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Research Article

Artificial Intelligence: A Review on AI Powered Applications in Pharmacy

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ABSTRACT

Artificial intelligence (AI) has recently expand its application in various sectors among which pharmaceutical industry is one of main beneficiary. AI in pharmacy has bright future ahead, with potential to improve patient outcomes, reduces cost, further optimize healthcare delivery. AI with robotics in the life of mankind has different advantages and disadvantages. The successful application of AI is dependent on availability of high-quality data, the addressing of ethical concerns, and the recognition of AI based approaches. This review article highlight the impactful use of AI in various areas of pharmaceutical sector such as Drug Discovery And Drug Development, Personalized Medicine, Pharmacovigilance, Automated Dispensing system Of Drug, Hospital Pharmacy, Patient Counseling And Education, Pharmaceutical Manufacturing, Clinical Decision Support.

INTRODUCTION

Artificial intelligence involves using computational models, algorithms or rules to enable machines to mimic human cognitive functions like learning and problem solving (1).The field of technology has significantly expanded since the revolution, replacing many challenging manual tasks and benefiting humanity. Artificial intelligence system replicate various human abilities and are widely used across industries to replace physical tasks traditionally performed by human.(2) In 1943,Warren Mc Culloch and Walter Pitts laid the foundation for AI by proposing the model of artificial neurons , marking the beginning of AI's development(3).In 1955 ,the first AI framework called Logic theorist was created by Allen Newell and Herbert A. Simon(4).AI was first described in 1956 by John Mc Carthy ,who coined the term know as birth of Al(5).

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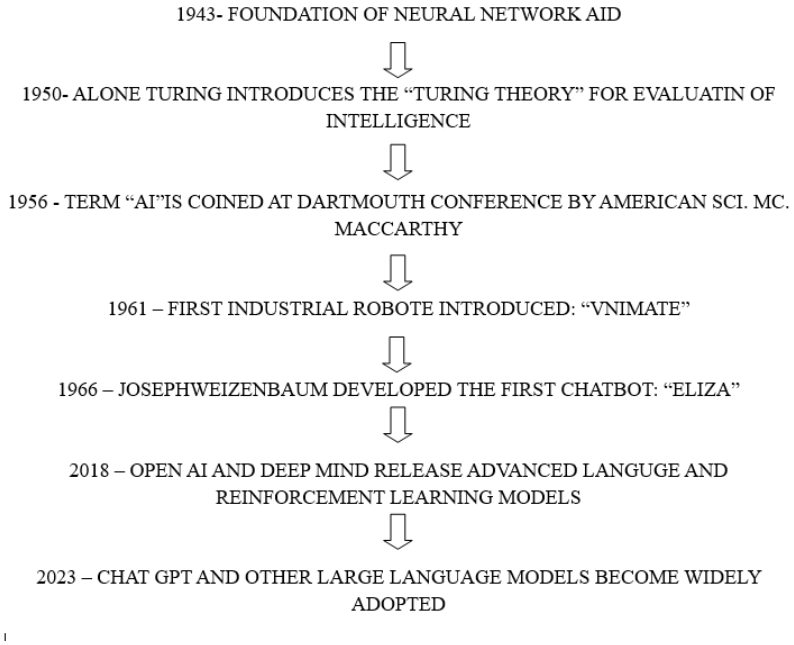
The integration of artificial intelligence has significantly transformed the pharmaceutical and healthcare industries(6).AI has become a vital tool in pharmaceutical sciences in drug discovery . AI analyzes large datasets , identifies patterns and screens millions of compounds to find potential drug candidates speeding up and improving the accuracy of outcomes(7). The top ten pharmaceutical companies using AI include Pfizer ,Roche, Novartis, Johnsonand Johnson, MSD, Sanofi, AbbVie, Glaxo SmithKline, Amgen and Gilead Sciences (8). AI techniques can predict the three dimensional structure of proteins rapidly using only their one dimensional amino acid sequences, significantly accelerating structural analysis(9).In 2020 Baidu introduced the linear fold of AI algorithm to assist medical and scientific teams in developing a COVID -19 vaccine. This algorithm was capable of predicting the RNA sequence of the SARS-CoV-2 virus in just 27 seconds , making it 120n times faster than traditional methods(10).Topol (2019) in the Lancet Digital Health emphasizes AI's significant role in revolutionizing healthcare by enhancing diagnosis, treatment, drug discovery and personalized medicine ,while also reducing costs and improving outcomes(11).

