Artificial Intelligence in Medication Management and Prescription Interpretation: A Systematic Review

Aamina Banu, M.F.F. Nuha and Chaman Wijesiriwardana

Abstract With modern lifestyles becoming increasingly demanding, more individuals are experiencing chronic illnesses, memory limitations, and time constraints, all of which contribute to poor medication adherence and various health issues. Consequently, recent studies have increasingly explored Artificial Intelligence (AI)-based approaches to improve medication adherence. The purpose of this study is to examine how AI has been used recently in areas that affect medication management, such as voice assistance, prescription decoding, and medication reminders. This paper followed the PRISMA framework to examine studies published between 2012 and 2025. The system architecture, usability, target users, and practical applicability were the criteria used to evaluate each of these studies. There was a noticeable improvement in prescription decoding using Optical Character Recognition (OCR), applications using Natural Language Processing (NLP), and reminder systems with AI. However, significant challenges remain, including limited accessibility for elderly and low-literacy users, insufficient personalization, and lack of real-world validation. Overall, this paper provides insights into understanding the existing solutions and the future directions needed for AI in medication management.

***Index Terms*— AI in Healthcare, Medication Adherence, Medication Reminder Systems, OCR-based Prescription Decoding, Voice Assistants**

I. Introduction

In health-related factors, Medication adherence is very important, but it is still a challenge worldwide in healthcare systems [1]. According to World Health Organization (WHO) in 2023, worldwide, 16% of the population has some kind of disability, and some of them are having severe hardship in their daily functions and require medical care and monitoring continuously. People living in developing countries usually have poor adherence to medications because of limited healthcare services and not being able to access healthcare services [2] which worsen their health condition, leading to higher hospitalization and high healthcare costs [1], [3]. WHO statistics states that to achieve Sustainable Development Goals (SDGs) in good health and well-being, it is important to improve medication adherence.

Despite increased attention, medication adherence remains limited worldwide due to psychological, behavioral, and cognitive factors. [4]. Complicated medicine schedules, memory loss, side effect anxiety, and low health literacy all have an impact on medication non-adherence [5], [6]. Medication adherence is also impacted by other factors, such as cultural traditions, a lack of communication in healthcare, and financial constraints, particularly in the elderly and vulnerable population [1], [7], [8]. Therefore, a smart, adaptable solution that can provide individualized care and guarantee ongoing care outside of traditional clinics is required [9], [10].

Recent advances in AI have led to the development of reminder systems, NLP-based applications, and OCR-driven prescription decoders. With the help of these technologies, medication errors can be reduced, patient understanding can be improved, and consistency in treatment can also be enhanced. However, existing research remains fragmented and mainly focuses on individual components, rather than on a user-centered platform that can address multiple adherence-related challenges simultaneously [1]. Furthermore, the existing applications are not completely accepted in the practical world because of limited user testing and failure to address privacy and ethical issues in real-world healthcare [11], [12].

Therefore, in this review AI-based techniques for prescription decoding and medication management are systematically reviewed to identify methods which are efficient, and assess their results, and identify the limitations and issues. The review was guided using the following research questions:

- RQ1: What are the AI techniques that are used in medication management systems and prescription decoding?
- RQ2: How are these AI techniques effective in improving medication adherence and the prescription decoding accuracy?

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- RQ3: What are the common challenges, limitations, and ethical issues that are identified from the existing AI-based medication management research?

This review is to help researchers and practitioners to design an inclusive medication management system which can improve medication adherence and the overall well-being in the real-world by a unified synthesis that identifies developments, gaps, and directions for future AI-based healthcare innovation by combining the fragmented studies on prescription decoding, reminder systems, and adherence monitoring.

The rest of the paper is structured as follows: Section 2 provides a review of related work in AI-based medication management and prescription decoding. Section 3 details the research methodology that was followed in this paper, including the PRISMA framework and data collection process. Section 4 discusses the findings obtained from the reviewed literature in detail, and addresses each of the research questions and also outlines the proposed conceptual framework based on the identified results. Finally, Section 5 concludes the paper by summarizing the major findings, highlighting limitations, and suggesting directions for future research.

II.LITERATURE REVIEW

This review examines existing research on AI-based medication adherence systems, which includes prescription decoding, reminder systems, voice assistants, and smart monitoring tools. The main goal is to synthesize evidence across these fragmented areas to highlight key advancements, limitations, and research gaps. By doing this, the review aims to support the development of a patient-centered, scalable, and clinically effective medication management system that prioritizes usability, inclusivity, and cultural adaptability for especially elderly and vulnerable populations worldwide.

AI has become increasingly important in healthcare, offering support in diagnosis, treatment planning, and patient monitoring. Despite this, research on medication adherence and AI technologies is mostly studied separately. Prescription decoding, reminders, and adherence monitoring are usually treated as different systems, making solutions fragmented. Few studies combine these components into a complete system that manages the full medication process. This review addresses that gap by analyzing studies and pointing out the weaknesses that limit real-world use.

