

Artificial Intelligence in the Management of Asthma: A Review of a New Frontier in Patient Care

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Abstract: Asthma, a chronic respiratory condition, impacts over 339 million individuals globally, including 25 million in the United States, contributing to significant morbidity and healthcare costs. Despite advances, challenges persist in managing exacerbations, ensuring medication adherence, and patient education. This narrative review explores the transformative potential of artificial intelligence (AI) in improving asthma management through predictive analytics, personalized treatment, and continuous patient engagement. A search of the United States National Library of Medicine's PubMed database was performed for articles pertaining to asthma and artificial intelligence, machine learning (ML), neural network, or deep learning. The current research on AI applications in asthma care was then reviewed, including algorithms, AI-driven tools for personalized medicine, and digital platforms for patient engagement. Case studies and clinical trials assessing AI's impact on predictive accuracy and treatment adherence were reviewed. AI, particularly ML, enhances asthma management by analyzing data from wearables and patient records to predict exacerbations, stratify risk, and inform personalized treatment. Studies demonstrate AI's capability to recommend tailored interventions, monitor adherence through smart applications, and facilitate real-time treatment adjustments. Ethical challenges include ensuring patient trust, data security, and equitable technology access. In conclusion, AI's integration in asthma care holds significant promise for predictive interventions, personalized regimens, and continuous support, ultimately aiming to improve patient outcomes and reduce healthcare burdens. Continued advancements in AI will bridge current care gaps, fostering a patient-centric, proactive approach in asthma management.

Keywords: artificial intelligence, asthma, machine learning, personalized medicine

Introduction

Asthma is a chronic respiratory disease affecting over 339 million people worldwide, including approximately 25 million in the United States, 5.5 million of whom are children.^{1,2} Characterized by recurring symptoms such as wheezing, coughing, and shortness of breath, asthma can interfere with daily activities, disrupt sleep, and significantly diminish quality of life. Severe cases often result in missed school or work and may require urgent medical intervention. The economic impact is substantial. In the US alone, annual costs, including healthcare expenses, lost productivity, and premature mortality, are estimated at \$81.9 billion.¹

Despite the availability of effective treatments, asthma management remains a challenge. Exacerbations, or flare-ups, are often triggered by allergens, respiratory infections, or environmental pollutants and can be life-threatening. Medication adherence is a major barrier to control. Studies suggest that only 30–50% of patients consistently follow their treatment plans. Contributing factors include complex regimens, side effects, and limited understanding of the disease. Additionally, patient education is often inadequate. Empowering patients with knowledge about identifying triggers, proper inhaler technique, and early symptom recognition is essential to improving outcomes.^{1,3,4}

Artificial intelligence (AI) has potential to revolutionize asthma care through real-time data analysis, personalized treatment plans, and continuous patient support (Figure 1). AI algorithms can analyze vast amounts of health data from wearable devices and electronic health records to identify patterns and predict asthma exacerbations before they occur. Interventions can be based on individual patient profiles, improving adherence and outcomes. Furthermore, AI-powered applications and chatbots can provide continuous support to patients by offering medication reminders, educational resources, and instant responses to queries. These advancements have the potential to enhance patient engagement, reduce hospital visits, and ultimately improve the quality of life for those with asthma.

Several authors have reviewed and provided guidance on asthma management.^{5,6} Exarchos et al performed a systematic review of AI or machine learning techniques used in research studies focusing on asthma screening and diagnosis, patient classification, management and monitoring, and treatment.⁷ Kaplan et al further reviewed the use of AI in evaluating radiological images and pulmonary function test for the diagnosis of lung cancer, interstitial lung disease, and chronic obstructive pulmonary disease.⁸ The purpose of our paper is to provide a narrative review and explore the transformative potential of AI in improving asthma management through applications of predictive analytics, personalized treatment, and continuous patient engagement. In addition, we suggest future directions for the use of AI in asthma management. Compared to previous authors who focused on *technical AI*, we aim to provide a clinician perspective toward the effective integration of AI in the daily practice of asthma care. The review will be structured as follows. First, we will discuss and review *AI Applications in Asthma Management*. The second section will cover *AI Powered Asthma Support Services*, followed by examples of published studies that showed *Successful AI Implementations in the Literature*. The last section will cover *Ethical and Practical Considerations* regarding the use of AI.

