

Research Article

Towards Proactive Medication Safety: Artificial Intelligence-Based Prediction, Detection, and Prevention of Drug-Related Problems in Clinical Practice

Dr. Animesh Das* 

Healthcare Executive, Doctor of Pharmacy, Rajiv Gandhi University of Health Sciences, Bangalore, 560090,
Karnataka, India

Email: dranimeshdas3113@gmail.com

***Related declarations are provided in the final section of this article*

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Correspondence Author:

Dr. Animesh Das*

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Abstract

Background

Medication-related problems, including adverse drug reactions (ADRs), adverse drug events (ADEs), drug–drug interactions (DDIs), medication errors, and inappropriate antimicrobial use, remain important challenges in clinical practice. Artificial intelligence (AI) has developed rapidly and may help healthcare professionals identify medication-related risks earlier. Previous studies have reported the use of machine learning, deep learning, natural language processing, and newer generative AI methods in pharmacovigilance, drug–drug interaction prediction, clinical decision support, and antimicrobial stewardship.

Objective

This study aimed to review AI's role in predicting, detecting, and preventing drug-related problems and to compare its applications across pharmacovigilance, drug–drug interaction prediction, clinical decision support, medication safety, and antimicrobial stewardship.

Methods

We conducted a literature review of 39 selected articles on AI and medication safety. The literature was organised into major areas, including ADR/ADE prediction and pharmacovigilance, DDI prediction, clinical decision support, generative AI and EHR-based medication safety applications, and

antimicrobial stewardship. The findings were compared according to AI methods, clinical purpose, safety application, benefits, and major limitations.

Results

The reviewed literature shows that AI can analyse large amounts of clinical and medication data to identify patients at risk of ADRs and ADEs, detect possible DDIs, support medication decisions, and improve pharmacovigilance. Machine learning and deep learning methods have shown promising results in prediction and classification tasks. AI has also been used to support antibiotic selection, antimicrobial resistance prediction, and antimicrobial stewardship. Generative AI and large language models are emerging in DDI identification, clinical decision support, and pharmacovigilance. However, most studies remain retrospective, and external validation and prospective clinical testing are still limited.

Conclusion

AI has strong potential to support a proactive medication-safety system by predicting risks, detecting problems early, and supporting preventive action. However, AI should support rather than replace healthcare professionals. Future research should focus on high-quality data, external validation, explainable AI, patient privacy, clinical integration, and real-world testing. The ultimate goal should be to develop safe, reliable, and patient-centred AI systems that help reduce medication-related harm and improve clinical outcomes.

Keywords: Artificial Intelligence; Medication Safety; Drug-Related Problems; Pharmacovigilance; Adverse Drug Reactions; Drug–Drug Interactions; Clinical Decision Support Systems; Antimicrobial Stewardship

INTRODUCTION

Artificial intelligence (AI) is an advanced branch of computer science that enables machines to learn from large amounts of data, identify patterns, process information, and support human decision-making. AI includes important technologies such as machine learning, deep learning, and natural language processing, which allow computers to analyse both structured and unstructured data. In healthcare and pharmacovigilance, these technologies can process large volumes of patient records, adverse event reports, clinical notes, medication information, and other health data more efficiently than traditional manual methods. AI can help automate repetitive tasks, identify hidden patterns, detect potential safety signals, and support the prediction of adverse drug reactions and other drug-related problems. By improving the speed and accuracy of data analysis, AI has the potential to support healthcare professionals in making timely clinical decisions and improving medication safety. However, the successful use of AI requires high-quality data, proper validation, transparency, ethical implementation, and

continued human clinical judgment. AI is a modern technology where the patient supports their medication with one click and also maintain their medication profile for their necessary, now a days modern medical healthcare system doing very well coordination to detection the problem with help of the patient's basic information above, its mention that are the details from the taking the single patients with day-by-day data collection and make a patient strong profile with the real-world evidence. Some parts of the healthcare team there also using modern AI for documentation purposes, and less time is spent, leading to more work productivity in patient care with their care management.

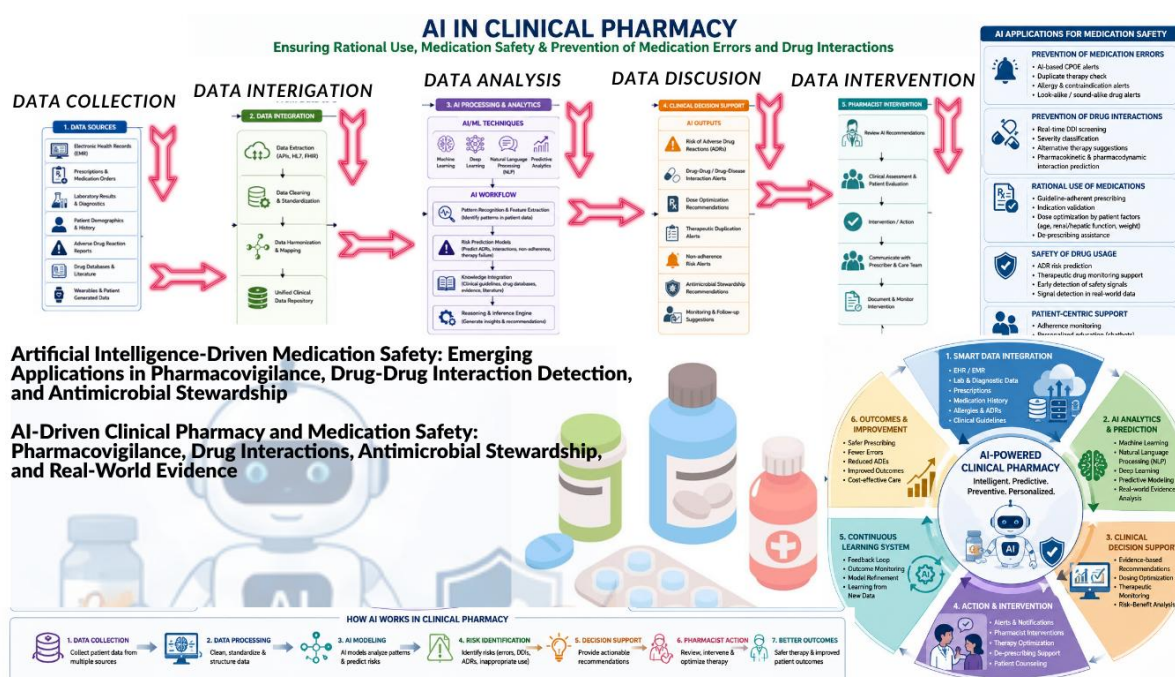
Artificial intelligence has the potential to improve pharmacovigilance and medication safety by supporting the early identification of adverse events, adverse drug reactions, drug-drug interactions, and other important drug safety signals. AI can process large amounts of structured and unstructured data, including adverse event reports, electronic health records, clinical notes, medical literature, and other safety information. These technologies can reduce the time and effort required for routine data processing, identify relevant patterns, and support faster detection of potential drug-related problems. This can help healthcare professionals take timely action and may contribute to the prevention of further medication-related harm. [5](#)

Artificial intelligence can improve pharmacovigilance and medication safety by supporting the detection, validation, and evaluation of drug safety signals. Machine learning and natural language processing can analyse large amounts of structured and unstructured data, including adverse event reports, patient information, clinical records, and other drug safety data. These technologies may help identify important patterns and possible adverse drug reactions more quickly than traditional manual methods. AI can therefore support healthcare professionals in the early identification of potential drug-related problems and allow timely clinical intervention to reduce patient harm. Medication safety is a big challenge for healthcare teams, like doctors and pharmacists, to avoid unnecessary or unwanted reactions with drugs and between single drugs with another drugs; day by day, it's increasing the side effects. [8](#)

Artificial intelligence has the potential to improve pharmacovigilance and medication safety by making the detection and prediction of adverse drug reactions faster and more accurate. Traditional pharmacovigilance methods may have difficulty managing large amounts of data and can lead to underreported adverse drug reactions or missed drug-related problems. Machine learning can analyse structured patient and drug safety data to identify patterns and predict patients who may be at risk of adverse drug reactions. Natural language processing can also analyse unstructured information from electronic health records and identify possible side effects, drug-related events, and potential drug interactions. These AI-based approaches can support healthcare professionals by providing early safety signals and helping them make timely clinical decisions. Electronic health records are the perfect data source for AI and machine learning process that do data validation and analyse the data with the patients' profile sources and check the data for analysis and categorise it automatically, ultimately yielding better results. This way, AI can work on patient profile data for specific data, such as medication safety and medication monitoring. [9](#)

Artificial intelligence has the potential to improve medication safety by supporting the early prediction, detection, and prevention of drug-related problems, particularly adverse drug reactions. Pharmacovigilance requires the collection and analysis of large amounts of data from sources such as electronic health records, adverse event reporting systems, published literature, and patient information. Traditional methods may be inefficient when handling complex and large datasets, which can result in underreported adverse drug reactions and missed drug interactions. Artificial intelligence, particularly machine learning and natural language processing, can help overcome these challenges by identifying patterns, analysing patient and medication data, and extracting important information from unstructured clinical records. Machine learning models can identify possible risk factors and predict patients who may be more likely to experience an adverse drug reaction, while natural language processing can detect potential drug-related events from clinical notes. These AI-based approaches can support healthcare professionals in making timely clinical decisions and may help prevent medication-related harm.

