IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Smart Asthma Management with Astreva: Integrating Predictive Analytics, Self-Care, and Patient Empowerment

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ABSTRACT: KNN--predicts the asthma exacerbation by using the information entered by the user, previous medical records and the environment. The site also includes a virtual asthma diary, breathing exercises modules, and educational information, which along with prediction allows patients to participate actively in self-management. An integrated chatbot assistant provides real-time support whereas automated emergency Asthma is among the most common chronic respiratory diseases, with millions of patients worldwide with it, and a high health burden because of frequent exacerbations, emergency visits, and lower quality of life. Traditional management measures do not offer any real-time tracking and unprofiled interventions, and patients can fall victim to sudden attacks. These gaps are what Astreva-AsthmaWellness framework is conceptualized to be based on and fill; bringing together predictive analytics, personalized care and patient empowerment tools into one digital healthcare solution. The system also uses machine learning algorithms, which are developed at high levels-such as alerts are raised in case of critical conditions, so that there is proper communication to the healthcare providers and caregivers in a timely manner. Astreva also focuses on the holistic wellness aspect by incorporating lifestyle management aspects like medication reminders, physical activity tracking and stress reduction tips. This is a two-fold aim of predictive care and general well-being to minimize hospital hospitalization, increase compliance in treatment and also improve the quality of life among individuals with asthma. Astreva-AsthmaWellness offers a scalable, usable, and smart model of healthcare that bridges the gap between clinical expertise and digital innovation and is appropriate in managing chronic diseases in the era of modernity.

Keyword: Exercise, AI Chat-bot, Smart Reminder, AOI insight.

Introduction

Asthma is a long term respiratory disease, which attacks the respiratory tracts, resulting in the difficulty of breathing, by causing inflammation, swelling and constriction of the muscle around the respiratory tracts. It is one of the most common chronic diseases in the world that attacks both children and adults and it continues rising as a medical

problem in the society. The symptoms such as the wheezing, coughing, chest tightness and shortness of breath can manifest at any given time, and may vary in their severity. The triggers of these attacks are very diverse and they may be caused by dust, pollen, air pollution, cold air, stress and exercise. Such triggers are unexpected and they make asthma difficult to manage as well as directly affecting the quality of life of patient because it can make him/her unable to perform normal physical and social activities. The conventional approaches to asthma management derive on the inhalers, drugs, symptom diaries, and frequent visit to medical practitioners. Even though these methods have their level of success, they are largely reactive. Patients also respond to the symptoms after they have been suffered as opposed to preventing an attack before it occurs. These inadequate predictive support subject the patients to unexpected exacerbations likely to lead to the cases of emergency visits that occur very often, hospitalization and in a more severe event, death. Moreover, the existing mobile health applications that are presently in the market in regards to the issue of asthma are mostly reminders or data recording and does not provide personalized and data-driven information, which could be applied to avert an emergency. The sphere of digital healthcare technologies has offered the opportunities in the sphere of chronic disease management within the past several years. In the case with machine learning, the analysis of patient health history, patient-supplied data, and environmental factors such as air quality and the concentration of allergens are offered to identify whether the attack is possible or not. The predictive analytics, coupled with mobile applications, wearable device, and real-time tracking, can shift to the proactive care management, instead of the reactive one. Such systems not only remind the patients of the risks they might be exposed to, but they also provide them with lifestyle management, including breathing exercises, stress-reduction methods and fitness tracking that play a critical role in long-term wellbeing. It is proposed to come up with a smart asthma management model where prediction and patient empowerment are incorporated in this project. The machine learning algorithms which will be applied in the system to forecast asthma exacerbation will be KNN as it will use data input by the user, previous health history as well as the environmental triggers. It will also include certain supporting functionalities, including an asthma diary, medication reminders, a breathing exercise course, and a chatbot to guidance in real time. Timely contact with the caregivers and the healthcare providers will be done in case of an emergency situation through emergency alerts. Besides prediction, the platform is aimed at holistic health since it is a combination of the fitness monitoring and lifestyle management aimed at reducing the number of visits to hospitals, improving the adherence to the treatment and enriching the everyday life of the asthma man. Asthma is a serious health problem on the planet, and the unpredictable exacerbations of the condition present serious difficulties concerning patients and medical care. Machine learning can also provide new opportunities to identify high-risk individuals before their symptoms get worse with the emergence of digital health data. This research paper discusses an ensemble-based prediction model which would enhance early recognition of asthma exacerbation. Through an examination of the massive clinical data, the paper emphasizes the usefulness of AI-based applications to facilitate prompt and tailored asthma treatment. Asthma remains a significant health issue on a global scale, especially in those areas where access to special treatment is inadequate. Prediction of asthma conditions is a vital process that should occur early and precisely to reduce the complications and enhance the management of the patients. As the number of digital health records grows, machine learning can be utilized as a promising prospect of more trustworthy asthma prediction. The current research is aimed at creating an interactive ML model that would improve prediction accuracy based on the real-world data of the population of the selected regions in Africa.