AI Applications in Asthma Management

Predictive Analytics and Risk Stratification

The utility of AI, and specifically the AI subset of machine learning (ML), lies not only in its ability to analyze greater amounts of data than any clinician, but also in its ability to interpret data and make predictions about patient outcomes. Various models of ML have been described across subspecialties in the medical literature, including in asthma care. Given the unpredictability of a patient's asthma progression or the frequency of their exacerbations, ML offers

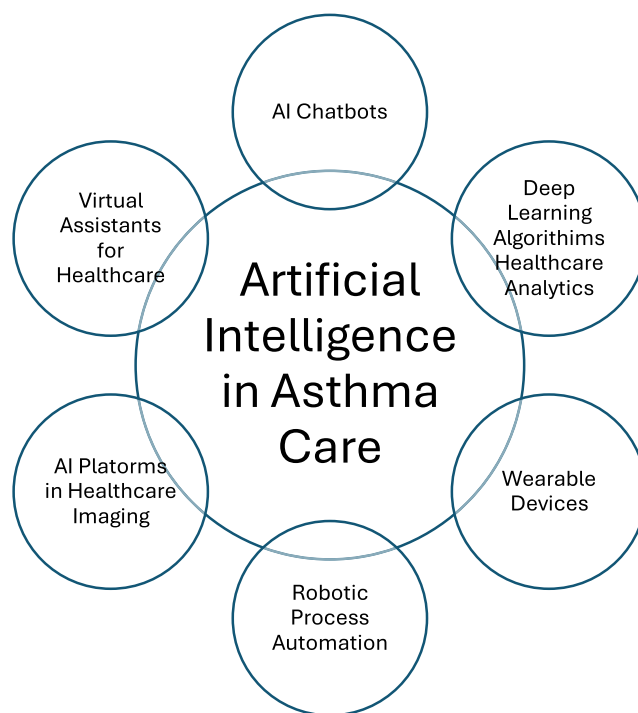


Figure 1 Artificial Intelligence in Asthma Care – Applications.⁵

a potentially invaluable management tool. Previously identified factors influencing asthma progression/exacerbations include medical history, biomarker phenotype, pulmonary function, level of healthcare system support, compliance to prescribed therapy, comorbidities, personal habits, genomics, allergic status, occupation, and environmental conditions.⁹ The breadth of contributing factors, and the likely presence of heretofore unidentified factors, demonstrates the need for ML and advanced predictive models in providing proactive care to asthma patients.

Studies have shown promising results in the success of ML at prediction of asthma exacerbations, both with and without remote monitoring devices. For example, Finkelstein and Jeong utilized telemonitoring techniques and ML for early prediction of asthma exacerbation. Using a 7-day window of monitoring, their ML model was able to predict asthma exacerbation on day 8. In particular, an adaptive Bayesian network predicted exacerbations with a sensitivity, specificity, and accuracy of 100%, concluding that “machine learning techniques have significant potential in developing personalized decision support for chronic disease telemonitoring systems”.¹⁰ Another study utilized ProAir Digihalers to monitor patient medication use and along with clinical and demographic data, a ML model demonstrated high diagnostic accuracy in predicting asthma exacerbations.¹¹ Logistic regression, decision tree, naïve Bayes, and perceptron algorithms were used. A model based on logistic regression showed the highest area under (AUC) the receiver operating characteristics (ROC) curve of 0.85, with a sensitivity of 90% and specificity of 83% in predicting severe asthma exacerbations.

Zein et al further examined over 60,000 patients with asthma at the Cleveland Clinic from 2010 to 2018 to develop a ML model to predict 1) non-severe asthma exacerbation, 2) emergency department visits, and 3) hospitalizations. Using a gradient boosting decision tree algorithm, their model was able to predict these outcomes with an AUC of 0.71, 0.88, and 0.85, respectively.¹² Similarly, Tong et al developed a ML model to predict hospital encounters at University of Washington. Based on over 82,000 patients in their dataset from 2011 to 2018, their model was able to predict hospitalization in asthma patients with an AUC of 0.90.¹³ Thus, using such ML models can help to predict exacerbations before they occur, identify high-risk patients, and guide targeted interventions with appropriate identification of required resources.

Personalized Treatment Plans

The value of AI and ML does not end at the prediction of asthma exacerbations, but extends into treatment decisions, as well (Table 1). Once a patient has been identified as high-risk or an exacerbation has been predicted, AI can further assist the clinician by recommending individualized medication regimens to best manage the projected outcomes. Asthma treatment presents a unique and emerging challenge to physicians given advancements in subclassification of asthma “pheno-endotypes”, which vary by patient and call into question the historic “one-size-fits-all” approach of asthma management.¹⁴ Given the need for

