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Future Trends in Pharmacy Education Reform: Integration of Big Data and Intelligent Technologies

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Abstract: *Pharmacy education is undergoing profound changes due to advances in big data and intelligent technologies. National policies, particularly educational reforms and the "Healthy China" strategy, emphasize innovation and practical orientation. Collaborative efforts among universities, industries, and research institutions are fostering interdisciplinary curricula and intelligent teaching models. The integration of intelligent technologies in drug development and education has significantly improved efficiency, precision, and practical skills, enhancing students' innovative abilities. Moving forward, pharmacy education will increasingly merge technological advancements with academic disciplines. Policy support, resource investment, and teaching innovations will continue to develop multi-disciplinary talent suited to the modern pharmaceutical industry. These changes are essential for strengthening the pharmaceutical sector and advancing the "Healthy China" strategy.*

Keywords: *Pharmacy education; Big Data; Intelligent Technologies; Healthy China; pharmaceutical industry*

1. Introduction

Pharmacy education plays a pivotal role in the rapidly evolving landscape of contemporary medical technology. With the widespread application of big data and artificial intelligence (AI), traditional models of pharmacy education are facing significant challenges, necessitating transformation. Historically, pharmacy education has focused primarily on the transmission of foundational scientific knowledge, with limited emphasis on interdisciplinary skill development. However, big data and AI technologies have now profoundly impacted various fields, including drug development, personalised medicine, and pharmaceutical market management. This shift demands that pharmacy professionals acquire a broader set of skills and knowledge to meet the emerging needs of the industry[1,2].

AI technology, through the analysis of vast amounts of medical and genetic data, can significantly accelerate the drug development process and improve the success rate of new drug discovery[1,3]. In the field of personalised medicine, the application of big data has made precision treatments a reality. By analysing patients' genomic data, specific treatment plans can be tailored to individuals, thereby improving therapeutic outcomes[4]. Additionally, in pharmaceutical market management, big data and AI have optimised supply chain management and market demand forecasting, enhancing the efficiency of drug distribution and allocation[5].

Hence, pharmacy education urgently requires systematic reforms in both curriculum design and teaching models, with a focus on developing students' interdisciplinary thinking, data analysis skills, and technological competencies[6]. At the same time, national policy support plays a critical role in ensuring that the education system adapts to technological advancements, fostering high-quality talent with diverse skill sets for the pharmaceutical industry[7]. This paper will explore the profound impact of big data and AI on pharmacy education in detail and propose corresponding reform strategies and policy recommendations.

2. Multidimensional Impact of Big Data and AI on Pharmacy

With the rapid advancement of technology, big data and artificial intelligence (AI) have become the

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driving forces behind transformative changes in the field of pharmacy[3,8]. Their widespread application has not only advanced drug development and personalised medicine but also significantly impacted the management and operations of the pharmaceutical market. In various sectors of pharmacy, big data and AI have helped the industry overcome longstanding challenges by enhancing efficiency, reducing costs, and optimising decision-making processes[9,10].

2.1 Transformation in Drug Development

Drug development has long been a complex and high-risk process. Traditional drug discovery workflows are time-consuming, costly, and have a relatively low success rate. On average, bringing a new drug from discovery to market takes 10 to 15 years and costs billions of dollars, with a failure rate exceeding 90%[11,12]. This process involves extensive experimentation and trial-and-error, with significant uncertainties in drug discovery, screening, and clinical trials. Moreover, the complexity of drug development is amplified by the need to integrate knowledge from various disciplines, including chemistry, biology, and medicine, further increasing the challenges associated with the process[13,14].

The introduction of big data and AI technologies is fundamentally transforming this scenario. By analysing genomic data, molecular compound data, and clinical trial data, AI can significantly accelerate drug screening, optimise clinical trial design, and enhance the success rate of new drug development[15]. AI has demonstrated strong computational and predictive capabilities in various stages of drug development, including target identification, molecular design, and response prediction. [16-18] Firstly, in drug target identification, traditional methods primarily rely on experimental trial-and-error and the intuition of scientists. However, with AI, vast amounts of genomic data can be processed in a short period, allowing AI to identify potential drug targets and analyse their behaviour under different pathological conditions[3,11]. Secondly, AI has made significant strides in drug molecule screening. Traditional drug molecule screening typically involves extensive experimentation to identify compounds with therapeutic activity. In contrast, AI, through deep learning models, can rapidly identify potentially therapeutic molecules from millions of compounds[19]. AI, leveraging deep learning models, can rapidly identify potentially therapeutic molecules from millions of compounds. By combining molecular dynamics simulations with AI algorithms, it is possible to quickly predict interactions between molecules and protein targets, thus enabling the design of drugs with optimal pharmacological properties.

