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How Digital Twins Transform Drug Development Processes

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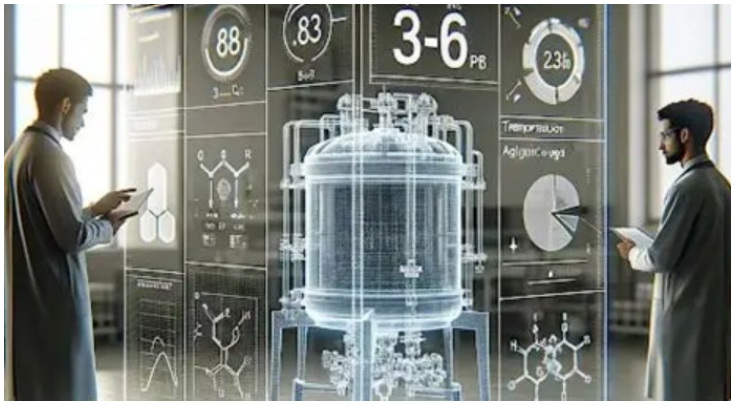
Digital twins enable a move from a slow, trial-and-error approach to a highly predictive, efficient, and data-driven drug discovery process—getting safer, more effective treatments to patients faster than ever before.



India, long recognised as the “pharmacy of the world,” has strengthened its position as the largest provider of generic medicines globally, accounting for over 20 per cent of the global supply by volume and contributing to 60 per cent of global vaccine demand. Over the past two decades, the country has evolved from a manufacturing powerhouse into a thriving pharmaceutical ecosystem, powered by cutting-edge research, biotech startups and a rising wave of digital and data science talent. This strong foundation has recently enabled a major transformation in the country’s pharmaceutical landscape. India’s pharmaceutical sector is entering a new chapter, driven by integrating traditional sciences with emerging technologies such as AI and data analytics.

India’s Global Capability Centres (GCCs): A launchpad for next-gen innovation

One of the key accelerators of this transformation has been the rapid growth of GCCs. India accounts for over 55 per cent of the world’s GCCs, benefiting from a unique blend of talent availability, cost competitiveness and supportive policies. In the Life Sciences and Healthcare (LSHC) sector, GCCs employ over 15 per cent of the total Indian GCC workforce. While many of these centres started by handling support functions, they now take on more strategic roles across R&D, drug development, regulatory analytics, commercialisation and post-market surveillance. These pharma innovation hubs are emerging across major Indian cities such as Bengaluru, Hyderabad, Pune and Mumbai. They focus on machine learning, natural language processing, computer vision and other AI techniques to fast-track the traditionally long and expensive drug development processes, clinical trials and regulatory approvals.

Digital twins: A new frontier in drug development

A key technological advancement emerging from these hubs is the application of digital twins in pharmaceutical research. Initially used in engineering and manufacturing sectors, digital twins in the pharmaceutical industry are virtual models of human systems that replicate biological processes. These replicas are built using vast volumes of biological, clinical and genomic data, enabling researchers to test how different patient profiles might respond to specific drugs without exposing individuals to experimental therapies. The implications of this approach are transformative.

Through digital twins, pharmaceutical scientists can simulate the progression of diseases, predict Adverse Drug Reactions (ADRs) and model patient diversity across age, gender, genetic traits and comorbidities. This ability to run in-silico trials, which are clinical trials conducted through virtual simulations, reduces the cost, duration and risk associated with traditional clinical testing. Moreover, it makes clinical research more inclusive by ensuring that underrepresented populations are factored into trial designs from the outset.

India's role in the global digital twin ecosystem

Globally, leading pharmaceutical companies are also leaning into this shift. Digital twin technology is being explored to simulate complex biological systems, optimise drug development and enhance clinical trial design. These models accelerate drug development timelines by integrating real-world data, imaging, genomics and AI while improving safety, precision and scalability across the pharmaceutical value chain. For instance, studies presented at the Alzheimer's Association International Conference 2024 in the US showcased how digital twins can reduce control group sizes in Phase 3 trials by up to 33 per cent. In a typical 1,000-person trial, reducing the control group by even 25 per cent could accelerate recruitment by four to five months. About 50 per cent reduction might shorten overall trial timeline by nearly a year, saving costs while speeding access to life-saving therapies.

India can potentially align with global trends and play an active role in shaping them. The country generates a vast amount of patient data daily, supported by its vast network of public and private hospitals, diagnostic labs and insurance systems. Moreover, under the central government's Ayushman Bharat Digital Mission (ABDM), more than 74 crore Ayushman Bharat Health Accounts (ABHA) have been created with nearly 50 crore health records digitally linked as of mid-2025. This data-rich environment provides the fuel to train digital twin models to identify biomarkers, predict disease outbreaks and personalise treatment strategies.

AI-led pharma GCCs in India have already started integrating this health data into simulation platforms to optimise key decisions around dosage levels, patient recruitment strategies, trial endpoints and even post-market monitoring. They are working on virtual patient cohorts using real-world health data to assess drug efficacy across diverse demographic and genetic profiles, improving precision and inclusivity in clinical research. Additionally, these GCCs are exploring machine learning algorithms to optimise protocol design, reduce patient dropouts and identify ideal trial sites based on epidemiological trends and resource availability. By combining domain expertise with deep tech capabilities, India's pharma GCCs focus on redefining global best practices in intelligent, patient-centric drug development.

India's regulatory landscape is also evolving rapidly to match the pace of this pharmaceutical innovation. The Central Drugs Standard Control Organisation (CDSCO) has introduced pilot initiatives to explore the integration of AI into drug approval processes, while regulatory sandboxes provide a safe space for pharma companies to test digital health solutions under controlled conditions. At the policy level, the government's Rs 500 billion Production Linked Incentive (PLI) scheme includes dedicated support for digital innovation, advanced R&D and AI adoption within the pharma sector. Together, these measures signal a strong commitment to building a future-ready regulatory framework enabling safe, scalable and tech-driven growth across India's life sciences ecosystem.

Another key enabler of this progress is India's growing network of academic institutions, research hospitals and digital health start-ups. Collaborative ecosystems allow innovation hubs to co-develop tools, share data ethically and validate models in real-world settings. By combining clinical domain knowledge with AI and software engineering, this multidisciplinary approach is expected to lead to faster prototyping and deployment of digital twin technologies. It can also help to bridge the gap between computational simulations and clinical realities, ensuring that the virtual models are grounded in practical, physiological insights.

The road ahead: Scaling AI and digital twin in pharma

AI is transforming every clinical development phase worldwide, from trial design to execution and outcome analysis. According to industry estimates, AI is expected to support 60–70 per cent of clinical trials by 2030, potentially saving $20–30

billion annually. While digital twins represent just one facet of this broader AI integration, their capacity to virtually assess drug safety and efficacy could significantly accelerate the journey from discovery to patient delivery.

India's pharmaceutical GCC hubs are expected to rely on a robust digital infrastructure to realise this potential. Cloud-based platforms that enable rapid data processing and model training at scale will be essential. The integration of high-performance computing with both structured and unstructured real-world data from sources such as electronic health records, wearable devices and genomics will enable the development of highly personalised and adaptive models. These platforms must be designed to comply with stringent global regulatory standards to ensure data privacy, model transparency and scientific rigour.

As digital twins evolve from experimental tools to everyday clinical applications, and AI continues to reshape how drugs are discovered, tested and delivered, India is well-positioned to contribute meaningfully to this global shift.

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