Development In Artficial Intelligence



APPLICATION OF AI IN PHARMACY :

1. Drug Discovery And Drug Development -

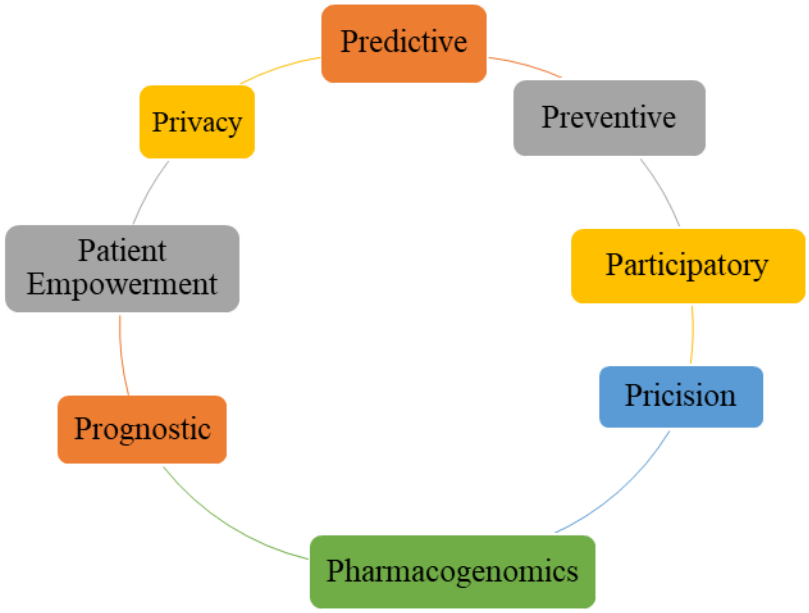
Now days AI plays an important role in pharmaceutical industries . AI is advanced technology that mimics human intelligence . Motive of use to AI that , it can handle large amount of data with automation and solve complex clinical problems. According to McKinsey Global Institute, the rapid advances in AI-guided automation will be likely to completely change the work culture of society. (12) Development of new drug is very lengthy and highly expensive process. Beside some examples shows power of computer assisted drug discovery process that revealing successful application of AI on this vivid area. DSP-1181 :As per report DSP-1181 is the first drug developed using AI that enters in clinical trials . DSP-1181 is developed by Exscientia in partnership with Japan's

Sumitomo Dainippon Pharma , and claims that it had taken less than 12 months from initial screening to the end of preclinical testing as contrasted to 4 years using conventional methods. (13) AI based tools are used to predict physicochemical properties like solubility, degree of ionization, partition coefficient , drug permeability which must be considerable factor during new drug designing. For example large data sets produced during previously compound optimization are used by MI [Machine Learning] to train the software. (14) In ligand based QSAR/QSPR modelling , the structural characteristics of drug molecule[e.g. Pharmacophore distribution, physicochemical properties, functional group,etc.] are commonly converted into computer readable number by using molecular discripators . (15) Multitask deep autoencoder presented by Xiang and colleagues for the prediction of the human cytochrome 450 inhibition, laying direction for reducing the side effects associated with inhibiting the CYP450 lane at AI.(16)

2. Personalized Medicine–

Personalized medicine involves prediction , prevention and treatment of diseases or illness as per individual's need . It is collection of biological, clinical, environmental, lifestyle and other data from large number of individual person characteristics.

8P's Of Personalised Medicine –



Pharmacogenomics personalize medicine so it can divide patient with specific disease into subgroups. Now this analogue rather than one-size-f its-all ,it have choice of small ,medium or large . (17) The tablet structure combined with patient specific requirements on drug release profiles, the algorithm can serve as tool for am automated design of 3D-printing tablets in the framework of personalized medicine. (18)

Bacteremia can causes morbidity and mortality . Bacteremia based on taken up to 6 days laboratory test. AI using electronics health records of hospital patients along with physician analysis of patient would shorten up to 6 days the start of early administration of personalized antibiotics and additional treatment and prevent subsequent complications. (19)

Personalized Medicine for –

A] CVD - By using echocardiographic characteristics recommended by guidelines assessing LDVV, hierarchical clustering produced groupings that distinguish patient prognosis better than standard- based categorization.

