

White Paper

Artificial Intelligence and Machine Learning Empowers Healthcare in China: an Algorithm-Driven Approach

Jointly Issued by IQVIA Data Science & Advanced Analytics team and Beijing ZGC Artificial Intelligence Technology Development Co. Ltd





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Executive Summary

The Chinese healthcare industry is experiencing a tremendous change due to macro-environmental factors which are challenging the growth and profitability of healthcare enterprises. In view of external economic environmental influences, the COVID-19 pandemic has disrupted the stability of R&D and the supply chain of pharmaceutical and medical device enterprises, subsequently reforming traditional marketing distribution channels and reshaping the demand-perception B2B and B2C markets, forcing enterprises to improve their market business strategies to cope with the changes.

Environmental policy has provided regulatory guidance to promote structural reform of the healthcare industry's supply chain. Regulators aim to control medical insurance costs by introducing Diagnosis-Related Group (DRG) reform and regular Volume-Based Procurement (VBP) to boost artificial intelligence (AI) in the healthcare industry, facilitating enterprises to reduce costs, increase efficiency, and drive innovation. In the technical environment, where new technologies such as big data and AI have advanced significantly, these contributions to the healthcare industry have provided new impetus for growth.

State-of-the-art AI technologies are integrated in the healthcare industry as a driving force to improve healthcare-related products and services, featuring wide applications such as computer vision (CV), natural language processing (NLP), and machine learning (ML). Confronted with changes in the economic, policy, and technological environment, the healthcare industry should be cognizant of the changes brought by artificial intelligence and machine learning (AI/ML) to the R&D, production, and distribution of products and services, as well as the great growth potential in new healthcare application scenarios from these technologies.

AI/ML technologies can enhance business agility and improve strategies by increasing fast, accurate decision-making, reducing costs through ready scalability, and facilitating business decision-making through in-depth insight. AI/ML brings changes to the entire product lifecycle from the following perspectives:

- 1) Drug discovery: AI/ML technology builds algorithmic models based on scientific theories to accelerate target discovery, lead compound synthesis and screening, and save development time in the laboratory;
- 2) Clinical trials: AI/ML technology analyses massive clinical trial data and patient records, intelligently and precisely recommending patients as per clinical trial requirements, thus accelerating the clinical trial process;
- 3) Product launch: AI/ML technology provides deep insight of strategic customer, accurate forecast of market size, agile strategy of optimal outreach, and flexible strategy adjustment plans leveraging massive data and continuous iteration of advanced model algorithms.

Empowering business success with AI/ML algorithms in the healthcare industry highly depends on enterprises and their partners' AI/ML capabilities in infrastructure, data assets, talent teams, and modelling technology. To fully integrate these technologies with business processes enterprises should look for partners with diverse data assets, leading advanced analytics capability, and extensive domain experience in the healthcare sector. Corporations can also benefit from advantages of good locations with strong computing infrastructure, business synergy from industrial conglomerations and policy support.

Part I: Market Outlook for China's Healthcare Industry

Core view: Macro environmental factors such as COVID-19 and regular VBP have brought uncertainty to the Chinese healthcare industry, challenging the growth and profitability of pharmaceutical enterprises. AI/ML technology can help enterprises reduce costs and increase efficiency in existing procedures, provide new growth impetus and achieve algorithm-driven growth.

1.1 Macro Environment

Economic environment

Core view: The COVID-19 pandemic has brought an inescapable impact on both the demand and supply side of the healthcare industry, so pharmaceutical enterprises need to improve their market strategies to cope with these changes.

The COVID-19 pandemic has challenged pharmaceutical and medical device enterprises' R&D, production, and supply chain stability.

The healthcare industry faces risks of stagnant clinical trial processes and disrupted upstream supply chain due to the spread of COVID-19. In clinical research and development, COVID-19 impedes patient recruitment, patient tracking, consistent dosing, and patient observation, causing patient dropouts and significantly increasing the cost of clinical research. In addition, the pandemic also poses a threat to the supply chain capabilities of the upstream and downstream industries; enterprises are confronted with bottleneck issues for raw materials, products in storage, and transportation, consequently escalating supply chain costs.

The pandemic has reformed the traditional marketing outreach channels of the healthcare industry.

For the B2B market, the interaction between different players in the healthcare system has significantly changed, where physician-representative and physician-patient interactions shift more to online channels. Traditional face-to-face visits by medical representatives were limited during the pandemic, and healthcare enterprises needed to conduct communication with healthcare professionals through online channels such as email, webinars, video calls, instant messaging

software, etc. For the B2C market, the pandemic and lockdown policies reshaped the information access channels and health consumption mediums of potential consumers. With a significant increase in online browsing time, consumers are more inclined to obtain healthcare knowledge from online channels, with up to 84% of respondents obtaining health knowledge through WeChat official accounts and 50% acquiring health information through APPs, online forums and websites. With the increasing accessibility of medical products and services, patient treatment procedures in areas such as chronic disease management are shifting from in-hospital to home (Dingxiang Doctor, 2022). In short, the COVID-19 pandemic has reconstructed the information access channels and business operations in both B2B and B2C markets, posing new challenges for the sustained growth of pharmaceutical enterprises.

The pandemic has reshaped the perception of demand in the healthcare market.

On the one hand, the pandemic has accelerated medical insurance cost control: investment in the medical insurance fund in pandemic prevention and control has put pressure on the growth and profit of non-COVID related products for pharmaceutical enterprises. On the other hand, the pandemic provides the consumer with an understanding of healthcare, promoting a "healthy lifestyle." Consumers have become increasingly aware of the concept of health and well-being, and a deeper knowledge of healthcare products leads to more diverse and detailed demands for pharmaceutical companies in segments including oral care and aesthetic medicine.

Policy environment

Core view: Medical system reform drives pharmaceutical enterprises to reduce costs, increase efficiency and deploy innovation.

Policy environment encourages pharmacy enterprises to adopt cutting-edge R&D and improves quality and speed for original drugs.

Multiple efforts are needed to improve the quality and speed of drug R&D and unleash pharmaceutical enterprises' innovative potential. The National Medical Products Administration (NMPA) continues to establish and improve drug review standard systems to promote patient-centered, scientific, and organized R&D of high-quality pharmaceutical products. NMPA is devoted to speeding up product approval and launch procedures to improve the market accessibility of innovative products and clinically urgent products. In recent years, NMPA has issued 361 guidelines for drug and medical device R&D, covering chemical drugs, biological products and other fields, providing scientific and standardised guidance for drug and medical device enterprises in product development, production, approval, and marketing (NMPA, 2022a). At the same time, NMPA focuses on accelerating drug review and approval processes, setting up "fast tracks" for breakthrough treatment procedures, conditional approval procedures, priority review and approval procedures, and

special approval procedures to accelerate drug development and launch (NMPA, 2022a). In 2021, NMPA achieved a 98.93% overall drug approval completion rate, a historic breakthrough (NMPA, 2022b). The focus of the pharmaceutical and medical device product approval environment improving quality and speed requires stronger R&D capabilities. Enterprises need to find unique competitiveness and profit growth points in an environment with fast product iterations, short life cycles, low margins and more intense competition.

Regular volume-based procurement strengthens the supply and accessibility of drugs and medical devices.

In-depth adjustment on the drug supply security system has significantly improved accessibility. Since 2018, the Chinese government has secured drug and medical device supplies by piloting and popularizing VBP for drugs and high-value medical consumables, improved the National Essential Medicine System (NEMS), and normalized annual adjustment on the list of medicines covered by the medical-insurance system to ensure the accessibility of essential drugs and devices. By the end of July 2022, the National Healthcare Security Administration (NHSA) had carried out seven national rounds of VBP, covering 294 drug varieties. NHSA expects to continue regularized, institutionalized and standardized VBP while expanding the list and speeding up the procedure, with

