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INDUSTRY TRENDS REPORT

HEALTHCARE, BIOTECH AND PHARMA SECTOR

AI & PRECISION MEDICINE

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EXECUTIVE SUMMARY

Precision medicine is an approach to healthcare that customizes medical treatment to the individual characteristics of each patient, especially their genetic makeup, lifestyle, and environment. The utility of precision medicine refers to its practical value in improving healthcare by making it more personalized, effective, and efficient impacting many healthcare domains. Here, precision diagnostics covers the screening, the diagnosis, the stratification and the disease monitoring and management levels

Technological advancements in genomic sequencing and multi-omics are the main drivers of precision medicine, as well as the integration of Big Data, AI and analytics in precision medicine. Moreover, there is also a growing need for precision/personalized treatment, regulatory frameworks and public health policies have become crucial enablers of precision medicine.

However, several key restraints hinder its full-scale adoption and effectiveness such as data privacy & security and high cost & reimbursement barriers. as well as ethical and social concerns, and regulatory complexity that can also hinder precision medicine rapid growth.

Advancements in precision medicine are significantly driven by ongoing developments in AI, machine learning (ML), and genetic technologies. These advancements have improved the understanding of disease biology and facilitated the creation of personalized treatment strategies.

Genome Mapping is one of the key areas of focus of precision medicine with many advancements. Modern sequencing technologies, especially next-generation sequencing (NGS), have revolutionized the ability to decode genetic information. Furthermore, recent advancements in genome mapping allows rapid identification of disease-causing variants

Another key advancement in precision medicine is AI-Supported CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats). Here, the integration of artificial intelligence (AI) with the CRISPR gene-editing technology aims to enhance the precision, efficiency, and safety of genetic modifications

Another key advancement is personalized gene therapy that involves designing and delivering genetic treatments that are specifically customized to an individual's unique genetic makeup. This enables several transformative outcomes in medicine and healthcare such as the development of tailored therapies for rare and inherited diseases and improving treatment outcomes.

Predictive Analytics is also a key area of development and advancement in precision medicine. Here, AI aids in predicting disease risks, which facilitates early interventions and the implementation of targeted preventive measures.

These advancements collectively contribute to more effective and personalized healthcare solutions, enhancing patient outcomes and optimizing treatment strategies. As precision medicine continues to evolve, the collaboration between AI and genetic technologies is expected to expand, leading to more effective and personalized healthcare solutions.

The integration of Artificial Intelligence (AI) in the pharmaceutical industry is revolutionizing the processes of drug discovery and production. Drug discovery is one of the key aspects of how AI supports these efforts. Here, AI enhances various stages of drug discovery including target identification, lead identification, lead optimization and preclinical development.

In target identification, AI platforms utilize foundational data sources and multi-omics to identify biomarkers and support target identification. In lead identification, computer-aided drug discovery platforms focus on lead identification, with AI vendors increasingly concentrating on this stage. In lead optimization, AI employs quantitative structure-activity relationship (QSAR) models to optimize leads and assess ADME/tox properties. In, preclinical development, AI aids in understanding biological systems through text mining and knowledge graphs, and it supports toxicology assessments using organ-on-a-chip models

Here, accelerated drug discovery and improved clinical trials are one of the key areas of interest, as well as economies of scale, as AI improves predictability in drug discovery, reducing timelines and costs by enabling better disease modelling and avoiding extensive testing. Furthermore, AI facilitates access to disparate data sources, allowing for generative AI-based de novo drug design, which is crucial for identifying the right targets

AI also plays a significant role in the production of medicines. With AI, automated manufacturing and process optimization are both enhanced in the production of medicines. Here, Companies like Pfizer (US) are leveraging AI for automated manufacturing processes, enhancing productivity and efficiency.

AI's role in pharmaceutical production extends also to supply chain optimization and inventory management. Here, AI applications in supply chain management help in real-time monitoring and management, ensuring a robust supply chain for active pharmaceutical ingredients (APIs).

The federated learning approach is showing that the rapid technological advancement in AI has brought new challenges, particularly regarding data privacy and the ethical use of personal information. In response, regulatory frameworks have evolved to address these risks. Here, there are many challenges in traditional AI and there is a need for privacy- preserving methods.

The decentralized learning approach and architecture significantly reduces privacy risks and aligns well with modern legal requirements, making it particularly attractive in highly regulated domains, such as GDPR in Europe.

Federated learning is commonly categorized into two main settings: cross-device FL and cross-silo FL. But it can also be classified on how data is partitioned among the participating parties, leading to two main categories: Horizontal FL and Vertical FL.