Literature Review

D. Adamu Aliyu et al. (2024), Researchers have applied several models, such as SVM, Random Forest, KNN, Decision Trees, Logistic Regression, and Deep Learning, to such data as hospital data, wearable devices, and asthma diaries to develop models for predicting asthma attacks. These studies were able to enhance the accuracy of the predictions through feature selection and parameter tuning but most systems require no real-time alerts, personalised care and lifestyle support. There are mobile apps with diaries and medication reminders but they do not usually integrate predictive analytics, or exercises such as

breathing or involve chatbot guidance. This exposes a need for a solution that brings together early prediction with features of complete wellness. The proposed system, Astreva-AsthmaWellness, discovers a solution to this by combining the power of machine learning prediction, real-time guidance, emergency alerts, and lifestyle management to improve asthma self-care at the same time as reducing risks [1]. D. Adamu Aliyu, E. Akashah Patah Akhir, M. Omar Abdullah Sawad, J. Shehu Yalli and Y. Saidu. (2025) Asthma exacerbation can be predicted using different methods such as Logistic Regression, Random Forests and Gradient Boosting, however, these techniques often fail to capture patient-specific variations. Deep learning methods such as RNNs and LSTMs have made temporal predictions better; but such methods are still limited in their ability to adapt to continuously changing health data. Reinforcement learning (RL) has been attracting attention lately due to its capability of optimizing decisions dynamically in a healthcare environment. Algorithms such as Deep Q-Learning and Actor-Critic have shown potential but the stability and adaptability of such algorithms is still a challenge. Proximal Policy Optimization (PPO) provides a more robust framework, which is also not yet applied in asthma management, and thus there remains room for research [2]. B. Kumar, D. Upadhyay, K. S. Gill and S. Devliyal. (2024), Asthma prediction has been of broad interest. Wide-spread algorithmic approaches have been explored leveraging machine learning techniques including Random Forest, Gradient Boosting and Support Vector Machines. Kumar et al. (2024) pointed out Random Forest as a classifier with good accuracy to predict the risk of asthma disease using patient health records with 75%, which has a moderate performance yet can still be used clinically. Deep learning models such as RNN and LSTM have further enhanced the temporal prediction but are restricted in updating themselves to develop data of the patient. Reinforcement learning (RL) has become a dynamic alternative, which allows continuous learning from patient environment relations. Algorithms like Deep Q-Learning, and Actor-Critic have shown promise but are difficult with regard to stability. Proximal Policy Optimization (PPO) with its powerful and adaptive policy updates provides some promise for personalized asthma management, but implementation is still in the early stages [3]. A. Kaur, K. S. Gill, R. Chauhan and H. S. Pokhariya. (2024), Asthma prediction based on machine learning algorithms: Recently the prediction of asthma has been extensively studied by using machine learning techniques, where Random forest models have shown their good predictive accuracy in dealing with various clinical and environmental data. These models are great in the management of complex datasets but still have problems adapting to evolving patient conditions in real-time. The deep learning techniques like RNNs and LSTMs enhance the prediction of time-oriented information but still do not have ongoing adaptability. Reinforcement learning approaches give a more dynamic approach by learning from the patient-environment interactions. Among them, Proximal Policy Optimization provides stable and adaptive predictions, so this is a promising direction for personalized asthma management [4]. T. Soni, D. Gupta and M. Dutta. (2024), Asthma prediction has been widely studied with machine learning models, like Decision Trees, Random Forests and K-Nearest Neighbours. Decision Tree algorithms have demonstrated high accuracy and provide interpretations as well as efficient processing of complicated clinical, environmental, and genetic data. Random Forest models also offer strength and scalability, but accuracy is often in the middle range on the predictive aspect. Despite these advances, conventional machine learning methods are not easily able to adapt to the changes in patient conditions. Deep learning techniques such as RNNs and LSTMs can capture the temporal variations however, they are still not continuously adaptable. Reinforcement learning techniques, namely Proximal Policy Optimization appears to introduce dynamic decision-making and might be a potential for personalized asthma management [5]. Vatsal, S. Kumar, Riya, S. Rampal, M. Gaur and M. Gaur. (2024), Previous research has found that traditional clinical assessments often do not predict asthma attacks because of the complexity of interaction between environmental and physiological factors. To build a healthy and efficient care system, studies that apply machine learning show better accuracy by using patient history, comorbidities, and real-time health data. Ensemble models, in particular, have shown good performance, using multiple algorithms to represent different the asthma progression pattern. Existing findings have collectively highlighted the increasing role of AI-based models to improve respiratory disease forecast [7].