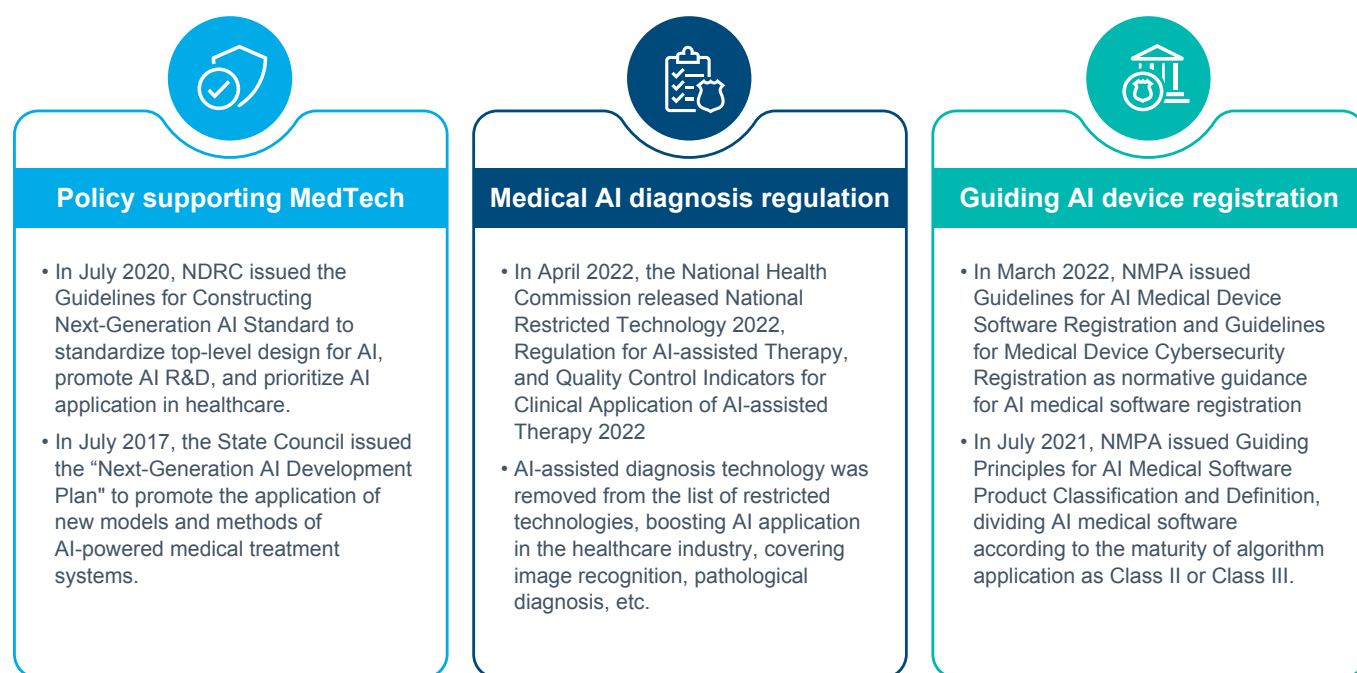
the expectation of more than 350 drug varieties to be covered in each province by the end of 2022 (State Council, 2021). During this period, the National Health Commission plans to dynamically adjust and optimize NEMS and continue improving the catalog adjustment management mechanism. They will conduct regular adjustments of the national essential drug catalog once every three years by integrating factors such as the clinical application practice of drugs, changes in drug standards and new drug launches (General Office of the State Council, 2018). The drug supply security policy, featured in VBP policy, has pushed enterprises to significantly reduce drug and medical device prices for the in-hospital market, creating long-term challenges for the profits and growth of pharmaceutical enterprises.

Integrated medical system reform facilitates pharmaceutical supply-side reform.

Medical products and services play an important role in the integrated

medical system reform. Supply-side reform of drugs and medical devices intertwines closely with the reform of state-owned hospitals to facilitate rational drug use and diagnosis/treatment standardization becoming the core of the steady development of medical system. Improving the quality and reducing the price of drugs and medical devices are also closely integrated with medical insurance payment reform. The DRG/DIP reform will start in 2022, and is expected to be introduced nationwide in 2024 and achieve full coverage by the end of 2025 (National Medical Security Administration, 2021). In the new era featuring medical insurance fund control measures, comprehensive medical insurance payment reform and state-owned hospital reform, pharmaceutical and medical device enterprises will face both opportunities and challenges (Figure 1.1)

Figure 1.1: Artificial Intelligence + Medical Policies



Source: Public information, collected by IQVIA

Technology environment

Core view: Advanced new technologies such as big data, AI, and ML offer rich application in healthcare industry, creating new growth potential

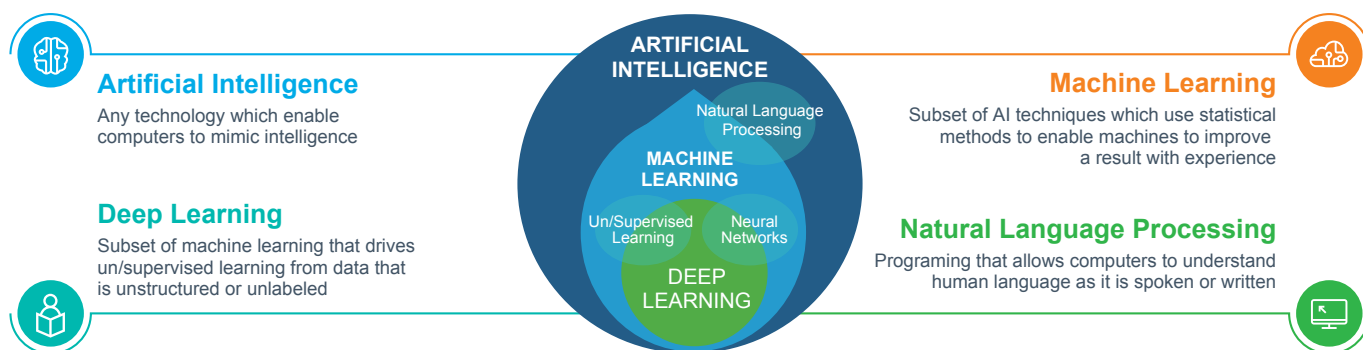
Data with large volumes, high structural diversity, and fast growth in the healthcare market depends on AI and ML technologies for value-added analysis and research.

Traditional digital analytics can hardly uncover the true value of the massive amount of structured and unstructured information in the healthcare market, while AI and ML technologies can better empower decision-making. AI refers to systems and machines that can mimic human intelligence to perform tasks and iteratively improve themselves based on the information collected. ML is a part of AI technology that can be implemented through statistical models and methods that allow computers to improve predictive or explanatory capabilities through experience accumulation (IBM, 2022). The application of AI and machine learning technologies in the healthcare industry can help enterprises reduce costs and make better business decisions.

AI/ML technology is increasingly applied in various healthcare processes. Cutting-edge AI/ML technology featured by computer vision (CV), natural language processing (NLP) and machine learning (ML) have widely penetrated various structures in the healthcare industry as a driving force for improving healthcare services.

In recent years, the accelerated maturation of AI technology has enriched its applications in the healthcare field. At present, the application of AI technology covers medical image processing, clinical decision support system (CDSS), precision medicine, health management, medical informatization, drug development and medical robotics. AI/ML-driven healthcare applications are dedicated to helping reduce costs and increase efficiency, improving diagnosis and treatment, enhancing patient experience, reducing disease risks, and comprehensively empowering pre-hospital, in-hospital, and post-hospital patient experience. (Figure 1.2).

Figure 1.2: Artificial Intelligence and Machine Learning Technology



Source: public information, collected by IQVIA

1.2 Industry and Industry Environment

Core view: AI/ML technology revolutionizes the R&D, production and circulation of pharmaceutical and medical device enterprises, unleashing great potential in new applications to help upgrade the industry.

AI/ML technology can be organically integrated with the whole process of product R&D, production and distribution, effectively reducing uncertainty in each link whilst promoting cost reduction and efficiency improvement in the whole product cycle.

In the R&D process, AI/ML technologies can be integrated into the drug candidate design and screening process to design and optimize lead compounds. Through query and comparison of big database, AI/ML facilitates the integration of advanced synthesis routes of target compounds, making preferential recommendations, thus shortening the development cycle of new drugs and reducing development costs. In the production process, AI/ML technology can help design the production process and realize digital production transformation to further improve production efficiency, shorten the inspection cycle, accurately control costs, and control the quality of drugs and medical devices to the greatest extent. In the distribution chain, AI/ML technology can help enterprises establish integrated intelligent marketing channels and communication platforms, improve channel control, and

enhance the accuracy of academic content and product promotion, effectively reducing sales costs. It also helps enterprises obtain feedback data from patients and doctors through customized services, enhances the timeliness and comprehensiveness of information feedback, and provides support for product and service optimisation. In turn, it can effectively improve the experience of doctors and patients (Industrial Internet Industry Alliance, 2021).

AI/ML technology can open new application scenarios and unlock new growth potential.