B] ADHF – AI with unstructured data had the best performance for identifying ADHF .(20)

3. Pharmacovigilance -

Complication of pharmacovigilance is essential to reduce the incidence and severity of adverse effects. The review begins by explaining the core principles of pharmacovigilance and its importance in drug safety monitoring. It the explores how AI technologies, like machine learning and natural language processing, are being used to improve the efficiency and accuracy of detecting adverse events and assessing risks. Additionally, the review highlights various AI-driven methods in pharmacovigilance, such as analyzing electronic health records, mining social media, and integrating with other healthcare databases.(21) AI is reshaping the landscape of pharmacovigilance by enhancing the efficiency, accuracy, and scalability of safety monitoring. From early detection of risks to improved regulatory compliance, AI enables better patient safety and supports proactive, data-driven decision-making. Bycontinuously improving and adapting to new data, AI can help pharmaceutical companies respond more quickly to emerging safety concerns and ensure a safer, more reliable drug supply.(22) Intelligent automation is increasingly being used in pharmacovigilance to enhance the efficiency, quality, timeless, and consistency of individual Case Safety Report (ICSR) processing, ultimately aiming to improve patient safety by speeding up the identification and communication of product safety information. In 2018,TransCelerate launched the Intelligent Automation Opportunities (IAO) initiative to help organization mange the growing volume of ICSRs. The IAO team focused on evaluating risks and barriers to adopting intelligent automation in pharmacovigilance, with the goal of improving sscalability, efficiency, and quality in processing safety data.(23) A large amount of artificial intelligence technology is required to electronically store pharmacovigilance related data to urgently implement data-driven automated methods across all aspects of pharmacovigilance to assist healthcare professionals. The challenges of implementing AI-based pharmacovigilance in resource-limited settings, categorizing them into four main areas:

A] Establishing a database for AI systems.

B] Lack of human resources.

C] Weak AI technology.

D] Insufficient government support.

The paper also discusses potential solutions and future directions for improving pharmacovigilance frameworks in such settings.(24)

Monitoring the safety of medicines-

1.Government 2.Industry 3.health professionals 4.patient 5.hospital and academia 6.medical and pharmaceutical associations 7.consumers 8.WHO 169 year ago the history of pharmacovigilance started on the 29 Jan 1884,Hannah greener,a19-year-old girl from England, died after receiving chloroform as an anesthetic for a toe- nail removal surgery. This event sparked concern and led to the establishment of a commission by the Lancet Journal to urge British doctors to report similar cases.(25) Since the 1960s,pharmacovigilance has been introduced in several regions. Governments and regulatory bodies monitor the postauthorization safety of medicines; this includes the World Health Organization Programme for International Drug Monitoring,

which was established in 19682, The European Medicines Agency (EMA).The Medicines and Healthcare products Regulatory Agency in the United Kingdom and the U.S. Food and Drug Administration.(26) A comprehensive evaluation of the national medicines regulatory authority, health facilities, and public health programs was conducted using a descriptive cross-sectional design. The study found that the national medicines regulatory authority scored 79%,meeting the standard for pharmacovigilance frameworks and capacity. However, health facilities and public health programs scored below 60%,highlighting the need for further operationalization of pharmacovigilance structures at these levels. The findings indicate that while Sierra Leones national pharmacovigilance center is functional and has strong leadership potential, there is a need to strengthen pharmacovigilance process at health facilities and public health programs to ensure effective risk management and safety data collection.(27) Pharmacovigilance, with its global significance, is an essential activity aimed at ddetecting, analyzing, and communicating drug safety issues that could affect public health across borders. The international network of pharmacovigilance centers, coordinated by the Uppsala Monitoring centre, would benefit from an independent review system that addresses contentious drug safety concerns, ensuring a broader public health impact. The Erice Declaration provides a framework for the collection, analysis, and communication of drug safety issues, emphasizing the balance between scientific and clinical integrity and the publics right to be fully informed on the other. It is a process that requires the active commitment of all involved-regulators, policy makers, health personnel, journalists, and pharmaceutical manufactures. scrupulous attention is required in the practice of pharmacovigilance to the issues of patient confidentiality.(28)

CASE PROCESSING LIFECYCLE IN PHARMACOVIGILANCE -

4. Automated Dispensing System Of Drugs–

Automated Drug Dispensing System is a pharmacy process where machine or robots handle prescription dispensing instead of humans. These systems are commonly used in hospitals to mange and distribute medication in wards, emergency rooms, and critical care units, especially in decentralized medication management settings. Medication are verified before dispensing to patients as well as barcode scanning an double checking by pharmacy staff to minimize and detect dispensing errors at check-in. Artifical intelligence has the potential to revoluationize pharmacies by computerized drug identification and overcomes barcode scanning.(29) ADDs are viewed as innovative soluations that can significantly enhance the safety, efficiency and workflow of medication administration. these systems integrate digital and information technologies to automate the storage, packaging, and dispensing of medication.

