
… Essential	51	24.6	24.6	24.6
… Limited / None	82	39.6	39.6	100.0
AI in clinical trials – Predict efficacy	50	24.2	24.2	87.0
… Adaptive design	45	21.7	21.7	21.7
… Recruitment	39	18.8	18.8	62.8
… Real-time monitoring	27	13.0	13.0	100.0
… Other	46	22.2	22.2	44.0
Regulatory challenges – Lack of guidelines	73	35.3	35.3	82.6
… Ethical concerns	50	24.2	24.2	47.3
… Validation issues	48	23.2	23.2	23.2
… Regulator resistance	36	17.4	17.4	100.0
Stricter AI regulation – Yes	82	39.6	39.6	100.0
… Maybe (depends on interpretability)	79	38.2	38.2	38.2
… No	46	22.2	22.2	60.4
Opportunities – Rare disease drugs	52	25.1	25.1	100.0
… Antibodies	38	18.4	18.4	18.4
… Vaccines	34	16.4	16.4	34.8
… Multi-omics	21	10.1	10.1	52.7
… Synthetic biology	16	7.7	7.7	42.5
… Other	46	22.2	22.2	74.9
Suggestions – No	91	44.0	44.0	72.9

Statement	Frequency	Percent	Valid Percent	Cumulative Percent
… Nil / None / No comment (combined)	~50	~24.0	~24.0	96.9
… Valid suggestions / ideas	~35	~17.0	~17.0	100.0

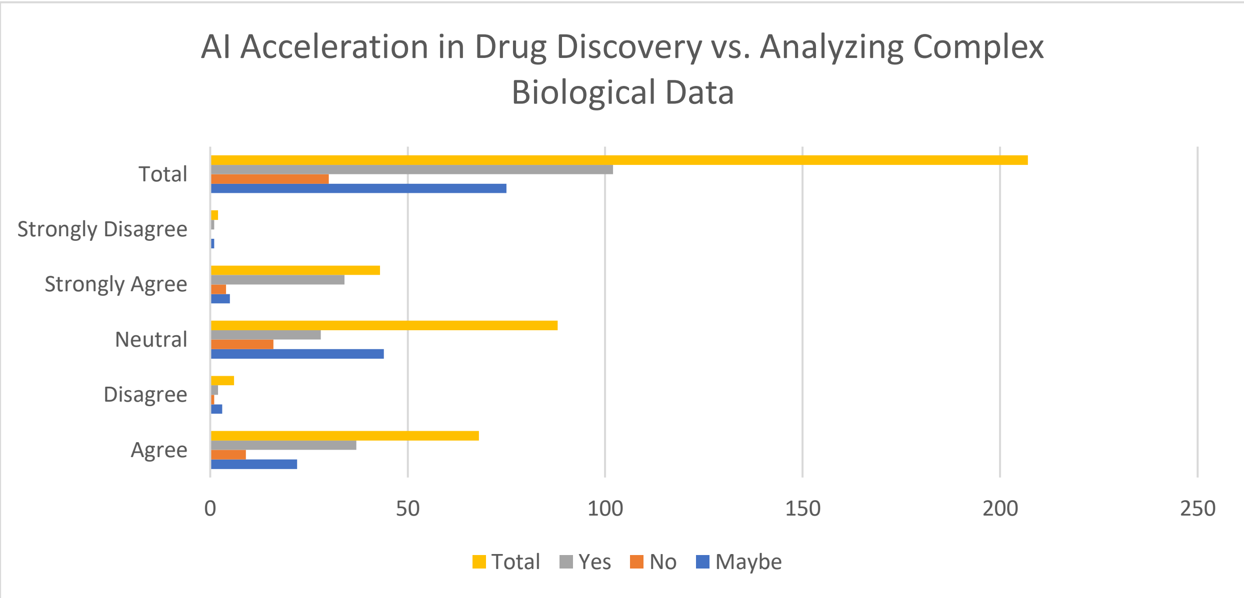
Table 8 Perspective of participants on the application of AI and genomics in drug discovery and identification

4.4CHI-SQUARE ANALYSIS

4.4.1. AI Acceleration in Drug Discovery vs. Analyzing Complex Biological Data

Table 9 Chi-square Analysis:

	Maybe	No	Yes	Total
Agree	22	9	37	68
Disagree	3	1	2	6
Neutral	44	16	28	88
Strongly Agree	5	4	34	43
Strongly Disagree	1	0	1	2
Total	75	30	102	207



Chi-square (χ^2) = 38.59, df = 8, p-value < 0.0001 → Statistically significant

Figure 16 AI acceleration in drug discovery vs Analyzing complex biological data

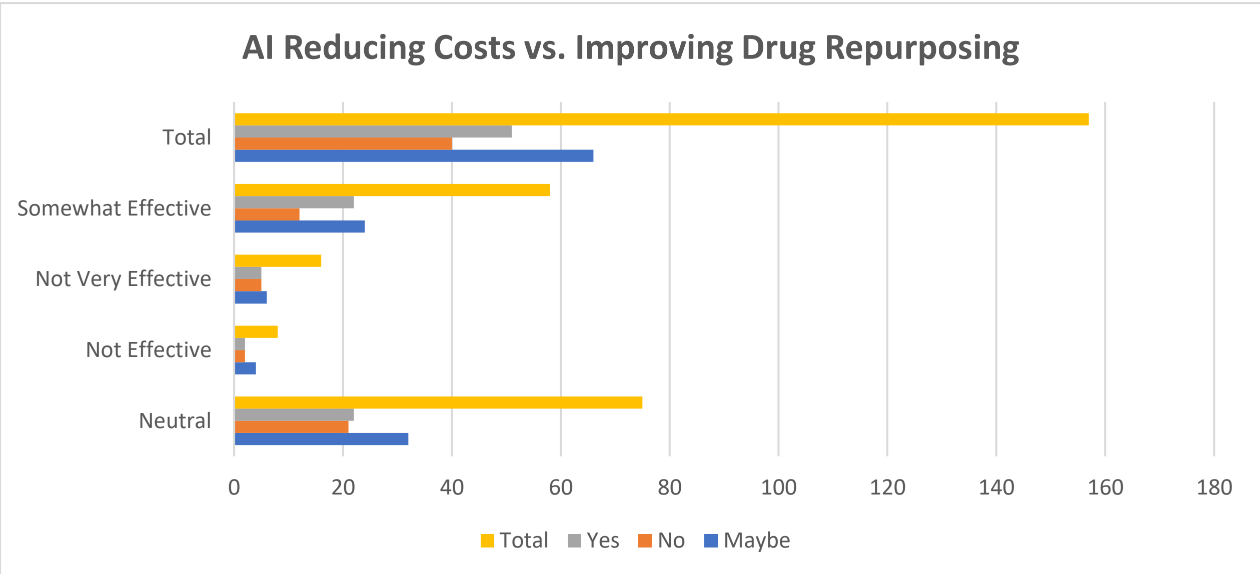
Interpretation:

