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AI-Powered Innovations: Shaping The Pharmaceutical Industry in India and Emerging Global Trends

Ruhee Sachdeva[1], Dr. Sanjeev Mohan Sharma[2]

[1]Research Scholar, [2]Professor
[1]S.R.K. Pg. College, Firozabad
[1]Dr.Bhimrao Ambedkar University, Agra, U.P. (INDIA)

Abstract

This is a descriptive research designed to analyze the current trends and applications of AI in the pharmaceutical industry in India. The Indian pharmaceutical industry is currently undergoing a significant technological shift through the integration of Artificial Intelligence and Machine Learning to improve efficiency across drug discovery, clinical development, and healthcare delivery (Kandhare et al., 2025). Findings suggest that AI is significantly reducing drug development time, improving accuracy in diagnostics, and optimizing production processes. However, challenges such as high implementation costs, lack of skilled professionals, and data privacy concerns still limit widespread adoption. In 2018: National Strategy for Artificial Intelligence "AI for All" Released by NITI Aayog, document outlines the vision to position India as a leader in AI for economic growth and social inclusion. It provides recommendations for AI adoption across industries, including healthcare, education, agriculture, smart cities and transportation. In 2021: "Principles for responsible AI": Launched by NITI Aayog, these principles are a continuation of the National Strategy for Artificial Intelligence. The principles examine ethical considerations surrounding the implementation of AI solutions in India. This study is based on secondary data collected from research papers, industry reports, company publications, and credible online sources. Findings reveal that while full-scale AI integration is a recent development—with only 40% of the top "Nifty Pharma" companies having fully embedded AI into their business models by 2024—specific leaders such as Cipla, Lupin, and Biocon have successfully deployed AI for manufacturing efficiency, patient monitoring, and cyber security (Maharshi et al., 2026). For smaller firms, this paper provides a strategic framework for SMEs to leverage AI as a tool for innovation, environmental sustainability, and operational resilience (Maharshi et al., 2026; Mehta, 2025).This paper provides a strategic overview of how firms of various sizes can leverage AI for innovation and operational resilience. To explore this further descriptive analysis was also done to understand the level of familiarity, understanding, and perspectives among pharmaceutical professionals regarding the role and impact of artificial intelligence in pharmaceutical operations, research, and development. The study is conclusive, given the novelty of AI technologies and LLMs, many professionals may not yet be familiar with their use or have integrated them into routine practice(Hasan et al., 2026).

Keywords: artificial intelligence, Sun Pharmaceuticals, innovation, digital transformation,

1. Introduction

The Indian pharmaceutical industry, often hailed as the "pharmacy of the world," is currently undergoing a paradigm shift from traditional manufacturing toward a technology-driven innovation hub. With the sector projected to reach a market valuation of USD 130 billion by 2030, the integration of Artificial Intelligence and Machine Learning has transitioned from a futuristic concept to a present-day strategic necessity (Kimta & Dogra, 2024a, 2024b). This transformation is critical for maintaining India's global competitiveness, as AI offers the potential to drastically reduce the high costs and protracted timelines typically associated with drug discovery and clinical development (Kimta & Dogra, 2024; Mehta, 2025). AI is accelerating R&D processes by identifying drug targets, predicting molecular interactions, and enhancing toxicity assessments. It is also transforming clinical trials through AI-driven patient recruitment, trial planning, and improving production quality, predictive maintenance, etc. in manufacturing and supply chains(EY India, 2025).

The main limitation of the use of AI in pharma is that data given by AI is a black box phenomenon; it is not known how the conclusion is reached by AI technology. AI cannot be a model of the human brain. There is a false notion that automation leads to unemployment and a reduction of human intervention in the pharma industry. Skilled data scientist's software workers and AI experts are required to handle all these technological activities and these AI are not perfect and accurate. To check their reliability human intervention is mandatory mainly in healthcare sectors. (Bhat et al., 2025).This highlights a substantial gap between the industry's technological aspirations and its current operational reality. The research is necessary to identify that, is it the limitation of AI itself which is limiting the scale at which Large Indian firms have been able to adopt AI as a tool to scale till now and how far small firms can learn from them.