2.2 The Rise of Personalised Medicine

Personalised medicine, or precision medicine, tailors diagnostic and therapeutic strategies based on an individual's genomic, environmental, and lifestyle data. Driven by advances in genomics, systems biology, and big data, this approach maximises treatment efficacy and minimises adverse effects. Big data integrates genomic, proteomic, metabolomic, and clinical data to help doctors design optimal medication plans for patients.[20]. In traditional medical models, physicians often rely on empirical judgments and standard treatment protocols. However, the advent of personalised medicine allows for the tailoring of optimal treatment plans based on each patient's genetic information, thereby enhancing treatment efficacy and reducing the likelihood of adverse drug reactions[21-23]. For instance, personalised medicine has found extensive application in cancer treatment. Gene sequencing technologies help physicians analyse genetic mutations in cancer cells to identify the most appropriate targeted therapies[23]. AI, by analysing vast amounts of patient genetic data, assists doctors in predicting how different drugs will react in individual patients, thereby avoiding the trial-and-error approach to medication[10,24]. For example, gene sequencing allows doctors to accurately identify patients who are most likely to benefit from Herceptin, significantly improving treatment outcomes[25].

2.3 Digital Management of the Pharmaceutical Market

Digital management plays a crucial role in drug production, supply chain operations, and market demand forecasting. The digitalisation of the pharmaceutical market has become an inevitable trend for modernising the industry, enhancing efficiency, and optimising resource allocation. The application of AI and big data has not only transformed drug production processes but also significantly improved the accuracy of supply chain management and market demand predictions.In traditional pharmaceutical supply chains, issues such as information asymmetry, resource wastage, and drug shortages or surpluses are common. Big data analysis enables pharmaceutical companies to accurately forecast drug demand, allowing for timely adjustments in production schedules to avoid overproduction or shortages.

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3. Core Directions of Pharmacy Education Reform

In the context of rapid technological advancements, pharmacy education faces new challenges and opportunities. The swift development of emerging technologies such as big data and artificial intelligence (AI) has rendered traditional pharmacy education models insufficient for meeting the demands of the modern pharmaceutical industry for high-quality, multidisciplinary talent. Hence, pharmacy education requires systematic reform, particularly in areas such as curriculum design, practical skills development, and intelligent learning methods.

3.1 Multidisciplinary Curriculum Design

Traditional pharmacy education curricula typically focus on foundational subjects such as biology, chemistry, and pharmacology, with limited emphasis on fields closely related to modern pharmaceutical researchs[26,27]. With AI and big data increasingly used in drug development, pharmacy students must acquire not only traditional pharmaceutical knowledge but also skills in programming, data analysis, and statistics. These skills are crucial for improving drug development efficiency and addressing complex pharmaceutical challenges. Currently, most pharmacy curricula focus mainly on knowledge transmission, lacking integration with disciplines like programming and data science. AI, for example, speeds up drug discovery by analyzing genomic data and screening compounds, yet traditional education does not include systematic training in these areas. Therefore, pharmacy education needs urgent reform to include multidisciplinary concepts such as programming, statistics, and data science. Courses should integrate tools like Python and R, and incorporate statistics to enhance students' abilities in experimental design and data analysis. This approach will better prepare students for the evolving pharmaceutical industry. For instance, Stanford University has successfully integrated computer science and AI courses into its pharmacy program, fostering interdisciplinary skills.[28].

3.2 Integration of Theory and Practice

A major challenge in pharmacy education is the gap between theoretical knowledge and practical skills. To address this, the curriculum needs to enhance practical components and integrate theory with real-world applications. Traditional lab experiments and internships often lack cutting-edge technologies like AI. Reform should focus on increasing practical experience by incorporating AI and big data tools into drug development. Collaborations between universities and pharmaceutical companies can provide students with hands-on experience and skills in advanced technologies through industry-academia partnership projects.

3.3 Intelligent Learning Approaches

Intelligent learning methods, powered by AI, are transforming pharmacy education by offering personalized learning paths based on students' progress and needs. Adaptive teaching systems adjust content and plans to enhance learning efficiency and effectiveness. Students can select specific courses through intelligent platforms, which recommend tailored resources and exercises[29]. Additionally, online education platforms provide diverse pharmacy-related courses, further supporting individualized learning.