Medication adherence is a significant challenge worldwide, particularly for patients with chronic diseases. Not taking medicines properly can worsen illnesses, increase hospital visits, and increases in healthcare costs. AI has recently helped by providing personalized reminders, predictive monitoring, and smart assistance, which has led to several review studies.

Reis et al. [13] conducted a literature review on seven studies assessing the use of AI technology to improve medication adherence, including machine learning algorithms like XGBoost, voice assistants like Alexa®, IoT devices, and AI-driven mobile apps. The results showed a significant improvement in medication adherence, with a relative increase of 32.7% in insulin adherence using voice assistants and an overall adherence rate of 89.7% for AI-driven mobile apps, compared to 71.9% in controlled groups. Although this data points to the potential of AI to improve medication adherence, the literature review conducted by Reis et al. [13] also points to a considerable set of limitations. These were primarily found in pilot studies with a relatively controlled population, where the presence of caregivers and eventual familiarity with technology may have impacted the results. Moreover, the relatively high levels of adherence to mobile apps may represent a transient behavior rather than a persistent long-term habit, as the respective studies lasted for fewer than eight weeks. Mobile apps were more effective compared to IoT devices and voice assistants, which may represent their ability to deliver customized alarms and alerts. However, the lack of standard outcome measures across the seven studies makes it difficult to draw robust conclusions or compare effect sizes directly.

Zavaleta-Monestel et al. [14] synthesized 26 studies on AI interventions for chronic and non-communicable diseases, highlighting the use of conversational agents, smart devices, and ML classifiers. They found that AI systems improved patient education, monitoring, and personalized feedback, particularly when integrated with pharmacist support. Critically, while the breadth of this review is useful, the heterogeneity in study design, population demographics, and adherence metrics limits generalizability. For instance, elderly populations were underrepresented, which is concerning given that older adults are among the most medication non-adherent groups. Moreover, the review noted privacy and legal concerns, yet few included studies implemented privacy-preserving mechanisms, reflecting a gap between technical feasibility and ethical implementation.

Kukade et al. [15] examined AI-driven solutions aimed at personalized care, including smart pill dispensers, predictive machine learning models, and ingestible sensors. They emphasized the role of precision medicine, where individual behavioral and genetic data can guide treatment decisions. One of the key strengths of this review is its focus on personalized interventions rather than generic solutions. However, most of the systems discussed were still at the prototype or pilot stage, which limits their use in real healthcare settings. The authors also raised concerns about algorithmic bias and limited transparency, which could increase inequalities if these systems are deployed without proper evaluation.

Singh and Kaushik [16] focused on OCR- and ML-based prescription decoding. Their hybrid systems achieved over 85% accuracy with printed prescriptions but underperformed with handwritten, multilingual, or cursive prescriptions. While technically robust for standard prescriptions, these systems generally operate in isolation, without integration with reminders or adherence monitoring. This highlights a recurring gap: improving technical accuracy alone does not necessarily translate to better adherence outcomes. Unlike mobile apps or smart pill dispensers, these OCR systems do not actively support patient engagement, limiting their practical utility.

Peng et al. [17] conducted a meta-analysis of 14 RCTs with 1,785 participants, evaluating mobile apps for adherence. They reported adherence improvements of 12–18%, with a moderate overall effect size (Cohen's d = 0.40). The analysis demonstrates that mobile interventions can positively influence adherence, yet critical limitations exist. Most trials had short follow-up periods, preventing assessment of long-term sustainability, and study designs varied widely, complicating direct comparisons. Cultural

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adaptability was also limited, suggesting that interventions developed for one population may not generalize well to others.

Across these studies, several patterns emerge. First, most AI interventions focus on single-function systems (e.g., prescription decoding, reminders, or monitoring), resulting in fragmented solutions that fail to address the full medication adherence pathway. Second, dataset limitations, particularly for handwritten and multilingual prescriptions, reduce model effectiveness. Third, the majority of studies emphasize technical accuracy rather than usability, accessibility, or patient-centered design. Fourth, ethical and regulatory concerns, including privacy, transparency, and accountability, are often overlooked. Finally, real-world validation is minimal; interventions are typically tested in small, controlled environments with short follow-ups, limiting generalizability.

In summary, while AI demonstrates significant potential for improving medication adherence, these studies collectively highlight the need for integrated, explainable, and patient-centered AI solutions. Effective real-world deployment requires combining technical accuracy with usability, inclusivity, and ethical safeguards. The IAMME framework, proposed in this review, directly addresses these gaps by unifying prescription decoding, reminders, adherence monitoring, and clinical feedback into a single platform.

III. Research Methods

The purpose of this Systematic Literature Review (SLR) was to identify, evaluate, and synthesize studies on AI-based medication management and prescription decoding systems that were published between January 2012 and October 2025. The years 2012–2025 were chosen to cover the significant developments in AI and healthcare informatics. Deep learning became popular in 2012, which transformed the application of NLP and OCR, which are crucial for prescription decoding. The review is restricted to studies conducted up to October 2025 to ensure that recent innovations are included in the review in order to maintain a clear and relevant scope for the review. The review followed PRISMA principles to ensure rigor, transparency, and reproducibility [18]. The PRISMA framework includes four stages: identification, screening, eligibility, and inclusion, ensuring alignment with the research objectives and minimizing bias.[19].