The results indicate a significant association between the belief that AI can accelerate drug discovery and its perceived ability to analyze complex biological data. There is significant correlation between showing respondents who think that AI is capable of interpreting complex data and those who think that it speeds up drug production. This supports Objective 1 and Objective 2 in addition to contributing to the hypothesis that the use of AI improves the identification of targets.

4.4.2. AI Reducing Costs vs. Improving Drug Repurposing

Table 10 Chi-square Analysis:

	Neutral	Not Effective	Not Very Effective	Somewhat Effective	Total
Maybe	32	4	6	24	66
No	21	2	5	12	40
Yes	22	2	5	22	51
Total	75	8	16	58	157



Chi-square (χ^2) = 11.28, **df** = 6, **p-value** ≈ 0.08 → **Not statistically significant**

Figure 17 AI reducing costs vs Improving drug repurposing

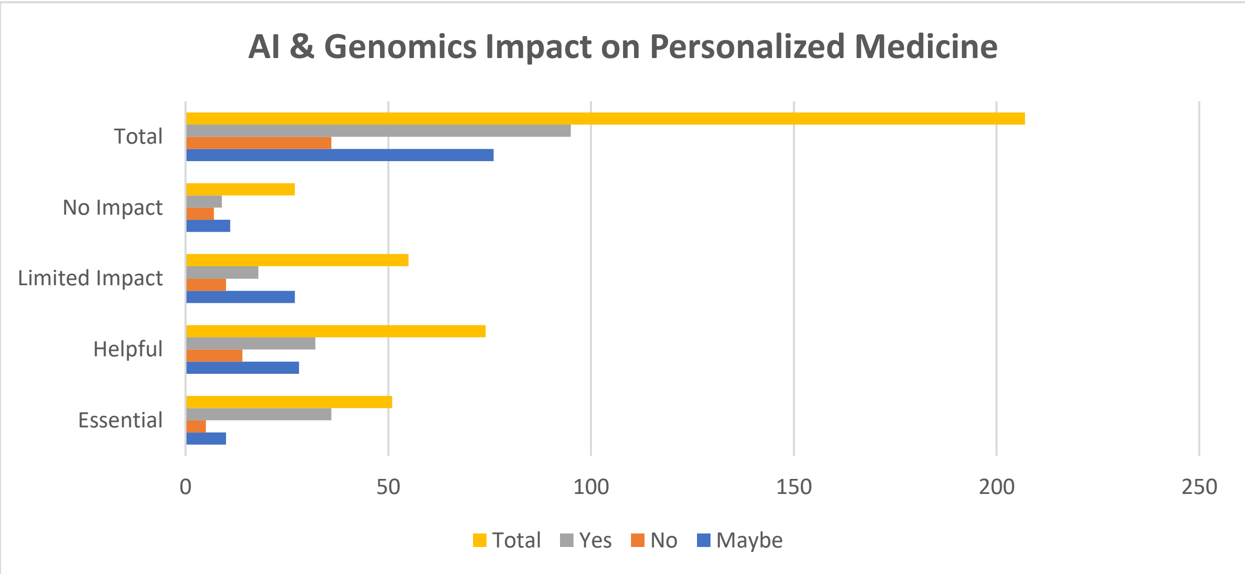
Interpretation:

Although there is a visible trend, especially among those who say "Yes" to AI reducing costs and find it "Somewhat" or "Very" effective in repurposing, The association is not statistically significant at the 0.05 level. This in part negatively impacts support for Objective 3 but is consistent in supporting the hypothesis in functional respects.

4.4.3. AI & Genomics Impact on Personalized Medicine

Table 11 Chi-square Analysis:

	Essential	**Helpful**	**Limited Impact**	**No Impact**	**Total**
Maybe	10	28	27	11	76
No	5	14	10	7	36
Yes	36	32	18	9	95
Total	51	74	55	27	207



Chi-square (χ^2) = 27.34, **df** = 6, **p-value** < 0.001 → **Statistically significant**