4. Policy-Driven Pharmacy Education Reform

The reform and development of pharmacy education are not only dependent on advancements in technology and disciplines but also on national policies for guidance and support. In recent years, the government has vigorously promoted education reform and the development of the pharmaceutical industry, accelerating the transformation and upgrading of pharmacy education through policy guidance and resource investment. Against this backdrop, pharmacy education faces unprecedented opportunities and challenges.

4.1 The Role of National Policies in Driving Pharmacy Education Reform

The importance of education has been highlighted in national development, urging for significant advancements in educational excellence[30]. This focus guides reforms in pharmacy education, which must align with national needs and supply innovative talent to the pharmaceutical and health industries.

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Under the "Healthy China" strategy, pharmacy education should not only develop talent but also enhance national health and support the pharmaceutical industry. In terms of practical policy measures, China has introduced a series of supportive policy documents for pharmacy education, such as the "14th Five-Year Plan for National Health" and "China's Education Modernization 2035"[31,32]. These documents stress the need to strengthen the training of high-level pharmacy professionals and promote the deep integration of pharmacy education with the pharmaceutical industry. Such policies provide crucial support for curriculum reform, faculty development, and research innovation within pharmacy programs. Furthermore, these policies encourage universities to collaborate with enterprises and research institutions, fostering industry-academia partnerships that drive technological innovation and educational development. This collaborative approach offers more practical opportunities for the cultivation of pharmacy talent.Driven by the "Healthy China" strategy, pharmacy education reform is increasingly focused on addressing national pharmaceutical industry needs. The government supports universities in developing industry-relevant courses, emphasizing both innovation and practical skills. This includes integrating emerging fields like big data and AI into drug research and development. National policies promote industry-academia-research collaborations and incentivize technology adoption, accelerating these advancements in pharmacy education.

4.2 Policy Recommendations

To advance pharmacy education reform, strengthening collaboration among universities, enterprises, and research institutions is crucial. Governments should promote long-term partnerships and joint projects through policies that support this integration. For instance, universities could work with pharmaceutical companies to co-develop curricula, leveraging companies for practical resources and research institutions for technical support, thus creating a unified industry-academia-research model. This collaboration enhances educational quality and speeds up research application, fostering innovation in the pharmaceutical sector. Policies should include financial support, tax incentives, and other measures to encourage corporate participation in educational and research initiatives, making such partnerships a key driver in improving pharmacy education and talent cultivation.

Incorporating AI technology into pharmacy education is another critical area. AI has revolutionized drug screening, development, and clinical trials by enhancing efficiency and precision. To integrate AI effectively, government policies should support technology training, curriculum development, and resource investment. Universities should be encouraged to offer AI-focused pharmacy courses and collaborate with AI companies to create specialized learning platforms. Investments should also be made in AI laboratories within pharmacy programs, and faculty training should be prioritized to ensure educators can effectively teach and guide students in AI technologies.

5. Conclusion

The rapid advancement of big data and AI is transforming pharmacy education by enhancing drug development efficiency and precision. Students now use big data platforms for real-time analysis and AI systems for virtual experiments and simulated trials, aligning education with industry needs and boosting innovation and practical skills. Future reforms will emphasize interdisciplinary curricula, integrating fields like computer science and bioinformatics, and deepen collaborations with industry to improve practical training. Universities should leverage policies and resources to cultivate well-rounded talent, combining pharmacy knowledge with technical skills. This integration of big data and AI offers significant opportunities for advancing pharmacy education and developing innovative talent.

References

[1] Paul, D. et al. Artificial intelligence in drug discovery and development. Drug Discov Today 26, 80-93 (2021).
[2] Zhang, H., Wei, Y. & Mani Saravanan, K. Artificial intelligence and Computer-Aided Drug Discovery: Methods Development and Application. Methods (2024).
[3] Aljofan, M. & Gaipov, A. Drug discovery and development: the role of artificial intelligence in drug repurposing. Future Med Chem 16, 583-585 (2024).
[4] Ashley, E. A. Towards precision medicine. Nat Rev Genet 17, 507-522 (2016).
[5] White, B. J., Amrine, D. E. & Larson, R. L. BIG DATA ANALYTICS AND PRECISION ANIMAL AGRICULTURE SYMPOSIUM: Data to decisions. J Anim Sci 96, 1531-1539 (2018).