Table 1 Use of AI for Personalized Treatment Plans

Key Take Away Points:
Predictive Analytics for Asthma Exacerbations
AI, especially machine learning (ML), can analyze vast datasets such as environmental factors, patient history, and wearable sensor data to predict asthma exacerbations. This proactive approach allows clinicians to intervene early, reducing the risk of severe episodes in high-risk patients.
Risk Stratification and Personalized Interventions
ML models are capable of stratifying patients by risk, enabling targeted interventions for those most likely to experience exacerbations. The ability to identify high-risk patients enhances asthma management and optimizes healthcare resource allocation.
AI-Driven Personalized Treatment Plans
AI algorithms can recommend individualized medication regimens by analyzing patient-specific data such as biomarkers, comorbidities, and genetic information. This tailored approach allows for more precise treatment, which is particularly valuable in cases of severe asthma where traditional methods are less effective.
Real-Time Monitoring and Treatment Adjustments
AI-powered tools enable continuous monitoring of a patient's condition, allowing clinicians to adjust treatment plans based on real-time data. This dynamic feedback loop supports precision medicine, improving patient outcomes by adapting therapies as conditions evolve.

cumbersome biomarker measurement and comorbidity assessment, the newer, “tailored” approach to asthma care is only being utilized in the most severe cases. Researchers have theorized, however, that utilization of tailored monoclonal antibodies in mild asthma cases may provide additional benefit and possibly even achieve remission.¹⁴ The time-consuming nature of this tailored approach demonstrates a significant opportunity for AI in asthma care.

As previously mentioned, AI can evaluate and comprehend enormous volumes of data and draw conclusions that would be extremely taxing for a clinician. High-risk patients can be recognized, tailored treatments can be suggested, and real-time treatment response monitoring can be performed with AI-powered devices.¹⁵ With real-time monitoring, results may be continuously predicted and the treatment plan can be further customized. According to Johnson et al, the integration of artificial intelligence and precision medicine will help prevent illness, detect undiagnosed illnesses early, reduce the burden of disease, and reduce the expense of avoidable medical care for a variety of illnesses.¹⁶ Because of the variability observed in asthmatic patients, this condition is especially well-suited for the use of predictive and precision therapy.

Enhancing Medication Adherence

An important possibility for integrating AI into the management of chronic illnesses like asthma is to improve medication adherence (Table 2). Numerous factors, including those pertaining to the patient, the doctor, and the healthcare system, can influence medication adherence.¹⁷ According to Chan et al, medication adherence is below ideal, averaging about 50% and declining significantly more in high-risk groups. There is still a gap in our knowledge and approach to improving drug adherence, even if there are sufficient resources.¹⁸ A combination of treatments that address several levels of disease severity are required to optimize and achieve effective adherence goals.¹⁷

Limited patient engagement as a result of low literacy and cognitive abilities can be linked to patient-related drug adherence. Focusing on how medical information is given to patients rather than whether it is communicated could be one way to counteract this.¹⁹ There is potential for improving medication adherence by addressing these multi-process issues through the integration of digital technologies and artificial intelligence. Computer-based systems, smartphone apps, and electronic monitoring devices are examples of modern technologies that can measure dosages, send reminders, monitor adherence, and provide information.^{17,18} According to a number of studies, patients who use digital interventions may have 15% increased adherence.

Despite the fact that AI has been demonstrated to improve medicine adherence, its practical use is limited. Currently, the use of AI depends on having access to digital technologies, which is impacted by patient demographics, privacy and access issues, and general trust in AI. This may worsen healthcare inequities and adds to the overall efficacy of AI

Table 2 Enhancing Medication Adherence Through AI-Driven Solutions

Key Take Away Points:
AI-Driven Reminders and Alerts
AI-powered alerts and reminders, with their well-organized schedules and prompt notifications, can greatly improve prescription adherence. Improved treatment outcomes result from patients staying on track, particularly those with complicated medication regimens.
Personalized Feedback for Enhanced Engagement
AI-powered personalized feedback can examine patient adherence trends to provide treatments and support that are specifically suited to each patient. By customizing feedback, patients receive support and direction tailored to their requirements, which can improve medication compliance and engagement.
Addressing Challenges in AI Utilization
Although AI technology has the potential to increase adherence rates, patient demographics and access will determine its success. In order to prevent healthcare inequities and optimize AI's effectiveness, issues like privacy concerns, digital literacy, and trust in AI must be resolved.
Customizable AI Tools for Equitable Outcomes
Patients can be empowered with tools that are tailored to their lifestyles when artificial intelligence is included into digital platforms for medication management. AI has the potential to improve fair outcomes in the management of chronic diseases and reduce adherence disparities as it develops.

technologies in medication adherence.¹⁷ AI, however, offers the ability to empower patients through platforms that may be customized to overcome adherence gaps and achieve fair outcomes as research and technology progress.