This automation can help hospitals:

1)reduce medication errors.2)improve administration accuracy.3)increase workflow efficiency in the pharmacy. The current state of literature Automated Dispensing Devices and highlights several key gaps in research related to their effectiveness, safety, and broder economic and organization impact.(30) The integration of internet of things technology into pharmacy automation has transformed medication dispensing, addressing challenges in traditional systems. IoT-enabled smart pharmacy automation systems improve efficiency and patient safety by utilizing real-time data monitoring, inventory management amd automated dispensing. The design, implementation and benefits of SPAS, emphasizing their role in enhancing medication accuracy, reducing errors, and optimizing pharmacy workflows.it also the challenges and future prospects of SPAS, including concers about security, integration with existing healthcare systems.(31) The retrospective study evaluated the effectiveness of an Automated Dispensing Cabinet integrated with information technology for drug distribution in a surgical unit at Taichung Veterans General Hospital in 2019.The study focused on key outcomes such as medication delivery time, healthcare profrssional work time,transportation manpower, dispensing errors,and nursing staff satisfaction.

5. Hospital Pharmacy -

Artificial Intelligence in hospital pharmacy is transforming how healthcare professionals manage medications, patient care, and pharmacy operations. AI technologies, including machine learning, natural language processing (NLP), and robotics, are being used to optimize processes, enhance patient safety, and support clinical decision-making. Below is a detailed explanation of AI applications in hospital pharmacy:

- Clinical Decision Support Systems (CDSS):

AI-powered CDSS assist pharmacists and clinicians by providing evidence-based recommendations for drug selection, dosing, and potential interactions.(32)These systems analyze patient data (e.g., lab results, medical history) to:

a. Identify drug-drug interactions.

b. Adjust dosages based on kidney or liver function.

c. Suggest alternative medications for allergies or contraindications.

For example, IBM Watson Health uses natural language processing to analyze medical literature and patient records, helping pharmacists make informed decisions.

1. Medication Reconciliation and Adherence:

AI tools streamline the process of reconciling medication lists, ensuring consistency across care settings. (33) They:

a. 1.Detect discrepancies in prescriptions versus actual patient use.

b. 2.Support personalized reminders or adherence programs using AI-powered apps.

For example, AI chatbots remind patients to take medications and provide real-time feedback to hospital systems.

2. Drug Inventory and Supply Chain Management:

AI helps hospitals optimize drug inventory by predicting demand, minimizing waste, and preventing stockouts. AI models analyze ;Historical usage patterns, Seasonal variations & Supply chain disruptions.(34)

For example, automated inventory management systems like Omnicell use AI to forecast stock levels.

3. Personalized Medicine and Pharmacogenomics:

AI integrates genetic data with clinical records to personalize drug therapies. (35) For instance:

a. Machine learning models predict patient responses to drugs based on genetic markers.

b. Tailored drug regimens are designed to maximize efficacy and minimize side effects.

Example: Systems like Tempus and GNS Healthcare leverage AI for pharmacogenomics-based recommendations.

4. Automation in Dispensing and Compounding:

AI-driven robots are increasingly used in hospital pharmacies for, Automated drug dispensing,

Compounding sterile and non-sterile preparations & Reducing human errors in dosage and labeling. (36)

For example, Swisslog'sPillPick system automates the storage, dispensing, and tracking of medications.

5. Pharmacovigilance and Drug Safety:

AI helps monitor adverse drug reactions (ADRs) and enhances pharmacovigilance efforts by a Analyzing electronic health records (EHRs) and social media for ADR signals&Flagging potential safety issues faster than traditional methods. (37)

6. Patient Education and Engagement:

AI tools support pharmacists in educating patients about their medications. (38)Chatbots and virtual assistants:

a. Provide 24/7 responses to medication-related queries.

b. Educate patients on proper drug usage and potential side effects.

Challenges in Implementing AI

a. Data Quality and Integration: AI requires high-quality, interoperable data, which can be challenging in fragmented healthcare systems.

b. Ethical Concerns: Issues like patient privacy, bias in AI algorithms, and accountability for AI-driven decisions need resolution.

c. Cost and Expertise: Implementing AI systems requires significant investment and training for healthcare staff.

Future Directions:

a. Development of real-time AI analytics for rapid decision-making.

b. Integration of AI with wearable devices for continuous monitoring.

c. Expansion of AI into predictive analytics for hospital readmission risks and therapy outcomes.

AI is transforming hospital pharmacy by enhancing operational efficiency, reducing medication errors, and supporting precision medicine. Its potential will grow as technologies advance, making AI an indispensable tool in modern healthcare.

6. Patient Counseling and Education -

When it comes to patient counseling and education research, various AI tools and approaches can enhance the effectiveness of communication, improve patient understanding, and optimize health outcomes. Effective communication between healthcare professionals and patients has become a priority in medicine, as it has been shown to positively influence pat inients' well-being, adherence to treatment, recall and understanding of medical information, ability to cope with disease, quality of life, and overall state of health. (39,40) Previous studies have shown high rates of discordant communication between physicians and patients, leading to poor mutual understanding . (41) To accomplish this, the use of both AI and VR technologies hold the potential to allow such communication support tools to be increasingly suited to individual patients and healthcare environments. Below is a detailed explanation of AI in patient counsiling and Education :

1) Decision Support systems

AI-driven decision support tools are used in clinical settings to guide both patients and healthcare providers in making informed decisions. (42) These tools analyze patient medical history, test results to recommend personalized treatment plans and predict potential health risks.