Artificial intelligence, especially generative AI and large language models, has the potential to improve proactive medication safety by supporting the prediction, detection, and prevention of medication-related harm. These technologies can be used to identify and predict drug-drug interactions, support medication review and clinical decision-making, detect adverse drug events, and improve pharmacovigilance activities. AI models can analyse different types of health information, including electronic health records, online databases, clinical documents, and other structured and unstructured data, to identify possible medication-related risks. Generative AI may also help healthcare professionals review prescriptions, detect dosage errors, identify adverse drug events, and support safer medication management. ¹⁷



LITERATURE REVIEWS

Artificial intelligence has the potential to improve pharmacovigilance and medication safety by supporting the identification of adverse events, drug-drug interactions, and important drug safety signals. AI can analyse both structured and unstructured data from sources such as clinical notes, electronic health records, case reports, and drug safety databases. It can also reduce repetitive manual work, improve the speed of data processing, and identify hidden patterns that may be missed by traditional methods. These abilities can help healthcare professionals detect potential drug-related problems earlier and support timely clinical decisions and interventions. However, clinical evaluation and human expertise remain important for assessing causality, interpreting safety signals, and ensuring the reliable use of AI in clinical practice. ¹

Artificial intelligence can improve pharmacovigilance and medication safety by using machine learning, deep learning, and natural language processing to detect and predict adverse drug reactions. The study developed an AI-based approach that combined structured patient data, such as demographics, laboratory results, medical history, and drug exposure, with unstructured data from clinical notes and patient reports. Advanced models, including Random Forest, XGBoost, CNN, BERT, and GPT, were used to identify hidden patterns and potential adverse drug reactions that may be missed by traditional monitoring methods. The use of AI can support faster detection, improved prediction, and timely clinical intervention, thereby helping healthcare professionals reduce medication-related harm and improve patient safety. The study also highlights the importance of using reliable and diverse clinical data to develop accurate and effective AI-based pharmacovigilance systems. ²

Artificial intelligence, particularly machine learning and natural language processing, plays an important role in improving pharmacovigilance and medication safety. AI can automate time-consuming processes, analyse large amounts of drug safety data, and identify important patterns and safety signals more quickly than traditional methods. Machine learning models such as random forest and gradient boosting can support the detection of previously unknown adverse drug reactions, while natural language processing can assist in the validation and evaluation of drug safety information. These AI-based approaches can help healthcare professionals identify potential drug-related problems earlier, support timely intervention, and improve patient safety. However, the use of AI requires proper transparency, ethical implementation, and reliable validation to ensure its safe application in clinical practice. ³

Artificial intelligence and machine learning have shown strong potential to improve medication safety by predicting adverse drug reactions and supporting proactive pharmacovigilance. Machine learning models can analyse different patient-related factors, such as demographic information, laboratory values, comorbidities, and medication data, to identify patients who may be at a higher risk of developing adverse drug reactions. AI can also improve the speed and accuracy of drug safety monitoring by automating the detection of important patterns and drug-event associations. However, the study highlights that many AI models still have limited external validation, which may affect their reliability in different clinical settings. Therefore, the development of well-validated and multifactorial AI models is important for improving their clinical use and supporting early prediction, detection, and prevention of medication-related harm. ⁴

Artificial intelligence can improve pharmacovigilance and medication safety by automating repetitive tasks and analysing large amounts of structured and unstructured drug safety data. AI tools can help identify adverse events, potential drug-drug interactions, and important safety patterns from sources such as clinical notes, electronic health records, medical literature, case reports, and discharge summaries. This can reduce the time, effort, and cost involved in traditional pharmacovigilance and support faster identification of potential drug-related problems. However, the article emphasises that AI cannot completely replace clinical experts because causality assessment and complex safety decisions still require human judgment. Therefore, AI should be used as a supportive tool alongside healthcare professionals to improve the early detection and prevention of medication-related harm. ⁵

Artificial intelligence, including machine learning and natural language processing, can improve pharmacovigilance and medication safety by automating time-consuming tasks and identifying important drug safety signals more efficiently. AI-based models can analyse large amounts of clinical and drug-related data to detect previously unknown adverse events and adverse drug reactions. Machine learning methods, such as random forest and gradient boosting, have shown strong potential for improving signal detection, while natural language processing can support the analysis and validation of safety information. These technologies may also reduce human workload and errors, support earlier identification of medication-related risks, and help healthcare professionals take timely action to improve patient safety. However, the use of AI requires proper transparency, ethical implementation, and reliable validation before widespread clinical use. ⁶

Artificial intelligence, especially generative AI and large language models, has the potential to improve medication safety by supporting the prediction and early detection of adverse drug events and other drug-related problems. These AI systems can analyse large amounts of information from electronic health records, online databases, social media, and clinical documents to identify important safety signals, including rare adverse events. AI techniques such as neural networks and other predictive models can use patient data, genetic information, and clinical records to identify patients at risk and support safer prescribing and medication management. However, the article also highlights that current evidence is not sufficient to confirm that AI can independently reduce medication-related harm in real clinical practice. Therefore, AI should be used as a supportive tool alongside healthcare professionals, with proper validation and clinical evaluation before wider implementation. ⁷

Artificial intelligence and machine learning have shown strong potential to improve medication safety by supporting the prediction and early detection of adverse drug reactions. AI-based models can analyse patient demographics, laboratory results, comorbidities, medication history, and other clinical factors to identify patients who may be at a higher risk of drug-related problems. These technologies can also improve pharmacovigilance by automating the detection of drug safety signals and reducing the need for extensive manual data processing. However, the study found that many prediction models have limited external validation, which may affect their reliability and use in different clinical settings. Therefore, the development of well-designed and properly validated AI models is important to improve the prediction, detection, and prevention of medication-related harm and support safer clinical practice. ⁸

Artificial intelligence has the potential to improve medication safety and pharmacovigilance by supporting the early prediction, detection, and prevention of adverse drug reactions and other drug-related problems. Machine learning can analyse patient characteristics, prescriptions, diagnoses, and other clinical data to identify patterns and predict patients who may be at higher risk of experiencing an adverse drug reaction. Natural language processing can analyse unstructured information from electronic health records and identify possible side effects and drug-related events. These AI technologies can reduce manual workload, improve the speed and accuracy of data analysis, and support healthcare professionals in making timely clinical decisions. However, the effectiveness of AI depends on the quality and completeness of available data, proper validation, ethical protection of patient information, and continued human clinical judgment. ⁹

Generative artificial intelligence has the potential to improve drug safety and pharmacovigilance by supporting the detection of adverse events, prediction of drug-related risks, and analysis of large amounts of safety data. By using machine learning and automation, generative AI can process complex datasets more efficiently and help reduce the workload involved in pharmacovigilance activities. These technologies may improve adverse drug reaction detection, support data-driven risk prediction, and strengthen safety monitoring for medicines during drug development and after marketing. However, further research is needed to evaluate the accuracy and quality of AI-supported safety analysis before its wider use in clinical practice. Overall, generative AI may contribute to a more proactive approach to medication safety by supporting the early prediction and detection of potential drug-related problems. ¹⁰

Machine learning has shown strong potential for improving the prediction of drug-drug interactions, which are an important cause of adverse drug reactions and medication-related harm. The review describes how machine learning models can use information from drug, side-effect, and drug interaction databases, along with chemical, biological, and phenotypic drug characteristics, to identify possible interactions. Different approaches, including traditional machine learning, deep learning, recommender systems, and knowledge graph-based methods, have been developed to improve the detection and prediction of potential drug-drug interactions. These computational methods can provide a faster and more efficient alternative to traditional experimental approaches and may support safer drug development and clinical decision-making. However, challenges remain in data quality, model performance, and the need for further development and validation before these methods can be widely applied in clinical practice. ¹¹

Artificial intelligence has shown strong potential for predicting drug-drug interactions, which can cause adverse drug reactions and serious medication-related harm. Traditional methods for identifying drug interactions are often time-consuming and labor-intensive, whereas AI-based approaches can analyse large amounts of drug-related data and improve the accuracy and efficiency of prediction. This review classifies AI-based drug-drug interaction prediction into three main areas: undirected interaction prediction, prediction of specific drug interaction events, and asymmetric interaction prediction. AI and machine learning methods can use available drug databases and different computational techniques to identify potential interactions and support clinical decision-making. However, further research is needed to address the challenges and

improve the reliability of these models for practical use. Overall, AI-based prediction of drug-drug interactions may support safer prescribing and help prevent medication-related harm. [12](#)