Remote Monitoring and Telehealth

Numerous AI-based methods have been developed to enhance current telehealth and remote monitoring systems and improve patient outcomes. One study describes the application of a multi-modal machine learning system that combines real-time ambient data with AI-based respiratory sound detection to give patients and caregivers early warning forecasts.²⁰ Another study analyzed air pollution and meteorological data to predict hospital admissions across the population using artificial neural networks.²¹ In a third study, early alerts for patients with respiratory disease were generated using a pollution-monitoring sensor network distributed among patients with respiratory issues. AI-linked remote monitoring devices have a wide range of capability, from prognostication based on the analysis of respiratory sounds to real-time projections of the incidence of respiratory disease based on meteorological and air quality data to localized pollution-monitoring.^{20–22}

24/7 AI-Powered Asthma Support Services

Online AI Chatbots and Virtual Assistants

AI chatbots and virtual assistants are becoming increasingly valuable in healthcare through enhancing patient access to medical information and supporting healthy lifestyle modifications. Over the years, AI has evolved to integrate information from imaging and clinical findings, disease progression, treatment response, and general scientific information.²³ AI can serve as a “second clinician”, by providing access to expanding databases, which can help with treatment plan decision-making and reduce patient misperception regarding their clinical problems.²³ AI offers personalization and a simple way to connect to health information and expertise. Chatbots that provide medication information are just one of the several ways AI-powered chatbots might support patients by delivering medication guidance. In a survey study with geriatric experts, Gudala et al concluded that voice-based chatbots are most likely to help older patients overcome accessibility challenges, improve media literacy, and provide access to medical information. However, usability will depend on the ease of use of the technology, native language support, personalization, integration with pharmacy and physicians, and medication list tracking.²⁴ Recently, Ghazali performed a study examining the accuracy and reliability of ChatGPT’s ability to complete the Asthma General Knowledge Questionnaire for Adults (AGKQA), utilizing three general practitioners to score ChatGPT’s answers.²⁵ In the categories of asthma etiology and pathophysiology, medications, and severity assessment and symptom management, ChatGPT was accurate 100%, 70%, and 91.7%, respectively. The study highlighted that a chatbot can be used as a valuable patient education tool. Finally, AI-powered technologies have also demonstrated effectiveness in changing lifestyles.²⁶

Continuous Patient Engagement

Demographic barriers play a significant role in patient engagement among the asthma population. Physicians treating asthma patients are less informed about their patient’s financial status and workplace situations—factors critical to understanding and managing their care.²⁷ These barriers, such as missing appointments due to lack of transportation or the inability to take time off work, ultimately hinder patients from receiving timely treatment and assessing the severity of their asthma.²⁸

AI platforms offer continuous monitoring and assistance, which is essential for managing long-term illnesses like asthma. Tsang et al’s longitudinal study showed how machine learning techniques can support asthma self-management. The study showed that utilizing self-reported characteristics such as the frequency of symptoms and the use of quick-relief puffs, logistic regression and probabilistic classifiers could accurately predict times of instability in asthma patients, with area under the receiver operating characteristics curve (AUC) > 0.87.²⁹

Additionally, AI has the potential to improve health outcomes and increase patient involvement, according to a randomized clinical trial conducted by Nayak et al.³⁰ A voice-based conversational AI application for controlling basal insulin titration in individuals with type 2 diabetes was the focus of the study. Compared to patients receiving normal therapy, patients who utilized the AI application achieved appropriate insulin dose much more quickly and had

higher adherence rates. The results of the Tsang and Nayak investigations highlight AI’s capacity to enable prompt and efficient interaction with patients, which can also be used to manage long-term illnesses like asthma.^{29,30}

Emergency Response and Decision Support

Patients with asthma may delay seeking care due to uncertainty about whether their symptoms require medical attention, concern about disrupting family and friends, and a tendency to minimize the severity of their symptoms.³¹ This hesitation can have serious consequences, especially when prompt medical intervention is critical. AI has been found to positively impact the care of pediatric patients with asthma who visit the emergency department.³² AI also has the potential to enhance adult emergency care for adult patients with asthma.

In a retrospective study by Goto et al, analysis of representative data on emergency department patients with asthma or COPD exacerbations demonstrates the potential of machine learning for real-time assessment and guidance in the emergency setting.³³ The study compared the effectiveness of several machine learning models: including lasso regression, random forest, gradient-boosted decision tree, and deep neural networks against the traditional Emergency Severity Index (ESI) in predicting critical outcomes like hospitalization and critical care. The machine learning models, particularly the gradient-boosted decision tree and random forest models, significantly outperformed the ESI regarding predictive accuracy and net reclassification improvement (NRI), showcasing the ability to accurately assess symptom severity in real time. While the study is limited by its retrospective analysis of the National Hospital and Ambulatory Medical Care Survey, these findings suggest that integrating machine learning into ED triage could be a powerful assistive technology, enhancing decision-making by providing timely and accurate guidance.