Statement of the problem While large Multi-National Corporations have the capital to pilot AI-driven manufacturing and patient care systems, the broader ecosystem—particularly small and medium-sized enterprises—faces daunting challenges, including a lack of dual-competency talent, high infrastructure costs, and the absence of robust data protection laws in India (Goswami et al., 2023; Kimta & Dogra, 2024).

The research is to explore the possible problems faced by large firms already, and small firms might face while investing and adopting in AI despite its advantages.

Objectives

The research is necessary to have an exploratory study of current landscape of AI adoption by large pharmaceutical firms in India and How far Small firms can learn from them. By analyzing the successful implementation strategies of leading Indian MNCs—such as Cipla's focus on "Green AI" for sustainability, Lupin's AI-driven patient monitoring, and Sun Pharma's integration of predictive modeling to optimize manufacturing workflows—this study seeks to identify scalable frameworks for smaller organizations (Desai & Editor, 2025; Huanbutta et al., 2024; Maharshi et al., 2026). Understanding how these innovations can be adapted for firms with limited resources is essential for ensuring that the entire Indian pharmaceutical sector, not just its largest players, can survive and thrive in an increasingly digitized global market (Kulkov, 2021; Patil & Swaroop, 2025). Moreover, current literature suggests that while organizational readiness hinges on technical feasibility and regulatory

compliance, the transition is essentially a requirement for maintaining resilience within the global manufacturing value chain (Sharma et al., 2021). Beyond these technical applications, there is a pressing need to move beyond isolated scientific success stories and evaluate these phenomena through a broader management lens to foster long-term organizational sustainability (Miozza et al., 2024).

2. Literature Review

AI implementation remains in its nascent stages within the Indian context (Kirtania et al., 2024). While major global players have adopted these technologies across diverse segments, many Indian firms are just beginning to integrate AI into their core business processes (Maharshi et al., 2026).

Research is necessary to understand how the successful strategies of Indian MNCs can be scaled for the broader ecosystem, particularly for smaller firms facing challenges such as high operational costs and regulatory burdens (Greeshma et al., 2025). This study analyzes current adoption trends and provides a framework for small firms to utilize AI effectively.

1. Functional Applications of AI: In the pharmaceutical sector, AI is multifunctional, impacting production cycles, drug therapies, and supply chain management (Maharshi et al., 2026). It is used to analyze complex data for target identification, selection of excipients, and predicting synthetic routes for new medicines (Kirtania et al., 2024; Serrano et al., 2024).
2. Adoption Patterns by Firm Size: Research indicates that large pharmaceutical companies primarily use AI to transform production, sales, marketing, and analysis business processes (Kulkov, 2021). Conversely, smaller firms tend to focus their AI efforts on research and development, master data management, and reporting (Kulkov, 2021).
3. The Rise of Green AI: A significant trend in the Indian sector is the adoption of "Green AI" to enhance sustainability. This involves automating manufacturing processes to conserve energy and manage waste, water, and green supply chains effectively (Maharshi et al., 2026).
4. Operational and Regulatory Barriers: Despite its potential, AI integration is hampered by high operational costs and a lack of proprietary infrastructure (Greeshma et al., 2025). Furthermore, the industry faces regulatory challenges as it navigates the implications of AI-driven personalized medicine and drug safety (Kandhare et al., 2025; Serrano et al., 2024).

   Examples of Indian MNCs Adopting AI

   While significant progress has been made since 2022, deep integration is currently concentrated among a few leading entities (Maharshi et al., 2026).