In recent years, the integration of AI technologies with the healthcare field has intensified, and the application of AI healthcare has expanded. In addition to assisting pharmaceutical and medical device enterprises and hospital operations in drug development, precise marketing, and medical information technology, AI/ML has also become an important source of innovative growth for independent medical service products. Built on unparalleled data, advanced models, and computing power, AI/ML creates new growth points with "Software as a Medical Device (SaMD)". With the continuous refinement of rich and diverse medical data, the business application of AI/ML in the healthcare field will continue expanding. (Figure 1.3)

Figure 1.3: Summary and Outlook of AI + Technology Application Scenarios

Established applications	Swift development	Future expectations
<ul style="list-style-type: none"> AI + Precision Medicine <ul style="list-style-type: none"> AI-assisted diagnose CNNs, Transformer Personalized medicine Naïve Bayes, SVM, DL Genomics Transformer, VAEs CDSS NLU, knowledge graph, image recognition AI + Compliance <ul style="list-style-type: none"> Minutes Anomaly detection Video monitor Face, object, voiceprint recognition AE detection NER, sentiment analysis AI + Public Health <ul style="list-style-type: none"> Infection prevention Agent-based simulation Rare disease detection ML-based Predictive model AI + Health Management <ul style="list-style-type: none"> AI assistant NLU, sentiment analysis, NER Wearable device ML-based Predictive model AI + Hospital Management <ul style="list-style-type: none"> Smart EMR NER, text classification, semantic determination AI triage Speech recognition, NLU, random forest 	<ul style="list-style-type: none"> AI + Device R&D <ul style="list-style-type: none"> Surgical assistance 3D rebuilt, object detection, semantic segmentation Surgical robot Motion2Vec, Multi-task SHN Device quality inspection OCR, image recognition, anomaly detection AI + Pharma <ul style="list-style-type: none"> Drug discovery GANs, VAEs Drug Response Prediction GNN, MC search AI + Plastic Surgery <ul style="list-style-type: none"> Personalized plastic surgery 3D rebuilt and printing Plastic surgery effect display VR, AR AI + Smart Contract <ul style="list-style-type: none"> Smart insurance claim OCR, Blockchain Blockchain EMR and prescription Blockchain AI + Privacy <ul style="list-style-type: none"> Medical image generation GANs, diffusion models Federated learning Privacy threat, attacker and security model, Secure multi-party computing, Homomorphic encryption, differential privacy 	<ul style="list-style-type: none"> AI + Device R&D <ul style="list-style-type: none"> Remote Surgery 5G, VR, AR Digital Health 3D rebuilt and printing Prosthetics EMG sensor array, reinforcement learning Organ-on-a-chip Predictive model, image recognition, semantic segmentation, object tracking AI + Future Concept <ul style="list-style-type: none"> brain-computer interface Signal processing, transfer learning, deep learning Human digital twin Multidisciplinary modeling, big data analysis, ultra-performance computing, machine learning, simulation

Source: public information, collected by IQVIA

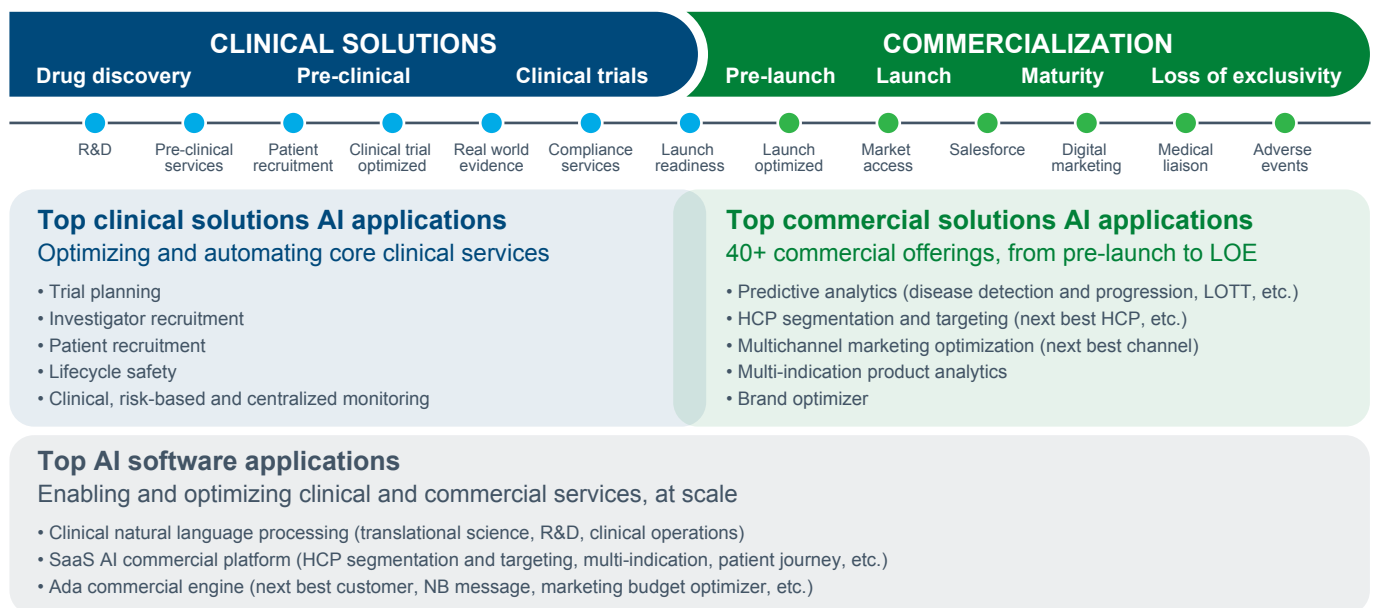
Part II: Algorithm-driven Approach: Advanced Analytics for Pharmaceutical Enterprises in the Digital Era

Core View: AI/ML Technology Uses Data, Experience, and Algorithms to Empower Business Decisions and Help Enterprises Reduce Costs and Increase Efficiency throughout the Product Lifecycle

With the continued impact of the COVID-19 pandemic, the healthcare industry is facing a more competitive environment and rapidly changeable consumer demands. The changing market environment requires enterprises to gradually shift to digitalization to improve their ability to respond, provide more personalized services, and innovate their businesses to revolutionize their original business processes and models in order to meet possible challenges. In the face of big data with a large magnitude and high complexity, AI/ML-assisted advanced analytics can effectively process and analyze market demand, transform business operations and decisions into algorithms and models, and empower multiple applications throughout the product lifecycle through leading speed, accurate decision, easy scalability, and in-depth insight. This helps enterprises reduce costs, improve operational efficiency, and achieve digital transformation (Figure 2.1).

In drug discovery period, AI/ML technology can build algorithmic models based on scientific theories, accelerate target discovery, lead compound synthesis and screening, and save development time in laboratory. In clinical trials phase, AI/ML technology can analyze mass clinical trial data and patient records to identify patients intelligently and accurately for enrollment according to clinical trial requirements, thereby accelerating the clinical trial process. In the product launch stage, AI/ML technology can perform iterative algorithms based on unparalleled data and advanced models to provide agile, accurate, and flexible strategic customer insights, market scale prediction, and optimal reach strategy design.

Figure 2.1: AI/ML Technology Empowers Multiple Applications throughout the Product Lifecycle



Source: IQVIA internal materials

2.1 Leading Speed: AI/ML Learning Technology Enhances Business Agility

The fast-changing business environment requires enterprises to collect and analyze real-time information efficiently, quickly and comprehensively to obtain feedback based on valuable analysis to adjust business strategies in a timely manner. Traditional business analysis often fails to meet the requirements of fast, agile and efficient response to this fast-changing market. AI/ML technology relies on algorithms to automate data collection and analysis, allowing enterprises to make real-time, rapid business strategy adjustments and enhance business agility.

Case Study 1: Clinical trial optimization

Drug development is characterised by high technology, high investment, high risk and long lead time. The composite success rate across all development phases and therapy areas declined to 5.0% in 2021, which can be attributed to an appetite for increased scientific risk in clinical development programs as the bar for efficacy and safety rises, as well as increased pauses in product development due to

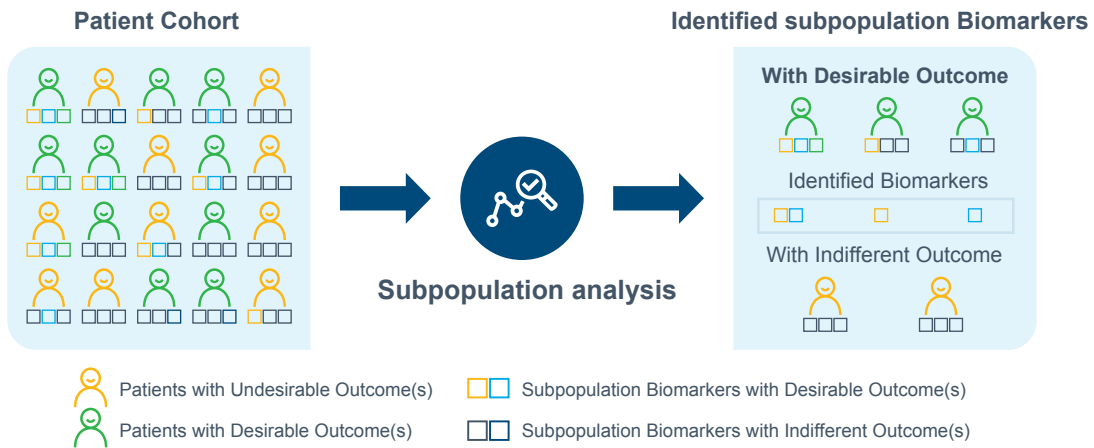
the pandemic. Across disease areas, probability of success varies considerably, and 2021's composite success rate fell below the 10-year trend in all areas except for vaccines and cardiovascular (IQVIA, 2022). Overall, the high investment, high risk, and long development cycle contribute to the soaring new drug development cost. Pharmaceutical enterprises are concerned with improving the

success rate of drug development, shortening the development time, accelerating the clinical trial process, and reducing the cost of development.