Artificial intelligence and machine learning have strong potential to improve pharmacovigilance by supporting the early prediction and detection of adverse drug reactions in hospitalised patients. Machine learning models can analyse different clinical factors, including patient demographics, laboratory values, comorbidities, medical history, and medication profiles, to identify patients who may be at higher risk of drug-related harm. AI can also automate adverse drug reaction detection, analyse large pharmacovigilance databases, and identify important drug-event associations more efficiently than traditional methods. However, the review found that many models had limited external validation, which may affect their reliability in different clinical settings. Therefore, well-designed and properly validated AI models are needed to improve their clinical use and support proactive medication safety and better patient outcomes. [13](#)

Machine learning can improve the prediction of drug-drug interactions, which are an important cause of adverse drug reactions and medication-related harm. This study developed a multi-feature approach using molecular fingerprints, enzymes, pathways, and drug targets to improve the accuracy of drug-drug interaction prediction. GPT-4o was used to convert complex free-text drug interaction information into structured data and identify the direction of interactions between drugs. The study also used SMOTE to manage imbalanced data and improve the prediction of less common interaction types. The deep neural network model achieved high predictive accuracy, showing that combining artificial intelligence, multiple drug features, and advanced data processing can support more accurate and reliable identification of potential drug-drug interactions. These findings suggest that AI-based models may help improve proactive medication safety and support safer clinical decision-making. [14](#)

Generative artificial intelligence has the potential to improve medication safety by supporting the prediction and identification of drug-drug interactions, providing clinical decision support, and automating pharmacovigilance activities. Large language models can assist healthcare professionals in prescription review, dose assessment, medication reconciliation, deprescribing, and answering medication-related questions. AI-based systems may also help identify potential adverse drug events earlier by analysing large amounts of clinical and medication-related information. However, the current evidence shows that many AI tools still require further validation, as problems such as inaccurate responses and limited real-world clinical testing may affect their reliability. Therefore, generative AI should be used as a supportive tool with healthcare professional oversight to improve the prevention of medication-related harm and promote safer clinical practice. [15](#)

Artificial intelligence and machine learning have strong potential to improve medication safety by predicting drug-drug interactions and identifying patients at risk of adverse drug events. Recent computational approaches use multiple sources of information, including drug structures, biological targets, clinical data, electronic health records, pharmacovigilance databases, and biomedical literature, to detect potentially harmful drug combinations. Advanced methods such as graph neural networks, knowledge graphs, deep learning, and multimodal models can improve the prediction of interaction types and related adverse outcomes. These AI-based systems may

also support clinical decision-making by identifying unsafe medication combinations and helping healthcare professionals take preventive action. However, many models still require better external validation and prospective clinical testing before they can be widely used in routine clinical practice. Overall, AI-based drug-drug interaction prediction can contribute to proactive medication safety and help reduce preventable drug-related harm. [16](#)

Artificial intelligence, including machine learning and natural language processing, has strong potential to improve pharmacovigilance and proactive medication safety. AI-based models can analyse large amounts of drug safety data and identify possible adverse drug reactions and previously unknown safety signals more efficiently than traditional methods. Machine learning methods such as random forest and gradient boosting have shown improved performance in signal detection, while natural language processing can support signal validation and evaluation. These technologies can reduce manual workload, identify important patterns, and help healthcare professionals take earlier action to prevent medication-related harm. However, proper transparency, ethical use, reliable datasets, and clinical validation are important to ensure the safe and effective use of AI in pharmacovigilance and clinical practice. [17](#)

Computerised clinical decision support systems can improve medication safety by helping healthcare professionals prevent medication errors and adverse drug events during clinical practice. This rapid review found that computerised provider order entry systems combined with medication-related decision support were associated with reductions in medication errors and adverse drug events. Improved and targeted decision support systems were also more effective in supporting safer medication use. However, challenges such as frequent alert overrides, alert fatigue, inappropriate responses to alerts, overdependence on technology, and workflow disruption may reduce their effectiveness. Therefore, clinical decision support systems should provide relevant and well-designed alerts and be carefully integrated into clinical practice to support proactive medication safety and reduce preventable drug-related harm. [18](#)

Artificial intelligence has strong potential to improve medication safety and reduce preventable medication errors in primary care. AI-based systems and clinical decision support tools can support healthcare professionals in detecting prescribing errors, inappropriate medications, drug interactions, dosing problems, and other medication-related risks. The systematic review found that 10 out of 14 included studies reported a reduction in medication errors following the use of AI or algorithm-based tools. AI can also support drug management throughout prescribing, dispensing, and medication administration while helping to provide more personalised treatment. However, further large-scale research and user-friendly, well-integrated systems are needed to improve the wider use of AI in routine clinical practice. Overall, AI can play an important role in proactive medication safety by helping prevent drug-related harm before it affects the patient. [19](#)

Generative artificial intelligence and large language models have strong potential to reduce medication-related harm by supporting drug-drug interaction prediction, clinical decision support, and pharmacovigilance. These technologies can help identify and classify adverse drug events, analyse medication-related information, support medication review, and improve clinical decision-making. AI may also assist in recognising adverse drug reactions, detecting safety signals, and reviewing medication charts, allowing earlier identification of potential risks.

However, the review found that current studies have mainly been observational, and no included studies tested these systems prospectively in real clinical settings. Therefore, further research, high-quality datasets, clinical validation, and careful integration into healthcare practice are needed. Overall, generative AI can support a more proactive approach to medication safety by helping healthcare professionals predict, detect, and prevent drug-related problems before they cause serious patient harm. [20](#)

Machine learning has strong potential to improve medication safety by predicting adverse drug events using electronic health record data. This systematic review and meta-analysis found that different machine learning algorithms, including Random Forest, Support Vector Machine, XGBoost, and LightGBM, can identify patients at risk of specific adverse drug events. These models showed generally good predictive performance and can support the early identification of medication-related harm before serious clinical outcomes occur. However, differences in patient populations, databases, predictors, and machine learning methods create challenges in comparing and applying these models widely. Therefore, future research should focus on standardised methods, diverse datasets, multicentre validation, and real-world clinical testing. Overall, AI-based prediction models can support a proactive approach to medication safety by helping healthcare professionals predict, detect, and prevent adverse drug events at an earlier stage. [21](#)

Machine learning has strong potential to improve medication safety by predicting adverse drug events and identifying patients who may be at higher risk of medication-related harm. This systematic review found that commonly used algorithms, including Logistic Regression, Random Forest, and XGBoost, showed generally good predictive performance, particularly during internal validation. Machine learning can analyse complex healthcare data and identify hidden patterns that may not be easily detected using traditional statistical methods. However, important challenges remain, including class imbalance, missing data, limited external validation, and concerns about the generalizability of prediction models. Therefore, further research using diverse datasets and strong external validation is needed before these models can be widely used in clinical practice. Overall, machine learning can support a proactive approach to medication safety by enabling earlier prediction and prevention of adverse drug events. [22](#)

Machine learning has strong potential to improve patient safety by automatically detecting and predicting adverse drug events, adverse drug reactions, and other patient safety problems using electronic health records. This systematic review of 41 studies found that algorithms such as Support Vector Machine, Random Forest, Conditional Random Field, and BiLSTM-CRF were commonly used to identify and classify safety events. Advanced natural language processing methods were especially useful for extracting medication-related information from unstructured clinical notes and identifying relationships between drugs, adverse events, and their severity. Recurrent neural networks and BiLSTM-CRF showed strong performance in detecting adverse drug events, while other algorithms were useful for adverse drug reaction detection. However, most models had not been externally validated or prospectively tested in real clinical settings. Overall, machine learning combined with electronic health records can support early detection and prediction of medication-related harm, contributing to proactive medication safety and better clinical decision-making. [23](#)

Artificial intelligence, machine learning, and natural language processing have strong potential to improve pharmacovigilance and medication safety by analysing both structured and unstructured information from electronic health records. The review found that these technologies can identify specific adverse drug events and detect previously unknown safety signals that may not be recognised through structured data alone. AI-based methods can also automate the analysis of large amounts of clinical text, helping overcome the limitations of traditional spontaneous reporting systems and underreporting of adverse events. However, there is considerable variation in the methods and validation approaches used across studies, which may limit wider clinical implementation. Therefore, standardised methods and stronger validation are needed to improve the reliability of AI-based pharmacovigilance systems. Overall, the use of AI with electronic health record data can support earlier detection of medication-related harm and contribute to a more proactive approach to patient safety. [24](#)