A. Keywords Utilized

A selected set of keywords was used for this literature search. The keywords were grouped into three main groups which were AI techniques, domain focus, and population or context. Boolean operators (AND, OR) were applied to systematically combine these groups and refine the search results.

AI techniques: (“Artificial Intelligence” OR “Machine Learning” OR “Deep Learning” OR “Natural Language Processing” OR “Optical Character Recognition” OR “Reinforcement Learning”)

Domain focus: (“Prescription decoding” OR “Medical prescription” OR “Handwritten prescription” OR “Medication adherence” OR “Medication reminder system”)

Population / Context: (“Elderly” OR “Older adults” OR “Patients” OR “Healthcare” OR “Clinical setting”)

Combined Boolean search string: (“Artificial Intelligence” OR “Machine Learning” OR “Deep Learning” OR

“Natural Language Processing” OR “Optical Character Recognition” OR “Reinforcement Learning”)

AND (“Prescription decoding” OR “Medical prescription” OR “Handwritten prescription” OR “Medication adherence” OR “Medication reminder system”)

AND (“Elderly” OR “Older adults” OR “Patients” OR “Healthcare” OR “Clinical setting”)

These search strings were applied across multiple digital libraries, including Google Scholar, IEEE Xplore, Scopus, and ScienceDirect, to ensure comprehensive coverage of relevant peer-reviewed literature.

B. Databases and Frameworks

IEEE Xplore, PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar for grey literature were the academic databases where the search was conducted. These databases were chosen due to their reliability and applicability in clinical research, healthcare informatics, and computer science.

In order to ensure transparency and reproducibility, multiple Boolean search strings were applied across each database. The number of studies retrieved from each database for each search string was recorded and summarized, as recommended for systematic literature reviews.

TABLE I
SUMMARY OF REVIEWED STUDIES ON AI-POWERED MEDICATION ADHERENCE SYSTEMS

Article	Focus Area	Key Findings	Reported Limitations
[13]	AI-based adherence tools (apps, IoT, voice assistants)	AI-based systems improved medication adherence by 6.7 - 32.7%, and the real-time monitoring also remained effective.	Small sample sizes, risk of bias, and minimal real-world validation.
[14]	AI in pharmaceutical care	Adherence was improved when pharmacists were integrated into care pathways through chatbots, mobile apps and smart devices.	Methodological variability, lack of standardized metrics, and ethical or privacy issues.
[15]	AI for adherence and personalized care	Ingestible sensors, predictive analytics, and genomic personalization made adherence and personalized treatment effective.	Most systems were prototypes; which included challenges with transparency and accountability.
[16]	OCR and prescription recognition	Hybrid OCR–ML models improved prescription decoding accuracy, supporting adherence.	Often struggled with cursive or multilingual prescriptions and did not integrate with adherence tools.
[17]	Mobile adherence apps (meta-analysis)	Mobile apps significantly improved adherence, with a reported effect size of $d = 0.40$ ($p < 0.001$).	Included low evidence, short-term trials, and limited cultural adaptability.

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TABLE II
SEARCH RESULTS ACROSS DATABASES FOR DIFFERENT SEARCH STRINGS

Database/Source	Search String (Applied)	Search Results Identified	Studies Selected
Google Scholar	("Artificial Intelligence" OR "Machine Learning" OR "Deep Learning" OR "Natural Language Processing" OR "Optical Character Recognition") AND ("Medical prescription" OR "Handwritten prescription" OR "Medication adherence" OR "Medication reminder system")	17,800	18
IEEE Xplore	("Artificial Intelligence" OR "Machine Learning" OR "Deep Learning") AND ("Medical prescription" OR "Medication adherence")	623	9
ScienceDirect	("Artificial Intelligence" OR "Deep Learning") AND ("Prescription decoding" OR "Medication management")	13,563	5
Scopus	("Artificial Intelligence" OR "Machine Learning") AND ("Medication adherence" OR "Medical prescription")	514	3
Total			**35**

C. PRISMA Workflow

PRISMA 2020 framework was followed to guarantee transparency and reproducibility in the systematic review. First, 120 papers that were published between January 2012 and October 2025 was found through database searches. After that, 110 unique publications were found because of relevancy using titles and abstracts after duplicates were removed. The studies that were excluded were among non-peer-reviewed and studies that were not published in English language, as well as publications that did not use AI, ML, DL, NLP, or OCR techniques.

After that, 45 studies were subjected to a full-text evaluation. According to the inclusion criteria, studies had to be published in peer-reviewed journals or at conferences between 2012 and 2025, use AI/ML/DL/NLP/OCR methods for medication adherence or prescription decoding, and show empirical findings such as adherence rates, F1-scores, or OCR accuracy. Non-peer-reviewed sources, review papers lacking primary data, and generic AI studies were not included. 35 studies were included in the final synthesis after these criteria were applied.