IQVIA's Advanced Analytics team uses ML technology and survival analysis models to identify key biomarkers that segment populations in non-optimal single-arm clinical trials, enabling effective data resampling from failed clinical trial data sets and avoiding studies

failure. The Advanced Analytics team also combines clinical trial data with advanced data science techniques for a user-friendly platform that allows drug development users to customise their analysis and obtain results quickly. With the help of AI/ML technology, sub-population data identification can be widely used in R&D and commercialization to improve data utilisation and help clinical trials succeed, helping enterprises save time and investment (Figure 2.1.1).

Figure 2.1.1: AI/ML Technology Empowers Clinical Trials Optimization



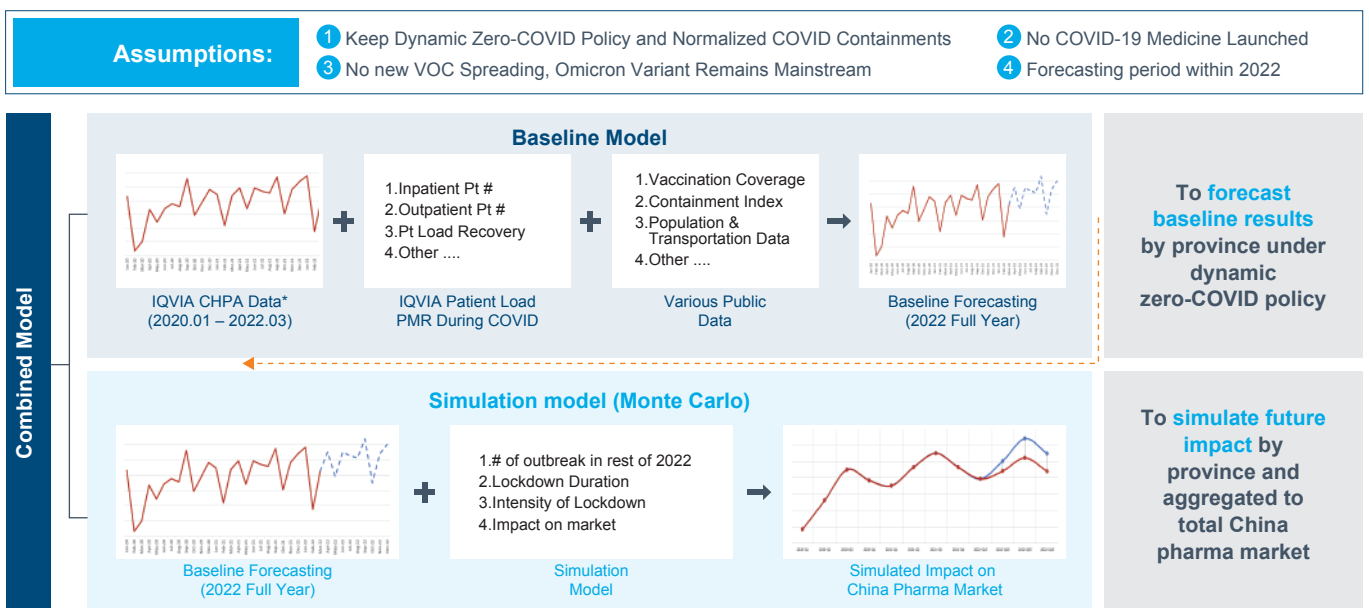
Source: IQVIA internal materials

Case Study 2: COVID-19 Impact forecasting in 2022

In early 2022, the spread of Covid-19 Omicron variant exerted a huge impact on the healthcare market and the overall economic environment, with metropolises such as Shanghai and Beijing being hit by the outbreak, which has inhibited patient access and clinical trial activities to varying degrees. IQVIA's Advanced Analytics and Primary Intelligence teams worked to quantify the impact of the new breakouts, taking into account key factors affecting the pharmaceutical market such as lockdown duration, variant type and probability of future

outbreaks. The team conducted extensive simulations using Monte Carlo methods to provide a real-time dynamic forecast of the Chinese pharmaceutical market for the next 6 months based on IQVIA's professional perspective. The results received excellent feedback from clients, aiding them to recognize the latest changes in market dynamics following the new outbreak and providing comprehensive guidance for their next business plans (Figure 2.1.2).

Figure 2.1.2: AI/ML Technology Enable Forecasting Pandemic Trend



Source: IQVIA internal materials

2.2 Precise Decision: AI/ML Technology to Improve Decision Accuracy

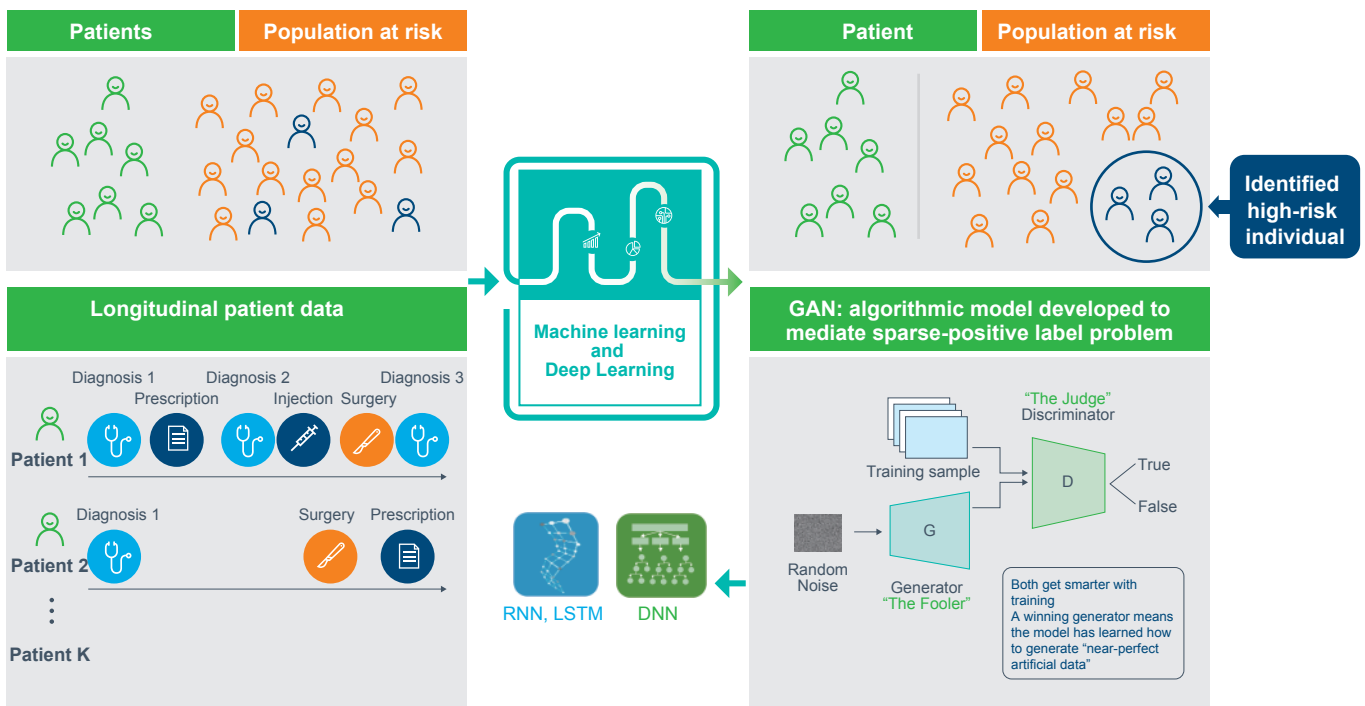
The latest changes in China's healthcare market have posed new challenges to the precision of enterprises' decision making. Faced with the changeable market demand, regulatory requirements, and continuous medical reform measures, pharmaceutical and medical device enterprises need to take be cognizant of market changes, reasonably optimize their decision-making models, and generate accurate market insights to develop optimal corporate and business strategies. In recent years, with the significant increase in the quantity and quality of data in the healthcare market, AI/ML technology has played an increasingly major role in empowering enterprise decision-making processes and improving accuracy. The deep combination of decision-supporting processes based on AI/ML algorithms with knowledge in the medical field can significantly improve decision-making accuracy in areas such as disease diagnosis, pharmacovigilance and medical information communication.