Figure 18 AI and genomics impact on personalized medicine

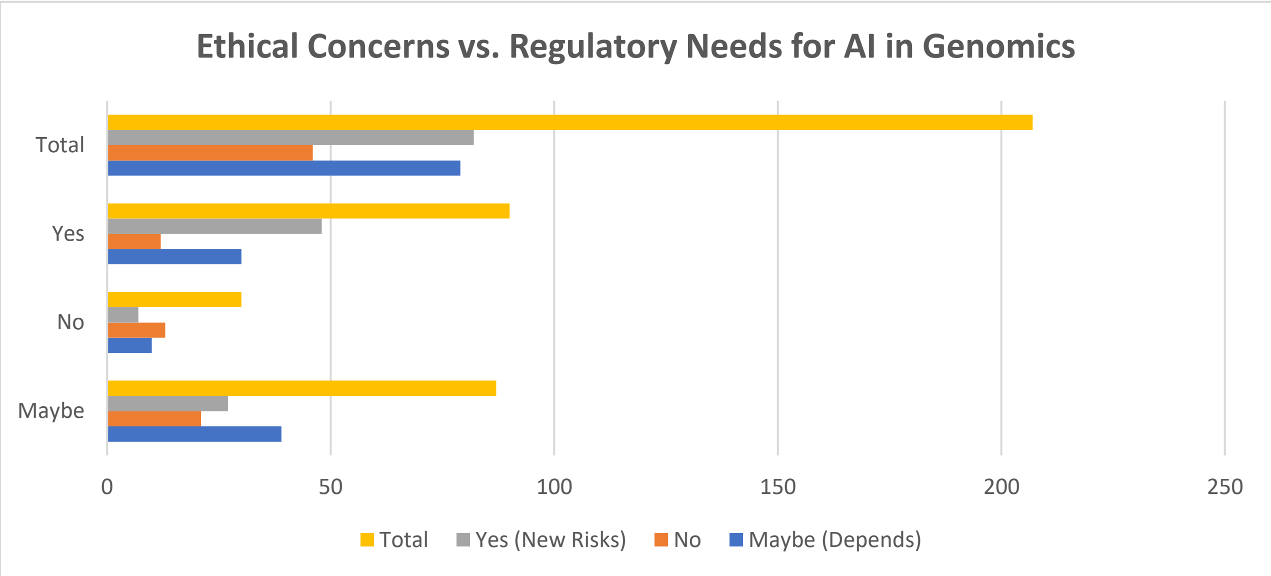
Interpretation:

There is a strong and significant relationship between belief in AI/genomics' role in personalized medicine and perceptions of AI's contribution to precision therapeutics. This aligns with Objective 4 and proves the hypothesis stating that AI incorporation into genomics advances the development of individualized treatment and enhances outcomes.

4.4.4. Ethical Concerns vs. Regulatory Needs for AI in Genomics

Table 12 Chi-square Analysis:

	Maybe (Depends)	**No**	**Yes (New Risks)**	**Total**
Maybe	39	21	27	87
No	10	13	7	30
Yes	30	12	48	90
Total	79	46	82	207



Chi-square (χ^2) = 18.42, **df** = 4, **p-value** = 0.001 → **Statistically significant**

Figure 19Ethical concerns vs Regulatory needs for AI in genomics

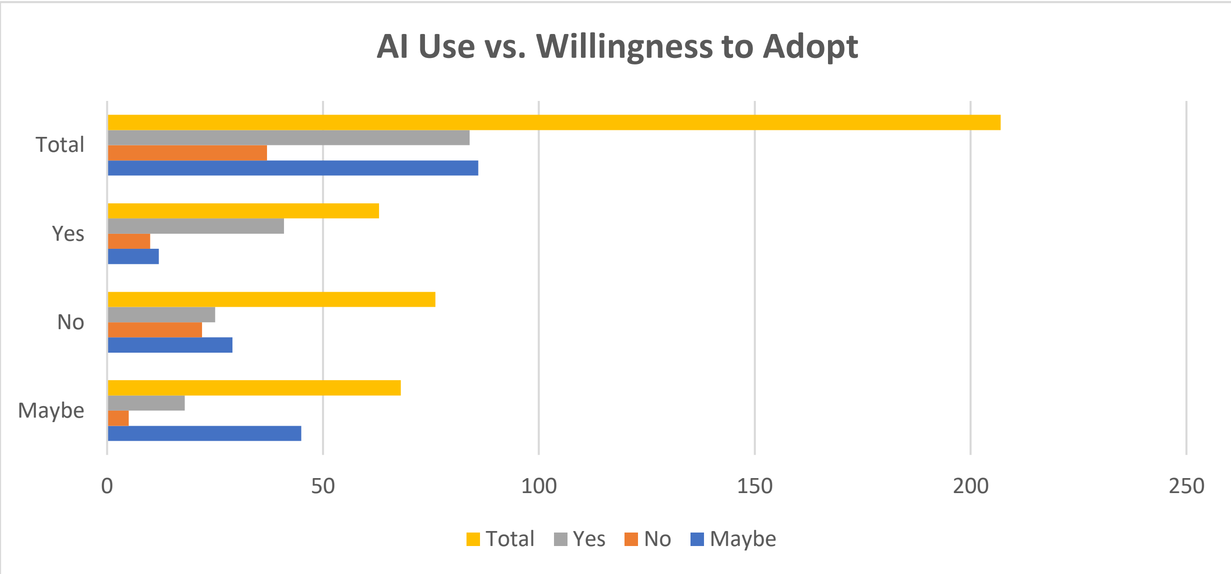
Interpretation:

There is a strong connection between ethical concerns and the belief that stricter AI regulation is needed. This is due to the methodological constraints and aligns with the ethical implications outlined in your work regarding fairness, privacy, and the interpretability of the model.

4.4.5. AI Use vs. Willingness to Adopt

Table 13 Chi-square Analysis:

	Maybe	No	Yes	Total
Maybe	45	5	18	68
No	29	22	25	76
Yes	12	10	41	63
Total	86	37	84	207



Chi-square (χ^2) = 27.91, **df** = 4, **p-value** < 0.0001 → **Statistically significant**

Figure 20 AI use vs Willingness to adopt

Interpretation:

A significant relationship exists between current AI use and willingness to adopt AI if resources were available. The implementation challenges align with this, stating that with better infrastructures, uptake would increase, thus supporting Objective 3 and the hypothesis: AI adopters are much more likely to increase usage.

Table 14 Summary of Chi-square Results

Table Topic	Significant?	Supports Objectives	Supports Hypothesis
AI speed & efficiency vs. complex data analysis	Yes	Obj. 1, 2	Yes
Cost reduction vs. drug repurposing effectiveness	No	Partially (Obj. 3)	Limited
Personalized medicine impact	Yes	Obj. 4	Yes
Ethics vs. regulation needs	Yes	Ethics + Methods	Yes (indirectly)
Current AI use vs. future adoption	Yes	Obj. 3	Yes

4.5 CONCLUSION

This study explored the intersection of artificial intelligence (AI) and genomics in drug discovery across India, focusing on how these technologies can revolutionize drug development, therapeutic precision, and cost-efficiency. From 207 participants based in academia, research organizations and industry, the findings present a grad optimism in a world of clear reality hurdles.