In order to gather information on study objectives, dataset characteristics, AI techniques, model architectures, evaluation metrics, usability testing, target populations, and reported limitations, data extraction was carried out using a standardized form. Using a narrative approach to quality appraisal took into account factors like reproducibility, evaluation clarity, dataset robustness, and methodological rigor. The studies were divided into three quality categories: high, medium, and low.

Because the study designs, metrics, and outcomes varied so much, the results were narratively synthesized. The research was separated into three primary categories: rule-based or ML-based reminder algorithms, voice-assisted or interactive systems, and OCR/NLP-based prescription decoding. Both qualitative and quantitative metrics were examined, including usability, accessibility, and ethical considerations, as well as decoding accuracy and adherence improvement. Conflicting results were interpreted according to the context and quality of the study.

The PRISMA flow diagram in Fig.1 illustrates the study selection procedure and lists the total number of records found, screened, assessed for eligibility, and added to the final synthesis.

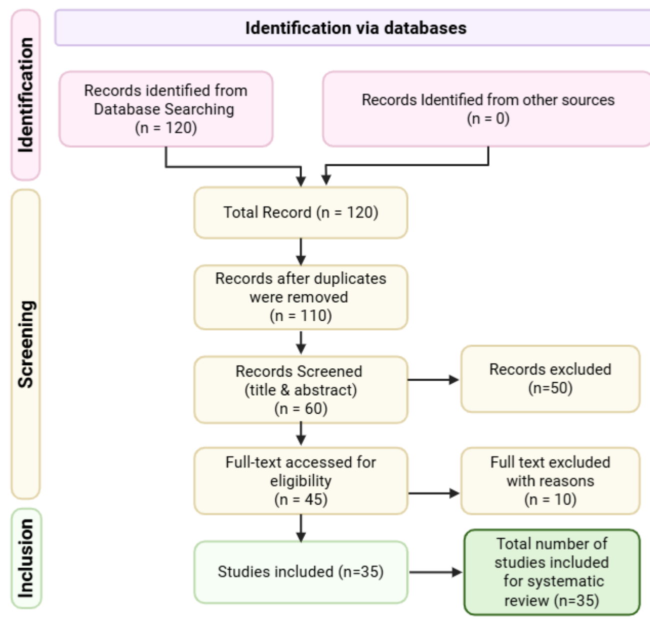

Fig. 1. PRISMA flow diagram illustrating the study selection process for the systematic review

IV. RESULTS AND DISCUSSION

RQ1: What are the AI techniques that are used in medication management systems and prescription decoding?

It is evident that the complexity of prescription management cannot be properly solved by a single approach [16], [20]. To interpret medication names, dosages, and timings, most researchers in the prescription decoding field using OCR to extract text from prescriptions was frequently done with rule-based NLP models to ML models joined together [21], [22]. These methods were less dependable for handwritten or multilingual documents, but they worked well for printed prescriptions.

Medication reminder system improved adherence with reminder phone calls, text messages, pagers, interactive voice

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response systems, videotelephone calls, and programmed electronic audiovisual reminder devices [23]. The IoT was also among the technology used by reminder systems [24], [25], [26]. Smart pill dispensers and medicine boxes were commonly combined with microcontrollers that managed delivery schedules and alarms [24], [26]. Systems that are connected with smart home platforms can send reminders by voice, smartphone notifications, or display prompts [25].

More sophisticated uses of AI have been made in adherence monitoring [14]. In recent studies, chatbots and mobile health apps also use predictive models to deliver personalized reminders that adapt to the preferences and actions of each patient [15].

Despite these advancements, several challenges persist. OCR-based solutions struggle with multilingual prescriptions and handwriting errors [16]; IoT-based reminders mostly need stable connectivity and technical setup; and predictive adherence models need a lot of user data, which raises privacy and accessibility issues.

Rather than integrating monitoring, reminders, and prescription decoding into a unified system, most studies focus on a single component. Few used Explainable AI (XAI) for transparency [27], and the lack of consistent benchmarking made it difficult to compare effectiveness across different platforms.

Table III shows that AI in medication management mainly falls into three areas: prescription decoding, reminder systems, and adherence monitoring. OCR and NLP are widely used for decoding prescriptions, which shows that accurately reading and interpreting text is still a core challenge. Reminder systems mostly use IoT devices and voice assistants, focusing on automating alerts and prompting users rather than making intelligent decisions. Meanwhile, adherence monitoring is mostly using predictive models and chatbots, which is moving toward more personalized and adaptive support. However, these techniques are usually applied individually, highlighting that most solutions are fragmented and there's a clear need for fully integrated systems that manage the entire medication process.