Case Study 1: Rare disease prediction

Rare diseases are characterised by low clinical case data, complex disease types and high misdiagnosis rate. Accurate diagnosis of rare diseases has always been a common challenge for doctors and patients. With the help of AI/ML algorithms, IQVIA's Advanced Analytics team has developed a rare disease prediction model that learns the data and symptom characteristics of confirmed rare disease cases, assisting doctors to classify and diagnose rare diseases accurately and efficiently to eliminate expensive, complex and time-consuming laboratory tests, in addition to reducing reliance on doctors' experience in rare disease diagnosis process. The rare disease prediction model can cover millions of people, output the disease probability score of rare diseases based on each

patient's medical record data, identify potential patients with rare diseases above the threshold value and reduce the missed diagnosis and misdiagnosis of rare diseases, thus improving the accuracy and efficiency of rare disease diagnosis. The rare disease screening model based on generative adversarial network (GAN) and long short-term memory network (LSTM) can learn the characteristics of confirmed patients from a large number of patient data, and accurately identify individual patients with potential disease risk under the premise that the existing confirmed cases are sparse, thus providing accurate and targeted decision assistance for rare disease prevention and diagnosis. (Figure 2.2.1)

Figure 2.2.1: Generative Adversarial Network Simulates Identification of Potential Patients



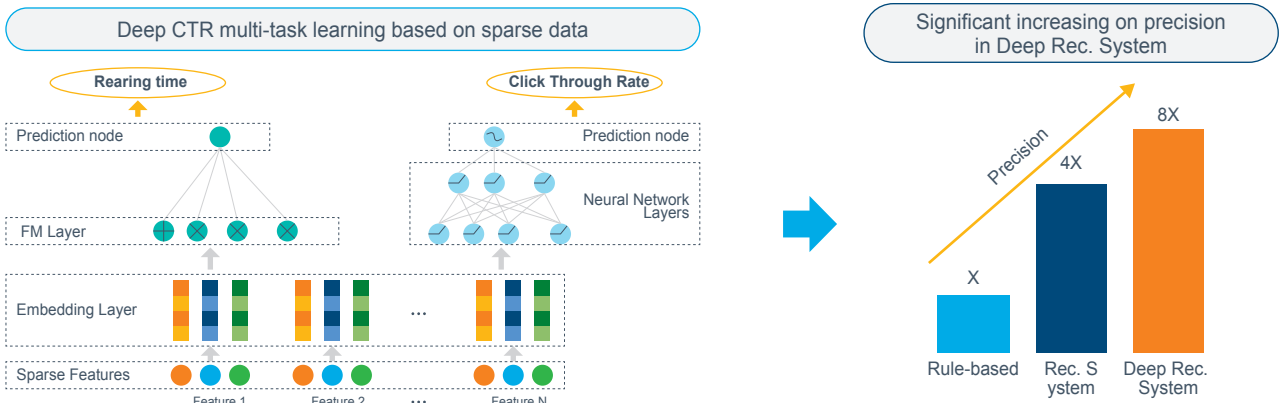
Source: IQVIA internal materials

Case Study 2: Omni-channel marketing intelligent recommendation system

In traditional mode, the communication between pharmaceutical and medical device enterprises and healthcare professionals relies on the experience of medical representatives. It is difficult to achieve a comprehensive reach on treatment concepts and disease views. AI/ML analysis tools can help pharmaceutical and medical device enterprises optimise the communication channels to provide more

accurate and comprehensive treatment information and solutions. By integrating internal data and public data, AI/ML algorithms can generate intelligent and precise marketing suggestions to better take advantage of omnichannel marketing and deliver accurate drug information and advanced treatment concepts to medical professionals (Figure 2.2.2).

Figure 2.2.2: Omni-Channel Intelligent RecSys Improves Precision



Source: IQVIA internal materials

2.3 Easy Scalability: AI/ML Technology Provides Solution Scalability

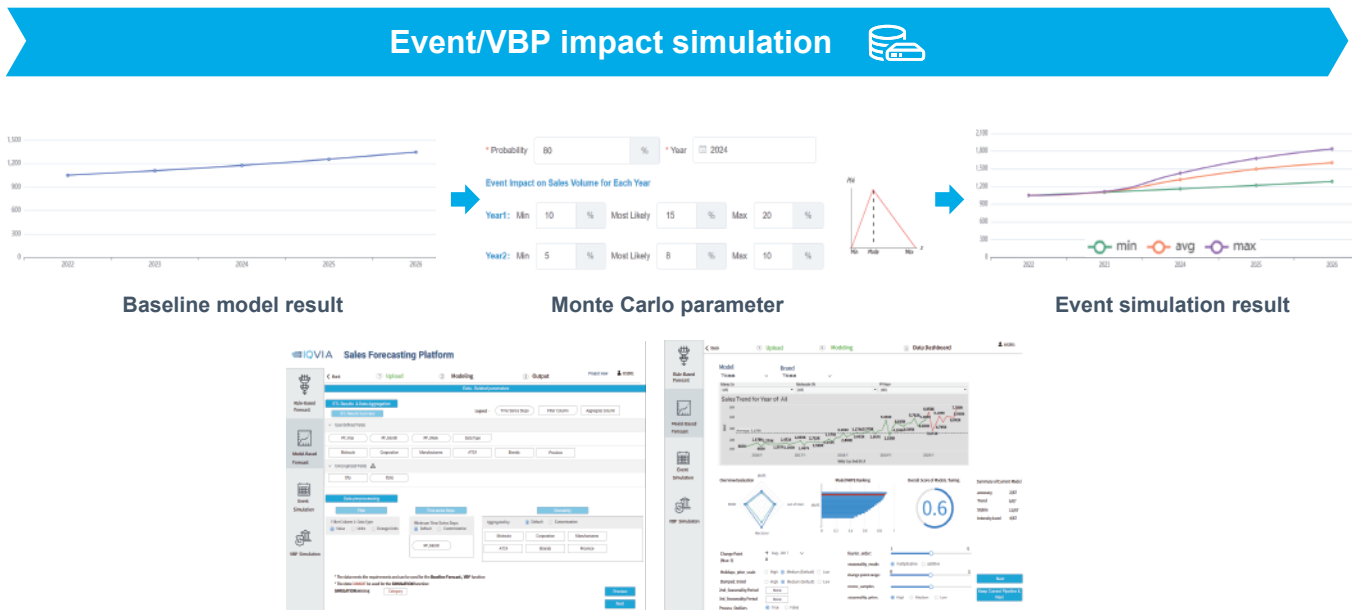
The ever-changing market status and rapidly growing data in China's healthcare market pose challenges for enterprises to make business decisions. Faced with a complex and changing market, pharmaceutical enterprises need to frequently make real-time and precise adjustments to business decisions in response to market events. Traditional business analysis decisions often require repeated calls to historical experience to complete the required tasks, which may result in a waste of human resources and decision-making time. AI/ML technology can greatly improve the scalability of the solution and provide agile speed and accurate predictions, allowing enterprises to call encapsulated algorithms according to their own business needs and achieving flexible expansion of algorithms, data and models.

Case Study 1: Sales forecasting platform

With regularized VBP, more enterprises need to frequently forecast the market volume and market share of their various pipeline products based on the latest trend of centralised volume procurement. Considering the continuous expansion of the categories of VBP, it is normal for enterprises to do this kind of forecasting and make commercial promotion strategies for multiple products. Traditional business forecasting processes require individual data collection, model building, parameter adjustment and output forecasting for each product affected by similar events, with high human resource

consumption and long project cycles. With the assistance of AI/ML technologies, enterprises can use a user-friendly platform that integrates AI/ML pre-trained models, combine their own uploaded data and market data within the platform, define the nature, impact, and time window of important market events, and flexibly call algorithmic models based on statistical methods to forecast sales affected by the events. The sales forecasting platform is easily scalable and greatly enhances the efficiency of market decision making. (Figure 2.3.1)

