



AI in Asthma Treatment

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ABSTRACT

Over 339 million people worldwide, including 25 million in the US, suffer from asthma, a chronic respiratory disease that significantly increases morbidity and healthcare expenses. Patient education, medication adherence, and exacerbation management continue to be difficult despite advancements. Through predictive analytics, individualized care, and ongoing patient involvement, this narrative review investigates the revolutionary potential of artificial intelligence (AI) in enhancing asthma management. Articles about asthma and artificial intelligence, machine learning (ML), neural networks, or deep learning were found by searching the PubMed database of the US National Library of Medicine. Algorithms, AI-driven tools for tailored medication, and digital platforms for patient engagement were all examined in the current research on AI uses in asthma care. We examined case studies and clinical trials that evaluated how AI affected treatment adherence and prediction accuracy. By evaluating data from wearables and patient records to forecast exacerbations, stratify risk, and guide individualized treatment, artificial intelligence (AI), especially machine learning (ML), improves asthma management. Research shows that AI can assess adherence through intelligent applications, suggest customized therapies, and enable realtime therapy modifications. Ensuring patient trust, data security, and fair access to technology are ethical challenges.

Keywords: asthma, a chronic respiratory disease

INTRODUCTION

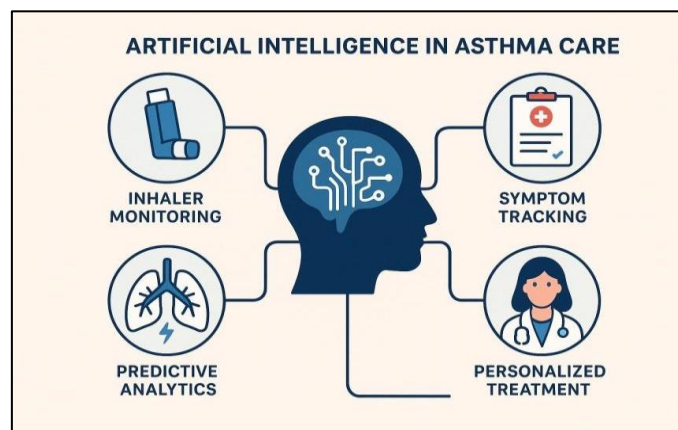
Over 339 million people worldwide suffer from asthma, a chronic respiratory condition that affects about 25 million in the 5.5 million of whom are children in the United States. {1,2} characterized by persistent symptoms like coughing, wheezing, and Asthma and shortness of breath can drastically lower quality of life, interfere with everyday activities, and disturb sleep. Extreme situations frequently lead to missed work or school and may necessitate immediate medical attention. It has a significant economic impact. In the United States Costs alone, such as medical bills, lost productivity, and early death, are projected to reach \$81.9 billion annually. One Although there are now effective treatments for asthma, managing the condition is still difficult. Flare-ups, or exacerbations are potentially fatal and are frequently brought on by allergens, respiratory illnesses, or environmental contaminants. One of the biggest obstacles to control is medication adherence. Research indicates that only 30 to 50 percent of patients regularly adhere to their plans for treatment. Complicated regimens, adverse effects, and a lack of knowledge regarding the illness. Furthermore, patient education is frequently insufficient. Giving patients the information they need to recognize To improve results, triggers, appropriate inhaler technique, and early symptom recognition are crucial. {1, 3, 4 }

With real-time data analysis and individualized treatment, artificial intelligence (AI) has the potential to completely transform asthma care strategies, as well as ongoing patient assistance (Figure 1). Large volumes of health data from wearable devices can be analyzed by AI algorithms and electronic medical records to spot trends and anticipate asthma flare-ups before they happen. Interventions are based on specific patient profiles, enhancing results and adherence. Additionally, chat bots and apps driven by AI can Give patients ongoing assistance by providing them with educational materials, medication reminders, and prompt answers to their questions These developments could decrease hospital stays, increase patient involvement, and ultimately raise the standard of asthma sufferers' lives.



AI Applications in Asthma Management

Risk stratification and predictive analytics



Artificial intelligence (AI), and more especially the AI subset of machine learning (ML), is useful not only because it can analyze larger Not only does it have access to more data than any clinician, but it also has the capacity to analyze data and forecast patient outcomes. In the medical literature, several ML models have been described for a variety of subspecialties, including the treatment of asthma.