Additionally, non-asthma studies have explored AI and its impact on emergency care. A retrospective study by Byrsell et al compared the recognition of out-of-hospital cardiac arrest by human dispatchers versus machine learning. The findings revealed that machine learning could identify cardiac arrests more quickly than dispatchers and at a comparable rate to human dispatchers, highlighting the potential for machine learning to also identify asthma exacerbations efficiently.³⁴ These studies underscore the potential of AI to improve emergency asthma management by guiding patients on when to seek emergency care, thus addressing the uncertainty and minimization of symptoms that often lead to delayed care (Table 3).

Table 3 Barriers to Asthma Management and the Role of AI in Improving Care

Key Take Away Points:
Barriers to Asthma Management
Physicians often lack insight into asthma patients’ financial and workplace challenges, which impacts care management. Common barriers like missed appointments due to transportation issues or inability to take time off work delay treatment and exacerbate asthma severity.
AI’s Role in Ongoing Monitoring
AI platforms support continuous patient engagement, using self-reported data to predict asthma instability and facilitate timely interventions. Studies show high accuracy in AI models for predicting asthma exacerbations, improving patient outcomes through early warnings and data-driven insights.
AI-Driven Enhancements in Chronic Condition Management
AI-based tools, such as voice assistants for diabetes management, improve adherence and accelerate optimal dosing, demonstrating potential for similar applications in asthma care. Research supports AI’s ability to overcome logistical barriers in chronic disease management, offering continuous support and engagement.
AI in Emergency Asthma Care
Machine learning models outperform traditional methods in predicting critical asthma outcomes in emergency settings, enhancing real-time decision-making. AI technology can guide patients on when to seek emergency care, reducing delays caused by uncertainty or symptom minimization.

Successful AI Implementations in the Literature

A search of the United States National Library of Medicine's PubMed database was performed with the assistance of a library sciences specialist. The following search terms were used: asthma, artificial intelligence, machine learning, neural networks, and deep learning. Clinical trials, randomized controlled trials, and systematic reviews written in the last 10 years were examined. This search strategy provided 28 studies related to the use of artificial intelligence in asthma management. After screening for relevancy, 7 articles were included (Figure 2).

AI has shown significant promise for use as a diagnostic tool for asthma care, particularly the use of ML algorithms. In a randomized control trial by Seol et al, researchers created an Asthma Guidance and Prediction System (A-GPS) that integrated AI-assisted decision tools into pediatric asthma care. Utilizing ML, A-GPS provided physicians a summary of relevant clinical information, predictions of future asthma exacerbations, and personalized management recommendations.³⁵ Compared to the standard asthma care, A-GPS did not show any reduction in asthma exacerbation

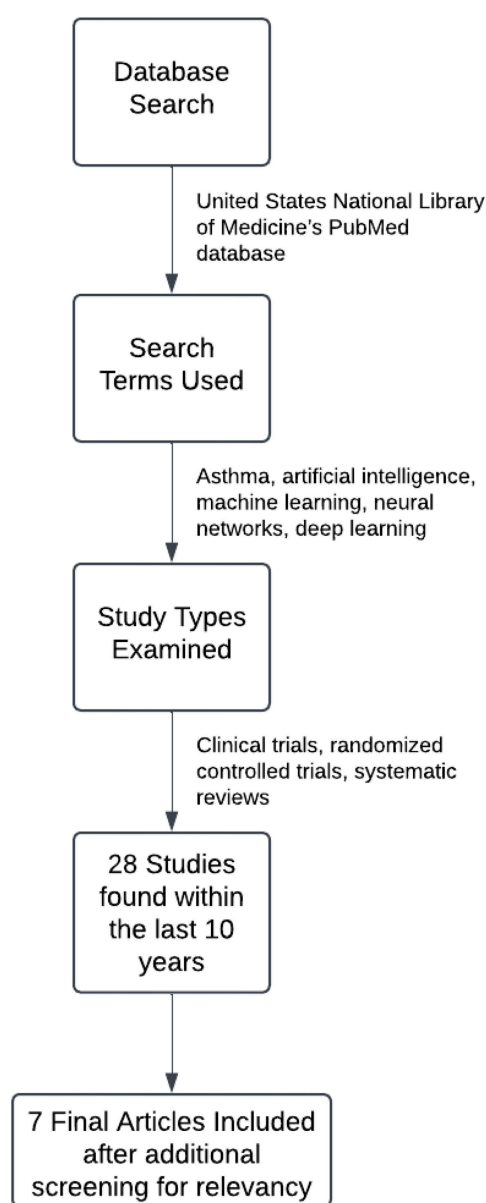


Figure 2 Methodological Process for Systematic Review of AI Applications in Asthma Management.

rates. However, it significantly reduced clinician burden of time spent reviewing electronic medical records. This study highlighted AI's potential to streamline care by decreasing workload without compromising patient outcome.