Machine learning has strong potential to improve medication safety by predicting the individual risk of adverse drug events using observational health data such as electronic health records, medical records, and administrative claims. This review highlights that machine learning can analyse complex relationships between patient characteristics, diagnoses, laboratory values, medications, and other clinical factors to identify patients who may be at risk of future drug-related harm. The development of personalised adverse drug event prediction is further supported by new data sources, including genetic information, screening data, and wearable devices, along with advanced deep learning approaches such as transformer models. However, challenges related to missing or inaccurate data, appropriate event labelling, complex temporal data, model interpretability, and validation remain important. Overall, machine learning-based prediction can support proactive medication safety by helping healthcare professionals identify high-risk patients early and take preventive actions before adverse drug events occur. [25](#)

Machine learning has strong potential to improve medication safety by predicting adverse drug events and identifying patients at high risk before serious harm occurs. This systematic review found that machine learning models can analyse large amounts of outpatient health data, including electronic health records, administrative claims, and pharmacovigilance data. Algorithms such as Logistic Regression, Random Forest, and XGBoost showed promising performance in predicting adverse drug events, with ensemble methods demonstrating particular potential. However, important challenges remain, including class imbalance, missing data, limited external validation, and the risk that models may not perform equally well in different clinical settings. Therefore, future research should focus on stronger validation and real-world clinical testing. Overall, machine learning can support a proactive approach to medication safety by helping healthcare professionals identify high-risk patients early and take preventive action against drug-related harm. [26](#)

Large language models have the potential to improve medication safety by automatically detecting adverse drug events from unstructured clinical notes in electronic health records. The study highlights that many adverse drug events are underreported or recorded only in free-text clinical documentation, making manual detection difficult and time-consuming. The researchers used a clinical language model to identify adverse drug events, related drugs, and associated clinical findings from discharge notes. The findings showed that only a small proportion of

discharge notes explicitly linked an adverse drug event with a specific drug, demonstrating the need for improved automated detection methods. Overall, artificial intelligence and large language models can support pharmacovigilance by identifying hidden medication-related harm from clinical records and may help healthcare professionals take earlier preventive action to improve patient safety. [27](#)

Machine learning has strong potential to improve medication safety by predicting adverse drug events and identifying high-risk patients before serious harm occurs. This systematic review found that machine learning models can analyse large healthcare datasets, including electronic health records, administrative claims, and spontaneous reporting systems. Logistic Regression, Random Forest, and XGBoost were among the most commonly used algorithms, while ensemble models showed promising predictive performance. However, important limitations included class imbalance, missing data, and limited external validation, which may reduce the generalizability of these models in different clinical settings. The review highlights the need for more rigorous validation and better integration of machine learning models into clinical workflows. Overall, machine learning-based prediction can support proactive medication safety by enabling early identification, monitoring, and prevention of adverse drug events. [28](#)

Artificial intelligence, machine learning, and deep learning have strong potential to improve pharmacovigilance by automatically detecting adverse drug events from clinical and other health-related text data. This review found that deep learning models generally performed better than traditional machine learning methods for extracting adverse drug events, while advanced models such as BERT showed strong performance in identifying drug-related events and their relationships. Natural language processing can analyse unstructured information from electronic health records, biomedical literature, social media, and drug labels, which may help identify medication-related harm that could otherwise be missed. However, challenges remain in improving the accuracy of adverse event extraction and ensuring reliable performance across different datasets. Overall, AI-based text analysis can support earlier detection of adverse drug events, strengthen pharmacovigilance, and contribute to proactive medication safety and improved patient outcomes. [29](#)

Large language models have the potential to improve medication safety by supporting the detection of clinically significant drug-drug interactions that may lead to adverse drug reactions. This study compared ChatGPT, Claude, and Gemini using real-world pharmacovigilance reports and found that the models showed high sensitivity in identifying drug-drug interactions. However, all models had limited ability to correctly exclude interactions when no true interaction was present, which could lead to false-positive results. The study also found that the accuracy of the models decreased with more complex interaction cases, and incorrect or fabricated information could affect pharmacovigilance assessment. Therefore, large language models may serve as supportive tools for detecting potential medication-related risks, but human expertise and clinical pharmacologist verification remain essential. Overall, AI can contribute to proactive medication safety, but further improvement and validation are needed before these systems can be independently used in clinical practice. [30](#)

Artificial intelligence has strong potential to improve antimicrobial stewardship by supporting the prediction of antimicrobial resistance and helping healthcare professionals make safer and more individualised treatment decisions. AI-based models can analyse electronic health records, microbiological results, and other clinical information to identify patients at risk of multidrug-resistant infections and support appropriate empirical antibiotic selection. AI can also improve diagnostic stewardship by helping clinicians decide when diagnostic tests are needed and by supporting the interpretation of microbiological results. During treatment, AI may assist with antibiotic de-escalation, intravenous-to-oral conversion, treatment duration assessment, and prioritisation of patients for stewardship review. However, challenges such as limited external validation, data quality, integration into clinical workflows, interpretability, and clinician acceptance remain important. Overall, AI can support proactive medication safety by promoting appropriate antimicrobial use and reducing the risk of medication-related harm, but it should support rather than replace clinical judgement. ³¹

Artificial intelligence and machine learning have strong potential to improve antimicrobial medication safety by supporting appropriate antimicrobial selection, prescribing, and antimicrobial stewardship. This scoping review found that AI-based clinical decision support systems can analyse patient information and microbial resistance patterns to provide more personalised treatment recommendations. AI can help reduce inappropriate antimicrobial use, improve prescription accuracy, shorten unnecessary treatment duration, minimise side effects, and predict antimicrobial resistance. Machine learning models can also support early identification of resistance patterns and help healthcare professionals make safer treatment decisions. However, challenges related to data quality, bias, privacy, clinical integration, and lack of standardisation remain important. Overall, AI can support proactive medication safety by improving antimicrobial use, preventing inappropriate prescribing, and reducing the risk of antimicrobial resistance and related patient harm. ³²

Artificial intelligence and machine learning have strong potential to improve antibiotic stewardship and medication safety by supporting appropriate antibiotic selection, dose adjustment, and adherence to stewardship guidelines. This systematic review found that AI-based models can help predict antimicrobial resistance, identify patients who may require changes in antibiotic therapy, and improve the accuracy of empirical antibiotic prescribing. Several studies also showed that machine learning can support optimised antibiotic dosing, particularly for drugs such as vancomycin. By analysing patient and clinical data, AI can help healthcare professionals make more personalised and timely treatment decisions, which may improve therapy appropriateness and reduce unnecessary antibiotic use. However, challenges remain in implementing these systems across different healthcare settings, particularly because of differences in resources and infrastructure. Overall, AI can support proactive medication safety by improving prescription practices, preventing inappropriate antibiotic use, and reducing the risk of antimicrobial resistance and related patient harm. ³³

Artificial intelligence and machine learning have strong potential to improve antimicrobial stewardship by supporting accurate prediction and better clinical decision-making. This systematic review and meta-analysis included 80 studies and found that machine learning models showed good predictive performance and diagnostic accuracy across different antimicrobial

stewardship settings. AI-based systems demonstrated useful sensitivity, specificity, accuracy, and predictive values, indicating their ability to identify important clinical risks and support appropriate antimicrobial treatment. The integration of AI may help healthcare professionals improve antimicrobial prescribing, reduce unnecessary or inappropriate antibiotic use, and contribute to controlling antimicrobial resistance. Overall, the study suggests that AI can support proactive medication safety by providing more precise treatment decisions and better use of healthcare resources. [34](#)

Digital tools and artificial intelligence have strong potential to support antimicrobial stewardship and improve the quality of antimicrobial prescribing in hospitals. This systematic review included 31 studies and found that clinical decision support systems were the most commonly used tools, followed by electronic health record alerts, machine learning models, telemedicine, and mobile applications. Most studies showed improvements in appropriate antimicrobial therapy and reductions in antibiotic consumption. However, the effects on clinical and microbiological outcomes were inconsistent, and the overall quality of evidence was limited. The review highlights the need for standardised outcome measures and stronger research to confirm the real clinical benefits of these technologies. Overall, AI and digital tools can support proactive medication safety by improving antimicrobial prescribing and reducing unnecessary antimicrobial use. [35](#)

Machine learning and electronic health record-based prediction models have strong potential to improve medication safety by identifying adverse drug events early in hospitalised patients. This systematic review included 25 studies and found that prediction models can support the diagnosis and prognosis of adverse drug events using structured clinical data. However, many studies had important limitations, including poor reporting of patient characteristics, inadequate handling of missing data, inappropriate model development methods, and lack of external validation. Another major challenge was that many models identified adverse symptoms without properly confirming whether the drug actually caused the event. Therefore, future research should use better reporting standards, stronger validation methods, and causal assessment of adverse drug events. Overall, AI-based prediction models can support proactive medication safety by helping healthcare professionals identify potential drug-related harm earlier during hospital care. [36](#)