The evidence directly supports the primary research question: adopting AI in the genomic research and drug development process can help overcome target identification, drug interaction prediction, and drug design and repurposing Therefrom market loss, as well as diagnose and address health issues for those with genetic predispositions to diseases and conditions. The findings have also been supported by descriptive and inferential statistics although there were some practical and infrastructure constraints encountered.

4.5.1 Key Conclusions by Objective

Objective 1: Use of AI to identify therapeutic targets and increase efficiency

Survey responses and chi-square analysis strongly support the role of AI in expediting therapeutic target identification. The results showed that there was a significant correlation between the response to the question of whether AI speeds up drug discovery and the response to the question on how effective is AI in analyzing biological data ($\chi^2 = 38.59$, $p < 0.0001$).

Additionally, all participants appreciated the use of AI and genomics, and almost a half of them recognized the capacity of AI in target identification in biological data analysis.

This confirms that AI accelerates both the speed and accuracy of the first stages of drug discovery through scanning large sets of genomic data to identify hitherto unknown targets for modulation.

Objective 2: Integration of AI and genomics to identify novel targets and improve drug interaction accuracy

Participants displayed strong support for this objective, with 49.3% affirming that AI can analyze biological data and 46.4% agreeing on AI's predictive power in toxicity and drug interaction assessments. Several responses were not highly technical, but all responses reflected the belief in AI tools, suggesting that WU Libraries aligns with Objective 2.

The findings show that combination of data analysis with principles of genomics using an AI platform enhances ability of researchers in modeling biological interactions leading to improved drug-target prediction.

Objective 3: Accelerating drug design and repurposing using AI

The use of AI for **drug repurposing** and **cost reduction** received mixed but insightful responses. While 40.6% of the respondents opined that AI could lower the drug development costs, 36.7% remained skeptical due to structures and resources aligned to that task.

Nevertheless, when generalizing AI for drug repurposing, 52.2% of participants expressed that it was useful, while 36.2% gave a neutral opinion. Since cost and repurposing was not statistically significant ($\chi^2 = 11.28$, $p \approx 0.08$) it implies that even though participants find value, the extent to which tangible benefits have been realized remains low.

However, another chi-square test was conducted showing that the current AI users were willing to further adopt AI if resources were available ($\chi^2 = 27.91$, $p < 0.0001$). This re-emphasizes the roles of access, funding and facilities. Therefore, objective 3 is only partly true as there is potential but the challenges must be acknowledged when it comes to implementing the goals.

Objective 4: Advancing personalized medicine through AI-genomics integration

Results robustly support this objective. A significant chi-square relationship ($\chi^2 = 27.34$, $p < 0.001$) confirms that those who view AI/genomics integration as beneficial for personalized medicine also recognize its role in diagnostics and treatment customization. Moreover, 60.3 % of the participants (24.6% of them are 'essential,' 35.7% of them are 'helpful') perceive AI as a positive factor in terms of personalized medicine.

Nevertheless, 39.6% of the respondents mentioned that AI's role was either limited or unclear, pointing at an implementation and awareness issue. Nevertheless, these observations validate the role of AI for genomics to improve the future of precision medicine in India, which is fully in line with Objective 4.

4.5.2 Broader Trends and Barriers Identified

1. **Awareness vs. Expertise Gap**: Although, there is interest and awareness, only 0.5 % of those surveyed considered themselves as experts in the applications of AI in genomics suggesting a need for capacity building and training across disciplines.

2. **Institutional Engagement**: Regarding the distribution of participants, 61.8% of them are university-associated, and 55.1% of them are graduate students, which might reflect a high propensity of early-career investigators but a lack of comprehensive AI-Genomics training programs.

3. **Ethical and Regulatory Landscape**: Ethical issues were reported to be the most significant challenge felt by 43.5% of the participants followed by unclear regulations at 35.3%. Following the variable test on ethical concerns on AI regulation ($\chi^2 = 18.42$ $p = 0.001$), majoritarian endorsed tighter regulation consistent with national/global discourses on AI in health research.

4. **Technical & Data Challenges**:

    - **Data Standardization (21.7%)** and **Privacy (16.9%)** problems remain unsolved.

    - Trust in AI-generated insights remains incomplete (41.1% trust vs. 39.6% unsure).

- Low AI tool usage (only 30.4%) underscores that real implementation lags behind theoretical understanding.

5. **Opportunities & Use Cases**:

    - Engagement in rare disease treatment (25.1%), antibody development (18.4%), vaccine development (16.4%) shows that there are great opportunities for AI in India's biotech and pharma industries.

    - AI is most dynamically used in **preprocessing (29%)**, **predictive modeling (27.5%)**, and **drug-target prediction (22.7%)**, show early-stage integration achievement.

Table 15 Objective Support Summary

Objective	**Supported?**	**Evidence**
Obj. 1: Use AI to identify therapeutic targets and increase speed	**Yes**	100% agreed on AI-genomics advantages; strong chi-square support
Obj. 2: Improve accuracy of drug interaction prediction	**Yes**	49.3% supported AI for biological analysis; aligns with predictive goals
Obj. 3: Accelerate drug design and repurposing	**Partially**	Mixed opinions on cost reduction and AI usage; usage limited by access
Obj. 4: Enhance personalized medicine	**Yes**	Significant chi-square support; strong belief in AI's future role

In conclusion, such evidence strongly reinforces the idea that the integration of AI and genomics is not merely a 'pie in the sky' for humanity – but a definite reality that can greatly benefit India's biomedical sector. Challenges and trends regarding policy, data, protocols, and industry structure must be managed effectively for India to transform into a world-first player in AI-based drug discovery and precision medicines.

CHAPTER FIVE CONCLUSION AND RECOMMENDATION

5.1 DISCUSSION

The survey's findings offer a thorough summary of the dynamics and current status of AI and genomics-based drug discovery research in India, emphasizing important trends, obstacles, and prospects. The data, which came from 207 individuals, shows a dynamic but changing environment that is marked by interdisciplinary methods, academic engagement, and a growing interest in cutting-edge technologies like computational biology and artificial intelligence (AI). The results of the survey provided more light on how Indian researchers view and prepare for the use of AI in drug discovery and the function of genomics in locating potential therapeutic targets. These results point to an environment characterized by both increasing awareness and substantial uncertainty, particularly with regard to perceived efficacy and practical implementation. In India's developing biomedical innovation ecosystem, an understanding of these processes is essential for directing future research initiatives, educational initiatives, and industrial partnerships.