- Sun Pharmaceutical Industries Ltd.: Sun Pharma has demonstrated innovation in AI integration to maintain its competitive edge in the global generics and specialty drug markets (Greeshma et al., 2025). The company focuses on enhancing its digital transformation and expanding its ethical AI capabilities to drive long-term growth and market leadership (Greeshma et al., 2025).
- Cipla Ltd.: Cipla utilizes AI within its manufacturing and supply chain units to improve inventory and quality management (Maharshi et al., 2026). Through "Green AI," the company aims to achieve sustainability goals such as carbon neutrality and zero landfill status by optimizing energy usage (Maharshi et al., 2026).
- Lupin: Lupin has implemented AI and machine learning specifically for patient care (Maharshi et al., 2026). It developed a digital application that monitors the vitals of heart patients, providing

real-time data to increase health awareness and assist in healthcare delivery (Maharshi et al., 2026).

- Biocon: Biocon uses AI to strengthen its cyber security systems, which is critical for protecting proprietary client data and preventing breaches in international research collaborations (Maharshi et al., 2026).

The best methodology which Sun Pharmaceuticals in its press report has released that their growth model has been a "Pragmatic mix of organic and inorganic growth initiatives to have growth and profitability". Their documented roadmap for FY 26 has been stated as-

1. Company is adopting data-driven tools to optimize clinical trials, enhance patient targeting and strengthen supply chains. AI-enabled drug discovery, real-world evidence platforms and integrated digital health solutions are redefining how pharmaceutical organizations engage with patients and deliver care outcomes. Digital Health and Advanced Analytics AI, machine learning and data-driven tools are transforming drug discovery, clinical trials and patient engagement. The growing adoption of digital health solutions is improving the speed, efficiency and personalization of care delivery.
2. Operational agility has also improved, supported by advancements in modular manufacturing and predictive analytics. Supply Chain and Operational Agility In response to economic and geopolitical shifts, company continues to invest in building more resilient supply chains. The use of real-time analytics, AI-led forecasting and modular production models helped enhance responsiveness and efficiency.
3. Moderate spending include greater emphasis on generics and biosimilars, performance-linked pricing mechanisms and cost-sharing arrangements with patients
4. Higher volumes and new product launches
5. Field force expansion
6. Enhance compliance across manufacturing operation, and working towards achieving full regulatory resolution at the three facilities facing US FDA action
7. Ensure the readiness for upcoming launches, namely LEQSELVI and UNLOXCYT
8. Advancing pipeline of Global Specialty products
9. Preparing the business for potential disruptions arising from tariffs and geopolitical issue
10. Ensuring supply chain continuity and simultaneously focus on inventory optimization
11. Enhancing IT systems to facilitate business operations and ensure security and digital transformation
12. Embedding sustainability practices across operations as per clear and actionable targets to achieve sustainability goals
13. Continuing focus on cost and operational efficiency
14. Sustaining the positive momentum in improving overall return ratios
15. Sustainable cost reduction via technology interventions and process enhancements
16. Improving manufacturing efficiency, optimizing production footprint, and reduce overall fixed costs.

Among all the above points pt 1,2,15 AI is the moderator.

3. Research Methodology

Research Design

Primary data

The primary objective of this study was to gather insights regarding the perceptions and attitudes of pharmaceutical professionals toward AI utilization in their industry. A comprehensive literature review was conducted to frame the research context and to justify the importance of understanding AI's role within the expanding pharmaceutical landscape. A cross-sectional survey-based study was conducted between June 06, 2025 and June 12, 2026, among pharmaceutical professionals and AI developers. An online questionnaire was administered via email using Google Forms to professionals working in different sectors of the pharmaceutical industry. The study employed an exploratory design to assess current awareness, attitudes, and perceptions regarding AI adoption in pharmaceutical practice.

Random selection facilitated equitable representation of individuals within each organizational category, while convenience sampling accounted for practical considerations, including accessibility and availability of participants. A sample size of around 150 participants was taken from pharmaceutical industry and AI developers to calculate chi square test of Independence .

Secondary data-

Based on the strategic analysis of Sun Pharmaceutical Industries Limited, the ABCD analysis specifically focused on their adoption of AI in pharmaceutical manufacturing and business transformation (Greeshma et al., 2025).