METHODOLOGY

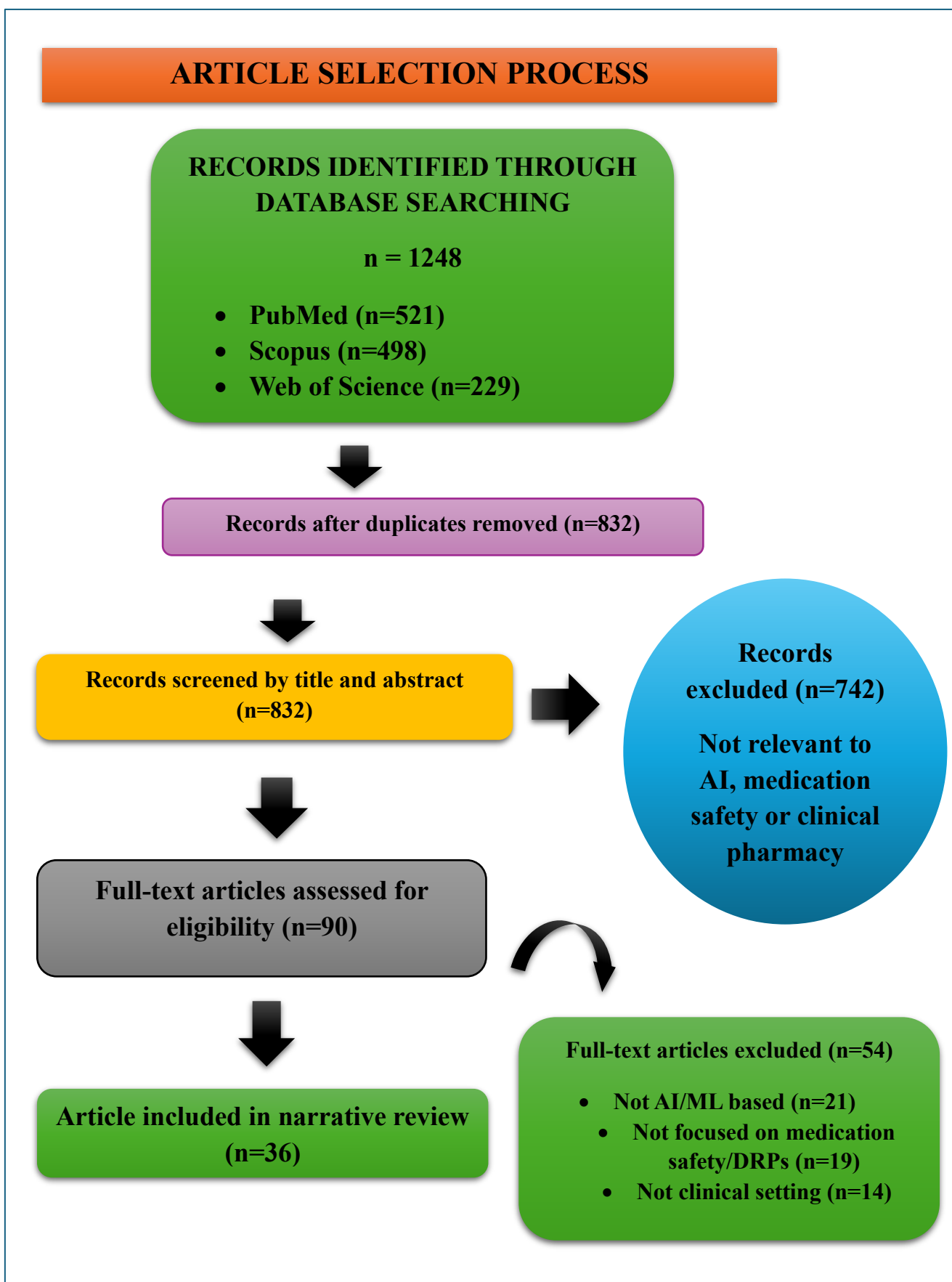


FIGURE 1: Article selection process

RESULT

This study examines the growing role of Artificial Intelligence (AI) and Machine Learning (ML) in improving medication safety and preventing drug-related problems in different areas of healthcare. AI-based systems can support pharmacovigilance by identifying, monitoring, and predicting adverse drug reactions and adverse drug events. These technologies can also help detect different types of drug interactions, including drug-drug interactions, food-drug interactions, drug-environment interactions, and interactions related to genetic factors. In addition, AI can support clinical decision-making systems by helping healthcare professionals select appropriate medicines, doses, and treatment plans for individual patients. One important area is antimicrobial drugs, especially antibiotics. Antibiotic resistance is increasing worldwide and has become a major threat to public health. AI can support the rational use of antibiotics by helping healthcare professionals choose the correct drug, appropriate dose, duration of treatment, and possible side effects. Machine learning models may also help predict antimicrobial resistance and identify patients at higher risk of treatment failure. Overall, AI in clinical pharmacy can improve medication safety, reduce adverse drug reactions, prevent unnecessary drug use, and help prevent drug resistance and harmful interactions by accounting for environmental and patient-related factors.

AI Applications Across Medical and Healthcare Fields, 2022–2026 [37,38,39](#)

Table 1: AI Applications Across Medical and Healthcare Fields, 2022–2026

No.	Medical Healthcare Field	Major AI Applications (2022–2026)	Main Purpose	AI Use Level
1	Oncology	Cancer detection, tumour classification, radiotherapy planning, prognosis, treatment selection, drug discovery	Early diagnosis & personalised treatment	Very High
2	Cardiology	ECG analysis, cardiac imaging, arrhythmia prediction, cardiovascular risk prediction, heart-failure prediction	Early detection & risk prediction	Very High
3	General Medicine	Diagnosis support, risk prediction, medication	Safer clinical decisions	Very High

		review, clinical decision support, EHR analysis		
4	General Surgery	Surgical planning, image analysis, complication prediction, robotic surgery, postoperative risk prediction	Safer surgery & outcomes	High
5	Pediatrics	Disease prediction, neonatal monitoring, pediatric imaging, medication dosing, clinical decision support	Pediatric diagnosis & safety	High
6	Orthopedics	Fracture detection, bone imaging, surgical planning, implant positioning, rehabilitation	Diagnosis & surgical planning	High
7	Obstetrics & Gynaecology (OBG)	Fetal monitoring, ultrasound analysis, pregnancy-risk prediction, infertility support, cervical cancer screening	Maternal & fetal safety	High
8	Psychiatry	Mental-health prediction, risk assessment, NLP of clinical notes, digital phenotyping, treatment support	Early identification & monitoring	High
9	Ophthalmology	Diabetic retinopathy, glaucoma, retinal disease, fundus-image analysis, vision prediction	Automated screening & diagnosis	Very High
10	Pulmonology	Chest X-ray/CT analysis, pneumonia detection, COPD prediction, lung cancer detection, respiratory monitoring	Diagnosis & prognosis	Very High

11	Clinical Pharmacy	Medication-error detection, drug-interaction prediction, dose optimisation, medication review, ADR prediction	Medication safety	Very High
12	Intensive Care / ICU	Sepsis prediction, deterioration prediction, mortality prediction, ventilation support, monitoring	Early intervention	Very High
13	MICU	Sepsis, infection, organ failure, mortality and deterioration prediction	Critical-care decision support	Very High
14	Insurance / Health Insurance	Risk prediction, fraud detection, claims analysis, cost prediction, utilisation management	Financial & operational management	High
15	Antimicrobial Stewardship	AMR prediction, antibiotic selection, dose optimisation, treatment-duration support, de-escalation	Reduce inappropriate antibiotic use	Very High
16	Pharmaceutical Industry	Drug discovery, target identification, molecule design, toxicity prediction, clinical-trial optimisation	Faster drug development	Very High
17	Laboratory Medicine	Laboratory-result interpretation, diagnostic prediction, pathology, biomarker analysis, abnormal-result detection	Faster & accurate diagnosis	Very High
18	Healthcare Departments	Patient-flow prediction, resource planning, population-health analytics, disease surveillance	Health-system management	High

19	Hospitals	Bed management, patient deterioration prediction, clinical decision support, documentation, workflow optimisation	Hospital efficiency & safety	Very High
20	Clinics / Outpatient Care	Diagnosis support, appointment prediction, documentation, triage, patient monitoring	Improve clinical workflow	High
21	Retail / Community Pharmacy	Prescription screening, drug-interaction alerts, medication adherence, patient counselling support	Safer dispensing	Moderate–High
22	Emergency Department / Emergency Wards	Triage, deterioration prediction, sepsis prediction, imaging, admission prediction	Rapid decision-making	Very High
23	Medical Training / Education	AI tutors, clinical simulation, case generation, personalised learning, examination preparation	Medical education	High
24	Pharmacovigilance	ADR detection, adverse-event extraction, safety-signal detection, risk prediction, report processing	Early drug-safety detection	Very High
25	Drug Safety / Safety Associations	Signal detection, case processing, literature screening, causality support, safety surveillance	Drug-risk monitoring	High–Very High
26	Nursing	Patient deterioration prediction, workload prediction, documentation, fall prediction, monitoring	Nursing safety & workflow	High