5.2 RESEARCH FOCUS AREA:

The diversity of research domains represented among responders is a noteworthy finding. The most popular field (28%), bioinformatics, is fundamental to the integration of biological data and computer tools for pharmaceutical applications. This is in line with worldwide patterns where complicated biological datasets are analyzed using bioinformatics as the foundation. Pharmacology (16.9%), genomics (17.4%), and AI & computational biology (11.1%) all highlight how interdisciplinary modern drug development is. The comparatively lower percentage of academics with an interest in AI (11.1%) highlights the fact that, despite its importance, AI is still a relatively new field in India. This disparity points to a problem as well as a chance to further integrate AI into drug development and genomics pipelines.

It's interesting to note that 26.6% of participants said their areas of interest fell outside of conventional classifications, suggesting the rise of new or hybrid fields that might involve translational medicine, systems pharmacology, or machine learning. The idea that innovation in drug development is increasingly taking place at an intersection of several disciplines is supported by this trend.

- **Early-Career Researchers Driving Engagement:**

Early-career researchers are well represented in the respondents' demographic profile. High student commitment and interest for this profession is demonstrated by the fact that more than half (55.1%) are graduate students seeking master's or doctoral degrees. This is encouraging for the future because it points to a pool of skilled workers who might accelerate advances in genomics and artificial intelligence in the years to come. Postdoctoral researchers (8.7%) and faculty members (9.2%) are two smaller but equally significant groups that provide knowledge and guidance. The remaining 22.7% under "Other" probably represent a wider ecosystem outside of academia and include independent researchers, industry professionals, and employees of startups or biotech companies. This combination of non-academic and academic stakeholders may promote cross-sector cooperation and expedite real-world implementations.

- **Institutional Landscape:**

Universities are the largest institution in terms of research (61.8%), highlighting their crucial role in expanding training and knowledge in genomics and artificial intelligence. This is consistent with India's larger scientific infrastructure, where institutions frequently act as centers for innovative and cutting-edge research. About 15% go to specialized research institutes and other institutions, indicating that these organizations are also important, especially in specialized fields like clinical translation or computer modeling. But only 7.7% come from public sector institutes, which raises questions about how underutilized government-funded research centers are in this quickly developing field. Increasing public sector involvement could increase the country's ability to carry out significant, large-scale initiatives.

- **Integration of AI and Genomics:**

The overwhelming (100%) support for the possible advantages of combining AI and genomics in drug discovery fits very well with the body of research that highlights the benefits of AI in speeding up the drug development process. The idea that AI can strengthen target selection and enhance predictive analytics with regard to drug interactions and safety is strongly supported by this sentiment.

- **Cost Reduction Perspectives:**

Although there is cautious optimism about AI's ability to lower drug research costs 40.6% of respondents are confident in this potential it is noteworthy that a sizable portion of respondents indicated neutrality or doubt. A realistic view of the obstacles to AI adoption in India is provided by this understanding of the existing constraints and infrastructure difficulties. To achieve the cost savings that stakeholders expect, it emphasizes the need for focused investment in essential infrastructure and data quality enhancement.

- **Competency of AI in Biological Data Analysis:**

The fact that almost half of the participants thought AI could analyze biological data suggests that they all had a tendency to use AI to find genetic targets. To increase confidence in AI applications, training and education on bioinformatics tools may be essential, according to the sizable percentage of respondents who are still skeptical.

- **Regulatory and Ethical Issues:**

Many participants acknowledged challenges to ethics, especially those related to algorithmic bias and data privacy. This reflects the increasing awareness of ethical issues in the use of AI in various industries. The demand for stricter regulations emphasizes how urgently India needs a regulatory structure that can effectively handle these moral dilemmas while striking a balance between innovation and protecting the interests of the general public and patients.

- **Trust in AI Outputs:**

Conflicting opinions on insights produced by AI highlight a larger issue with technology adoption: establishing confidence in AI systems. The sizeable percentage of participants who voiced mistrust highlights the need of model interpretability and validation as well as the necessity of initiatives to increase AI process transparency.

- **Adoption Barriers:**

Despite the high level of interest depending on resource availability, the survey results show that many stakeholders have little experience with AI solutions. This disparity shows that although there is interest in AI applications, concrete measures must be made to guarantee that stakeholders have the resources and resources needed to successfully incorporate AI into their processes.

- **Future Focus areas:**

The results that suggest fields like antibody therapy and the treatment of uncommon diseases as top research priorities are essential for guiding future investment and policy initiatives. These fields illustrate regional healthcare issues that AI and genomics could help with, in addition to being in line with worldwide developments in customized medicine.

5.3 CONCLUSION

The study emphasizes how AI, especially when combined with genomics, has the potential to revolutionize personalized medicine and drug discovery. AI greatly improves drug-target prediction by modeling intricate biological interactions (Objective 2) and speeds up and improves the accuracy of therapeutic target identification by efficiently analyzing huge genomic datasets (Objective 1), according to survey results and chi-square studies. Though responses were mixed and not statistically significant, suggesting unrealized potential due to resource and structural restrictions, there is optimism over AI's involvement in speeding up drug repurposing and lowering costs (Objective 3). But a majority of respondents saw AI as helpful for precision medicine, and a high association was observed between the integration of AI and genomics with improvements in personalized medicine, diagnostics, and therapy customisation (Objective 4). Key obstacles still exist in spite of these encouraging trends: a glaring disparity in knowledge and proficiency in AI-genomics applications; a lack of institutional training programs; ethical and legal issues; difficulties with data standards and privacy; and a low level of practical AI tool usage. However, prospects in the production of antibodies, vaccines, and treatments for uncommon diseases, as well as early-stage AI integration in preprocessing and predictive modeling, indicate that AI is gaining traction in India's biopharma industry.