2) Personalized Educational Content

AI systems can generate personalized health education based on a patient's specific condition, demographic information and preferences. (43)

3) Chatbots and Virtual Assistants

AI powered chatbots, such as Babylon Health and Ada Health,offer real time patient counsiling by answering common questions and providing general health care advice. (44) Then the Virtual Assistants are designed to simulate human conversation, allowing patients to access health care information anytime, reducing wait times and improving access to care.

Benefits of AI in patient counsiling and Education :

1)Personalization: AI can tailor patient education materials to individual needs, improving comprehension and adherence to treatment protocols.

2)Accessibility: AI tools can provide healthcare information 24/7, helping patients in remote or underserved areas access necessary resources. (45)

3)Cost-Efficiency: By automating repetitive tasks and answering common questions, AI reduces the need for direct interaction with healthcare professionals, freeing them to focus on more complex issues.

4)Scalability: AI systems can handle a large volume of patient inquiries simultaneously,

making it easier to reach and educate a larger number of patients. (46)

This review explores the integration of AI in patient counseling and education, its benefits, challenges, and future directions. It focuses on how AI tools can support patients throughout their healthcare journey, from prevention to treatment adherence and long-term management. (47)

7. Pharmaceutical Manufacturing -

Artificial intelligence has the potential to improve drug manufacture, quality control, and active quality decision-making in the pharmaceutical industry.(48) AI is increasing production and efficiency by streamlining repetitive automation operations and pharmaceutical manufacturing processes. By optimizing variables like temperature, pressure, and response time, artificial intelligence (AI) techniques can boost process effectiveness, cut down on cycle times, and minimize waste production. Pharmaceutical companies can use automation and process optimization to increase plant productivity, uniformity, and quality.(49) By making it easier to discover abnormalities, contaminants, and inconsistencies early on, artificial intelligence supports a pharmaceutical company's quality control and quality assurance procedures. AI-enabled visual data analysis from production processes, such as tablet appearance, packaging integrity, and label accuracy, to detect flaws and match quality standards. (50)

Use of AI in Pharmaceuticalindustry:-

a. Improving drug discovery process

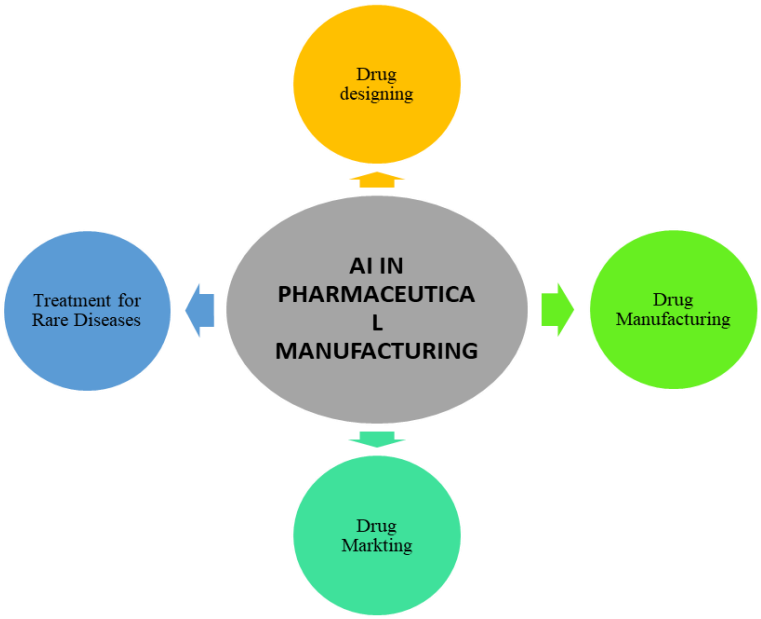
b. Diagnostic assistance to deliver personalized treatment.

