Scoping Review of Risk Prediction Models for Renal Involvement in Children with Henoch-Schönlein Purpura: A Postprint

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Abstract

Background: Henoch-Schönlein purpura (HSP) is a common systemic vasculitis in childhood, with a high proportion of renal involvement. In recent years, research on risk prediction models for renal injury in HSP has increased, but significant differences exist in the selection of predictors and modeling methods. Objective: This study aims to systematically summarize the construction characteristics, common predictors, and methodological quality of existing risk prediction models for renal injury in children with HSP, providing a basis for researchers to conduct related studies and for clinicians to identify high-risk children early. Methods: Using a scoping review method, we systematically searched PubMed, Embase, Cochrane Library, Web of Science, CNKI, Wanfang Data Knowledge Service Platform, VIP, and China Biology Medicine (CBM) from their inception until 2025-06-01. Two researchers independently performed literature screening and data extraction, using the CHARMS checklist to extract model-related information and the Prediction Model Risk of Bias Assessment Tool (PROBAST) to evaluate the risk of bias and applicability. Results: A total of 13 studies were ultimately included, comprising 6 Chinese and 7 English studies, with sample sizes ranging from 165 to 1,294 cases. The incidence of renal injury in HSP ranged from 26.67% to 63.75%, and the area under the receiver operating characteristic curve (AUC) ranged from 0.55 to 0.956. The most common predictors were age, recurrent purpura, persistent purpura, D-dimer, and serum albumin. PROBAST quality assessment indicated that the included studies had a high risk of bias, primarily related to retrospective study designs, inadequate handling of missing data, and a lack of external validation. Conclusion: Existing risk prediction models for renal injury in children with HSP have a high risk of bias, affecting their reliability and clinical dissemination. Future research should focus on prospective designs, standardized reporting, optimization of predictors, and the implementation of multicenter external validation to

construct more robust and generalizable risk prediction tools.

Full Text

Preamble

Chinese General Practice

Abstract

General practice (GP) serves as the cornerstone of the primary healthcare system, playing a vital role in maintaining public health and managing chronic diseases. This paper explores the current state, challenges, and future directions of general practice in China. By analyzing the integration of machine learning and deep learning technologies into clinical decision support systems, we examine how digital health interventions can enhance the quality of care provided by general practitioners. Furthermore, we discuss the importance of standardized residency training and the implementation of the family doctor contract service model in improving health outcomes across diverse populations.

Introduction

In recent years, the Chinese healthcare system has undergone significant reforms aimed at shifting the focus from hospital-centric acute care to community-based primary care. General practice is at the heart of this transformation. As the first point of contact for patients, general practitioners (GPs) are responsible for providing comprehensive, continuous, and coordinated care. However, the rapid aging of the population and the increasing burden of non-communicable diseases (NCDs) have placed unprecedented pressure on primary care providers.

To address these challenges, the integration of advanced technologies, such as artificial intelligence (AI) and big data analytics, has become a priority. These tools offer the potential to assist GPs in early diagnosis, risk stratification, and personalized treatment planning. For instance, the application of a predictive model $\mathcal{M}$ can be defined as:

$$\hat{y} = f(x; \theta)$$

where x represents patient clinical data, θ denotes the model parameters, and $\hat{y}$ is the predicted health outcome. Such models can significantly reduce diagnostic errors and improve the efficiency of clinical workflows.

The Role of Machine Learning in General Practice

Machine learning algorithms have demonstrated remarkable success in analyzing complex medical datasets. In the context of general practice, these algorithms can be used to identify patterns in electronic health records (EHRs) that may be overlooked by human clinicians. For example, deep learning architectures, such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), are increasingly utilized for medical imaging analysis and longitudinal patient monitoring.

[Figure 1: see original paper]

As shown in [Figure 1: see original paper], the workflow for implementing a machine learning-based decision support system involves data acquisition, preprocessing, feature extraction, and model evaluation. The objective is to provide GPs with actionable insights at the point of care.

Reviews and Monographs

Scoping Review of Risk Prediction Models for Renal Injury in Children with Henoch-Schönlein Purpura

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Background

Henoch-Schönlein Purpura (HSP) is the most common systemic vasculitis in childhood, characterized by a high incidence of renal involvement. Research into risk prediction models for kidney injury is steadily increasing; however, significant disparities remain regarding the selection of predictive factors and modeling methodologies.

Objective

The objective of this study is to systematically summarize the construction characteristics, common predictive factors, and methodological quality of existing risk prediction models for HSP kidney injury in children, providing a basis for researchers to conduct related studies and for clinicians to identify high-risk children at an early stage.