5.4 RECOMMENDATION

Several recommendations can be made to enhance the integration of AI in drug discovery and identification, particularly in the context of genomics**:**

- Investment in Education and Training: To close the knowledge gap in AI and genomics applications, educational institutions and biopharmaceutical companies should fund training initiatives. Workshops, classes, and certifications that concentrate on AI techniques, the interpretation of genetic data, and their uses in personalized medicine and drug discovery can fall under this category.
- Interdisciplinary Collaboration: Encourage cooperation among regulatory agencies, genomic researchers, AI specialists, and physicians. Developing interdisciplinary teams can improve knowledge and application of AI technologies, assisting in overcoming the structural and resource constraints that have been discovered.
- Development of Standardized Protocols: Provide precise rules and industry best practices for sharing, standardizing, and protecting privacy of data in genomic and artificial intelligence research. This would address ethical issues and enable more efficient data consumption and collaboration.
- Policy Advocacy: Talk to legislators about regulatory issues pertaining to AI in healthcare. This entails elucidating laws unique to AI in personalized medicine and drug discovery as well as creating frameworks that encourage creativity while safeguarding patient information.

- Public-Private Partnerships: Promote collaborations between the government, educational establishments, and pharmaceutical firms. These kinds of partnerships can combine resources, improve research capacities, and foster an atmosphere that is favourable to the use of AI in drug discovery.
- Focus on uncommon Diseases: Give research and development efforts aimed at these areas, where AI can have a major influence, top priority given the prospects in treating uncommon diseases. This can enhance patient outcomes and hasten the creation of customized treatments.
- Improving Infrastructure: Make an investment in the support systems and computing infrastructure required for effective data processing and the implementation of AI models. This covers bioinformatics facilities and cloud computing resources.

Through the implementation of these recommendations, stakeholders can fully utilize AI in combination with genomics to transform drug discovery in the Indian healthcare industry.

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APPENDICES

APPENDIX 1

Ethics Application & Declaration Form

GRIFFITH COLLEGE

DISSERTATION TITLE: LEVERAGING AI AND GENOMICS IN DRUG DISCOVERY AND IDENTIFICATION IN INDIA

RESEARCHER'S NAME: ABHIRAMI KRISHNA

PROGRAMME OF STUDY: MASTERS IN DIGITAL TRANSFORMATION IN LIFE SCIENCE

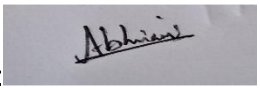
SUPERVISOR'S NAME: DEIRDRE FINN

DECLARATION:

The information in this application form is accurate to the best of my knowledge. I undertake to abide by the principles outlined by Innopharma/Griffith College ethics policy in my research dissertation. I confirm that I have completed a full ethics assessment for my research dissertation as per the college guidelines. I will not begin my primary research until such approval from my supervisor and/or ethics Committee has been obtained.

I pledge to carry out my research according to the Innopharma/Griffith College academic integrity standards. Any results presented in my dissertation will be from my own, original research, I will reference and/or acknowledge any material or sources used in its preparation and I will not plagiarise the work of anyone else.

For Student:

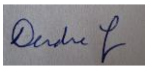
STUDENT SIGNATURE: 

DATE:25/03/2025

The research contained within this research dissertation proposal has been approved.

For Supervisor:

Ethics Committee Approval Required: No ✓ ☐

SUPERVISOR SIGNATURE: 

DATE:25/03/2025

For Ethics Committee (if required):

Ethics Committee Approval Given: No ✓ ☐

ETHICS COMMITTEE MEMBER SIGNATURE:

DATE:

NOTE: Supervisors are responsible for ensuring their students fill in this form correctly and that all ethical areas have been considered.

SECTION 1: DESCRIPTION OF RESEARCH STUDY

1.1 Purpose and objectives of research

PURPOSE OF THE STUDY

The purpose of this study is to explore and assess the possibilities of integrating genomics and artificial intelligence (AI) to transform drug identification and discovery procedures in India. This study intends to tackle India's distinct healthcare issues by utilizing the nation's diverse genetic landscape and cutting-edge AI algorithms to expedite and enhance medication development effectiveness. The study likely focuses on how AI can evaluate enormous volumes of genomic data from India's heterogeneous population in order to find new therapeutic targets, forecast the toxicity and efficacy of drugs, and create individualized treatment plans. By combining AI and genomics, the study aims to get beyond the drawbacks of conventional drug development techniques, which might save time and money when introducing new drugs to the market while meeting the health demands of India's population.

OBJECTIVES

The aim of using AI and genomics in drug development and identification is to increase process speed, accuracy, and efficiency while lowering costs and enhancing therapeutic results.

- To use AI to identify therapeutic targets, to examine how this makes the process faster and more efficient.
- To examine how AI and genomics can be used to find new drug targets, and to develop drug interactions more accurately.
- To use AI for effective drug design and repurposing and to accelerate the drug discovery process.

- To integrate artificial intelligence with genomics to advance personalized medicine by enabling precise diagnosis, tailored treatments, and improved health outcomes.

1.2 Research methodology: *[300 words maximum/ detail how you will acquire your primary data (focus groups/interviews/online surveys etc). Proposed questions for questionnaires and/or interviews **must be included** in the appendix].*

Quantitative Data Surveys: To obtain quantitative data, a sizable sample of people can be surveyed. Structured questions with predefined response options include ranking questions, multiple-choice questions can be asked. The purpose of the survey is to investigate the most recent developments, difficulties, and uses of AI in genomics-driven medication development. This study aims to evaluate the impact, potential, and future directions of artificial intelligence (AI) in transforming pharmaceutical innovation by obtaining perspectives from professionals, academics, students and colleagues and healthcare practitioners.

SECTION 2: POSSIBLE ETHICAL ISSUES

Answer 'yes' or 'no' to the following questions.

