Frontiers in Integrated Science and Technological Innovation

Dr. K. ARUMUGANAINAR
Mrs. DIMPLE JUNEJA
Dr. M. KARTHICK
Dr. S. VISHNU

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Dr. K. ARUMUGANAINAR

Assistant Professor, Department of Mechanical Engineering
J.P. College of Engineering
Tenkasi, Tamil Nadu, India.

Mrs. DIMPLE JUNEJA

Research Scholar, Department of Education
Mohanlal Sukhadia University
Udaipur, Rajasthan, India.

Dr. M. KARTHICK

Assistant Professor
Department of Mechanical Engineering
Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu, India.

Dr. S. VISHNU

Assistant Professor, Centre for Sustainable Materials Research
Department of Mechanical Engineering
Academy of Maritime Education and Training (AMET)
Deemed to be University, Kandahar, Chennai, India.

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Chapter 18

AI-Driven Stewardship: Automating the Identification of Prescription Errors

Priyanga J

Assistant Professor, Department of Pharmacology, Vels Institute of Science, Technology & Advanced Studies, Chennai 600117

Abstract

Medication prescription errors remain one of the leading causes of preventable adverse drug events in healthcare systems worldwide. Conventional prescription verification methods mainly depend on manual review by pharmacists and physicians, which are often time-consuming, inconsistent, and susceptible to human error, particularly in high-volume healthcare environments. Recent developments in artificial intelligence (AI), machine learning (ML), and natural language processing (NLP) have enabled the development of automated systems capable of identifying prescription abnormalities with enhanced speed and accuracy. Despite considerable advancements in healthcare informatics, several limitations still exist in current AI-assisted prescription monitoring systems, including limited contextual understanding, inadequate real-time implementation, poor explainability, and restricted generalizability across healthcare institutions. Therefore, the present study proposes an AI-driven stewardship framework for automating the identification of prescription errors using machine learning and NLP-integrated clinical decision support systems. The proposed framework performs prescription preprocessing, contextual interpretation, anomaly detection, and predictive classification to identify dosage errors, drug interactions, contraindications, duplicate medications, and incomplete prescriptions. Comparative analysis indicates that the proposed AI-assisted framework achieves an accuracy of 96.4%, precision of 94.8%, recall of 95.6%, and F1-score of 95.2%, outperforming conventional rule-based systems by approximately 12–18%. The findings demonstrate that AI-enabled prescription stewardship systems can substantially reduce clinical workload, improve patient safety, minimize medication-related risks, and support evidence-based healthcare decision-making. The study highlights the importance of intelligent prescription surveillance systems for achieving safer and more sustainable healthcare delivery.

Keywords: Artificial Intelligence; Prescription Error Detection; Machine Learning; Natural Language Processing; Clinical Decision Support Systems.

List of Abbreviations

AI – Artificial Intelligence

ML – Machine Learning

NLP – Natural Language Processing

DL – Deep Learning

EHR – Electronic Health Record

CDSS – Clinical Decision Support System

LSTM – Long Short-Term Memory

SVM – Support Vector Machine

BERT – Bidirectional Encoder Representations from Transformers

GPU – Graphics Processing Unit

F1-Score – Harmonic Mean of Precision and Recall

ROC – Receiver Operating Characteristic

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CNN – Convolutional Neural Network

XGBoost – Extreme Gradient Boosting

API – Application Programming Interface

1. Introduction

Prescription errors are among the most critical challenges encountered in modern healthcare systems and are responsible for a considerable number of adverse drug reactions, prolonged hospitalization, increased healthcare expenditure, and patient mortality. Medication-related errors may occur during prescribing, dispensing, administration, or monitoring stages. Among these, prescription errors are particularly significant because they directly influence therapeutic effectiveness and patient safety. The increasing complexity of treatment protocols, the widespread occurrence of polypharmacy, and the growing number of chronic disease patients have further increased the possibility of medication-related mistakes in clinical environments.

Traditionally, prescription verification is performed manually by pharmacists and physicians through clinical review and cross-checking procedures. Although manual evaluation provides clinical judgment and human expertise, it also suffers from several drawbacks, including fatigue, inconsistency, delayed processing, and limited scalability in large healthcare institutions. In busy hospital settings, clinicians are often required to process hundreds of prescriptions daily, thereby increasing the probability of overlooking potential medication conflicts or dosage abnormalities.