1. **Advantages (A)**

- Global Market Leadership: Sun Pharma's dominant position in the global generics and specialty drug markets provides a robust platform for scaling AI-driven manufacturing processes across international borders (Greeshma et al., 2025).
- Innovation-Driven Strategy: The company's focus on healthcare innovation allows it to integrate AI into its core business model, moving beyond simple automation to high-level strategic transformation (Greeshma et al., 2025).
- Ethical Governance: Sun Pharma emphasizes ethical practices and corporate social responsibility, which provides a framework for the responsible use of AI and data, ensuring long-term institutional trust (Greeshma et al., 2025).
- Financial Capability: As a leading Indian MNC, the firm possesses the capital necessary to absorb the high initial costs of digital transformation that many smaller competitors cannot sustain (Greeshma et al., 2025).

2. **Benefits (B)**

- Business Transformation: AI integration facilitates a shift from traditional manufacturing to a more agile, technology-led model, driving long-term value creation for stakeholders (Greeshma et al., 2025).
- Healthcare Delivery Enhancement: By adopting AI, Sun Pharma improves its ability to innovate in specialty drug segments, which directly enhances the effectiveness of drug therapies and patient outcomes (Greeshma et al., 2025; Serrano et al., 2024).

- Sustainable Growth: The use of digital tools helps the company maintain its competitive edge in complex markets, ensuring consistent growth even in high-pressure regulatory environments (Greeshma et al., 2025).
- Operational Resilience: AI-driven digital systems provide the company with better data-driven insights for decision-making, leading to more resilient supply chains and production schedules (Desai & Editor, 2025; Greeshma et al., 2025).

3. **Constraints (C)**

- High Operational Costs: A primary constraint identified for Sun Pharma is the significant financial burden associated with maintaining and upgrading advanced AI and digital infrastructure (Greeshma et al., 2025).
- Regulatory Burdens: Navigating the diverse and evolving regulatory landscapes in global markets for AI-integrated products remains a complex and resource-heavy task (Greeshma et al., 2025).
- Infrastructure Gaps: The current lack of proprietary, large-scale AI infrastructure in the Indian context forces a reliance on external technologies, which can limit absolute control over technological evolution (Greeshma et al., 2025; Rakočević & Markovic, 2024).
- Data Protection Sensitivity: Managing the massive datasets required for AI-driven global operations necessitates rigorous compliance with international data privacy laws, which acts as a constant operational constraint (Greeshma et al., 2025).

4**. Disadvantages (D)**

- High Initial Investment Risks: The capital-intensive nature of AI adoption means that failure in implementation can lead to significant financial losses (Greeshma et al., 2025).
- Operational Complexity: Transitioning from established legacy manufacturing systems to AI-enabled "Smart Manufacturing" can lead to temporary disruptions in production and organizational friction (Chikhale et al., 2026; Greeshma et al., 2025).
- Cyber security Vulnerabilities: Increasing the digital footprint through AI creates new attack surfaces, making proprietary drug data and manufacturing processes vulnerable to cyber-attacks (Greeshma et al., 2025; Maharshi et al., 2026).
- Requirement for Specialized Talent: The dependency on AI requires a workforce with rare dual-competencies in both pharmaceutical sciences and high-level data analytics, leading to high recruitment and retention costs (Greeshma et al., 2025; Kimta & Dogra, 2024)

From the ABCD analysis and primary data of Sun Pharma alternate Hypothesis were drawn so that firms of different size (large and small) can identify with the Advantageous, benefits, challenges and disadvantageous factors while adopting AI and can take required initiatives to be competitive in the market. The participants were asked to register their perception about AI in pharmaceutical market in India in 3 categories-Strongly agree, agree as 1st category, neutral and 2nd ,disagree and strongly disagree an 3rd and chi square test was applied.

1. Pre-Adopting AI for ethical practices and CSR, H1 is supported as it is found to be statistically significant and has a positive relationship with size of firm.