ML presents a potentially useful management tool, especially when considering the unpredictable nature of a patient's asthma progression or the frequency of their exacerbations. Previously recognized variables affecting the development or flare-up of asthma include pulmonary function, medical history, biomarker phenotype, degree of support from the healthcare system, and adherence to prescribed medication, environmental factors, comorbidities, personal habits, genetics, allergy status, and occupation. {5}

Given the variety of contributing factors and the likelihood of previously undiscovered factors, it is imperative that ML and sophisticated predictive models for proactive asthmatic patient care. Research has demonstrated encouraging outcomes in terms of machine learning's ability to predict asthma flare-ups, both with and without Devices for remote monitoring. For instance, Finkelstein and Jeong used machine learning and tele monitoring methods for earl Forecast of an asthma attack. Their machine learning model was able to predict asthma using a 7-day monitoring window Worsening on the eighth day. Specifically, exacerbations were predicted by an adaptive Bayesian network with sensitivity, specificity, And precision of 100%, determining that "machine learning methods have substantial potential in creating customized Decision support for tele monitoring systems for chronic illnesses. {6} Pro Air Digi halers were used in another study to monitor patients. medication use, and a machine learning model showed excellent diagnostic accuracy in combination with clinical and demographic data in forecasting flare-ups of asthma. {7} The following algorithms were used: perceptron, naïve Bayes, decision trees, and logistic regression. The receiver operating characteristics (ROC) model with the highest area under the curve (AUC) was a logistic regression model. curve of 0.85, predicting severe asthma exacerbations with 90% sensitivity and 83% specificity.

In order to create an ML, Zein et al. also looked at more than 60,000 asthmatic patients at the

Cleveland Clinic between 2010 and 2018 model to forecast 1) hospitalizations, 2) ED visits, and 3) non-severe asthma flare-ups. Making use of a gradient With an AUC of 0.71, 0.88, and 0.85, their model successfully predicted these results using the boosting decision tree algorithm. in turn. {8} At the University of Washington, Tong et al. created a machine learning model to forecast hospital encounters. based on In their dataset, which included more than 82,000 patients between 2011 and 2018, their model was able to forecast hospitalization among asthmatic patients. with a 0.90. {9} AUC Consequently, applying such machine learning models can assist in anticipating exacerbations before they happen and identifying high-risk patients, and direct focused interventions while properly identifying the resources needed.



Individualized Therapy Programs

Table 1: Personalized Treatment Plans Using A

Important takeaways
Analytics-Based Prediction for Asthma Exacerbations
Large datasets, including patient histories, environmental factors, and wearable sensor data, can be analyzed by AI, particularly machine learning (ML), to make predictions attacks of asthma. In high-risk patients, this proactive approach lowers the chance of severe episodes by enabling clinicians to intervene early.
Personalized Interventions and Risk Stratification
Patients who are most likely to experience exacerbations can benefit from targeted interventions made possible by ML models' ability to stratify patients by risk. The capacity to Finding high-risk patients improves asthma treatment and maximizes the use of medical resources.
AI-Powered Customized Therapy Programs
Through the analysis of patient-specific data, including genetic information, comorbidities, and biomarkers, AI algorithms can suggest customized drug regimens. details. More accurate treatment is possible with this customized strategy, which is especially helpful in cases of severe asthma where conventional techniques are less successful.
Monitor drug in and Modifications to Treatment in Real Time
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.

The usefulness of AI and ML extends beyond forecasting asthma flare-ups to include treatment choices. (Table 1). AI can help the clinician even more after a patient has been classified as highrisk or an exacerbation has been anticipated. by suggesting customized schedules to effectively control the anticipated results. Treatment for asthma presents a distinct and developing difficulty for doctors in light of developments in the sub classification of asthma "pheno-endotypes," which differ from patient to patient and challenge the long-standing "one-size-fits-all" method of managing asthma. 14 Since comorbidity assessment and biomarker measurement are laborious, the more recent, "tailored" approach to asthma treatment is only being used in the most serious situations However, scientists have hypothesized that using customized monoclonal antibodies in mild Patients with asthma may benefit further and even experience remission. {10} The lengthy process of this customized approach shows that AI has a lot of potential for treating asthma.