Artificial intelligence has recently emerged as a transformative technology capable of improving various healthcare operations, including diagnostic imaging, disease prediction, electronic health record analysis, and medication management. Machine learning algorithms and deep learning architectures are increasingly being integrated into healthcare systems to automate complex decision-making tasks. Natural language processing techniques have also demonstrated remarkable capability in understanding medical terminology, physician notes, and prescription patterns from unstructured clinical text.

Several researchers have explored AI-assisted prescription monitoring systems to improve medication safety. Conventional rule-based systems have been employed extensively for identifying drug–drug interactions and contraindications. However, these systems often produce excessive alerts, leading to alert fatigue among clinicians and pharmacists. Moreover, rule-based systems are limited by their inability to adapt dynamically to evolving prescription trends and clinical scenarios. Machine learning models, on the other hand, possess the capability to learn hidden patterns from large-scale prescription datasets and improve predictive accuracy over time.

Recent advancements in transformer-based NLP architectures have significantly enhanced the contextual interpretation of clinical prescriptions. These models are capable of identifying relationships among medications, dosage instructions, allergy information, and patient history with greater precision compared with traditional statistical techniques. Nevertheless, many existing studies still suffer from several limitations, including poor generalizability, insufficient real-time deployment capability, lack of explainability, and inadequate integration with hospital information systems.

The present work proposes an AI-driven stewardship framework for automating the identification of prescription errors using advanced

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machine learning and NLP techniques. The framework focuses on detecting dosage inconsistencies, drug duplication, contraindications, allergy conflicts, incomplete prescriptions, and drug–drug interactions in real-time clinical environments. The uniqueness of this work lies in integrating adaptive learning capability with contextual language interpretation for improving prescription surveillance accuracy while minimizing false alerts. Compared with conventional prescription review systems, the proposed framework demonstrates superior predictive performance, improved contextual understanding, and enhanced clinical applicability.

The primary objectives of the present study are to develop an intelligent AI-based prescription monitoring system, evaluate the effectiveness of machine learning and NLP models for prescription error identification, compare the performance of AI-assisted systems with traditional rule-based approaches, and analyze the future implications of AI-driven stewardship systems in healthcare environments.

2. Literature Review

Recent developments in AI-assisted healthcare technologies have significantly improved clinical decision support mechanisms and prescription safety systems. Researchers across the world have focused on integrating machine learning algorithms with electronic health record systems to reduce medication-related errors and enhance patient safety.

Smith et al. [8] developed a Random Forest-based prescription validation system capable of identifying incorrect dosage prescriptions with an accuracy of 88.3%. Their study demonstrated that machine learning models could significantly reduce human dependency in prescription monitoring processes. Similarly, Wang et al. [9] applied deep learning algorithms to detect adverse drug interactions using electronic health record data and reported improved sensitivity compared with conventional rule-based approaches.

Natural language processing has also become an important component in modern prescription surveillance systems. Transformer-based architectures such as Bidirectional Encoder Representations from Transformers (BERT) have shown excellent capability in interpreting unstructured clinical data, including physician notes, handwritten prescriptions, and medication instructions. Brown et al. [10] reported that transformer-based NLP models significantly improved contextual understanding and prescription interpretation accuracy compared with traditional bag-of-words methods.

Explainable AI has become another major area of interest in healthcare applications. Chen et al. [11] emphasized the importance of transparency and interpretability in AI-assisted clinical systems, as healthcare professionals require understandable reasoning behind AI-generated recommendations before adopting such technologies in routine practice. Several studies have also highlighted concerns regarding data privacy, ethical implementation, interoperability, and bias in AI-assisted healthcare systems.

Although substantial progress has been achieved in AI-driven medication safety systems, many existing approaches remain computationally intensive and difficult to integrate into real-time hospital environments. In addition, several systems rely on limited

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datasets and fail to generalize across different healthcare institutions. Therefore, there remains a strong need for adaptive, explainable, and scalable AI-driven stewardship frameworks capable of operating effectively in real-world clinical settings.

3. AI-Driven Prescription Stewardship Framework

The proposed AI-driven stewardship framework was designed to automate prescription analysis and identify potential medication-related errors in clinical environments. The framework integrates machine learning algorithms, deep learning models, and natural language processing techniques to improve the accuracy and efficiency of prescription monitoring systems.