Diagnostic accuracy of AI has also been implemented in asthma care. In a study by Porter et al, researchers developed an algorithm to diagnose respiratory conditions through the analysis of given datasets of cough sounds. Based on a five-symptom input obtained from the patient or guardian history and prerecorded cough sounds, the system performed comparably to an expert clinical adjudication panel.³⁶ While diagnostic quality of this algorithm could be improved with additional input, it has the added advantage of eliminating the need of physical exam without compromising care. Similarly, Nabi et al demonstrated other advantages of computerized analysis of wheeze sounds over traditional clinician diagnosis.³⁷ By utilizing spectral analysis and ML, researchers found that AI models can accurately classify and perhaps outperform physicians in determining asthma severity, highlighting its value as a non-invasive method for assessing airway obstruction.

Real World Application of AI in Asthma Management

AI application in real-world clinical settings is actively being explored. Recent studies are applying these algorithms for in-home monitoring of asthma patients. Zhang et al investigated various predictive methods utilized by ML to determine the efficacy of asthma exacerbation predictions through daily monitoring of peak expiratory flow and symptoms. They concluded that AI models utilizing logistic regression provided the best balance of sensitivity (90%) and specificity (83%) in detecting asthma exacerbations up to three days in advance.¹¹ Additionally, Porter et al indicated that automated cough analytic systems can also be integrated into smart phones to also allow for remote monitoring and diagnostic aid in acute care settings.³⁶

AI-powered systems are introducing a variety of clinical applications that enhance clinician decision and empower patients to manage their asthma more effectively, especially in preventing severe exacerbations. By integrating AI into smart devices such as phones, stethoscopes, or digital inhalers, physicians can quickly access patient data in real time to provide proactive care and reduce risk of emergency interventions outside the scope of traditional care methods.

Ongoing Research

While there has been evidence of the efficacy of utilizing AI in clinical decision making for asthma, current research is focused on advancing these tools by refining predictive algorithms and integrating more comprehensive data (Figure 3). In a systematic review by Koul et al, ML has particularly demonstrated potential in improving the accuracy and efficiency of airway disease diagnosis.³⁸ Some cases have even shown that AI systems may surpass the diagnostic performance of expert clinicians. More specifically, in examining twenty studies published between 2010 and 2023, Jayamini et al found that ML models utilizing shorter prediction windows (less than a month) outperform those predicting long-term risk.³⁹

However, while there is promise when it comes to AI integration in asthma care, there are limitations. Sanchez-Morillo et al found that the majority of predictive algorithms currently in use lack consistent predictors for respiratory conditions, leading to suboptimal performance. Due to limited patient cohorts and non-standardized protocols, existing predictive algorithms are not completely reliable in predicting asthma exacerbations at this stage.⁴⁰ Koul et al solidifies this finding, emphasizing the need for large, well-organized datasets and better refined AI algorithms to allow for systems to generalize across different patient populations and healthcare settings. They also indicate the need for a standardized protocol for dataset collection and algorithm validation in widespread use of AI for airway disease prediction.³⁸

Looking forward, these studies demonstrate the potential of AI in integrating with other technologies to revolutionize asthma care. With future research focusing on addressing these challenges and the continuous evolution of AI, its integration into routine clinical workflow can provide physicians clear predictions and actionable, trustworthy information. AI-driven methods will be the key in transforming patient care and reducing the burden on healthcare providers.

Ethical and Practical Considerations

Data Privacy and Security

AI provides significant advantages in the treatment of asthma, such as real-time monitoring, predictive tools, and customized treatment. But it also presents serious dangers to data security and privacy. AI systems handle vast amounts of private data, including genetic information and electronic health records (EHRs), which are susceptible to privacy