Figure 2.3.1: Sales forecasting Platform Enhances Decision Efficiency



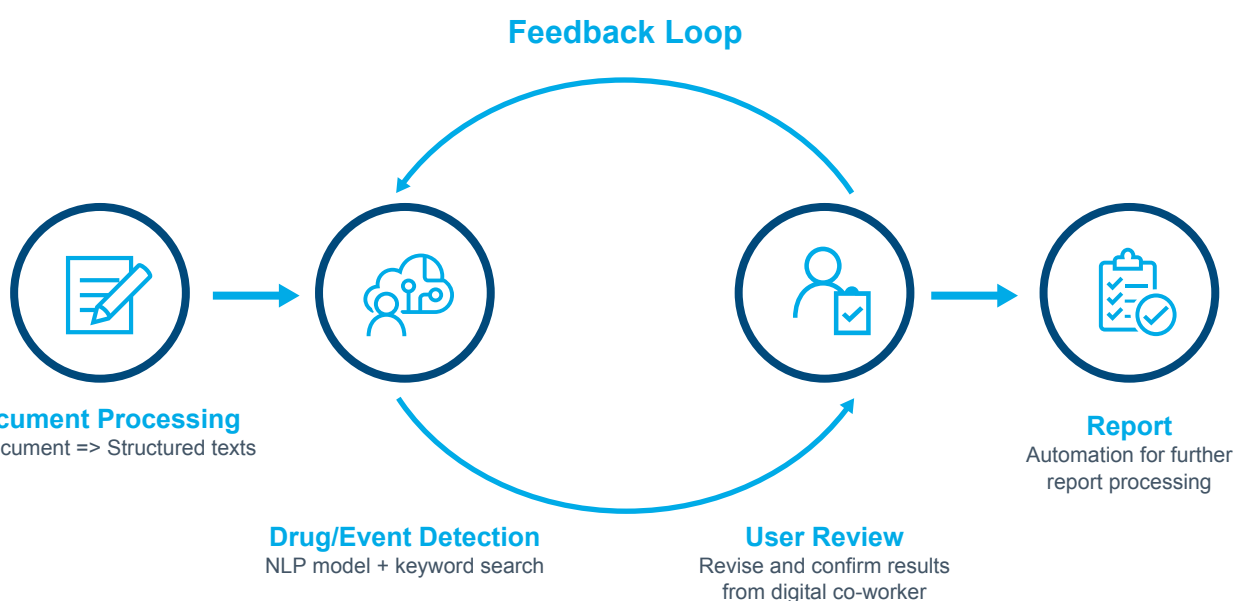
Source: IQVIA internal materials

Case Study 2: Adverse Drug event alert platform

Traditional pharmacovigilance practices rely on manual collection of adverse events, which incur efficacy problems such as high regulatory difficulty, limited resources of case processing team, and cumbersome collection of case information. AI/ML technology can effectively help enterprises overcome the bottlenecks in pharmacovigilance. The adverse event alert model based on BERT, LSTM, RNN and other algorithms can automatically determine adverse drug events based on data samples labelled by enterprises through pre-set keywords and learning structured text formed by in-depth interviews with enterprises. The adverse drug event alert platform has three major advantages: intelligent prompting, instant feedback, and self-learning. The platform can quickly capture negative events, extract key elements

of adverse events, and provide enterprises with intelligent prompting anchor points. The platform allows users to add, delete, and modify adverse event elements by themselves, and make appropriate adjustments to the model according to specific businesses. The platform can also achieve self-learning in the pharmacovigilance task through data accumulation to achieve self-learning, using uploaded documents to form structured data assets for natural language processing model iteration. The platform integrating AI/ML technology greatly improves the scalability and generalizability of the pharmacovigilance model: in a test environment, the model was able to reduce the average document review time for skilled users by up to 50% with no missed reports (100% recall rate). (Figure 2.3.2)

Figure 2.3.2: Adverse Drug Event Alert Platform Improves Scalability of Pharmacovigilance Model



Source: IQVIA internal materials

2.4 Deep Insights: AI/ML Technology Empowers Scientific Decision

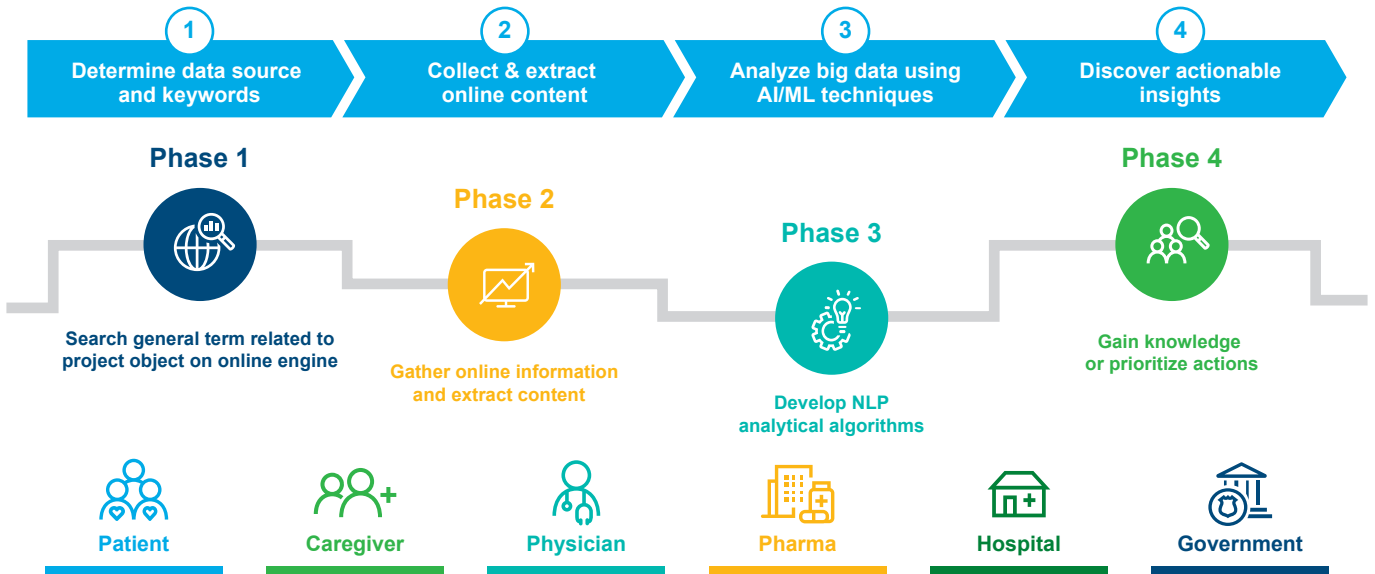
The continued development of China's healthcare market has created abundant sources of varied data. AI/ML technology can help enterprises to better utilize and interpret the rich market data in unprecedented ways. Using ML and statistical models enterprises can collect, analyze, and understand data more comprehensively and efficiently through deep data mining and integration, form deep insights of the market and customers, and realize algorithm-driven business decisions.

Case Study 1: Social listening

With a vast market and complex industrial structure, healthcare enterprises need to keep an eye on the opinions and suggestions from multiple stakeholders such as doctors, patients, caregivers, medical institutions, pharmaceutical enterprises and government. With the development of mobile internet, pharmaceutical and medical device enterprises are able to collect opinions and information from multiple parties comprehensively and conveniently through online internet channels, providing strong support for

subsequent market decisions. Due to the large amount of relevant information generated by online channels and the complexity of the content, manual collection of such information often encounters the problems of high costs and omissions. AI/ML technology can assign real-time identification, collection and preliminary analysis of online channel information through natural language processing technology, helping enterprises to "listen to all sides" and form real-time insights of the market. (Figure 2.4.1)

Figure 2.4.1: Social Listening Enhances Market Insights



Source: IQVIA internal materials

Case Study 2: Causal analysis model drives marketing decisions

In order to improve marketing communication efficiency, pharmaceutical and medical device enterprises need to track and evaluate the promotional activities of new products after launch to adjust marketing strategies. In the field of medical communication, medical professionals' perception of drugs, devices, and treatment is influenced by several interrelated factors such as different forms of visits by medical representatives, marketing activities and academic support activities. Most of the traditional analysis methods are based on empiracally-driven searches for the main influencing factors, then find the core impacting factors through their correlation analysis in parallel with the target factors. However, due to the large number of influencing factors in the actual market and the correlation between the factors, it is difficult for the traditional analysis methods to show the causal relationship of the core market as a whole. Therefore, traditional market factor data analysis is difficult to generate correct

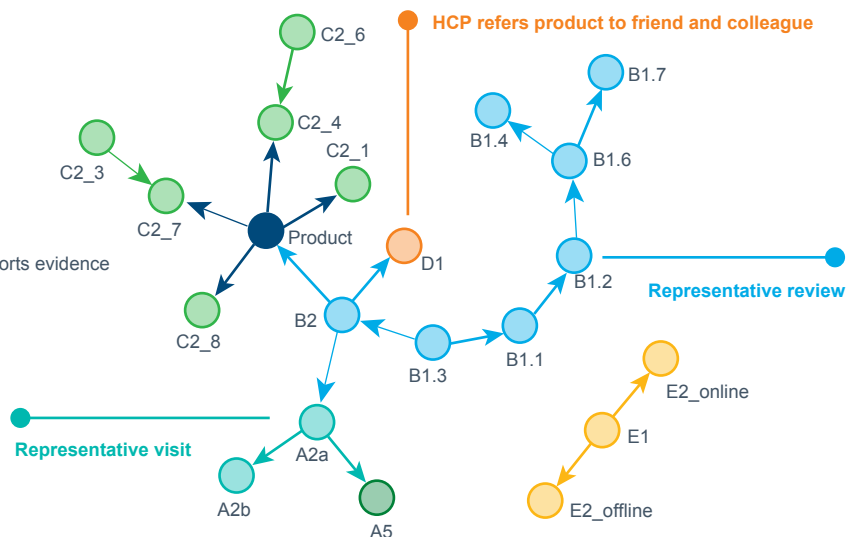
and profound market insights.