2. H2: The size of the firm is directly related and significant to the increase in financial viability to innovate after adopting AI.
3. H3: There is a positive and significant direct relationship between size of firm and role of AI in achieving sustainable growth.
4. H4: Size of firm and achieving operational resilience after Adopting AI are positively and significantly related.
5. H5: The size of a firm has a significant positive direct relationship to the role of AI to improve health care delivery.
6. H6: There is a positive and significant relationship between size of firm and high operational cost in adopting AI.
7. H7: The size of the firm after going through the transition of AI is positively related and significant.
8. H8: Size of firm and regulatory burdens after Adopting AI are positively and significantly related.
9. H9: Infrastructure requirements are perceived as a barrier to AI adoption and this perception increases with firm size.
10. H10: The larger the firm, the greater the likelihood of the investment risk of Adopting AI.
11. H11: There is a positive and significant correlation between the size of the firm and complex operations in relation to the adoption of AI.
12. H12: The overall result is that there is a significant and positive correlation between the size of the firm and the perception of cyber security threats in the context of 'Adopting AI'.
13. H13:There is a negative and significant correlation between firm size and specialized talent barriers encountered for AI use.

Chi square test of Independence at 95% confidence level, for d.f.-2, for a sample size of 150 participants at the critical values of 5.991, was checked for calculated value, and observations were made for AI trends among large and small firms. That there is positive significant relationship between the firm size and stakeholders trust, for CSR initiatives after AI adoption. There is also a significant positive relationship between the firm size and financial viability to innovate with AI. The relationship between the firm size and perceived role of AI in sustainable growth is also positively significant. Relationship between the firm sizes and perception of achieving operational resilience after adopting AI is also significant. AI positively Influences all the firms to improve health care delivery. AI influences all firms and their operational cost therefore small and medium firms have to plan in accordance to the viability. There is significant relationship between all firms and global markets readiness in accepting AI and its endorsements due to its fixed algorithms and different regulations across the globe. All Firms face regulatory burdens due to complex nature of AI and ever evolving nature of regulations.

Firms and their capacity to develop infrastructure are significantly related for AI adoption due to high cost associated with it. Firm sizes and risk attached to AI adoption are associated. There is significant relationship between all the firm sizes complexity in operations primarily due to lack of trained personnel and complex nature of data. There is significant relationship between all the firm sizes and threat of cyber security. There is significant relationship between firm sizes and trained personnel requirements for AI adoption and the smaller firms are more vulnerable to get trained personnel. The gap in the analysis could be because of sampling technique where most of the participants were drawn from tier 2 & 3 cities where AI is still a budding concept.

1. **The Resource Gap (H_6, H_9, and H13):** Small firms find costs, infrastructure, and finding rare AI talent to be a much higher barrier than large firms.
2. **The Compliance Trap (H_8, H_{12}):** Large firms will likely report significantly higher regulatory burdens and cyber security risks because they are heavily targeted by hackers and closely watched by government regulators.
3. **The Scalability Advantage (H_2, H_3, and H4):** Large firms usually show a stronger relationship here because they have the massive data sets required to make AI innovation financially viable.

Conclusion:

The effects of AI depend on the size of the organizations.

Small pharmaceutical companies are mainly using AI to optimize their workflow, while medium-sized companies are using it for optimization and decision-making based on data.

From drug discovery and development to manufacturing and patient care, large pharmaceutical companies leverage AI in strategic ways to foster innovation, enhance production capabilities, and deliver improved patient outcomes.

This implies that company size plays a significant role in the adoption of AI in the Indian pharmaceutical sector with respect to its scope and impact.

The report underscores the importance of AI adoption for the life sciences sector as a strategic move, rather than an option.

Organizations must assess their current AI maturity level and develop a structured roadmap for integration to drive innovation and business growth.(EY India, 2025).