27	Radiology	Image interpretation, lesion detection, segmentation, workflow prioritisation	Diagnostic imaging	Extremely High
28	Pathology	Digital pathology, tumour detection, cell classification, biomarker prediction	Cancer & disease diagnosis	Very High
29	Public Health	Disease surveillance, outbreak prediction, population-risk assessment, emergency preparedness	Population health	High
30	Healthcare Administration	Hospital demand forecasting, staffing, resource allocation, quality monitoring	Operational efficiency	High

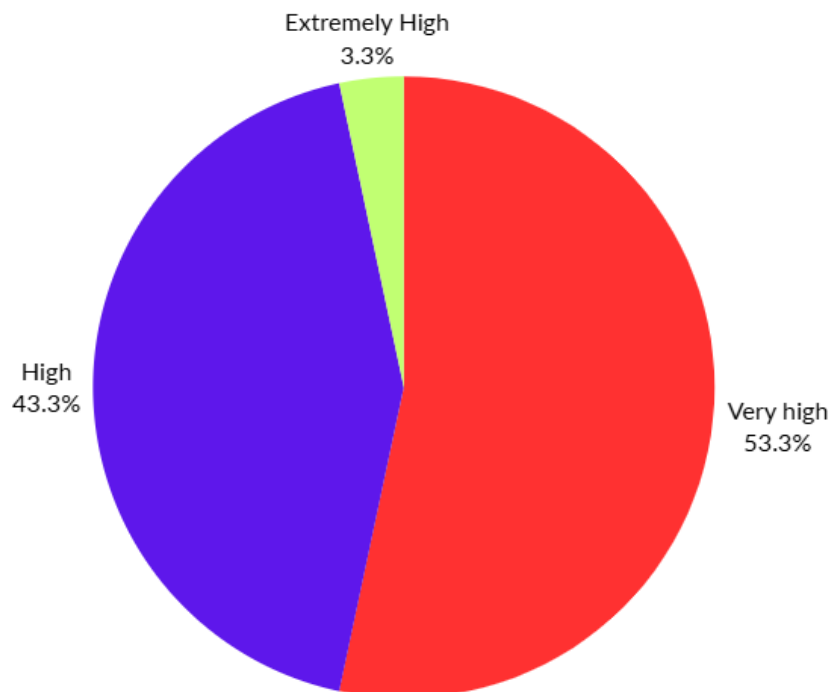


FIGURE 2: AI Applications Across Medical and Healthcare Fields, 2022–2026

AI in pharmacovigilance and ADE prediction

Artificial intelligence (AI) is increasingly used in pharmacovigilance to improve the early prediction, detection, and prevention of adverse drug reactions (ADRs) and adverse drug events (ADEs). AI methods, including machine learning (ML), deep learning, natural language processing (NLP), and large language models, can analyse large amounts of healthcare data faster than traditional methods. These systems can use electronic health records, clinical notes, laboratory results, medication history, and pharmacovigilance databases to identify patterns related to drug-related harm and new safety signals.¹⁻¹⁰ Machine learning models such as Random Forest, Support Vector Machine, XGBoost, and neural networks have shown good results in identifying patients who may be at high risk of ADEs and ADRs.^{21,22,25,26,28} AI can also help extract adverse events and drug-event relationships from unstructured clinical notes, which may reduce problems such as underreporting and delayed detection.^{23,24,27} Generative AI and large language models can further support adverse event detection, safety signal identification, medication review, and clinical decision-making.²⁰ EHR-based prediction models may help healthcare professionals identify medication-related harm at an early stage and take preventive action before serious outcomes occur. However, challenges such as poor data quality, missing information, limited external validation, model bias, and difficulties in clinical implementation remain.^{21,22,24,26,28} Overall, these studies show that AI has the potential to change pharmacovigilance from a reactive approach to a proactive medication safety system by supporting the early prediction, detection, monitoring, and prevention of ADRs and ADEs in clinical practice.

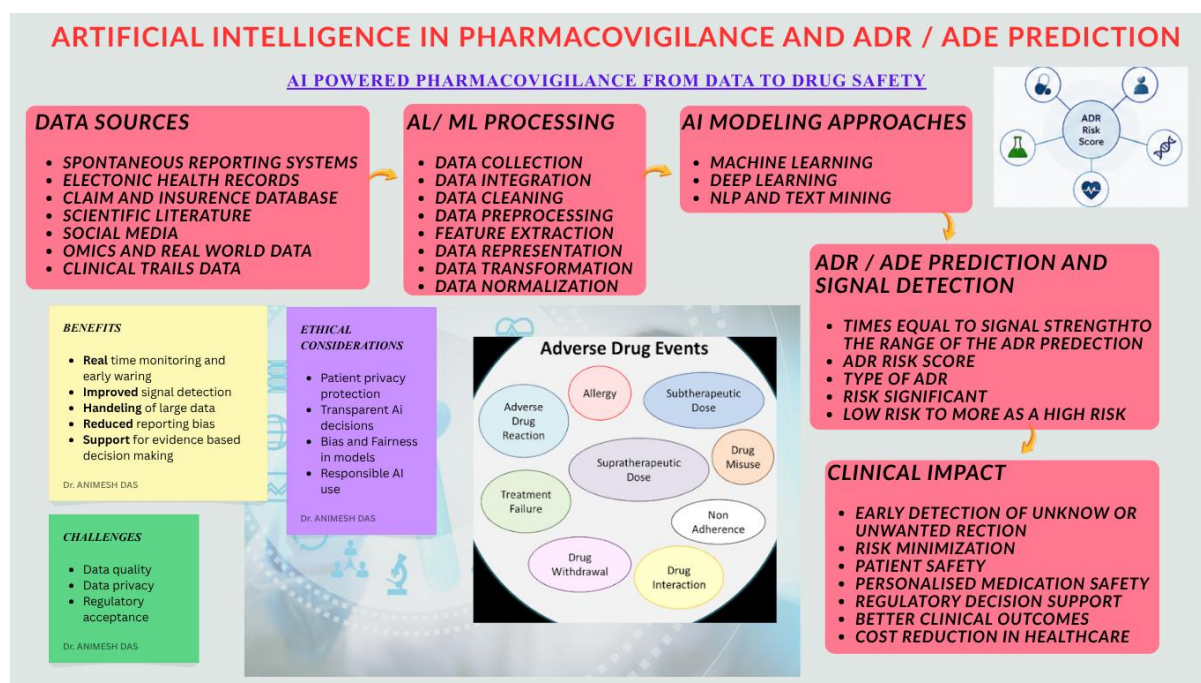


FIGURE 3: AI in Pharmacovigilance and ADR / ADE Prediction

AI in drug-drug interaction prediction

Artificial intelligence (AI) has become an important tool for predicting and identifying drug-drug interactions (DDIs), which are a major cause of adverse drug reactions and medication-related

harm. Traditional methods of identifying DDIs often depend on laboratory studies, clinical reports, and post-marketing surveillance, which can be time-consuming and may not detect new interactions early. AI and machine learning methods can analyse large amounts of data from drug structures, biological targets, drug databases, biomedical literature, electronic health records, and pharmacovigilance reports to identify possible interactions more efficiently.^{11,12} Different machine learning methods, including deep neural networks, graph-based models, knowledge graphs, and multi-feature learning approaches, have shown promising results in predicting known and unknown drug interactions.¹¹⁻¹⁶ These models can combine different types of drug information and identify complex relationships that may not be easily recognised by traditional methods. Some advanced approaches can also predict the direction and type of drug interaction, which may help in understanding the possible clinical effects of drug combinations.^{12,14} AI-based DDI prediction can support healthcare professionals by identifying potentially harmful drug combinations before they cause adverse effects in patients. This approach can improve clinical decision-making and contribute to safer prescribing practices.¹¹⁻¹⁶ Large language models also have potential in identifying clinically important drug interactions from pharmacovigilance reports and medical information. However, recent findings show that these models may produce false-positive results, provide incorrect information, and have reduced accuracy when interaction cases become more complex. Therefore, human expert review remains important when using AI tools for drug interaction assessment. Overall, the evidence suggests that AI can support a proactive approach to medication safety by predicting potential drug-drug interactions, identifying high-risk medication combinations, and helping prevent drug-related harm. However, further research, external validation, high-quality data, and clinical testing are needed before AI-based systems can be widely and independently used in routine clinical practice.