The causal graph model formed based on algorithms and data can be a good solution to deal with above challenges. Based on Bayesian networks, this model uses a directed acyclic graph to visually describe the causal relationships between variables, which is particularly suitable for revealing the actual causal mechanisms of the real observed data. This causal analysis technique not only can automatically extract causal relationships from real data with large magnitude, many variables, and complex relationships, which can significantly reduce the trial-and-error time in the analysis and the subjective influence of analysts. It can also explore the latent direct or indirect causal relationships among many factors that are difficult to discover manually and enhance the overall interpretability. (Figure 2.4.2)

Figure 2.4.2 Causal Analysis Model Enhance the Overall Interpretability

Key drivers to HCP product reference

- B2: HCP satisfaction towards medical representative visit
- B1.3: Providing clinical evidence and key information supports evidence
- B1.2: Knowing product difference clearly



Source: IQVIA internal materials

Part III: Looking for Partners

The business enablement of AI/ML algorithms in the healthcare industry is highly dependent on the capabilities of enterprises and their partners in terms of infrastructure, data assets, talent teams, technology models and some other aspects. To truly integrate these technologies with the enterprise and create more value, enterprises should look for partners with the following capabilities:

Data strengths

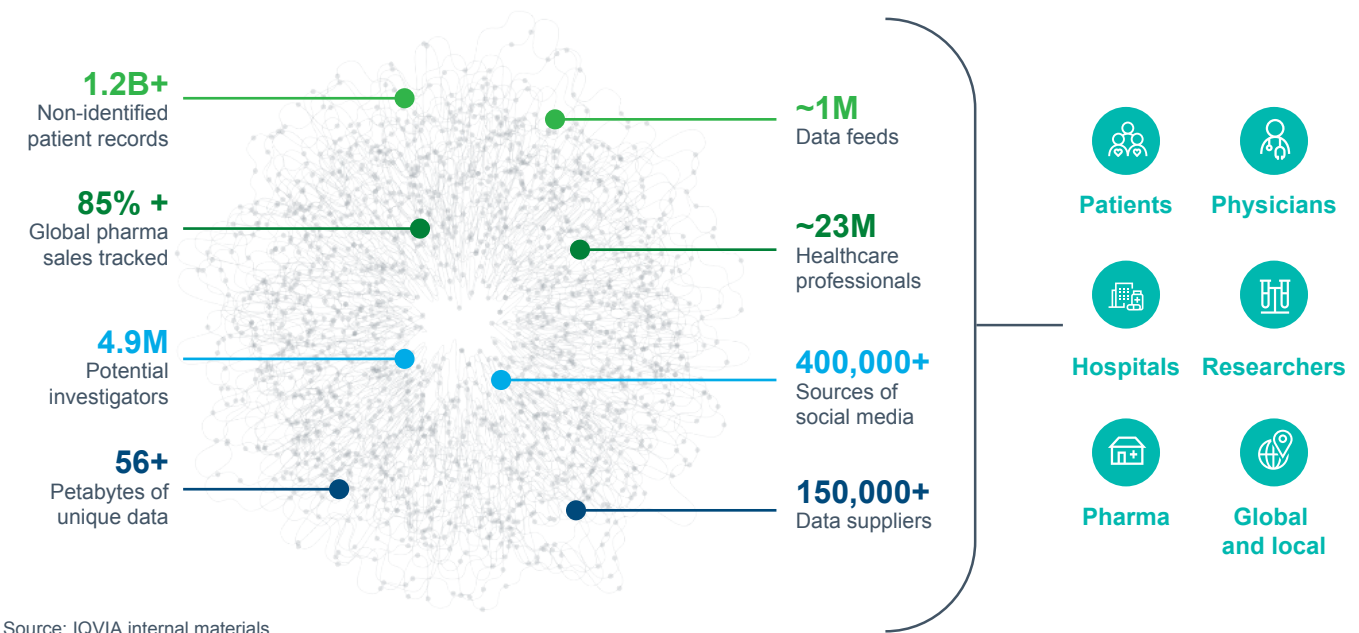
Vast structured and unstructured healthcare data sets.

Training, deployment, debugging, and application of AI/ML models all rely on massive amounts of data. The reliance of AI/ML algorithms on the quantity and quality of data requires enterprises and partners to continuously develop innovative and reasonable data collection methods, continuously expand data sources and optimise data collection methods. It requires healthcare industry enterprises and partners to acquire data with large volume, wide coverage, fast update speed, detailed granularity and robust application scenarios to provide a solid foundation for the application of AI/ML technology, helping enterprises to promote the progress of healthcare and human health.

Data compatibility and data integration capability.

AI/ML models require enterprises and partners to consider the availability of data and business applications, combine structured and unstructured data, and provide important research insights for enterprises. The deployment and application of AI/ML technology in healthcare requires breaking through data barriers, connecting data silos, and reflecting the advantages of synergy between enterprises' own data and large-scale centralised data in business practice. Partners should provide enterprises with data assets that are richly sourced and updated in a timely and granular manner, covering a variety of delivery formats and data interfaces to meet different levels of enterprise data needs (Figure 3.1).

Figure 3.1: Unparalleled Data



Source: IQVIA internal materials

Technology advantage

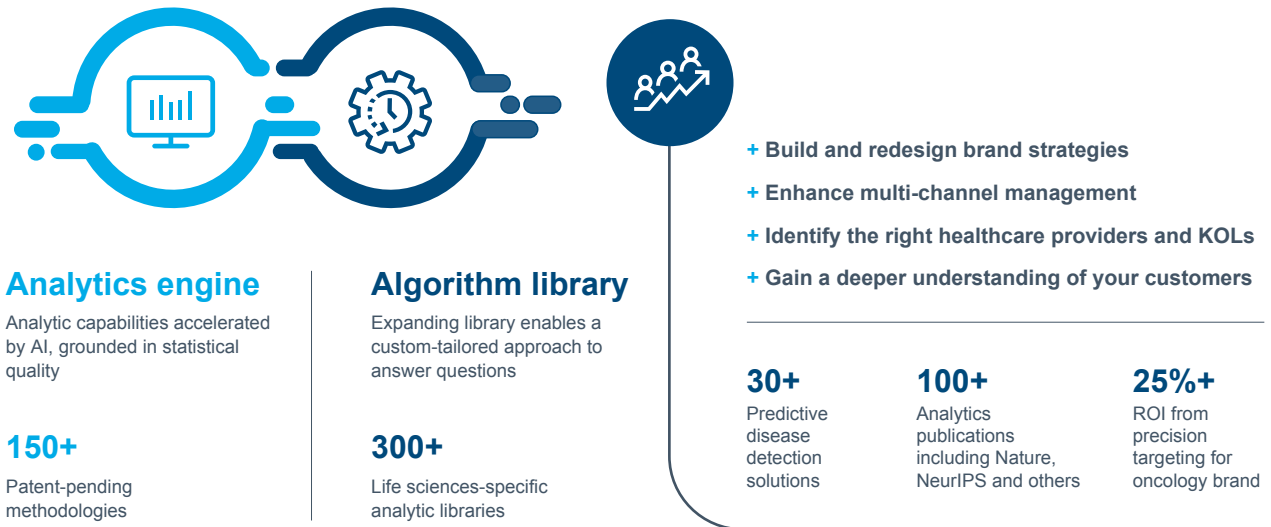
Advanced AI/ML technology.

The empowerment of AI/ML for enterprise is highly dependent on the training and deployment of algorithms. This requires enterprises and partners to be able to rely on technical accumulation in the field of machine learning and statistics, adopt professional methodology, build accurate and advanced models, provide solutions for non-deterministic scenarios in complex environments and promote the deep integration of AI/ML technology with the medical field. Relying on the enterprise-level AI/ML platform, pharmacy enterprises and partners are able to conduct data mining, data analysis, statistical modelling, and model training based on mass data as well as to achieve business empowerment with advanced technologies.

Data analysis and machine learning team.