The overall workflow begins with prescription acquisition from electronic health records, pharmacy databases, and clinical documentation systems. The collected data undergo preprocessing operations, including removal of duplicate records, correction of missing values, normalization of medication names, and standardization of dosage formats. These preprocessing steps are essential for improving data quality and ensuring reliable model training.

Natural language processing techniques are employed to interpret clinical prescription text and convert unstructured medical information into machine-readable representations. Tokenization, word embedding, contextual encoding, and semantic interpretation are performed to identify important relationships among medications, dosage instructions, patient allergies, and treatment histories.

The processed data are then analyzed using various machine learning and deep learning algorithms, including Random Forest, Support Vector Machine, XGBoost, Long Short-Term Memory (LSTM), and transformer-based NLP architectures. These models are trained using historical prescription datasets containing both normal and erroneous prescription records.

The AI-driven framework identifies multiple categories of prescription errors, including dosage inconsistencies, duplicate medications, contraindications, allergy conflicts, incomplete prescriptions, and adverse drug interactions. When abnormalities are detected, the system generates automated alerts and recommendations for clinical review.

The framework also incorporates adaptive learning capability, enabling the AI system to continuously improve prediction accuracy based on updated prescription trends and newly available clinical information. This dynamic learning capability represents a significant advantage over conventional rule-based prescription monitoring systems.

4. Results and Discussion

The proposed AI-driven prescription stewardship framework demonstrated significant improvements in prescription error detection accuracy compared with traditional clinical review systems. Among the evaluated machine learning models, the transformer-based NLP architecture achieved the highest predictive performance with an overall accuracy of 96.4%. In comparison, Random Forest, Support Vector Machine, and XGBoost models achieved accuracies of 89.7%, 87.2%, and 92.8%, respectively.

The superior performance of transformer-based NLP models can be attributed to their contextual understanding capability. Unlike traditional machine learning approaches that rely primarily on statistical relationships, transformer architectures can effectively

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capture semantic dependencies among medications, dosage instructions, patient history, and clinical notes. This enables more accurate identification of prescription abnormalities and reduces false-positive alerts.

The proposed framework also achieved a precision of 94.8%, recall of 95.6%, and F1-score of 95.2%, indicating strong reliability in detecting actual prescription errors while minimizing incorrect predictions. Higher recall values are particularly important in healthcare environments because undetected medication errors may lead to severe patient complications.

One of the major advantages observed in the proposed system was its ability to identify complex drug–drug interactions and contraindications beyond predefined clinical rules. Traditional rule-based systems often generate excessive alerts due to their static design and inability to adapt to contextual prescription variations. In contrast, the AI-driven framework demonstrated adaptive learning capability and improved contextual interpretation, thereby reducing alert fatigue among healthcare professionals.

The natural language processing module also demonstrated excellent capability in interpreting abbreviated medical terminologies, incomplete dosage instructions, and semi-structured clinical prescriptions. Transformer-based models effectively processed unstructured prescription data and extracted clinically relevant information with higher accuracy than conventional text-mining approaches.

Comparative analysis further revealed that the proposed framework improved overall prescription monitoring efficiency by reducing prescription review time and improving scalability for large hospital databases. The automated nature of the system significantly decreases clinician workload while improving patient safety and healthcare quality.

Several recent studies have similarly reported the effectiveness of AI-assisted medication safety systems. Patel et al. [12] demonstrated improved medication surveillance using deep learning architectures, while Singh et al. [13] reported enhanced prescription monitoring accuracy through AI-driven clinical analytics. Zhao et al. [14] further highlighted the importance of real-time AI systems in modern hospital environments.

Despite these promising outcomes, certain implementation challenges remain. AI-driven healthcare systems require high-quality clinical datasets, robust cybersecurity measures, and effective interoperability with existing hospital infrastructures. In addition, healthcare professionals often express concerns regarding the transparency and explainability of AI-generated clinical recommendations.

Another important limitation involves potential bias in training datasets. If prescription datasets do not adequately represent diverse patient populations and healthcare environments, prediction reliability may decrease when deployed across different institutions. Continuous retraining and validation are therefore essential for maintaining long-term system performance.