As stated earlier, AI is capable of analyzing and understanding vast amounts of data and coming to conclusions that would be Incredibly exhausting for a physician. It is possible to identify high risk patients, recommend specialized treatments, and provide real-time AI-powered devices can be used for treatment response monitoring. {11}. Results from real-time monitoring could be Consistently anticipated, and the course of treatment can be further tailored. Johnson et al. state that the incorporation of Precision medicine and artificial intelligence will help prevent disease, identify undiagnosed conditions early, and lessen the burden of Illness, and lower the cost of preventable medical treatment for a range of ailments. {12 }. Due to the fluctuations seen in Patients who suffer from asthma are particularly well-suited for predictive and precision there.

Improving Compliance with Medicines

Improving medication is a significant opportunity to incorporate AI into the treatment of long-term conditions like asthma. Compliance (Table 2). Several elements, such as those concerning the patient, the physician, and the medical system, can affect the adherence to medication. {13} Chan et al. report that medication adherence is less than ideal, averaging roughly 50% and dropping considerably more in high risk populations. There is still a gap in our understanding and methodology regarding enhancing medication compliance, even in the presence of adequate resources. {14}. A mix of therapies that target multiple To maximize and accomplish successful adherence goals, different disease severity levels are needed. Patient-related drug adherence may be associated with limited patient engagement due to low literacy and cognitive abilities. One strategy to combat this could be to concentrate on how medical information is delivered to patients rather than whether it is communicated This. In order to address these multi-process issues and potentially improve medication adherence, the integration of Artificial intelligence and digital technologies. Electronic monitoring tools, smartphone apps, and computer-based systems are Instances of contemporary technology that can provide information, monitor adherence, send reminders, and measure dosages. {15 } Several studies suggest that patients who use digital interventions may have a 15% higher adherence rate. Although AI has been shown to increase medication adherence, there is little practical application for it. At the moment, Access to digital technologies is necessary for the use of AI, and patient demographics, privacy, and Problems with access and general AI trust. In addition to increasing the overall effectiveness of AI technologies in medication adherence, this could exacerbate healthcare disparities. However, AI has the potential to empower



patients by providing them with platforms that could Be tailored to close adherence gaps and produce equitable results as science and technology advance.

Table 2: Using AI-Powered Solutions to Improve Drug Adherence

Important Takeaways
Alerts and Reminders Powered by AI
With their well-planned schedules and timely notifications, AI-powered alerts and reminders can significantly increase prescription adherence Patients who stay on track, especially those with complex medication regimens, experience better treatment outcomes.
Personalized Comments to Increase Involvement
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.
Overcoming Obstacles in the Use of AI
The success of AI technology will depend on patient demographics and access, even though it has the potential to improve adherence rates. In order to Concerns about privacy, digital literacy, and trust in AI must be addressed in order to avoid healthcare disparities and maximize AI's efficacy.
AI Tools That Can Be Customized for Equitable Results
When artificial intelligence is integrated into digital platforms for medication, patients can be empowered with lifestyle-specific tools. administration. As AI advances, it could lessen adherence disparities and enhance equitable outcomes in the management of chronic diseases.

24/7 Support Services for Asthma Powered by AI

Virtual assistants and online AI chatbots

AI virtual assistants and chatbots are growing in importance in the healthcare industry by improving patient access to Medical information and encouraging changes to a healthy lifestyle. AI has developed over time to incorporate Data from clinical and imaging results, illness progression, response to treatment, and overall scientific Information.{16}. By giving access to growing databases, AI can act as a “second clinician,” which can assist with Decision-making for the treatment plan and lessen patients’ misconceptions about their clinical issues.