TABLE III
AI METHODS APPLIED IN PRESCRIPTION DECODING AND REMINDER SYSTEMS

Application Domain	Methods / Technologies Used	Representative Studies
Prescription Decoding	OCR, Pattern Matching, NLP	[22]
Medication Reminder Systems	IoT-based pill dispensers, Voice Assistants, Smart Home Systems	[24], [25], [26]
Adherence Monitoring	AI-based mobile reminders, Chatbots, Predictive Models	[15]

Table IV compares the main AI techniques used in medication management, looking at what they are typically used for, their strengths, and their limitations. OCR and NLP are helpful for reading and interpreting prescriptions, but they often struggle with handwriting or multiple languages. IoT-based reminders, like smart pillboxes and dispensers, make it easier to stay on schedule and reduce the burden on caregivers, though they depend on hardware, electricity, and stable connectivity. Mobile apps and voice-based reminders are easier for users, especially older adults, but they need internet access and consistent interaction. Predictive AI and chatbots can personalize reminders based on a patient's habits, but they require lots of data and raise privacy concerns. In summary, each technique has its benefits, yet none can handle everything on its own, showing the importance of creating integrated solutions that bring these tools together for better medication management.

In summary, AI-based medication management systems include diverse technologies OCR and NLP for text recognition, IoT for reminders and automation, and predictive AI for personalized adherence with each offering distinct benefits and having specific limitations.

RQ2: How are these AI techniques effective in improving medication adherence and the prescription decoding accuracy?

Errors in interpreting prescriptions have been reduced a lot with use of OCR-based methods when compared with manual method [28]. User satisfaction increased and workload for caregivers were significantly reduced with the use of smart medication boxes [24], [26]. Elderly users were considered in the voice-based smart home reminder systems for medication adherence which improved accessibility and engagement across diverse user groups [25]. Moreover, AI-based mobile applications improved adherence to a measurable level, where a few studies reported very high adherence rates [29].

However, there were limitations that impacted adherence. Medical abbreviation used in prescriptions and messy handwriting limited OCR-based understanding of prescriptions [22]. IoT-based systems mostly need continuous power supply and internet connectivity [24] which is not suitable when it comes to low-resource environments [30]. When considering AI-based mobile application, they more or less depend on user data [17], [31] which is an issue with privacy and is not suitable in real-world applications.

Table V shows that AI-based systems can make a real difference in managing medications. They help make prescription reading more accurate, remind people to take their medicines on time, reduce the burden on caregivers, and generally make the experience smoother for users. Systems that decode prescriptions are especially reliable for printed text, while reminder systems especially automated ones help people stay on track without needing constant supervision. Adherence monitoring systems go a step further by offering personalized reminders that keep users engaged. However, the effectiveness of these tools often depends on the user. For older adults, for example, how easy and accessible a system is can be just as important as how technically accurate it is. This highlights the point that good design and understanding user needs are just as crucial as the AI behind the system. In summary, AI-based medication management systems improve, accuracy, medication adherence, and user engagement. However, the success of these systems depends on user satisfaction, integration and personalization with daily routines of the user.

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TABLE IV
COMPARISON OF AI TECHNIQUES IN MEDICATION MANAGEMENT SYSTEMS

AI Technique / Domain	Typical Use Case	Strengths	Limitations
OCR (Optical Character Recognition)	Prescription decoding (printed text)	Accurate text extraction for printed prescriptions; foundational for further processing	Poor performance on handwritten, cursive, multilingual, or low-quality prescriptions
NLP / Pattern Matching	Prescription decoding, text interpretation	Can extract medication names, dosages, and schedules; complements OCR	Limited by rule-based patterns; struggles with ambiguous or unconventional formats
IoT-based Reminders (smart pillboxes, dispensers)	Medication reminders, adherence prompts	Reduces caregiver workload; automated alarms and notifications	Hardware-dependent; requires electricity, correct pill loading, stable connectivity
Mobile App & Voice-based Reminders	Medication reminders, user engagement	Flexible, easy to use, especially for elderly; personalized notifications	Requires internet access; depends on regular user interaction; may not suit low-resource settings
Predictive AI / Chatbots	Adherence monitoring, personalized reminders	Adapts reminders based on user behavior; supports engagement and personalized care	Requires large user datasets; privacy and accessibility concerns; limited real-world validation

TABLE V
AI METHODS APPLIED IN PRESCRIPTION DECODING AND REMINDER SYSTEMS

Application Domain	Outcome Measures / Effectiveness	Representative Studies
Prescription Decoding	Accuracy of drug name recognition, reduction in transcription errors	[28]
Medication Reminder Systems	Improved adherence and reduced caregiver workload	[24], [26]
Adherence Monitoring	Personalized reminders, improved engagement, and adherence rates	[29]
User Experience	Ease of use, accessibility for elderly populations	[25]

RQ3: What are the common challenges, limitations, and ethical issues that are identified from the existing AI-based medication management research?

Though there is a huge potential in AI-based systems, many issues are still there. When considering the prescription decoding, it is still not reliable with handwritten prescriptions and prescriptions written in languages other than English [28]. Devices that have IoT are usually only handling one medication routine and entirely depend on the user to add tablets into the device correctly [26].