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[6] Bao, Y. et al. Assessing The Impact Of State Policies For Prescription Drug Monitoring Programs On High-Risk Opioid Prescriptions. Health Aff (Millwood) 37, 1596-1604 (2018).
[7] Frenk, J. et al. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. Lancet 376, 1923-1958 (2010).
[8] Arora, G. et al. Artificial Intelligence in Surveillance, Diagnosis, Drug Discovery and Vaccine Development against COVID-19. Pathogens 10 (2021).
[9] Mak, K. K. & Pichika, M. R. Artificial intelligence in drug development: present status and future prospects. Drug Discov Today 24, 773-780 (2019).
[10] Topol, E. J. High-performance medicine: the convergence of human and artificial intelligence. Nat Med 25, 44-56 (2019).
[11] Paul, S. M. et al. How to improve R&D productivity: the pharmaceutical industry's grand challenge. Nat Rev Drug Discov 9, 203-214 (2010).
[12] Wouters, O. J., McKee, M. & Luyten, J. Estimated Research and Development Investment Needed to Bring a New Medicine to Market, 2009-2018. JAMA 323, 844-853 (2020).
[13] Pushpakom, S. et al. Drug repurposing: progress, challenges and recommendations. Nat Rev Drug Discov 18, 41-58 (2019).
[14] Crunkhorn, S. Immunotherapy: Vaccine patch to treat melanoma. Nat Rev Drug Discov 17, 18 (2017).
[15] Hutson, M. How AI is being used to accelerate clinical trials. Nature 627, S2-S5 (2024).
[16] Zhavoronkov, A. et al. Deep learning enables rapid identification of potent DDR1 kinase inhibitors. Nat Biotechnol 37, 1038-1040 (2019).
[17] Stokes, J. M. et al. A Deep Learning Approach to Antibiotic Discovery. Cell 180, 688-702 e613 (2020).
[18] Jumper, J. et al. Highly accurate protein structure prediction with AlphaFold. Nature 596, 583-589 (2021).
[19] Smer-Barreto, V. et al. Discovery of senolytics using machine learning. Nat Commun 14, 3445 (2023).
[20] Lau, E. & Wu, J. C. Omics, Big Data, and Precision Medicine in Cardiovascular Sciences. Circ Res 122, 1165-1168 (2018).
[21] Alyass, A., Turcotte, M. & Meyre, D. From big data analysis to personalized medicine for all: challenges and opportunities. BMC Med Genomics 8, 33 (2015).
[22] Bonkhoff, A. K. & Grefkes, C. Precision medicine in stroke: towards personalized outcome predictions using artificial intelligence. Brain 145, 457-475 (2022).
[23] Schussler-Fiorenza Rose, S. M. et al. A longitudinal big data approach for precision health. Nat Med 25, 792-804 (2019).
[24] Zhang, Z. et al. Integrated analysis of single-cell and bulk RNA sequencing data reveals a pan-cancer stemness signature predicting immunotherapy response. Genome Med 14, 45 (2022).
[25] Xiong, X., Wang, X., Liu, C. C., Shao, Z. M. & Yu, K. D. Deciphering breast cancer dynamics: insights from single-cell and spatial profiling in the multi-omics era. Biomark Res 12, 107 (2024).
[26] Silva, R. O. S., de Araujo, D., Dos Santos Menezes, P. W., Neves, E. R. Z. & de Lyra, D. P., Jr. Digital pharmacists: the new wave in pharmacy practice and education. Int J Clin Pharm 44, 775-780 (2022).
[27] ElKhalifa, D. et al. Curriculum, competency development, and assessment methods of MSc and PhD pharmacy programs: a scoping review. BMC Med Educ 24, 989 (2024).
[28] Conley, M. & Yanny, A. M. Medicine's AI boom, <https://stanmed.stanford.edu/translating-ai-concepts-into-innovations/> (2020).
[29] Abdel Aziz, M. H. et al. A scoping review of artificial intelligence within pharmacy education. American Journal of Pharmaceutical Education 88 (2024).
[30] DESHENG, C. Xi: Build leading nation in education, <https://www.chinadaily.com. cn/a/202409/11/WS66e0ca93a3103711928a73ce.html> (2024).
[31] CHINA, T. P. S. R. O. China to promote national health during 14th Five-Year Plan, <https://english.www.gov.cn/policies/latestreleases/202205/20/content_WS62874295c6d02e533532b0bd.html> (2022).
[32] China, P. s. R. o., Council, T. S. & XinhuaNet. The CCPC and State Council Publishes ‘China's Education Modernisation 2035 Plan, <www.gov.cn/xinwen/2019-02/23/content_5367987.htm> (2019).