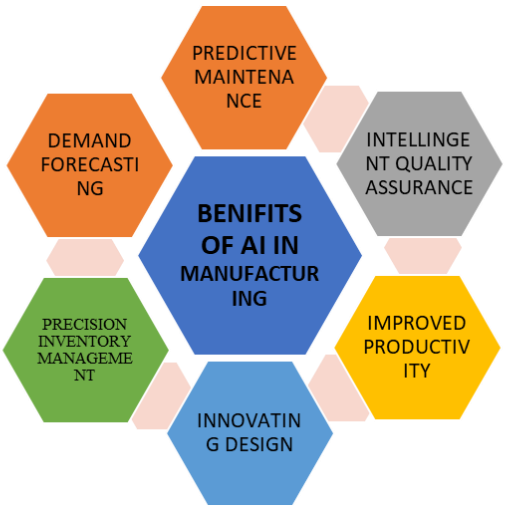
c. Enable pharma companies to sell and market improved.

d. More effective process of drug development and production.

e. Predict prevalent by using machine learning models.

Data security and privacy must be guaranteed when AI is used in the pharmaceutical and healthcare industries. Strong encryption and anonymization techniques are required for Protected Health Information (PHI). (51)





8. Clinical Decision Support -

Clinical decision support tools (DSTs) are computer programs that assist with three tasks: prognosticating the course of a disease or treatment, choosing treatments, and diagnosing patients.(52) The efficacy, efficiency, safety, and quality of healthcare can all be greatly impacted by clinical decision support. The CDS is an enhanced healthcare system that may be automated or not. Artificial intelligence (AI) techniques, specifically deep learning, reinforcement learning, and machine learning (ML). (53) Computer systems intended to influence clinician decision-making by delivering timely information, typically at the point of treatment, to assist in informing decisions on patient care are known as clinical decision support. (54) Health information and suggestions from providers to enhance clinical decision-making are known as clinical decision support. These systems make use of databases and technologies. to examine clinical recommendations, medical records, and patient data. (55) The purpose of AI in clinical decision support is to increase healthcare delivery efficiency, lower errors, and improve patient outcomes. (56)

RESULT AND CONCLUSION:

Most advanced machine ever made is a person. A few decades ago, everyone would have agreed with this phrase. But the current situation, has seen significant transformation. Humans are no longer seen as the most advanced devices. The brain of a person, which is said to be the most intricate system of information. AI is putting much effort to produce something that is far greater , more effective at any given work than a person, and it has done so with considerable success.More cooperation between various healthcare services offered to a single patient is made possible by AI. Artificial intelligence (AI) has the potential to be a helpful tool for patients by offering advice on when and how to take medications, assisting with patient education, and encouraging medication adherence. AI can also be used to determine the best way to communicate with healthcare professionals, how and where to get the most affordable healthcare, how to optimise health monitoring through wearable technology, how to integrate diet and exercise, and how to provide daily lifestyle and health guidance.AI technology has been identified for analyzing as well as interpreting some important fields of pharmacy like drug discovery and drug development; personalized medicine; pharmacovigilance; automated dispensing system of drug; hospital

pharmacy; patients counseling and education; Pharmaceutical manufacturing; clinical decision support, etc. The present pattern indicates that these techniques will become more widely available in the near future due to the ongoing advancement of generic high-level packages for research and deployment software, as well as easily understandable documentation.

REFERENCES

1. Bhattamisra, SK.; Banerjee,P.; Gupta, P.; Mayuren, J.; Patra, S.;Candasamy, M. Artificial IntelligenceIn Pharmaceutical and HealthcareResearch. Big Data Cogn. Comput.2023, 7, 10. https://doi.org/10.3390/bdcc7010010
2. Tarale S.,KakadA.andDr. Shaikh M.R.N:Review ArticleOVERVIEW: EMBRACING TOOLS OF ARTIFICIAL INTELLIGENCE IN PHARMACEUTICALS:Vol.04: Issue 06:http://www.scienceijsar.com
3. PatelSS.,ShahSA.:REVIEW ARTICLE Artificial Intelligence: Comprehensive Overview and its Pharma Application :Vol. 12 |Issue-04|:10.52711/2231-5713.2022.00054
4. Ulfa A.M.,Saputra A.,Yuswardi, Nguyen P.T : ROLE OF ARTIFICIAL INTELLIGENCE IN PHARMA SCIENCE : Vol 7, Issue 1, 2020http://dx.doi.org/10.31838/jcr.07.01.54
5. Artificial Intelligence in Pharmacy : http://dx.doi.org/10.47583/ijpsrr.2023.v80i02.001
6. Goswami S., Singh MK : Artificial Intelligence used in Pharmaceutical and Healthcare Industry: A Review: Volume 3, Issue 1, August 2023: 10.48175/IJARSCT-12471
7. Shaki F, Amilrkhanloo M, Jahani D, MiladChahardori M. Artificial Intelligence in Pharmaceuticals: Exploring Applications and Legal Challenges. Pharmaceutical and Biomedical Research. 2024; 10(1):1-10. http://dx.doi.org/10.32598/PBR.10.1.1257.1: http://dx.doi.org/10.32598/PBR.10.1.1257.1
8. ChaudhariMK.and PatelVP :A REVIEW ARTICLE ON ARTIFICIAL INTELLIGENCE; Change in Modern Techniques Of pharmaceutical Formulation and Development : Volume 7, Issue 9
9. FARGHALI H., CANOVÁ NK.,ARORA M.:The Potential Applications of Artificial Intelligence in Drug Discovery and Development: 10.33549/physiolres.934765a
10. JaiwalR.,NiccS .,Dr. Archana3,Patwal H.:A Review on The Evolution of Artificial Intelligence
11. Francis W. :The Future of artificial intelligence and it's impact on society .
12. Artificial intelligence in drugdiscovery and development (DebleenaPaulz, Gaurav Sanapz, SnehalShenoyz,DnyaneshwarKalyane, Kiran Kalia and Rakesh K. Tekade)
13. The Potential Applications of Artificial Intelligence in Drug Discovery and Development (Hassan FARGHALI, Nikolina KUTINOVÁ CANOVÁ, Mahak ARORA)
14. Artificial intelligence in drug discovery: recent Advances and future perspectives (José Jiménez-Luna, Francesca Grisoni, Nils Weskamp&Gisbert Schneider)
15. Artificial Intelligence for Drug Discovery, Biomarker Development,And Generation of Novel Chemistry
16. The future of technologies for Personalised medicine (Alison Harvey, Angela Brand, Stephen T. Holgate, Lars V. Kristiansen Hans Lehrach, AarnoPalotie and Barbsara Prainsack)
17. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=AI+in+personalised+medicine&oq=AI+in+personalised#d=gs_qabs&t=