SUBJECT MATTER

Does the research proposal involve:

Research into specific company activities that would be deemed sensitive or confidential	No
Research into politically and/or racially/ethnically and/or commercially sensitive areas	No
Sensitive, personal, professional or corporate issues	No

RESEARCH PROCEDURES

Does the research proposal involve:

Research that might damage the reputation of companies or participants	No
Research that may negatively affect the reputation of Griffith College/Innopharma	No
Use of personal records without consent	No
Use of company data without consent	No
The offer of any inducements to participate	No
Audio or visual recording without consent	No
Using a language other than English	No

PARTICIPANTS

Does the research proposal involve:

People who are not competent and/or fluent in English	No
Does your research group include any of the following vulnerable groups	No

(Adults with psychological impairments; Adults with learning difficulties; Adults under the protection/control /influence of others (e.g. in care/prison); Relatives of ill people (e.g. parents of sick children); Hospital or GP participants recruited in a medical facility; persons under the age of 18)

If you have answered NO to ALL questions, please go straight to Section 4.

If you have answered YES to ANY question in SECTION 2, you must fill in SECTION 3.

SECTION 3: STEPS TAKEN TO AVOID ETHICAL ISSUES

[Only fill in this section if you answered YES to ANY of the questions in Section 3. For example, if you answered yes to including participants who are not fluent in English, you might put forward a plan that offers your survey in two languages to take this into account. Another example could be a study where the researcher wants to include information about the care received by children with a long-term condition but it would not be ethical to approach the children directly but it might be acceptable to instead ask parents questions about their child's care. If these plans are acceptable to your supervisor, you may not need to apply for ethical approval from the Ethics Committee].

3.1. If your ethics relates to ***Subject Matter***, outline your action plan to work around any sensitive issues.
3.2. If your ethics relates to ***Research Procedures***, outline your action plan to deal with possible ethical issues in your research procedures.
3.3. If your ethics relates to ***Participants***, outline how you will protect vulnerable persons or those that do not have English as their first language.

SECTION 4: ABOUT YOUR PARTICIPANTS

4.1. Outline your participant profile and why you have chosen them for this study *[Do not provide names except where it is deemed impossible to conceal identity].*

This study involves participants like professionals, academics, students and colleagues. This would insights from field of experts. This study intends to assess the impact, potential, and future directions of artificial intelligence (AI) in transforming pharmaceutical innovation by gathering perspectives from professionals, academics, students, colleagues, and healthcare practitioners. The studies goal is to explore the latest advancements, challenges, and applications of AI in genomics-driven medication development.

4.2 How do you plan to gain access to/contact/approach your participant(s).

Technique for Gathering Data

Surveys: Surveys can be conducted online using tools like Google Forms and SurveyMonkey. The surveys can be sent via email, social media, and professional networks to reach a diverse sample of participants.

SECTION 5: INFORMATION, CONSENT AND CONFIDENTIALITY

5.1 **Participant Information Letter (PIL) for participants**

[You must submit an information letter for participants with this application, as part of your appendices document. For online surveys, it is sufficient to include a paragraph summarising and explaining the purpose of the research at the beginning of the survey. In all other research e.g. interviews, phonecalls, a PIL should be provided to each participant before they are asked for their consent to take part. A template PIL is available in Moodle].

Please confirm below that your information letter covers:

Description of the research topic and method	No
Details of what participation will involve	No
Rights to anonymity	No
Confidentiality	No
Rights to withdraw from the research	No

The contact details of the researcher and supervisor (if necessary) No

5.2 Informed Consent Form (ICF) for participants

[Informed consent is required for most research. For online surveys, it is sufficient to get the participant to tick two boxes at the beginning of the survey – one to state they understand the research and one to give consent. In all other research e.g. interviews, phonecalls, a signed consent form is required. If the data is gathered online e.g. zoom, a signed consent form can be scanned and sent to the researcher. A template ICF is available in Moodle. The signed ICFs, along with the surveys, audio files or interview notes etc. must be stored in the primary data folder on moodle and can be accessed by Innopharma staff for the purposes of verifying the authenticity of the research carried out and the data collected].

Please indicate below if your research requires a signed consent form by selecting the relevant option only:

Yes: my research requires signed consent and I have attached an ICF in the appendices of my application.
No: my research study involves an online survey only and/or does not require signed consent

SECTION 6: STORAGE OF DATA

[Please ensure that you are abiding by GDPR and the national Data protection laws https://www.hrb.ie/funding/gdpr-guidance-for-researchers/gdpr-and-health-research/).

*The student is responsible for storage of data and this will be handed over to the college in an electronic format as part of the thesis submission i.e. primary data and completed ICFs where applicable will be added to the primary data folder on moodle. The rationale is to keep data **as long as it is still useful** and there is an intention to use it further **for research** so if this is not the case then this can be stipulated here and a shorter retention period given.]*

6.1. How will you store the research data and for how long? How will you manage data protection issues?

Google Forms will be used to collect the research data, and it will be stored and protected. Following collection, the replies will be saved to a Microsoft Excel file for analysis. Identifiable information, such as email addresses, will be anonymized and kept apart from the survey results. It will be saved till the research is completed and saved for a year and then completely erased.

SECTION 7: NON-DISCLOSURE AGREEMENT & STUDENT CONSENT

7.1 Non-Disclosure Agreement (NDA)

Will the final dissertation contain any information pertaining to any source what would warrant the use of a Non-Disclosure Agreement (NDA) e.g. industry-based research?

No

7.2 Student consent

If a Non-Disclosure Agreement (NDA) is not required, does the Student consent to allow their completed dissertation to be held/published by Innopharma/Griffith College?

Yes

SECTION 8: RECORDING AND RETENTION OF DISSERTATION VIVA

8.1 Viva Recording

The Dissertation viva will be recorded. This recording may be used to facilitate assessment by Innopharma staff, a third reader if necessary and/or if requested by the external examiner for the Programme. The recording will be held in line with current GDPR guidelines and will not be made publicly available.

SECTION 9: DOCUMENT CHECKLIST

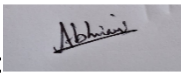
NOTE: Applicants must attach the following documents in electronic format to the appendix.

Which documents are added to the appendix? Please tick N/A if not applicable:

9.1 Participant Information Letter (PIL) for participant	N/A
9.2 Informed Consent Form (ICF) for participant	N/A
9.3 Questions/survey for interviewees/focus groups etc *(can be in draft form)*	Yes
9.4 Any other documents e.g. Non-Disclosure Agreement	N/A

I confirm that this application is complete and all required documents are included in the appendix.