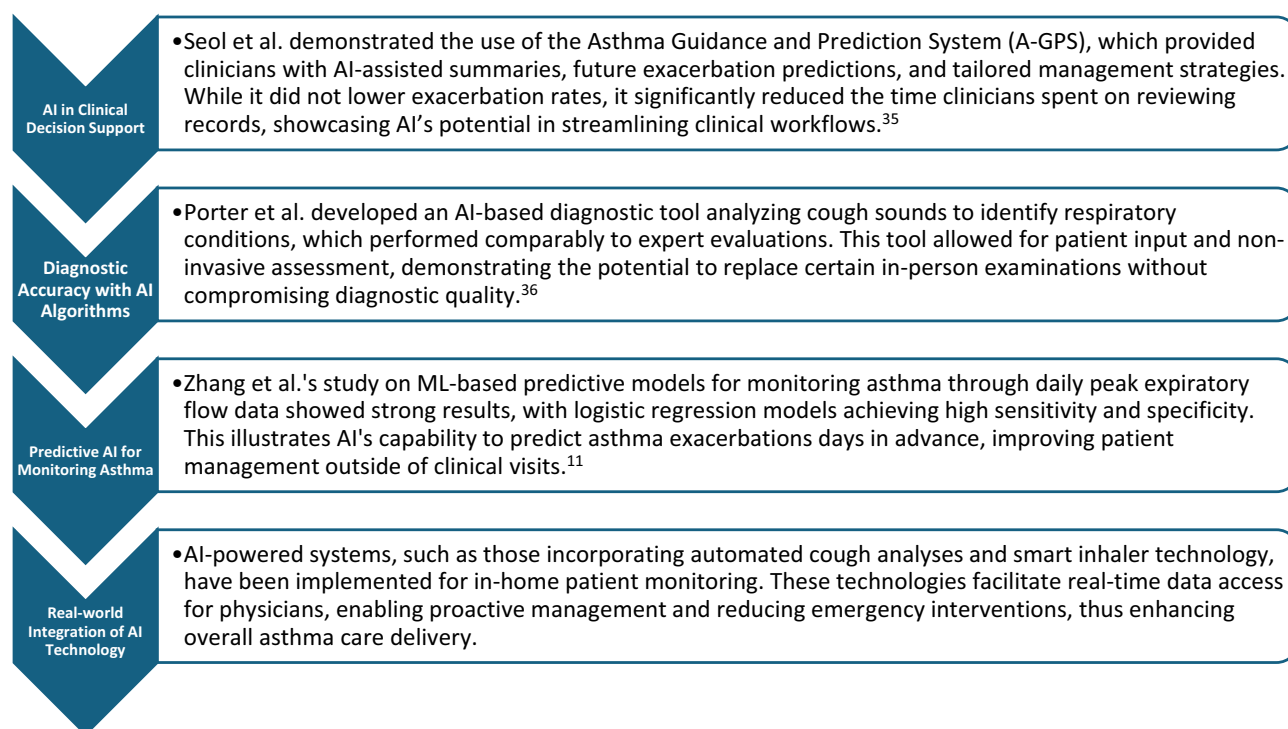


Figure 3 Real World Summaries: Applications and Impact of AI in Asthma Management.^{11,35,36}

violations. Patient privacy is protected by regulatory frameworks like Health Insurance Portability and Accountability Act (HIPAA) and General Data Protection Regulation (GDPR), but compliance can be difficult and calls for precautions like encryption, secure storage, and data reduction.^{41,42} AI systems are vulnerable to internal abuse and external cyberthreats, which makes robust security measures even more important. The significance of encryption, multi-factor authentication, and frequent audits is underscored by risks like “model inversion” attacks, which allow sensitive data to be deduced from AI outputs.⁴³ Furthermore, if AI systems are taught on skewed datasets, they may reinforce inequality.

Patient Acceptance and Trust

The successful application of AI in the treatment of asthma depends on patient acceptance and trust. Patients are encouraged to use AI tools because of the perceived advantages, which include better asthma management and real-time symptom monitoring. Acceptance is hampered, meanwhile, by worries about data protection and mistrust of businesses handling sensitive data.^{44,45} Additionally, adversarial noise introduced in the AI system can result in incorrect identification of lung sounds such as wheezes and crackles, and patient misdiagnosis, posing a challenge to the reliability of these systems.⁴⁶ Therefore, building trust requires being open and honest about how AI analyzes data and makes suggestions. If patients are aware of how their data is utilized and if AI enhances rather than replaces clinician decision-making, they are more inclined to trust its use in their care plan.⁴⁷ Therefore, building confidence and accelerating AI use in asthma care requires open communication about data privacy, ongoing feedback systems, and individualized treatment alternatives.⁴⁸ Table 4 provides a list of AI tools applicable in asthma care. The examples are based on the authors' knowledge and experience, and not necessarily comprehensive.