The deployment and application of AI/ML technology are highly dependent on talent teams of statistics, data science, and computer science. They have the ability to build a community of data science and big data analytics for the medical field, promote the research, development, and deployment of data science, and anticipate exploring and pioneering a new generation of data-based artificial intelligence platforms. These teams of highly intelligent experts should have cutting-edge expertise, continuous self-learning ability, rich experience in team collaboration, and ample business domain accumulation to provide a solid talent pool for healthcare enterprises to deploy business applications of AI/ML technology. (Figure 3.2)

Figure 3.2: Advanced Analytics



Source: IQVIA internal materials

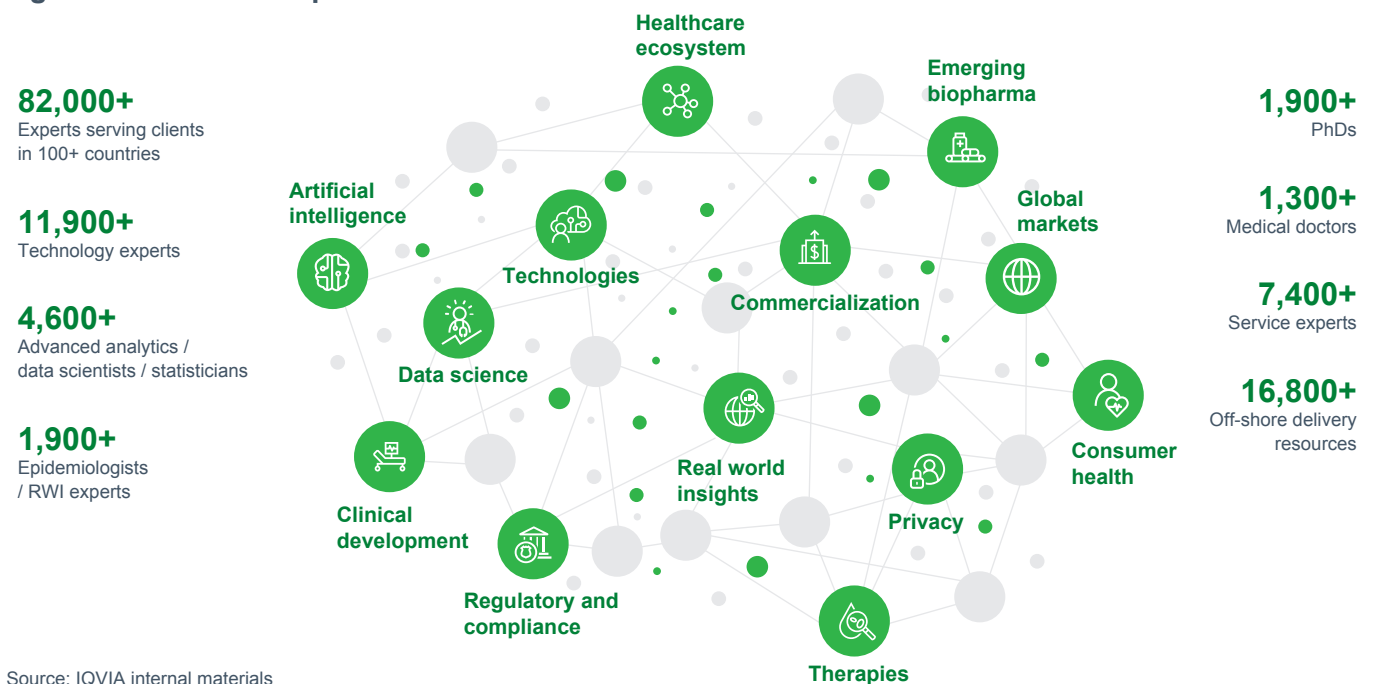
Industry experience

Comprehensive domain knowledge.

The integration of AI/ML technology with the healthcare sector requires enterprises and partners to have an extensive understanding of market trends, industry ecology, and cutting-edge technologies in the healthcare industry, and to accumulate substantial knowledge about China's healthcare industry in years of in-depth field cultivation. Predictions and judgments made by AI/ML models must be combined

with expert judgments of the healthcare industry to better create value. Enterprises and partners should accumulate extensive industry knowledge at an organizational level and acquire more experience in pharmaceutical fields through in-depth communication with medical experts to increase the applicability and interpretation of AI/ML models in business decisions. (Figure 3.3)

Figure 3.3: Domain Expertise



Source: IQVIA internal materials

Infrastructure and support

The close integration and business empowerment of AI/ML technology with the medical and health care industry also requires enterprises to pay attention to infrastructure and industrial synergies supporting construction when selecting sites and take advantage of policy and location together with the AI and medical industry clustering effect. Zhongguancun (Beijing West) Artificial Intelligence Technology Park is a key industrial park project built by Zhongguancun Administrative Committee, Mentougou District Government and Zhongguancun Development Group to promote industrial development. Located in Zhongguancun Mentougou Park, the project benefits from the advantages of multiple policies such as the policy of New Shougang Collaborative Support Zone and Shougang International Talent Community, the policy of West Beijing Industrial Transformation and Upgrading Demonstration Zone, the policy of Zhongguancun National Independent Innovation Demonstration Zone and the policy of Beijing "Two Districts".

Planned building of an industrial carrier of 800,000 square meters will provide diverse space carriers for leading enterprises, small and medium-sized enterprises, business offices, large R&D offices, incubation R&D, and others. It will provide hotel, commercial and industrial park support. With advanced design concepts and construction ideas, the part will intergrade production, living, and ecologically organic needs with industrial development and human needs.

The park focuses on AI technology-enables application links and concentrates on developing innovative industrial systems in three major segments: AI healthcare; smart audio visual and intelligent manufacturing, and deeply integrates the concepts of digital intelligence park, zero carbon park, and intelligent manufacturing on the building infrastructure. High-standard planning and construction and high-quality investment services provide medical and health industry enterprises with a good infrastructure. Location advantages and policy support and provide an important boost for the development of AI and medical and health industry. The park is committed to combining "inclusive

computing power + entrepreneurial services + innovation platform + high-quality talents" to promote the expansive integration of AI and healthcare by building an integrated cooperation platform.

Powerful arithmetic infrastructure.

The deployment and application of AI/ML technology requires a powerful arithmetic infrastructure. The high complexity and uncertainty of AI computing requirements in healthcare pose a great challenge to arithmetic infrastructure requirements. Enterprises and partners need to acquire arithmetic infrastructure to meet different needs such as mass data processing, intelligent business high-performance computing, AI model training and inference, and intelligent algorithm acceleration according to their own model training characteristics and business needs. Zhongguancun (Beijing West) Artificial Intelligence Technology Park, in conjunction with Zhiyuan Research Institute, provides services such as ultra-large-scale intelligent models. They cooperate with Huawei, Baidu and other leading enterprises to provide services covering autonomous, controlled and open-source intelligent computing centres, cloud-side end architecture, AI model algorithm migration and adaptation. They are able to provide enterprises with next-generation intelligent infrastructure featuring edge computing and network security, so as to promote the implementation of AI and medical treatment.

Synergistic AI and medical industry clustering.

The deployment and application of AI/ML technology benefit from the collaboration and knowledge spillover effects of upstream and downstream enterprise partners. Relying on comprehensive integrated platform services such as co-working, industrial investment and technology finance, Zhongguancun (Beijing West) Artificial Intelligence Technology Park has attracted a large number of AI healthcare start-ups, providing good industrial collaboration conditions for the implementation of AI/ML technologies.

Conclusion

In the post-epidemic era, China's healthcare industry is facing a more competitive environment with rapidly changeable customer needs. The changing market environment requires enterprises to gradually shift to digitalization to improve their responsiveness and provide more personalized services, as well as innovate and empower their businesses and original business processes and models to tackle possible challenges. In the face of big data with large magnitude and high complexity, high-level analytics represented by AI/ML technologies can effectively process and analyze market demand, transform business scenarios and business needs into AI algorithms and ML models. AI/ML can empower multiple application scenarios throughout the product lifecycle through leading speed accurate decision making, convenient expansion, and deep insight, subsequently helping enterprises to reduce costs, improve operational efficiency, and facilitate business decisions and digital transformation.

References

Biotechnology Innovation Organization, Informa Pharma Intelligence, and QLS Advisors (2021). *Clinical Development Success Rates and Contributing Factors 2011–2020*.

<https://pharmaintelligence.informa.com/resources/product-content/2021-clinical-development-success-rates>

DingXiang Doctor (2022). *2022 National Health Insight Report*.

<https://dxy.me/rvLJMf>

IBM (2022). *What is Artificial Intelligence*.

<https://www.ibm.com/cloud/learn/what-is-artificial-intelligence>

Industrial Internet Industry Alliance (2021). *White Paper on Digital Transformation of Biopharmaceutical Enterprises (2021)*.

National Medical Products Administration (2022). Quick overview of drug regulatory policies (No. 43): *Accelerating the improvement of drug technical guidelines system*.

<https://www.nmpa.gov.cn/directory/web/nmpa/xxgk/zhcjd/zhcjdyp/20220722155418133.html>

National Medical Products Administration (2022). *2021 Annual Drug Review Report*.

<https://www.nmpa.gov.cn/directory/web/nmpa/xxgk/fgwj/gzwj/gzwjyp/20220601110541120.html>

National Healthcare Security Administration (2021). *Notice of the National Health Insurance Administration on the issuance of a three-year action plan for DRG/DIP payment reform*.

http://www.gov.cn/zhengce/zhengceku/2021-11/28/content_5653858.htm

State Council (2021). *State Council Regular Policy Briefing*. January 29, 2021.

<http://www.gov.cn/xinwen/2021zccfh/4/index.htm>

General Office of the State Council (2018). *Opinions of the General Office of the State Council on improving the national essential drug system*.

http://www.gov.cn/zhengce/content/2018-09/19/content_5323459.htm

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