AI provides perso-Nalization and an easy method to access health knowledge and information. Chatbots that offer information about medications Are only a few of the ways AI-powered chatbots could help patients by giving them advice on their medications. In Voice-based chatbots are most likely to assist older people, according to a survey study conducted with geriatric experts by Gudala et al. Patients provide access to medical information, enhance media literacy, and overcome accessibility obstacles. But Usability will be determined by the technology’s simplicity of use, support for native languages, customization, and integration with Tracking of medication lists, as well as pharmacies and doctors. {17} Ghazali recently conducted research that looked at the accuracy And dependability of ChatGPT’s performance on the Adult Asthma General Knowledge Questionnaire (AGKQA) Evaluating Chat GPT’s responses using three general practitioners. {18} Regarding the etiology and pathophysiology of asthma, ChatGPT’s accuracy rates for siology, drugs, severity evaluation, and symptom management were 100%, 70%, and 91.7%, in that order. According to the study, a chatbots can be a useful tool for patient education. Lastly, AI- Additionally, powered technologies have shown promise in altering people’s lifestyles. {19}

Emergency Reaction and Guidance

People with asthma may put off getting help because they are unsure if their symptoms need to be treated by a doctor. Fear of upsetting friends and family, as well as a propensity to downplay how bad their symptoms are. {20}

This hesitancy Can have detrimental effects, particularly in cases where immediate medical attention is necessary. AI has been shown to have positive Influence the treatment of young asthmatic patients who come to the ER. {21}. Additionally, AI has the capacity to Improve adult asthmatic patients’ access to emergency care. Goto et al. conducted a retrospective study in which they analyzed representative data on asthmatic ED patients. or COPD flare-ups illustrates how machine learning can be used for in-the-moment evaluation and direction in the emergency situation. {22}. The study evaluated the efficacy of a number of machine learning



models, such as Lasso Deep neural networks, gradient-boosted decision trees, random forests, and regression in comparison to the conventional Emergency Hospitalization and critical care are examples of critical outcomes that can be predicted using the Severity Index (ESI). The models for machine learning, In particular, the random forest and gradient-boosted decision tree models performed noticeably better than the ESI in terms of Net reclassification improvement (NRI) and predictive accuracy demonstrate the capacity to precisely evaluate symptoms. severity in real time. Unfortunately, the study's retrospective examination of the National Hospital and Ambulatory According to the Medical Care Survey, incorporating machine learning into ED triage could be a potent Assistive technology, which improves decision-making by offering precise and timely direction. AI and its effects on emergency care have also been studied in non-asthma studies. A study conducted in the past by Byrsell et al. examined how machine learning and human dispatchers recognized out-of-hospital cardiac arrest. According to the results, machine learning could detect cardiac arrests faster than dispatchers and with A similar rate to human dispatchers, suggesting that machine learning could be used to detect asthma as well. Flare-ups effectively. {23} These studies highlight how AI could enhance the treatment of asthma in an emergency by Helping patients minimize symptoms and deal with uncertainty by advising them on when to seek emergency care Frequently result in care being delayed (Table 3).

Table 3: Asthma Management Obstacles and AI's Potential to Enhance Care

Important Takeaways
Obstacles in the Management of Asthma
Care management is impacted by doctors' frequent ignorance of the financial and occupational difficulties faced by asthma patients. Typical obstacles such as missed Treatment is delayed and asthma symptoms worsen when appointments are missed because of transportation problems or an inability to take time off work.
The Function of AI in Continuous Monitoring
AI systems enable ongoing patient interaction by predicting asthma instability and enabling prompt interventions based on self-reported data. Research indicates that AI models can accurately forecast asthma flare-ups, enhancing patient outcomes with data-driven Interventions and early warnings observations.
AI-Powered Improvements in the Management of Chronic Conditions
AI-based solutions, like diabetes management voice assistants, increase adherence and speed up the best dosage, showing promise for comparable uses in the treatment of asthma. AI's capacity to provide ongoing support and engagement while overcoming logistical obstacles in the management of chronic diseases is supported by research
AI in Asthma Emergency Care
When predicting crucial asthma outcomes in emergency situations, machine learning models perform better than conventional techniques, improving real-time making choices. AI can help patients decide when to seek emergency care, cutting down on delays brought on by symptoms or uncertainty reduction.

Practical and Ethical Considerations

Privacy and Security of Data

When it comes to treating asthma, artificial intelligence offers several benefits, including realtime monitoring, predictive tools, and personalized care. However, it also poses significant risks to privacy and data security. AI systems manage enormous volumes of private information that is vulnerable to privacy violations, such as genetic data and electronic health records (EHRs). Regulations such as the Health Insurance Portability and Accountability Act protect patient privacy. Act (HIPAA) and General Data Protection Regulation (GDPR), but adherence to these regulations can be challenging and necessitates taking precautions. such as data reduction, encryption, and safe storage. {24,25} AI systems are susceptible to both internal and external misuse. cyberthreats, which further emphasizes the significance of strong security measures. The importance of multi-factor authentication and encryption Risks like "model inversion" attacks highlight the importance of authentication and regular audits, as they allow sensitive data to be inferred from AI results. {26}. Additionally, AI systems may perpetuate inequality if they are trained on skewed datasets.