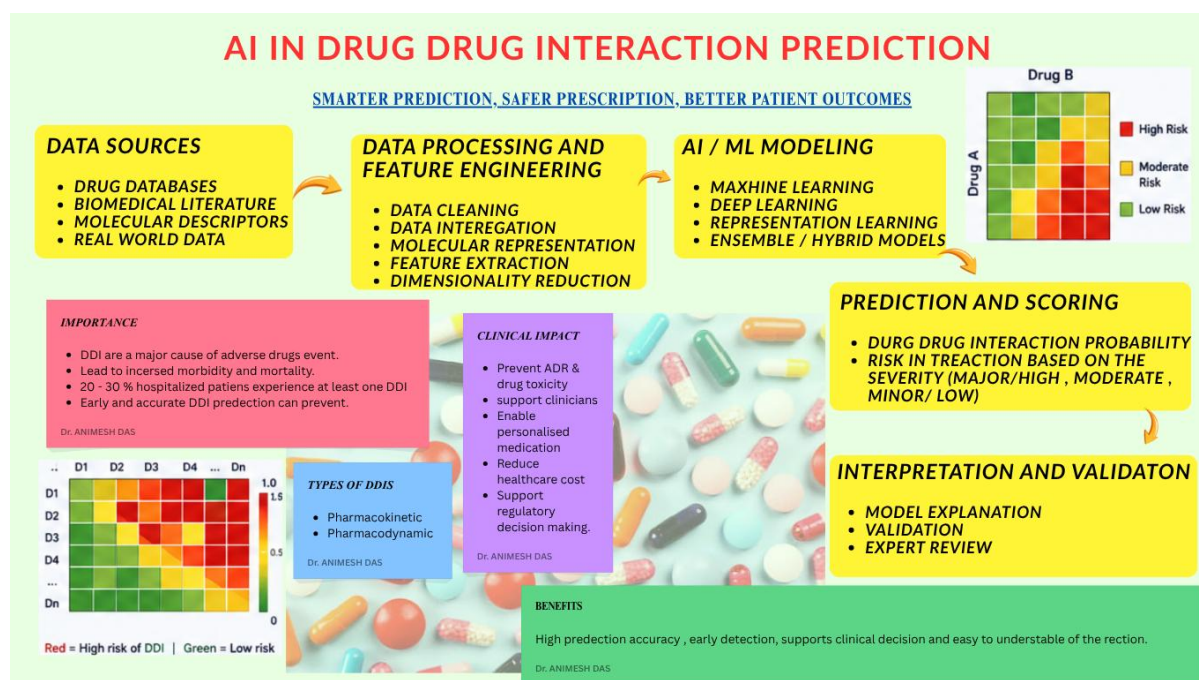


FIGURE 4: AI in DDI Prediction

AI in clinical decision-making and support systems

Artificial intelligence (AI) has an important role in improving clinical decision-making and medication safety through clinical decision support systems (CDSS). AI-based systems can analyse large amounts of patient information and provide healthcare professionals with timely support for identifying medication-related risks, adverse drug events, and possible treatment problems. These systems can help clinicians make safer decisions by providing alerts, recommendations, and risk predictions during patient care.¹⁷⁻¹⁹ AI and computerised decision support tools can support the detection of prescribing errors, inappropriate medications, drug interactions, and dosing-related problems. Studies have shown that these systems may reduce medication errors and adverse drug events when properly integrated into clinical workflows.^{18,19} Machine learning and natural language processing can further improve clinical decision support by analysing both structured and unstructured data from electronic health records. AI-based systems can identify important safety events, extract medication-related information from clinical notes, and support early recognition of adverse drug events that may otherwise be missed.²⁹ Large language models also show potential in supporting the identification of clinically important drug-drug interactions and medication-related risks. However, their performance may be affected by false-positive results, incorrect information, and reduced accuracy in complex clinical cases. Therefore, AI-based recommendations should be reviewed by healthcare professionals and should not replace clinical judgment. Despite their benefits, several challenges remain, including alert fatigue, frequent alert overrides, poor workflow integration, data quality issues, and overdependence on automated systems.¹⁸ Effective AI-based clinical decision support should provide relevant and accurate information without creating unnecessary alerts for healthcare professionals. Overall, AI-based clinical decision-making and support systems can contribute to proactive medication safety by helping healthcare professionals identify risks early, prevent medication errors, and make safer treatment decisions. Further clinical validation and proper integration into healthcare systems are needed for their successful use in routine clinical practice.

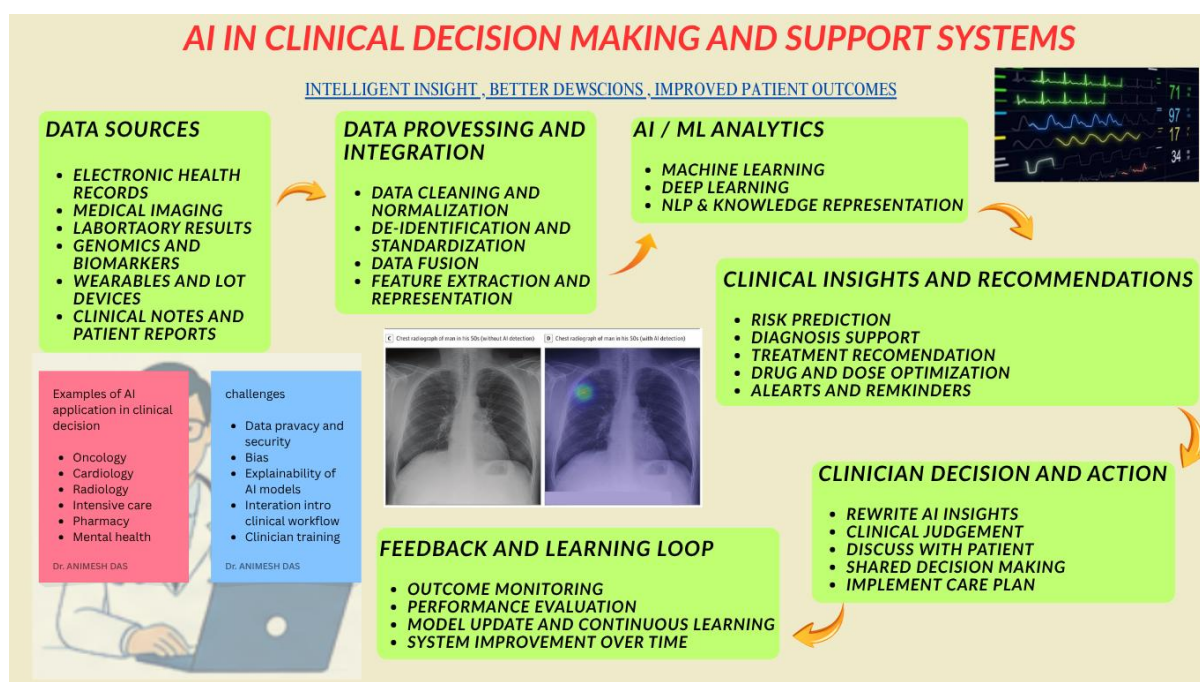


FIGURE 5: AI in clinical decision-making

Antimicrobial Stewardship and AI Application

Artificial intelligence (AI) is becoming an important tool in antimicrobial stewardship (AMS) because it can support safer and more appropriate use of antibiotics. AI and machine learning (ML) models can analyze patient information, laboratory results, microbiology data, electronic health records, and antimicrobial resistance patterns to help healthcare professionals select the most suitable antimicrobial treatment.³¹⁻³⁶ These systems can help predict antimicrobial resistance and identify patients who may be at higher risk of resistant infections. This information can support early and more accurate antibiotic selection and reduce the use of unsuitable treatments.^{31,32,34} AI-based clinical decision support systems can also provide treatment recommendations and alerts during prescribing, helping clinicians make better decisions based on individual patient information.³¹⁻³³ AI has also been studied for improving antibiotic prescription practices. Machine learning models can support decisions related to antimicrobial selection, dose adjustment, treatment duration, and changes in therapy. These applications may reduce unnecessary antibiotic use and improve adherence to antimicrobial stewardship guidelines.^{32,33,35} Evidence from systematic reviews shows that AI-based systems can improve appropriate antimicrobial therapy and reduce antibiotic consumption, although the effects on clinical and microbiological outcomes are not always consistent.³⁵ AI models have also shown good predictive and diagnostic performance across different AMS applications, supporting their possible use in antimicrobial decision-making.³⁴ Despite these benefits, several challenges limit the wider use of AI in antimicrobial stewardship. These include poor data quality, differences between healthcare settings, limited external validation, difficulties in integrating AI systems into clinical workflows, lack of standardization, and concerns about clinical acceptance. Therefore, AI should support healthcare professionals rather than replace their clinical judgment. Overall,

AI can strengthen antimicrobial stewardship by helping predict resistance, improve antibiotic selection, reduce inappropriate prescribing, and support safer and more personalized antimicrobial therapy. With proper validation and clinical integration, these technologies may contribute to proactive medication safety and help reduce antimicrobial resistance and drug-related harm.