A. A. Azeta, C. S., Edward & Ekpo, R. H. (2024), Predicting asthma using different machine learning methods, existing investigations have examined the many kinds of machine learning methods that can be used to forecast asthma, however, many of the traditional models struggle to achieve high level of accuracy because of the complexity nature of the respiratory patterns. According to some prior research, decision trees, KNN and Naive Bayes are able to risk identification of asthma but have limitations for identifying deeper nonlinear relationships within large data sets. Gradient boosting approaches are more effective in dealing with diverse clinical variables according to recent work. These findings demonstrate the need for advanced machine learning (ML) frameworks, such as XGBoost, to gain better predictive performance in the management of asthma [6].

Problem Status and Contribution

Asthma patients are often challenged by sudden and unpredictable exacerbation circumstances due to the lack of real-time monitoring, personalized insights and intelligent early-warning systems in traditional care models. Existing digital tools offer only very rudimentary symptom logging and medication reminders, without analysing the medical history, environmental factors triggering the attack or behavioural patterns causing asthma attacks. This lack of predictive capability makes patients riddled with event occurrences of emergencies, healthcare dependency, and disease management capability. Therefore, there is a need for an intelligent, integrated and patient-centric digital framework that can accurately predict asthma exacerbations and for self-management on a continuous basis.

This work represents an introduction of a comprehensive digital framework that is designed to revolutionize the management of asthma by intelligent prediction and continuous patient support. The contribution of the field is the development of machine learning-based prediction model using KNN to identify potential asthma exacerbation using analyse user inputs, medical history and environmental conditions. Alongside prediction, the system combines several self-management tools, such as a virtual asthma diary, breathing exercises, lifestyle monitoring and educational tools, to encourage active patient participation. A real-time chatbot assistant and automated emergency alerts ensure timely guidance and communication for emerging situations and thus reduce the possibility of abrupt attack. By integrating the use of predictive analytics, personalised care, and holistic wellness functionalities into one, this research provides a scalable and easy-to-use solution to improve treatment adherence and early detection while also improving the overall quality of life for people living with asthma.

Proposed Methodology

The proposed Astreva-AsthmaWellness system has a structured methodology that starts with gathering patient health data, medical history, input of symptoms and other environmental information like air quality, humidity, and allergen levels through manual inputs or connected wearable/IoT devices. This raw data is then pre-processed in the form of cleaning, normalizing, and feature extraction to make the data ready for machine learning analysis. The KNN-based predictive model is trained with historic datasets to learn patterns related to asthma triggers and early warning signs to make accurate and real-time prediction on potential asthma exacerbation. Once incorporated into the platform, the model continuously analyses updated patient inputs to give early warnings, personalised recommendations, medication reminders, breathing exercises and lifestyle changes. A built-in chatbot provides support for users in the form of giving them real-time guidance, answering questions, and helping them respond to mild symptoms before they worsen. In severe cases, the system automatically provides emergency notifications to caregivers, healthcare providers to ensure that timely intervention is undertaken. All patient interactions, prediction and health trends are then securely stored and fed back into the system to whittle and sharpen the model's performance, accuracy and enable long-term monitoring. This methodology is designed to provide a proactive, data-driven and patient-centred approach in managing asthma and also enabling an overall improved health outcome.

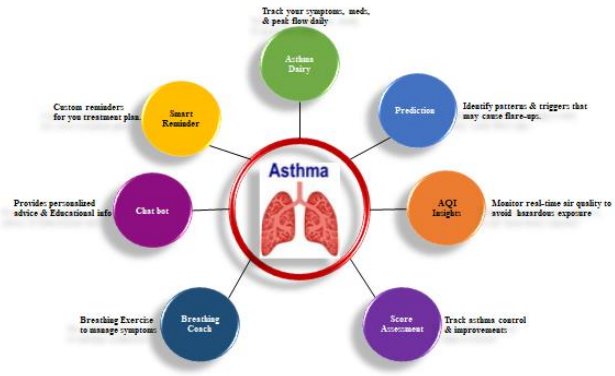

Figure 1: System Architecture for Proposed Methodology

System is based on a modular design methodology containing intelligent data analysis, user interaction and real-time response mechanism. The architecture provides for smooth communication between components for efficient management and prediction of asthma. User Interface (Web App). The system starts off with an intuitive using interface for the patient to enter symptoms like cough, wheezing, breathlessness etc. Dataset (). All user data such as profiles, log of symptoms, history of triggers, and chatbot interactions would be stored. The backend processes all the requests from users, and manages the data flow between the interface, database and analytics modules. Analytics & Monitoring This module analyses the trends and patterns of the symptoms using machine learning algorithms.