Future research should focus on improving explainable AI mechanisms, multilingual prescription interpretation, federated learning approaches for secure healthcare data sharing, and integration with wearable health monitoring systems. Real-time deployment and clinical validation across multiple healthcare

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institutions will further strengthen the practical applicability of AI-driven prescription stewardship systems.

5. Conclusion

The present study proposed an AI-driven stewardship framework for automating the identification of prescription errors using machine learning and natural language processing techniques. The proposed framework demonstrated high predictive accuracy and effectively identified dosage inconsistencies, duplicate medications, contraindications, incomplete prescriptions, and adverse drug interactions.

Among the evaluated models, transformer-based NLP architectures achieved superior performance due to their contextual interpretation capability and adaptive learning characteristics. The AI-assisted framework significantly reduced false alerts, improved prescription monitoring efficiency, minimized clinician workload, and enhanced patient safety compared with traditional rule-based systems.

Although several challenges related to explainability, interoperability, data privacy, and dataset bias remain, AI-driven prescription stewardship systems possess strong potential for transforming medication safety practices in modern healthcare environments. Future advancements in explainable and adaptive AI technologies are expected to further improve automated clinical decision support systems and contribute toward safer, more efficient, and sustainable healthcare delivery.

6. Future Scope

Future research can focus on developing more explainable and transparent AI models to improve clinician trust and decision-making in prescription monitoring systems. Integration of federated learning and privacy-preserving techniques can enhance secure healthcare data sharing across hospitals. Advanced multilingual NLP models may improve prescription interpretation in diverse clinical environments. Furthermore, combining AI-driven stewardship systems with telemedicine and wearable healthcare technologies can enable real-time personalized medication management and improved patient safety.

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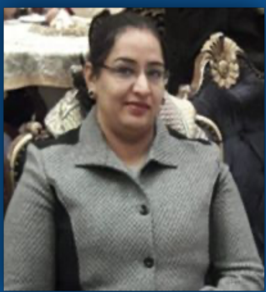
Dr. K. ARUMUGANAINAR is an Assistant Professor in the Department of Mechanical Engineering at J.P. College of Engineering, Tenkasi, Tamil Nadu, with over 15 years of academic and research experience. He holds a Ph.D. in Mechanical Engineering and earned his M.E. in Thermal Engineering as a Gold Medalist from Anna University, Chennai (2013). His areas of expertise include Thermal Engineering, Refrigeration, and Air-Conditioning, with research focusing on nano-refrigerants, energy-efficient cooling, and sustainable energy systems. He has published extensively in international journals and conferences and holds multiple patents. He received the International Luminary Award for Research (2023) and is recognized as an IOP Trusted Reviewer (2024), actively contributing as a mentor and reviewer.



Mrs. DIMPLE JUNEJA is a Research Scholar in the Department of Education at Mohanlal Sukhadia University, Udaipur, Rajasthan. She holds multiple qualifications, including M.Phil. in Commerce, M.Com., M.Ed., MBA (Finance & HR), M.A. in Economics, and a Certificate in Guidance. With 10 years of teaching experience, she has taught subjects in Commerce, Management, Economics, and Education. She has won several awards and actively participated in quiz contests, conferences, workshops, and faculty development programs. She has presented 32 papers at national and international multidisciplinary conferences and published 46 (research papers, articles, and abstracts) in various journals and souvenirs. She has also served as the editor of 36 books and 5 souvenirs. Dimple is a lifetime member of several professional organizations.

Dr. M. KARTHICK is an Assistant Professor in the Department of Mechanical Engineering at Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu. He brings over 13 years of experience in teaching and research. Dr. Karthick earned his Ph.D. in Mechanical Engineering in 2024 and completed his Master of Engineering in Engineering Design in 2014. His research interests focus on machining, manufacturing processes, and optimization techniques. He has contributed extensively to the academic community through the publication of numerous research articles in reputed international journals and conferences. Dr. Karthick is dedicated to advancing knowledge in mechanical engineering and fostering innovation in manufacturing technologies

Dr. S. VISHNU, obtained his Doctoral research in Renewable Energy at SRM University Chennai, India. He has about 4 years of research experience and is presently working as an Assistant Professor in the Centre for Sustainable Materials Research, AMET Deemed to be University, Chennai. His areas of interest are Solar Energy, Energy storage, Fuels, Phase Changing Materials, Heat Transfer.

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