Patients' health related information is continuously collected in the AI-based systems which raises concern on data privacy leading to ethical issues [15], [32]. Moreover, there are systems that act like "black boxes" without transparency which makes it difficult for patients and medical professionals to understand and predictions made. At the same time, most system do not consider vulnerable population like elderly users or users with low-literacy which reduces accessibility for diverse user groups [24].

Table VI highlights that the challenges with AI-based medication systems go beyond just technical issues. Many systems also struggle with usability, scalability, and ethical concerns. Prescription reading tools, still have trouble interpreting handwritten or multilingual prescriptions. Reminder systems often rely on specific hardware and are not very flexible, while smart pillboxes can only handle a limited number of medications, making it hard to expand their use. However, common issues like data privacy risks, lack of transparency, and accessibility barriers appear across different systems. This makes it clear that designing AI healthcare solutions isn't just about improving accuracy it's equally important to focus on making them user-friendly, ethically sound, and practical for real-world use.

TABLE VI
CHALLENGES AND LIMITATIONS IN AI-BASED PRESCRIPTION AND REMINDER SYSTEMS

Application Domain	Challenges and Limitations	Representative Studies
Prescription Decoding	Low accuracy for illegible handwriting, poor multilingual adaptability	[28]
Reminder Systems	Device dependency, pill loading, limited storage capacity	[24]
Smart Medicine boxes	Restricted to single medication, limited scalability	[26]
Ethical and Usability	Privacy, lack of transparency, accessibility challenges	[15], [24]

Table VII highlights the main gaps in current research and how they could be addressed in the future. One of the biggest challenges is that AI systems for prescription reading, medication reminders, and adherence monitoring are usually developed as separate solutions rather than as a single, integrated system. Another major issue is the lack of high-quality datasets especially for handwritten and multilingual prescriptions which limits the performance of deep learning models. Additionally, concerns around inclusivity and ethics emphasize the need for systems that are user-friendly, transparent, and protect patient privacy. These insights directly motivate the proposed Integrated AI-based Medication Management Ecosystem (IAMME), which brings all these

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components together in one system, prioritizes inclusive design, and validates its effectiveness in real clinical settings.

A. Critical Analysis and Cross-Study Comparison

The reviewed studies indicate that AI has made meaningful progress in prescription decoding and medication management. At the same time, a closer comparison of these studies shows that each approach has distinct strengths and limitations, largely influenced by the context in which it is applied. OCR-based methods perform considerably better than manual prescription reading when prescriptions are printed, as they help reduce interpretation errors and improve accuracy. However, conventional OCR systems combined with rule-based NLP continue to struggle with handwritten prescriptions, medical abbreviations, and multilingual content. More advanced deep learning-based OCR models, including CNN, LSTM, and CRNN architectures, demonstrate improved performance in these challenging scenarios, but their effectiveness depends on the availability of large, well-annotated datasets, which remain limited in most studies.

Medication reminder systems also show mixed outcomes. Smart devices such as pillboxes and automated dispensers can support timely medication intake and reduce caregiver involvement, but their effectiveness depends on reliable power supply, correct pill loading, and properly functioning hardware. In contrast, mobile applications and voice-based reminder systems offer greater flexibility and are often easier for older adults to use. However, these solutions typically require consistent internet access and sustained user interaction, which may be difficult to maintain in rural or resource-constrained environments.

AI-based adherence monitoring systems that rely on predictive models and chatbots have produced encouraging results in short-term studies, with several reporting improvements in adherence rates. Nevertheless, the lack of long-term evaluation limits confidence in their effectiveness in real-world healthcare settings. These systems also collect substantial amounts of personal health data, raising important concerns related to privacy and ethical use. Moreover, only a small number of studies incorporate XAI techniques, which affects transparency and may reduce trust among patients and healthcare professionals.

Across the literature, a key limitation is that most systems address only a single aspect of medication management, such as prescription decoding, reminder delivery, or adherence monitoring. Very few studies assess fully integrated solutions that combine all these functions. This fragmentation limits real-world applicability and makes it difficult to compare system performance across studies. In addition, vulnerable populations, including older adults, individuals with low literacy, and users in areas with limited connectivity, are often insufficiently considered during system design and evaluation.

In summary, while AI-based medication management systems offer clear advantages, technical accuracy alone does not ensure effectiveness in practice. Future solutions should emphasize better integration of system components, long-term evaluation in real healthcare environments, improved transparency, and stronger privacy protections. Addressing these factors is essential to developing systems that are practical, trustworthy, and accessible to diverse user groups.