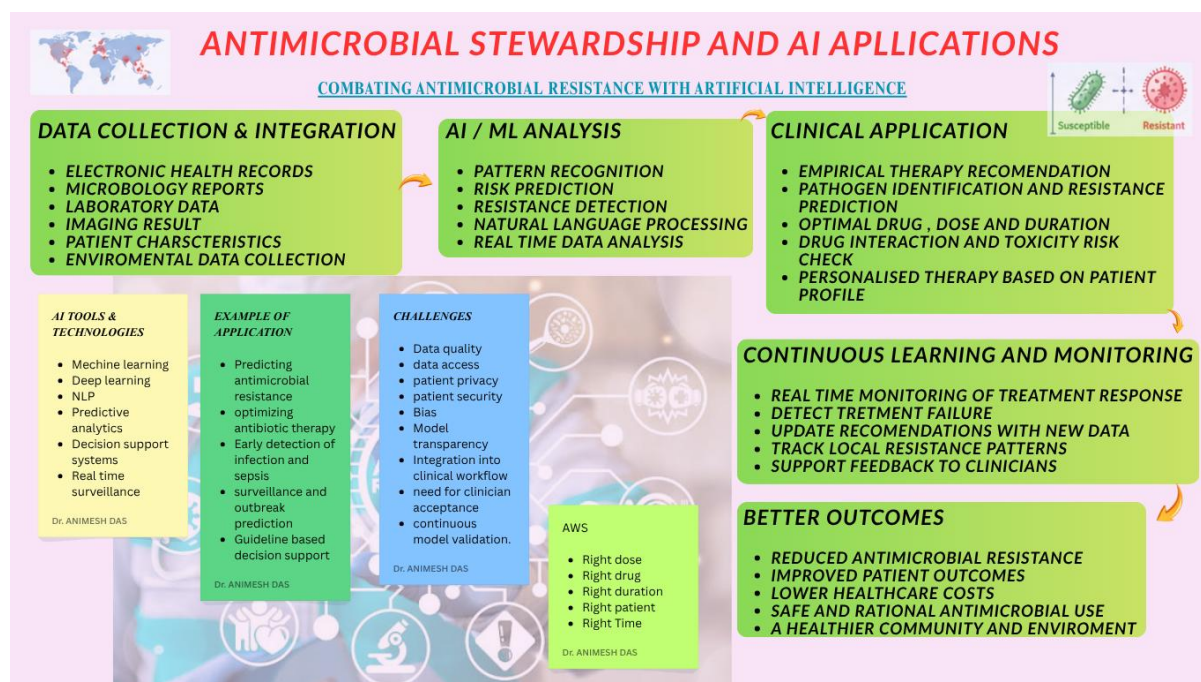


FIGURE 6: Antimicrobial Stewardship and AI Application

DISCUSSION

This study shows that artificial intelligence (AI) is changing medication safety from a reactive system to a more proactive system. AI has been studied for adverse drug reaction (ADR) and adverse drug event (ADE) prediction, drug–drug interaction (DDI) prediction, clinical decision support, pharmacovigilance, medication-error detection, and antimicrobial stewardship. The overall evidence suggests that AI can process large amounts of clinical, laboratory, medication, and electronic health record (EHR) data and identify medication-related risks earlier than traditional approaches.¹⁻¹⁰ This supports the main concept of the present research: predict the problem early, detect it accurately, and prevent patient harm. This direction is also supported by recent pharmacovigilance research showing increasing use of AI and machine learning for ADE prediction and detection.

A clear difference can be seen between the older and newer AI applications. Some studies mainly focus on pharmacovigilance, ADR/ADE detection, safety-signal identification, and processing of large safety databases. These studies show that AI can improve the speed of finding possible safety problems. However, they also show that data quality, missing information, and validation remain important limitations. This is similar to earlier pharmacovigilance evidence showing that AI has strong potential, but its full use in pharmacovigilance is still developing.¹⁻¹⁰

Some studies focus on further development toward prediction before harm occurs. These studies use machine learning, deep learning, graph-based models, and different drug features to predict DDIs. For example, Article 14 used molecular fingerprints, enzymes, pathways, targets, GPT-4o-based information extraction, and deep neural networks for DDI prediction, achieving high predictive performance. However, high model performance does not always mean that the model is ready for clinical use. Recent evidence shows that DDI studies are still mainly based on internal validation, while patient-level information and external clinical validation are less common. Therefore, this research should clearly separate technical accuracy from real clinical usefulness.^{[11-16](#)}

Many of the studies demonstrate the importance of AI-based clinical decision support systems (CDSS). These systems can provide alerts and recommendations during prescribing and help healthcare professionals identify medication errors, inappropriate medicines, and possible ADEs. Evidence from the literature supports reductions in medication errors with computerised medication-related CDSS, but alert fatigue, alert overrides, workflow problems, and overdependence on technology remain concerns. Therefore, AI should be considered a decision-support tool, not a replacement for doctors, pharmacists, nurses, or other healthcare professionals.^{[17-19](#)}

Some studies show the growing role of EHR-based AI, NLP, generative AI, and large language models. AI can extract medication and adverse-event information from clinical notes and identify patient-safety events. A systematic review of 41 studies found that models such as SVM, Random Forest, RNN, and BiLSTM-CRF can detect and predict patient-safety events, including ADEs and ADRs, but most studies lacked external or prospective validation. This finding is important because it shows that prediction alone is not enough; clinical validation is necessary before implementation.^{[20-30](#)}

There are some studies that demonstrate the importance of AI in antimicrobial stewardship (AMS). AI can support antimicrobial selection, resistance prediction, prescribing, and treatment optimization. The reviewed literature also identifies gaps in real-world implementation, data quality, ethical issues, clinical acceptance, and long-term outcomes.^{[31-36](#)}

STUDY LIMITATION

This study has some important limitations. First, the available literature on artificial intelligence (AI) in medication safety is still developing, and many studies are based on retrospective electronic health records, pharmacovigilance databases, or selected research datasets rather than real clinical practice. Therefore, the results of AI models may not always be the same in different hospitals, countries, or patient groups. Data quality is another major limitation because clinical data may contain missing, incorrect, incomplete, or differently recorded information. Second, many studies report good model accuracy but have limited external validation and real-world testing. This makes it difficult to confirm whether an AI model will work safely in another healthcare setting. Recent evidence shows that clinical validation and real-world implementation remain limited in AI-based pharmacovigilance research. Third, AI models may have problems with bias, explainability, privacy, and data security. A model trained using data from one population may give less accurate results for another population. In addition, AI cannot always

understand complex clinical situations or establish drug causality without expert review. Therefore, healthcare professionals must remain involved in final clinical decisions. Differences in AI methods, datasets, outcome definitions, and evaluation measures make direct comparison between studies difficult. Future research should focus on high-quality data, external validation, explainable AI, prospective studies, clinical implementation, and long-term patient-safety outcomes. These improvements are necessary before AI can be widely used as a reliable medication-safety tool.

FUTURE DIRECTIONS

Future research should focus on moving AI from experimental research into safe, reliable, and practical clinical use. First, more prospective and external validation studies are needed to test AI models in different hospitals, patient groups, and healthcare settings. Many current studies show good accuracy, but real-world testing is still limited. Recent evidence also recommends external and temporal validation, calibration, and real-world evaluation before wider use in drug safety. Future AI systems should become more explainable and transparent. Healthcare professionals need to understand why an AI system identifies a patient as high risk or predicts an ADR or DDI. Explainable AI methods may improve trust and support safer clinical decisions. Future research should develop integrated AI systems that combine EHR data, laboratory results, medication history, pharmacovigilance reports, clinical notes, and patient information. Such systems could provide continuous medication-risk monitoring and support early intervention. AI should be developed as a human–AI partnership, rather than a replacement for healthcare professionals. Complex tasks such as causality assessment still require expert judgment. Future studies should therefore include doctors, pharmacists, nurses, data scientists, regulators, and patients in AI development.

CONCLUSION

Artificial intelligence (AI) has strong potential to improve medication safety and patient care by helping healthcare professionals predict, detect, and prevent drug-related problems. This study shows that AI can be used in many important areas, including adverse drug reaction (ADR) and adverse drug event (ADE) prediction, drug–drug interaction (DDI) detection, clinical decision support, pharmacovigilance, medication-error detection, and antimicrobial stewardship. These findings support the idea that AI can help change medication safety from a reactive approach to a proactive approach, where possible risks are identified before serious harm occurs. AI should not replace healthcare professionals. Limitations such as poor data quality, bias, lack of external validation, privacy concerns, explainability problems, and false predictions must be carefully managed. Recent evidence also shows that real-world implementation and external validation are still limited. Therefore, the future of AI in medication safety should focus on human–AI collaboration, reliable validation, explainable models, data protection, clinical integration, and continuous monitoring. Recent international guidance also emphasises human oversight, validity, transparency, privacy, fairness, and governance for safe AI use in pharmacovigilance. Overall, AI can become an important tool for early risk prediction, accurate detection, and prevention of medication-related harm, supporting safer and more effective patient-centered healthcare.

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Ethics approval and consent to participate

The author declares that not applicable.

Consent for publication

The author declares that not applicable.

Competing interests

The author declares no competing interests.

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