



A systematic literature review of explainable risk assessment models for bronchial asthma

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Background: The reduced quality and risks to life brought on by bronchial asthma (BA) have heightened the need for trustworthy risk assessment solutions with deliberate interpretability and transparency. Improper management of BA, such as ignoring symptoms, improper inhaler technique, or recent admissions to the intensive care unit (ICU), puts a patient at a higher risk of future asthma exacerbations, complications, or even death. This paper details a systematic literature review on recent literature to identify and analyse current explainable artificial intelligence (XAI) risk assessment models used in BA or the assessment of risk in healthcare using XAI.

Methods: A systematic review of English literatures was conducted through Science Direct, Association for Computing Machinery (ACM) Digital Library, Springer, PubMed, and Scopus between January 1, 2019 and October 26, 2023. All studies that incorporated XAI or risk assessment models for BA or health were included for this review. A combination and permutation of the following search terms was used: “explainable artificial intelligence”, “risk assessment”, “risk assessment model”, “asthma”, and “health”.

Results: A total of 43 literatures were included after screening through 689 literatures combined from the specified sources, with duplicates and materials not meeting the inclusion criteria removed. Among them, five of the literatures conducted research on asthma, while seven conducted research on lung-related diseases using explainable machine learning (ML) or deep learning (DL) techniques. The model that had better performance when compared to the other models in the 12 most relevant literature out of the 43 was extreme gradient boosting (XGBoost), with it having better performance two out of the three times it was compared to other models. The most common output was risk prediction with 36 literatures, followed by diagnosis with seven literatures and classification with one.

Conclusions: XAI has been used within the domain of asthma for diagnosis or prediction of future hospital visits; however, there is a scarcity for studies on explainable predictive models for asthma exacerbation risks. Research on XAI within this domain has the potential to contribute towards explainability in asthma risk prediction.

Keywords: Explainable artificial intelligence (XAI); risk assessment model; bronchial asthma (BA); healthcare

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Introduction

Background

Bronchial asthma (BA) is a chronic respiratory disease that is prevalent in the lives of an estimated 300 million people worldwide and the cause of around 1,000 deaths each day (1). This long-term condition impacts the lives of individuals living with asthma, where there is a reduced quality of life or even the risk of death. Improper management of an individual's asthma condition, such as ignoring symptoms, may put that person at risk of experiencing asthma exacerbations, which are severe cases of asthma symptoms that make it difficult to breathe due to the narrowing of the lung's airways, inflammation, swelling, and increased production of (2). Each patient would have a Written Asthma Action Plan written specifically for them by their doctor to allow the patients to monitor their own symptoms and react accordingly (1). A Written Asthma Action Plan would have the dose of medication for a patient and the next action to be taken by the patient, such as going to the nearest hospital if the condition worsens. It also allows

the patients to check whether they are in the green zone, the yellow zone, and the red zone, with green being in "good condition", yellow being in "getting worse", and red indicating that patients should be alert as their condition is even worse. Inattentiveness towards asthma symptoms can be life-threatening. Artificial intelligence (AI) has been broadly used in the medical field, such as in medical imaging, healthcare tasks (3), and utilised in the care of BA, where it is used for the diagnosis and screening of asthma in patients, classifying patients, managing and monitoring asthma, and for the treatment of asthma (4). It is expected to enhance medical care using machine learning (ML) or deep learning (DL) models. However, AI is still confronted with the issues regarding transparency, interpretability, and explainability, which could affect the users' trust towards the AI model (5). The complex inference mechanisms of the AI models make it incomprehensible to its users. This limitation in AI is known as the "Black box", where the AI model processes input data through mathematical algorithms and produces output data, but it is not always known how the AI model reached the decision or prediction it has made. There are certain limitations in AI that research in explainable AI (XAI) wishes to address. Especially within the medical sector, where risk prediction models are required to be accurate, trustworthy, and precise.

Highlight box

Key findings

- Explainable artificial intelligence (XAI) has significant application in asthma risk prediction.
- Random forest was the most tried machine learning (ML) model in recent literature.
- Extreme gradient boosting was the ML model with the better performance in the 12 most relevant literatures.

What is known and what is new?

- Future risk of asthma exacerbation or a diagnosis of high risk in a patient is usually assessed by the patient's doctor or using a My Asthma Action Plan formulated by their doctor.
- XAI has shown promise in the prediction of risk with deliberation towards accuracy, interpretation, explainability, and patient risk assessment.

What is the implication, and what should change now?

- Research in XAI for risk prediction is seeing rapid development.
- Successful integration of XAI for clinical use in risk prediction of asthma will require clinical confirmation.

Rationale and knowledge gap

The increasing interest of using AI for risk prediction within a clinical setting extends the need for the models to be explainable. The scarcity of recent publications for XAI application in risk prediction for BA is highlighted within this literature review. Although many studies have used AI for diagnosis of asthma, lung-related diseases, and prediction for other diseases in the healthcare sector, there is a lack of literatures particularly on XAI for prediction of risk in BA. This paper aims to review the existing literature and find connections between them by sectioning and examining the selected literatures to procure a detailed insight regarding XAI-based risk assessment models by examining the models used, their architecture, their performances, the input data, and the outputs of the models before concluding with the