TABLE VII
GAPS IDENTIFIED, FUTURE DIRECTIONS, AND REPRESENTATIVE STUDIES IN EXISTING TOOLS

Gap/Limitation	Future Directions	Representative Studies
Fragmented AI pipelines	Develop end-to-end integrated workflows (decoding + reminders + adherence)	[24], [28]
Dataset limitations	Build larger, standardized, multilingual prescription datasets	[22]
Inclusivity challenges	Design voice-first, accessible systems for elderly and low-literacy users	[15], [25]
Privacy & Transparency	Adopt XAI and privacy-preserving ML	[15], [32]
Limited Clinical Validation	Conduct longitudinal real-world studies with diverse populations	[24], [28]

B. Conceptual Synthesis and Recommendations

This review emphasizes the importance of developing a single, patient-centered system that can manage all aspects of medication care in one place. The processes that often function independently recently include prescription decoding, medication reminders, and adherence tracking. In order to overcome this limitation, the review proposes an IAMME, which is a framework designed to integrate all of these functions. The system consists of four main parts. The first one decodes prescriptions, including handwritten or multilingual ones, using OCR and NLP technologies. The second one sends personalized reminders via mobile alerts, SMS, and voice assistants. The third gives patients personalized feedback according to how they take their drugs using predictive analytics. The final component allows doctors to effectively adjust treatments by providing them with patient data through a dashboard. In this ecosystem, important guidelines like scalability, clinical validation, data privacy, and system integration should also be adhered to. When used appropriately, IAMME can create a reliable, transparent, and easily accessible solution that improves long-term health outcomes and assists different patient groups in following prescribed medication regimens.

In addition to functional integration, IAMME follows important design principles such as scalability, clinical validation, data privacy, ethical compliance, and system interoperability. Figure 2 illustrates the overall conceptual framework of IAMME.

Table VIII presents a comparison between IAMME and existing medication management systems. Unlike most existing solutions, which focus on single functions such as prescription reading or reminders, IAMME provides an all-in-one platform. It improves prescription decoding accuracy by supporting handwritten and multilingual inputs, offers multi-channel and personalized reminder delivery, integrates adherence monitoring with clinical feedback, and enhances inclusivity through voice-first and multilingual interfaces. Furthermore,

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TABLE VIII
COMPARISON OF IAMME WITH EXISTING SYSTEMS AND IMPLEMENTATION CONSIDERATIONS

Feature / Component	Existing Systems	IAMME	Advantage / Improvement
Prescription Decoding	OCR + NLP, mostly printed prescriptions	OCR + NLP with deep learning, supports handwritten & multilingual	More accurate in real-world scenarios
Reminder Systems	IoT pillboxes, mobile apps, voice assistants	Multi-channel, personalized (SMS, mobile, voice, smart home)	Better accessibility, flexibility, personalization
Adherence Monitoring	Predictive apps, chatbots, ingestible sensors	Predictive analytics + doctor dashboard	Unified, adaptive, integrates feedback into care
Integration	Mostly single-function, fragmented	All-in-one platform	Reduces system fragmentation, improves clinical workflow
Inclusivity	Limited support for elderly & low literacy	Voice-first, multilingual, simple UI	Broader accessibility and usability
Privacy & Transparency	Few systems consider XAI / privacy	XAI + privacy-preserving ML	Enhances trust and compliance

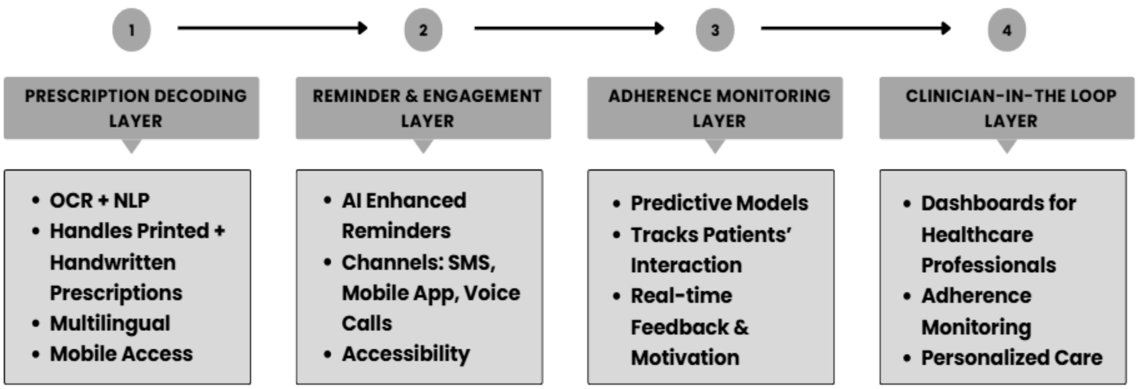

Fig. 2. Conceptual IAMME framework

IAMME incorporates XAI and privacy-preserving techniques, which improve user trust and support regulatory compliance.

Despite these advantages, several implementation challenges remain. From a technical perspective, IAMME requires large annotated datasets for accurate prescription decoding and reliable real-time data processing for predictive analytics. Operationally, reminder systems depend on stable internet or mobile connectivity. Integrating all modules into a single platform also increases system complexity. User adoption is another challenge, particularly for elderly users or individuals with low literacy, highlighting the need for training and extensive usability testing. Ethical and regulatory concerns, including data privacy, transparency, and compliance with healthcare regulations such as HIPAA and GDPR, must also be carefully addressed. Finally, large-scale deployment requires validation across diverse clinical environments, where cost and infrastructure limitations may affect scalability.