In Horizontal federated learning, the involved parties hold datasets containing information about different users, but the data shares the same features or schema. Conversely, Vertical federated learning applies to situations where different parties hold data concerning the same set of users, but the collected features or attributes differ. Both Horizontal and Vertical federated Learning frameworks present unique challenges related to model design, privacy guarantees, and data alignment mechanisms. The key motivations behind the rise of the federal learning approach include privacy and regulatory compliance, security and risk mitigation, data ownership and control, and collaboration without compromise.

It is transforming healthcare by enabling the development and sharing of predictive and diagnostic models without compromising patient privacy. It key benefits here include the collaboration without data sharing, more robust and accurate models, efficiency, security, scalability and built-in privacy and compliance.

This has caused many benefits in oncology for instance, mainly in diagnosis and treatment planning. Furthermore, in radiology and imaging, Federated learning is widely applied to medical imaging through inter-hospital collaborations. Moreover, in critical care and intensive care unit FL can link intensive care unit (ICU) monitors and electronic health records (EHR) across hospitals to predict patient risk.

In genomics and rare diseases, federated learning offers a powerful alternative, it enables decentralized model training across multiple centers without sharing raw data. Beyond common complex diseases, FL is especially promising for rare diseases, where data scarcity is a major obstacle. FL allows institutions to collaboratively analyse these small, distributed patient groups, uncovering genetic patterns or subtypes that would otherwise remain hidden.

Furthermore, the benefits of federated learning extend beyond diagnosis to drug discovery and development, especially for rare diseases where patient populations are small and geographically dispersed.

Intesa Sanpaolo Innovation Center insights highlight that federated learning offers significant potential across diverse sectors and is especially relevant in healthcare, where aging populations demand more personalized, sustainable, and data-driven care models. By enabling secure, privacy-preserving collaboration among healthcare stakeholders, it supports AI-driven innovation, improves diagnostic accuracy, enhances patient care pathways, and ensures long-term system sustainability, even in cases with limited data such as rare diseases.

INTRODUCTION

PRINCIPAL ABBREVIATIONS

AMDE/ tox	*Absorption, Distribution, Metabolism, Excretion and Toxicity*
API	*Application Programming Interface*
AI	*Artificial intelligence*
AIM	*Audience Identity Manager*
B	*Billion*
ctDNA	*circulating tumour DNA*
CRISPR	*Clustered Regularly Interspaced Short Palindromic Repeats*
CAGR	*Compound Annual Growth Rate*
CADD	*computer-aided drug discovery*
CNNs	*Convolutional neutral networks*
CNV	*Copy Number Variation*
DNA	*Deoxyribonucleic acid*
EHR	*Electronic health records*
EGFR	*Epidermal Growth Factor Receptor*
EHDS	*European Health Data Space*
EMA	*European Medicines Agency*
EMA	*European Medicines Agency*
FL	*Federated Learning*
FDA	*Food and Drug Administration*
GDPR	*General data protection regulation*
GANs	*Generative adversarial networks*
GA4GH	*Global Alliance for Genomics and Health*
gRNA	*guide RNA*
HCP	*Healthcare Professional*

IVD	*In vitro diagnostics*
HIPAA	*Insurance Portability and Accountability Act*
ICU	*Intensive care unit*
LLM	*Large Language Model*
LNP	*Lipid Nanoparticle*
ML	*Machine Learning*
MRIs	*Magnetic Resonance Imaging scans*
M&A	*Mergers and acquisitions*
NER	*named entity recognition*
NHS	*National Health Service*
NGS	*Next generation sequencing*
ODDI	*Oxford Drug Discovery Institute*
PETs	*Privacy-Enhancing Technologies*
QSAR	*Quantitative structure-activity relationship*
R&D	*Research and development*
RAG	*Retrieval-augmented generation*
RNA	*Ribonucleic acid*
SMRT	*Single-molecule real-time sequencing*
SaMD	*Software as a medical device*
UK	*United Kingdom*
US	*United States*
VAEs	*Variational autoencoders*
WES	*Whole-exome sequencing*
W	*Watt*

ABOUT INTESA SANPAOLO INNOVATION CENTER:

Intesa Sanpaolo Innovation Center is the company of Intesa Sanpaolo Group dedicated to innovation: it explores and learns new business and research models and acts as a stimulus and engine for the new economy in Italy. The company invests in applied research projects and high potential start-ups, to foster the competitiveness of the Group and its customers and accelerate the development of the circular economy in Italy.

Based in the Turin skyscraper designed by Renzo Piano, with its national and international network of hubs and laboratories, the Innovation Center is an enabler of relations with other stakeholders of the innovation ecosystem - such as tech companies, start-ups, incubators, research centres and universities - and a promoter of new forms of entrepreneurship in accessing venture capital. Intesa Sanpaolo Innovation Center focuses mainly on circular economy, development of the most promising start-ups, venture capital investments of the management company Neva SGR and applied research

For further detail on Intesa Sanpaolo Innovation Center products and services, please contact businessdevelopment@intesasanpaoloinnovationcenter.com

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