1731248692796&u=%23p%3D4al2n9ORxFAJ
18. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=AI+in+personalised+medicine&oq=#d=gs_qabs&t=1731249231117&u=%23p%3DmilHsH5JJOkJ
19. Artificial intelligence for cardiovascular disease risk assessment In personalised framework: a scoping review
20. Dr.Roy.P,Dr.Rizvi.W,Dr.Naeem.S.S; Artificial-Intelligence based Machine-Learning in Pharmacovigilance;Drug Saf(2023)2:6-7
21. Wani.P,Shelke.A,Marwadi.M,Somase.V,Borade.P,Pansare.K,Sonawane.G; ROLE OF ARTIFICIAL INTELLIGENCE IN PHARMACOVIGILANCE: A CONCISE REVIEW;Drug Saf(2022)13:6150-6151
22. Kassekert.R,Grabowski.N,Lorenz.D,Schaffer.C,Kempf.D,Roy.P,Kjoersvik.O,Saldana.G,Eishal.S;Industry Perspective on Artifical Intelligence/Machine Learing in Pharmacovigilance;Drug Safty(2022)45:439-448;https://doi.org/10.1007/s40264-022-01164-5
23. Liang.L,Hu.J,Sun.G,hong.N,Wu.G,He.Y,Li.Y,Hao.T,Gong.M; Artifcial Intelligence-Based Pharmacovigilance in the Setting of Limited Resources; Drug Safety (2022) 45:511–519 ;https://doi.org/10.1007/s40264-022-01170-
24. Moore.N,Berdai.D,Blin.P,Droz.C;Pharmacovigilance-The next Chapter;Drug safety(2019)
25. Cooper.D,PhD,Platt.RW,PhD,Hunsel.FV,PhD,Davies.M,BM,Yeomans,A,PhD,Lane.S,Msc,Shakir.S,MB ChB LRCP&S;The International Working Group on New Developments in Pharmacovigilance: Advancing Methods and Communication in Pharmacovigilances;Drug Safety(2024)46:565-569
26. Abiri.O.T,Johnson.C.N;Pharmacovigilance systems in resourcelimited settings: an evaluative case study of Sierra Leone;Drug Safety(2019)12:13;https://doi.org/10.1186/s40545-019-0173-2
27. Dr.Mehta.U,Hugman.B;THE IMPORTANCE OF PHARMACOVIGILANCE Safety Monitoring of medical products;Drug Safety(2002)
28. Zheng.Y,PharmD;Rowell.B,MA;Chen.Q,MSE;Kim.J.Y,Beng;Kontar.A.R,PhD;Yang.J,PhD;Lester.C.A,PhD; Designing Human-Centered AI to Prevent Medication Dispensing Errors: Focus Group Study With Pharmacists;Drug Safety(2023)7:e51921
29. Fogila.E,Asperti.F,Antonacci.G,Jani.Y.H,Garagiola.E,Bellavia.D,Ferrario.L; Automated Drugs Dispensing Systems in Hospitals: a Health Technology Assessment (HTA) Study Across Six European Countries;Drug Safety(2024)16:679-696
30. Dr.Kim E; Automation of Medication Dispensing through IoT-Enabled Smart Pharmacy Systems: Designs IoT-based pharmacy automation systems to streamline medication dispensing processes, reducing errors and enhancing efficiency in pharmacy operations;(2024)1
31. Liou.J.H,Wang.S.C,Hou.Y.C,Yen.C.H,Chen.H.M,Liou.W.S,Wu.M.F; Effect of an automated dispensing cabinet system on drug distribution effectiveness in a surgi
32. Li, R. Et al., “AI in Medication Management: Enhancing Clinical Decision-Making” [Journal of Clinical Pharmacy, 2023].
33. Doshi, V. Et al., “Impact of AI on Medication Adherence in Chronic Care” [Healthcare Technology Today, 2022].
34. Wang, H. Et al., “AI Algorithms for Optimizing Pharmacy Operations” [Journal of Healthcare Logistics, 2023].