For Student:

STUDENT SIGNATURE: 

DATE:25/03/2025

APPENDIX 2

SURVEY

LEVERAGING AI AND GENOMICS IN DRUG DISCOVERY AND IDENTIFICATION IN INDIA

Dear participants

I am Abhirami Krishna, pursuing a Master's in Digital Transformation in Life Science at Griffith College, Dublin.

I am conducting research on the topic Leveraging AI and genomics in drug discovery and identification in India. This survey aims to gather insights on the current understanding and perceptions of AI and genomics in drug discovery. It explores familiarity with AI in drug discovery, the importance of genomics in target identification, the potential of AI to accelerate drug discovery, cost implications, to predict toxicity and effectiveness of new medicines and the challenges and opportunities associated with integrating these technologies.

Your participants in this survey is completely voluntary, and response will remain confidential and anonymous. The data collected will be used solely for academic purposes.

If you have any questions or concerns, feel free to contact:

abhirami.krishna@student.griffith.ie

Thank you for your time and participation. Your contribution is invaluable to the success of this study.

1. What is your primary research area?
    - o Bioinformatics
    - o Genomics
    - o AI/Computational Biology
    - o Pharmacology
    - o Other
2. What is your current academic position?
    - o Graduate Student (Master’s/PhD)
    - o Postdoctoral Researcher
    - o Faculty (Assistant/Associate/Full Professor)
    - o Research Scientist
    - o Other
3. What type of institution are you affiliated with?
    - o University
    - o Research Institute
    - o Government Lab
    - o Other
4. How familiar are you with AI applications in genomics-based drug discovery?
    - o Not familiar
    - o Somewhat familiar
    - o Moderately familiar
    - o Very familiar
    - o Expert

General Understanding

5.Are you familiar with the use of AI in drug discovery?

(Yes/No/Maybe)

6.Is genomics important for identifying potential drug targets? (Yes/No/Maybe)

7.Do you believe AI can significantly accelerate drug discovery processes? (Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree)

Applications and Benefits

8.Would you agree that combining AI and genomics has advantages for drug discovery? (Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree)

9. Do you believe AI can reduce drug discovery costs significantly? (Yes/No/Maybe)

10. Can AI analyze complex biological data effectively to find new drug targets? (Yes/No/Maybe)

11. Can AI effectively predict the toxicity of new drug compounds? (Yes/No/Maybe)

Challenges and Concerns

12. Do you think the integration of AI and genomics in drug discovery faces significant challenges? (Yes/No/Maybe)
13. Are ethical concerns a barrier to using AI in genomics research? (Yes/No/Maybe)
14. Do you trust AI-generated insights in drug development? (Yes/No/Maybe)
15. Do you think cost is a major challenge in traditional drug discovery methods? (Yes/No/Maybe)

Future Perspectives

16. Do you foresee advancements in AI and genomics over the next decade for drug discovery? (Yes/No Maybe /)
17. Do you believe AI and genomics can significantly impact personalized medicine? (Yes/No/ Maybe)

Practical Implentation

18. Have you or your organization used AI tools for genomics research or drug discovery? (Yes/No/ Maybe)
19. Would you consider adopting AI technologies in your work if resources were available? (Yes/No/ Maybe)

AI & Genomics Integration

20. What types of AI technologies are most useful for genomics-based drug discovery?

- Machine Learning (ML)
- Deep Learning (DL)
- Natural Language Processing (NLP)
- Reinforcement Learning (RL)
- Generative AI (e.g., AI-driven molecule design)
- Other

21. What role does AI currently play in organization's research?

- Data preprocessing and analysis
- Predictive modelling for drug response
- Biomarker identification
- Drug-target interaction predictions

22. What level of automation does AI-based genomics research involve?

- Fully automated (end-to-end AI-driven process)
- Partially automated (AI-assisted but with human intervention)
- Minimal automation (primarily manual with some AI tools)
- No automation

Data and Computational Aspects

23.What are the biggest data-related challenges in using AI for genomics?

- Data quality and standardization
- Data scarcity for rare diseases
- Integration of multi-omics data
- Data privacy and security regulations
- Limited computational resources

24.How do you handle data privacy and security concerns when using AI in genomics?

- Data anonymization techniques
- Compliance with GDPR, HIPAA, or other regulations
- Use of secure cloud computing for AI processing
- Blockchain for data integrity
- Other

Clinical & Translational Impact

25.How effectively do you think AI can improve drug repurposing strategies?

- Very effective
- Somewhat effective
- Neutral
- Not very effective
- Not effective at all

26.How effectively do you think AI can predict the toxicity and effectiveness of new medicine compounds?

- Very effective
- Somewhat effective
- Neutral
- Not very effective
- Not effective at all

27. How do you see AI's role in **personalized medicine and precision therapeutics**?

- Essential for personalized medicine
- Helpful but not critical
- Limited impact
- No impact

28. What AI-driven approaches would be most useful in clinical trials?

- Patient recruitment optimization
- Predicting drug efficacy and toxicity
- Adaptive trial design
- Real-time monitoring of patient responses
- Other (please specify)

Regulatory & Ethical Considerations

29.What are the key regulatory challenges in applying AI to genomics-based drug discovery?

- Lack of clear regulatory guidelines
- Difficulty in validating AI-generated drug targets
- Ethical concerns in AI decision-making
- Resistance from regulatory bodies

30.Do you think AI-driven drug discovery should have **stricter regulations** compared to traditional methods?

- Yes, because AI introduces new risks
- No, existing regulations are sufficient
- Maybe, depending on the AI model's interpretability

31.What are the **biggest opportunities** for AI in genomics and drug discovery?

- Rare disease drug discovery
- AI-driven vaccine development
- AI for antibody and biologics discovery
- Integrating multi-omics data for drug target discovery
- AI-generated synthetic biology applications
- Other

32.Do you have any suggestions on how AI and genomics research can be better integrated into academic drug discovery efforts? (short answer)