1. Asthma Diary

The Asthma Diary module allows the patient to take notes and compare the symptoms of coughing, wheezing, chest tightness and breathlessness on a daily basis. Users are able to record the intake of medication, being exposed to the trigger (dust, smoke and weather change), and the activity level. This is a continuous collection of data to help in occurrence of recurring patterns and possible triggers. The system uses this data to give personalized data and allows both patients and healthcare providers to monitor in the long-term the progression and control of asthma.

2. Prediction

Prediction module is derived from the machine learning algorithms (e.g. K-Nearest Neighbors - KNN) to predict in advance the exacerbation of asthma touches. It measures the health data of users, the environment (air quality index and humidity) and past trends in the symptoms. The AI model identifies the patterns considered to be at high risk and provides more warnings or notifications to the users so that they can take some preventive actions. Such a predictive aspect reduces the amount of emergency hospital visits as well as improves the well-being of the patients with timely intervention.

3. AQI Insights

The Air Quality Index (AQI) Insights module is used to get real-time data on air quality and the level of pollution at the whereabouts of the user. It collects information of the tested environmental APIs and displays the indicators such as particulate matter i.e., PM 2.5, PM 10, temperature, humidity and no of pollen. Due to these insights, the system gives preventative suggestions, such as not going out when the pollution is high or wearing masks. This helps the patients to make informed lifestyle choices in order to prevent being triggered by asthma.

4. Score Assessment

The Score Assessment module is used to measure the general health of the user's respiratory system using a scoring algorithm which is a summation of the symptoms frequency, medication complies, lung performances and exposure to the environment. The score gives the level of asthma control by the user (e.g. good, moderate or poor) and refers the user to the right management interventions. These scores are useful in tracking an improvement or deterioration over time encouraging the users to continue with good asthma management habits.

5. Breathing Coach

Breathing Coach Module teaches breathing exercises and relaxation techniques to improve the lungs and boost the rate of breathing. It trains the user to engage in deep-breathing exercises by using interactive graphics, timers and audio cues to train them on the pursed-lip breathing, or diaphragmatic breathing. This feature can be utilized on a regular basis to develop the capacity of the lungs, reduce the shortness of breath and deal with anxiety associated with asthma symptoms.

6. Smart Reminder

The Smart Reminders module will ensure that a patient is unable to forget taking each medication, check-ups, or even exercises. It provides automatic notifications, SMS, or

notifications in the application based on the routine and medication plan of the user. The alerts can also be set based on the day-to-day inhaler activity, physician visit or weather notice. It is an attribute that promotes treatment adherence, prevents missed doses and results in the realization of routine asthma management and better health promotion.

7. Ai Chat-Bot

An asthma care AI chatbot is an instant question and answer service available to patients. The chatbot can respond correctly and understandably to any questions raised by the users on the matter of symptoms, medications, triggers, or day-to-day management. It assists patients to clear their doubts without having to visit the hospital because it guides patients at all times. This rapid response helps to manage oneself better and feel less worried in the ambiguous cases.

Result and Discussion

The Astreva-Asthma Wellness system showed very good performance in making predictions about the occurrence of asthma exacerbation based on the KNN model with great accuracy and the early warning of the symptoms. The model has successfully been used to analyse the patient health data with environmental indicators and the prediction that is made is more accurate and reliable in comparison to the old symptom-based strategies. The wellbeing of the users was enhanced by the specific functions like medication reminders, breathing exercises, and lifestyle education that enhanced medication adherence and self-management. The chatbot-based support system in real time and emergency alerting system during testing greatly minimized patient-caregiver response time, therefore, providing a quicker response between the three parties (patients, caregivers, and healthcare professionals). The data collection and the feedback loops were further enhanced by continuous data collection, which enhanced the learning efficiency of the model to make forecasting more patient-specific and more adaptable with time. All in all, the findings indicate that the proposed system contributes to the improved early diagnosis, promotes preventive care, decreases hospital reliance, and offers a convenient, efficient remedy to address the contemporary management of asthma.

CONCLUSION

The Astreva -AsthmaWellness system is an intelligent, all round, and patient oriented approach to managing asthma. Using predictive analytics based on K-Nearest Neighbors (KNN) and ongoing nutrition tracking and health advice, the platform will bridge the digital divide between traditional care and innovative digital health care. It does not only anticipate possible asthma exacerbations, but also gives the power to a patient by providing a personalized guidance and educational materials, as well as chatbot support in real-time. This is due to the inclusion of wearable devices connectivity, environmental surveillance and emergency alert system, which guarantees proactive and timely interventions. On the whole, Astreva will boost patient interaction, decrease the number of visits to hospitals, and encourage a preventive type of healthcare. It utilizes technology coupled with clinical acumen to provide a scalable, efficient, and comprehensive model of enhancing the quality of life of persons with asthma.

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