Three key categories of challenges hindering AI adoption within pharma organizations:

- **Ethical concerns**, such as algorithmic bias and transparency in AI decision-making, remain a key challenge. In pharmaceutical development, biases in AI models could lead to treatment protocols favoring certain demographic groups, compromising the goal of truly personalized medicine.
- **Technical challenges** related to data privacy, security and complex regulatory compliance. Navigating evolving regulations is critical for AI integration, requiring a strategic and informed approach.
- **Operational barriers**, including a shortage of AI-skilled professionals and resistance to change. AI is automating repetitive tasks and bringing operational efficiencies across all roles. As AI automates repetitive tasks, professionals must shift toward more strategic, AI-augmented roles.(EY India, 2025)

Lessons for Small Pharmaceutical Firms

The adoption strategies of major MNCs offer several practical lessons for smaller enterprises:

1.Where to focus AI in small businesses: For small businesses, AI is essential for research and development (R&D) and master data management (Kulkov, 2021).

In the case of smaller organizations, these zones can offer the better transformation since they can facilitate data-centric research without the requirement for a huge infrastructure set up for production-wide artificial intelligence (Kulkov, 2021).

2.Use AI for cost savings: Small businesses can adopt the "Green AI" approach and implement AI-driven automation to save energy in their production processes (Maharshi et al., 2026).This not only helps to ensure sustainability but can also result in cost savings for operations (Maharshi et al., 2026).
3. Prioritize Digital Transformation: Addressing the high operational costs issue, small businesses should consider digital transformation models to enhance stakeholder engagement and long-term value creation (Greeshma et al., 2025).
4. Embrace Patient-Centric Models: Including patient-specific diagnostics and treatment plans, small businesses can use AI to stay competitive with larger companies using patient monitoring tools (Greeshma et al., 2025; Kandhare et al., 2025).
5. Optimize Medical Writing & Regulatory Compliance with the help of AI
6. Implement Low-Cost Virtual Assistants for Sales & Marketing with the help of AI
7. Learn to deploy Open-Source AI for Drug Discovery & Repurposing with AI.

The technological shift is moving the industry away from a generic, volume-driven production to high-value, data-driven drug discovery and personalized medicine approaches (Kandhare et al., 2025).Reddy's Laboratories, are also concerned. Other big domestic companies like Sun Pharma and Dr. Reddy's Laboratories are not spared from worry. The predictive modeling and automated analytical platforms are already being embraced by Reddy's Laboratories to streamline and optimize intricate manufacturing processes and reduce clinical trial cycles (Desai & Editor, 2025; Huanbutta et al., 2024).

They are a meaningful blueprint for SMEs that can reduce the high barriers to entry in R&D by integrating similar cloud-based AI tools to optimize target identification and processes, thereby enhancing efficiency (Aritra et al., 2025; Mehta, 2025).
These agile digital tools can help small companies successfully strengthen their molecular screening capabilities while minimizing capital costs that are usually linked to early-stage research (Jain*, 2026).

Furthermore, strategic applications of deep learning and NLP(Natural Language Processing) enable smaller companies to gain the computational power required to navigate complex regulatory environments and improve pharmacovigilance practices (Jain*, 2026; Suri et al., 2024).

In addition to operational improvements, this holistic modernization reduces the high attrition rates associated with legacy drug development pipelines (Gouma et al., 2025).

To lower the level of silos and increase the interoperability of complex research ecosystems, firms can significantly reduce bottlenecks by re-designing the value chain that incorporates insights from multiple data sources (Ali et al., 2024).

In the end, an Industry 4.0 paradigm provides the opportunity for the creation of an extremely interconnected digital environment for even small, resource-challenged companies to leverage digital twins to improve process design and scale-up with reduced waste (Kimta & Dogra, 2024).

The move towards digital maturity is further supported by global Industry 4.0 trends, in which the pilot-scale platforms are equipped with process optimization and predictive maintenance features, driven by AI, to guarantee regulatory requirements and scalability (Luo et al., 2026; Niazi, 2023).

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