CATEGORY	KEY FINDINGS / SUMMARY
AI in Clinical Decision Support	Seol et al. demonstrated the use of Asthma Guidance and Prediction System (A-GPS), which offers AI-assisted summaries, future exacerbation predictions, and personalized management strategies. It did not reduce exacerbation rates, but reduced clinician review time, show AI's usefulness in workflow efficiency.
Diagnostic Accuracy with AI Algorithms	Porter et al. developed an AI diagnostic tool that analyzes cough sounds to detect respiratory conditions. Its performance was comparable to expert evaluations, providing a non-invasive option and reducing certain in-person assessments.
Predictive AI for Monitoring Asthma	Zhang et al. evaluation of ML-based models using daily peak expiratory flow data. Logistic regression models showed high sensitivity & specificity, helps predict asthma exacerbations days in advance, supporting proactive management.
Real-World Integration of AI Technology	AI-powered systems like automated cough analyzers and smart inhalers are now used for in-home monitoring. They enable real-time data sharing with clinicians, reduce emergency events, and improve overall

Patient Trust and Acceptance

Patient trust and acceptance are essential for the effective use of AI in the treatment of asthma. Patients are urged to employ AI technologies due to the alleged benefits, which include improved asthma treatment and real-time symptom tracking. Meanwhile concerns about data security and mistrust of companies that handle sensitive data hinder acceptance. {27} Furthermore, the AI system may mistakenly identify lung sounds like wheezes if adversarial noise is added, and crackles, as well as patient misdiagnosis, which could jeopardize these systems' dependability. Thus, establishing trust necessitates being forthright and truthful about how AI evaluates information and generates recommendations. If patients understand how their information is used, and if Clinicians are more likely to trust AI's use in their care plan because it complements their decision-making rather than replaces it. {28} Consequently, Increasing trust and utilizing AI in asthma treatment calls for constant feedback and transparent data privacy communication, systems, as well as customized treatment options. {29} A list of AI tools that can be used in asthma care is given in Table 4. The illustrations are not always exhaustive and are based on the writers' expertise and experience.

Integration of Health Care Providers

A few guiding principles should be adhered to in order to successfully incorporate AI into asthma management. AI remedies need to be able to quickly and easily fit into existing clinical workflows while minimizing physician disruption obligations. Because patient characteristics and asthma medication responses vary, it's critical to regularly check and verify AI systems to ensure their continued efficacy across diverse populations. To guarantee appropriate use, doctors must be informed about the workings of AI algorithms and their limitations. {30}. Liability concerns are crucial, particularly when AI makes false recommendations; doctors should exercise their own judgment instead of depending on only on AI outcomes. {31}. Preserving transparency, avoiding artificial intelligence, and making the technology accessible to all patients Some ethical considerations stem from growing health disparities. {32}

Guidelines for AI development have been provided by a number of professional organizations, with an emphasis on equity, Safety as well as fairness. These include lowering healthcare disparities, improving noteworthy clinical outcomes, avoiding Overtreatment or over diagnosis, as well as tailoring AI tools to local populations. {33} AI tools should help Joint decision-making between patients and doctors. AI can be fully utilized by clinicians to improve asthma. Management by adhering to these rules while addressing concerns of justice, trust, and data protection.

The use of AI in asthma treatment holds great potential to improve patient outcomes and optimize treatment effectiveness. However, it presents significant risks to privacy and data security, necessitating strong safeguards. Openness, data protection, and ensuring that AI strengthens rather than replaces the doctor-patient relationship will boost patients' confidence in its incorporation. AI can be effectively integrated to enhance patient outcomes and lessen concerns about privacy, security, and health disparities. asthma treatment by abiding by guiding principles such as ethical accountability, interoperability, and ongoing development {34}.