Despite these challenges, the IAMME framework effectively addresses the key limitations identified in current AI-based medication management systems. By prioritizing integration, inclusivity, ethical design, and real-world validation, IAMME provides a practical and scalable pathway toward reliable, accessible, and patient-centered AI-assisted medication management.

C. Limitations

This systematic review provides a broad overview of AI-based medication management and prescription decoding systems, but some limitations should be noted. First, only peer-reviewed studies published in English between 2012 and 2025 were included, which may have excluded research in other languages, grey literature, or studies with negative results.

Second, there was a variation in datasets and experimental settings, including differences in prescription formats, handwriting styles, patient groups, and healthcare environments. Many studies used small or simulated datasets, which may overestimate system performance in real-world use.

Third, most studies were short-term and lacked follow-up, making it hard to assess long-term adherence and usability. Real-world challenges such as infrastructure, user training, and integration with healthcare systems were also often not reported.

Finally, differences in how outcomes were measured (e.g., adherence rates, OCR accuracy, user satisfaction) made quantitative comparison difficult. These limitations suggest that future research should use standardized datasets, longer-term studies, and real-world testing to better evaluate AI-based medication management systems.

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TABLE IX
GAPS IDENTIFIED, FUTURE DIRECTIONS, AND REPRESENTATIVE STUDIES IN EXISTING TOOLS

Domain	Key Contributions	Gaps Identified	Representative Paper
Prescription Decoding	OCR systems reduced misinterpretation in printed prescriptions.	Low accuracy on handwritten scripts.	[20]
	Hybrid OCR + ML approaches improved drug name recognition.	Limited multilingual support.	[33]
	Deep learning (CNN, LSTM, CRNN) models enhanced recognition accuracy.	Requires large annotated datasets.	[34]
	Integrated OCR + NLP pipeline extracted drug names and dosage timings.	Errors with abbreviations and poor handwriting.	[28]
	Tesseract-based OCR benchmarked for prescription text recognition.	Struggles with noisy/low-quality scans.	[35]
	Preprocessing (binarization, segmentation) improved OCR outcomes.	Not generalized to diverse prescription formats.	[28], [34]
	Mobile photo–based OCR prescription decoder tested in pilot.	Performance decreased in real-world lighting.	[36]
	Dataset curation methods for prescription image recognition.	Dataset size too small for deep learning.	[35]
	Neural OCR architectures achieved >85% accuracy in printed text decoding.	Handwritten recognition accuracy still poor.	[16]
	Rule-based + ML integration enhanced structured extraction.	Overfitting to specific prescription datasets.	[36]
Reminder Systems	IoT-enabled pill dispensers automated medication delivery.	Device dependency and cost barriers.	[24]
	Smart pillboxes reduced caregiver monitoring workload.	Limited to single-medication handling.	[26]
	Mobile notification apps significantly improved adherence.	Short pilot duration, limited cultural adaptability.	[1]
	Voice-assistant reminders supported elderly usability.	Voice recognition issues in noisy environments.	[1]
	SMS/chatbot reminder systems increased adolescent adherence.	Small-scale trials, lack of personalization.	[15]
	Gamified mobile reminders increased engagement and adherence.	No long-term follow-up on sustainability.	[29]
Medication Adherence	AI-driven apps showed 10–20% improvement in adherence rates.	Small sample sizes.	[29]
	Predictive ML personalized reminder timing based on user behavior.	Needs continuous high-quality user data.	[14]
	Ingestible sensors confirmed pill ingestion reliably.	High cost and ethical/privacy issues.	[27]
	Chatbot/mobile app trials demonstrated very high adherence in short pilots.	Short-term study, no long-term validation.	[14]

D. Summary of Findings

With all evidence taken together, clear patterns have been identified. OCR-based tools have improved prescription decoding, while challenges remain with handwritten and multilingual scripts. Smart reminder systems, with mobile and voice notifications, has consistently improved adherence and user engagement. AI-based mobile applications showed noticeable adherence improvements in pilot projects.

V. CONCLUSION

Recent advancements in intelligent medication management systems are examined in this review, with a focus on adherence monitoring, reminder systems, and prescription decoding. The results highlight that AI-based methods such as OCR and NLP have improved prescription decoding accuracy, which reduces medication errors. IoT-enabled and AI-driven reminder systems have demonstrated measurable improvements in adherence rates, user satisfaction, and reduced caregiver workload, particularly among elderly users. Despite these advancements, challenges persist, including limited performance with

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handwritten and multilingual prescriptions, dependence on internet connectivity, privacy concerns, and accessibility barriers for vulnerable populations. Furthermore, most existing studies remain fragmented and rely on small datasets and controlled environments rather than real-world validation.

Future research could explore the potential implementation of the proposed IAMME framework which includes, a single platform for prescription decoding, medication reminder, adherence monitoring, and doctor-patient interaction. In order to guarantee that the framework can fit any healthcare setting, research can focus on data privacy, system scalability, and real-world validation. Researchers can also pay attention to include predictive analysis, voice-based support, and multiple language support to further improve accessibility and personalization.

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