35. Smith, J. Et al., "AI in Precision Medicine: Revolutionizing Drug Therapies" [Genomic Medicine Insights, 2021].
36. Patel, A. Et al., "Automation and AI in Hospital Pharmacy: Trends and Impact" [Pharmacy Automation Review, 2020].
37. Nguyen, T. Et al., "AI in Detecting Adverse Drug Reactions: A Review" [Drug Safety, 2022].
38. White, D. Et al., "Leveraging AI for Patient-Centric Pharmacy Services" [Journal of Patient Education, 2023].
39. H.-K. Wu et al. Current status, opportunities and challenges of augmented reality in education ComputEduc (2013)Link
40. L.B. Eisenmenger et al. Application of 3-dimensional printing in a case of osteogenesisimperfecta for patient education, anatomic understanding, preoperative planning, and intraoperative evaluation World Neurosurg (2017)Link
41. V.T. Covello. Risk communication: an emerging area of health communication research Ann IntCommunAssoc(1992)Link
42. He, J., Wu, J., & Zhang, J. (2020). "Artificial Intelligence in Healthcare: Past, Present and Future." Frontiers in Medicine, 7, 1-8. Link
43. Jiang, F., Jiang, Y., Zhi, H., et al. (2017). "Artificial Intelligence in Healthcare: Past, Present and Future." Seminars in Cancer Biology, 3(4), 64-72. Link
44. Patel, V. L., Arocha, J. F., & Zhang, J. (2021). "AI in Healthcare Decision Support and Patient Education." Journal of Biomedical Informatics, 115, 103276. Link
45. Verghese, A., Shah, S. H., & Harrington, R. A. (2020). "AI in Medicine: Can It Replace Human Doctors?" Journal of the American Medical Association (JAMA), 323(3), 125-127.
46. Saha GC, Eni LN, Saha H, Parida PK, Rathinavelu R, Jain SK, Haldar B. Artificial Intelligence in Pharmaceutical Manufacturing: Enhancing Quality Control and Decision Making. RivistaItaliana di FilosofiaAnalitica Junior. 2023;14(2):2023.
47. Vuppalapaty V. Enhancing Pharmaceutical Manufacturing Facilities through Artificial Intelligence: A Comprehensive Review. Journal of Machine Learning in Pharmaceutical Research. 2024 Mar 22;4(1); page no94-109.
48. Vuppalapaty V. Enhancing Pharmaceutical Manufacturing Facilities through Artificial Intelligence: A Comprehensive Review. Journal of Machine Learning in Pharmaceutical Research. 2024 Mar 22;4(1); page no94-109.
49. Patel P. Impact of AI on Manufacturing and Quality Assurance in Medical Device and Pharmaceuticals Industry. Available at SSRN 4931524. 2024 Jul 13
50. Yang Q, Steinfeld A, Zimmerman J. Unremarkable AI: Fitting intelligent decision support into critical, clinical decision-making processes. In Proceedings of the 201
51. CHI conference on human factors in computing systems 2019 May 2; page no1-11.
52. Ramgopal S, Sanchez-Pinto LN, Horvat CM, Carroll MS, Luo Y, Florin TA. Artificial intelligence-based clinical decision support in pediatrics. Pediatric research. 2023 Jan;93(2); page no334-41.
53. Ferdush J, Begum M, Hossain ST. ChatGPT and clinical decision support: scope, application, and limitations. Annals of Biomedical Engineering. 2024 May;52(5); page no1119-24.
54. Castaneda C, Nalley K, Mannion C, Bhattacharyya P, Blake P, Pecora A, Goy A, Suh KS. Clinical decision support systems for improving diagnostic accuracy and achieving precision medicine. Journal of clinical bioinformatics. 2015 Dec;5; page no1-6

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