Application

1. Clinical Decision Support System (CDSS)
2. Predictive Analytics Tools



3. Smart Inhalers & Remote Monitoring
4. AI-Integrated Mobile Health Apps
5. Natural Language Processing (NLP) Tools
6. Pulmonary Function Test Interpretation
7. AI-Powered Chatbots & Virtual Coaches
8. Genomic and Phenotype Stratification

Real World Application of AI in Asthma Management

The use of AI in actual clinical settings is being investigated. These algorithms are being used in recent research for in- asthmatic patients' home monitoring. Zhang et al. examined a number of ML-based prediction techniques to ascertain the effectiveness of predicting asthma flare-ups by tracking peak expiratory flow and symptoms every day. They came to a conclusion. that logistic regression-based AI models offered the optimal ratio of sensitivity (90%) to specificity (83%), in identifying flare-ups of asthma up to three days beforehand. {11}. Furthermore, according to Porter et al., automated cough analysis systems can be added to smartphones to enable remote monitoring and diagnostic support in emergency rooms. {35}

Numerous clinical applications are being introduced by AI-powered systems that improve clinician decision-making and empower patients to better control their asthma, particularly in avoiding severe flare-ups. By integrating AI into Digital inhalers, stethoscopes, and smartphones are examples of smart devices that allow doctors to instantly access patient data in real time. offer preventative care and lower the likelihood of emergency interventions that fall outside the purview of conventional care techniques.

Successful Applications of AI in the Literature

With the help of the US National Library of Medicine, a search of the PubMed database was conducted A specialist in library sciences. The following search terms were applied: machine learning, artificial intelligence, asthma, deep learning and neural networks. systematic reviews, randomized controlled trials, and clinical trials published in the last Ten years were looked at. {36} studies about the application of artificial intelligence in asthma were found using this search strategy administration. Seven articles were included after being screened for relevancy.

AI, especially machine learning algorithms, has demonstrated great potential as a diagnostic tool for asthma treatment Seol et al. developed an asthma guidance and prediction system (A-GPS) in a randomized control trial that incorporated AI-powered decision-making tools into the treatment of childhood asthma. A-GPS used machine learning to give doctors an overview of pertinent medical data, forecasts of upcoming asthma flare-ups, and individualized treatment suggestions. {37} Asthma exacerbation rates were not reduced by A-GPS when compared to standard asthma care.

AI's diagnostic precision has also been applied to the treatment of asthma. In a Porter et al. study, scientists created an algorithm that analyzes provided datasets of cough sounds to diagnose respiratory disorders. According to a five-symptom When given information from the patient's or guardian's medical history and previously recorded cough sounds, the system functioned similarly to an panel of expert clinical adjudicators. {38} Although this algorithm's diagnostic quality could be enhanced with more input, it has the extra benefit of doing away with the requirement for a physical examination without sacrificing treatment. Likewise, Nabi et al. showed additional benefits of computerized wheeze sound analysis over conventional clinical diagnosis. {39}. Using spectral analysis and machine learning, researchers discovered that AI models can correctly categorize and possibly even surpass doctors in identifying severity of asthma, emphasizing its usefulness as a non-invasive technique for determining airway blockage.

Conclusion

Benefits Summary

AI has the potential to revolutionize asthma treatment through predictive analytics, individualized treatment, enhanced Adherence, and continuous patient engagement. AI can precisely predict asthma exacerbations by evaluating environmental factors, patient history, and wearable sensor data. This allows for prompt, proactive interventions that lower hospitalization rates. Additionally, AI facilitates individualized treatment programs based on patient profiles, improving therapeutic Efficiency. AI-powered apps and



reminder systems are examples of digital tools that empower patients and encourage adherence. In self-control. When combined, these skills enhance overall care quality, patient outcomes, and clinical effectiveness.

Prospects for the Future

AI has the potential to become a vital component of asthma treatment, moving beyond predictive models to incorporate sophisticated Genomics, real-time clinical decision support, and diagnostics. Integrating healthcare systems seamlessly will allow Ongoing observation and customized treatments that adjust to the evolving needs of every patient. As technology advances, AI will help close care gaps and advance equity when it is made more accessible and ethical issues like data privacy are addressed. AI will propel a transition toward highly customized, preventive, and sustainable practices with continued research and innovation. Asthma treatment, establishing new benchmarks for illness control.

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