Healthcare Provider Integration

To integrate AI into asthma management successfully, several guiding principles should be followed. AI solutions must be able to integrate easily into current clinical workflows while causing the least amount of disturbance to physician duties. Since patient demographics and reactions to asthma medications change, it is essential to continuously monitor and validate AI systems so they can continue to be effective across various populations. To ensure proper use, physicians must be educated on the limitations of AI algorithms and how they operate.⁴⁹ Legal issues of liability are important,

Table 4 Selective AI Tools Available in Asthma Care*

Application	Examples	Description	Manufacturer/Company
Clinical Decision Support System (CDSS)	ISABEL, DXplain, asthma-specific CDSS modules in Epic/Cerner	AI systems that assist clinicians in diagnosing asthma and managing treatment plans based on clinical data.	ISABEL Healthcare, DXplain, various EHR vendors
Predictive Analytics Tools	Propeller Health platform, Cohero Health sensor data algorithms	AI models that analyze historical data and environmental factors to predict asthma exacerbations.	Propeller Health (ResMed), Cohero Health (Aptar)
Smart Inhalers & Remote Monitoring	Teva Digihaler, Adherium Hailie sensor	Inhalers equipped with sensors and AI to monitor usage, adherence, and technique.	Teva Pharmaceuticals (Digihaler), Adherium (Hailie)
AI-Integrated Mobile Health Apps	AsthmaMD app, MyAsthma app, Wellinks COPD/asthma management	Apps that track symptoms and use AI to personalize education and action plans.	AsthmaMD, MyAsthma, BreatheSmart, Wellinks
Natural Language Processing (NLP) Tools	NLP to extract “wheezing”, “exacerbation”, or medication noncompliance from clinical notes	AI that extracts asthma-related data from free-text EHRs for risk stratification.	Kaiser Permanente (internal use), academic/research consortia
Pulmonary Function Test Interpretation	Deep learning models analyzing spirometry curves, GE Healthcare’s PFT AI prototypes	AI algorithms interpret spirometry and other lung function data to assist in diagnosis.	Various academic groups, Philips, GE Healthcare (research stage)
AI-Powered Chatbots & Virtual Coaches	Woebot chatbot, Florence chatbot for asthma check-ins	Conversational AI agents that support asthma self-management through reminders and education.	Woebot Health, Florence Chatbot
Genomic and Phenotype Stratification	AI clustering algorithms for endotype discovery, ML for selecting biologics like dupilumab	AI used in precision medicine to analyze genomic/proteomic data and guide biologic therapy.	Academic research institutions, NIH-funded consortia

Notes: *This table is based on the authors’ knowledge of the available tools, and not necessarily a comprehensive list.

especially when AI generates inaccurate suggestions; physicians must use their own discretion rather than relying exclusively on AI results.⁵⁰ Making the technology available to all patients, maintaining openness, and avoiding AI from escalating health disparities are some ethical considerations.⁵¹

Several professional organizations have provided guiding principles for AI development, concentrating on equity, safety, and justice. These include reducing inequalities in healthcare, enhancing significant clinical results, preventing overdiagnosis or overtreatment, and customizing AI tools for regional populations.⁵² AI solutions ought to facilitate collaborative decision-making between physicians and patients. Clinicians can fully utilize AI to improve asthma management while addressing issues of justice, trust, and data protection by following these guidelines.

AI integration in asthma care has much promise to enhance patient outcomes and maximize therapeutic efficacy. Nevertheless, it poses serious hazards to data security and privacy, requiring robust protections. Transparency, data security, and making sure AI enhances rather than replaces the doctor-patient connection will increase patients’ trust in its integration. To improve patient outcomes and reduce privacy, security, and health disparity issues, AI can be successfully incorporated into asthma care by adhering to guiding concepts including interoperability, continuous development, and ethical accountability.

Conclusion

Summary of Benefits

AI offers transformative potential in asthma management through predictive analytics, personalized care, improved adherence, and continuous patient engagement. By analyzing environmental factors, patient history, and wearable sensor

data, AI can accurately forecast asthma exacerbations, enabling timely, proactive interventions that reduce hospitalizations. AI also supports personalized treatment plans tailored to individual patient profiles, enhancing therapeutic effectiveness. Digital tools such as AI-powered apps and reminder systems promote adherence and empower patients in self-management. Together, these capabilities improve clinical efficiency, patient outcomes, and overall quality of care.

Future Directions

AI is poised to become a cornerstone of asthma care, evolving beyond predictive models to integrate advanced diagnostics, genomics, and real-time clinical decision support. Seamless integration into healthcare systems will enable continuous monitoring and tailored interventions that adapt to each patient's changing needs. As technology becomes more accessible and ethical concerns such as data privacy are addressed, AI will help close care gaps and promote equity. With ongoing research and innovation, AI will drive a shift toward highly personalized, preventive, and sustainable asthma care, setting new standards for disease management.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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