Abstract

This scoping review systematically summarizes and analyzes the current state of research regarding the application of machine learning and deep learning techniques in predicting renal injury in pediatric HSP. We evaluate various architectural frameworks, ranging from traditional supervised learning models to advanced neural networks, and discuss their efficacy in predictive modeling and pattern recognition. Furthermore, this research identifies key challenges in the field, such as model interpretability and data scarcity.

Methods

1.1 Search Strategy

A systematic search was conducted across multiple electronic databases, including PubMed, Embase, the Cochrane Library, Web of Science, China National Knowledge Infrastructure (CNKI), Wanfang Data, VIP Database, and the China Biology Medicine (CBM) database. The search period spanned from the inception of each database through June 1, 2025.

1.2 Inclusion and Exclusion Criteria

Studies were included if they: (1) involved pediatric patients (age $<$ 18 years) diagnosed with HSP; (2) focused on the development or validation of a model to predict the risk of Henoch-Schönlein Purpura Nephritis (HSPN); and (3) provided clear descriptions of the predictors and modeling methods used.

1.3 Data Extraction and Quality Assessment

Two researchers independently extracted data using a standardized form. Model-related information was extracted using the CHARMS (Critical Appraisal and Data Extraction for Systematic Reviews of Prediction Modelling Studies) checklist. The methodological quality and risk of bias were assessed using the Prediction Model Risk of Bias Assessment Tool (PROBAST), evaluating four domains: participants, predictors, outcomes, and analysis.

Results

A total of 13 studies were ultimately included (6 Chinese and 7 English). Sample sizes ranged from 165 to 1,294 cases. The incidence of renal involvement in HSP ranged from 26.67% to 63.75%, with the area under the receiver operating characteristic curve (AUC) varying between 0.55 and 0.956. The most frequently identified predictors were age, recurrence of purpura, persistent purpura, D-dimer levels, and serum albumin. PROBAST assessment indicated a high risk of bias across the included studies, primarily attributed to retrospective designs, inadequate handling of missing data, and a lack of external validation.

Conclusion

Existing prediction models for renal injury in children with HSP are at high risk of bias, compromising their reliability. Future research should prioritize prospective designs, standardized reporting, and multicenter external validation to develop more robust risk prediction tools.

Keywords: IgA vasculitis; Henoch-Schönlein purpura; Renal injury; Children; Predictive models; Scoping review

Prediction of Renal Involvement in Children with Henoch-Schönlein Purpura

Henoch-Schönlein Purpura (HSP), also known as immunoglobulin A vasculitis (IgAV), is the most common systemic vasculitis in children. While the condition is often self-limiting, its long-term prognosis is primarily determined by the severity of renal involvement, referred to as Henoch-Schönlein Purpura Nephritis (HSPN).

Clinical Indicators and Risk Factors

Current research indicates that several demographic and laboratory parameters are associated with an increased risk of renal involvement. Age at onset is a significant factor, with older children often exhibiting a higher incidence of damage. Furthermore, the duration and recurrence of skin purpura are closely linked to kidney injury.

Laboratory markers provide essential diagnostic value. Elevated levels of urinary microalbumin, β_2-microglobulin, and N-acetyl-β-D-glucosaminidase (NAG) serve as early indicators of dysfunction. Additionally, inflammatory markers such as the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) have been identified as potential biomarkers.

Application of Machine Learning in Prognosis

With the advancement of medical informatics, machine learning techniques are increasingly applied to predict renal involvement. Commonly utilized algorithms include Random Forest (RF), Support Vector Machines (SVM), and Gradient Boosting Decision Trees (GBDT). These models can identify non-linear relationships, such as the synergistic effect of proteinuria levels and specific immunological markers like serum IgA/C3 ratios.

Challenges and Future Directions

Despite progress, the high risk of bias in current models limits their clinical application. Future research should prioritize prospective study designs and the optimization of predictive factors.

Materials and Methods

1.1 Research Questions

The primary questions include: (1) What risk prediction models for renal damage in children with HSP have been established? (2) What are the specific predictors involved? (3) What modeling techniques were utilized, and what was their performance?

1.2 Search Strategy

A systematic search was conducted across PubMed, Embase, Cochrane Library, Web of Science, CNKI, Wanfang, VIP, and CBM. Taking PubMed as an example, the search strategy is detailed in .

1.3 Inclusion Criteria

(1) Population: Pediatric HSP patients (<18 years). (2) Content: Development/validation of risk prediction models with at least two predictors. (3) Design: Cohort, case-control, or cross-sectional studies.

1.4 Exclusion Criteria

(1) Comorbid severe diseases. (2) Studies without a formal prediction model. (3) Conference abstracts or case reports. (4) Duplicate publications or unavailable full texts.

1.5 Data Extraction

Two researchers independently extracted data using the CHARMS checklist [?]. Extracted information included study design, sample size, handling of missing data, and model performance metrics.

1.6 Quality Assessment

The PROBAST tool [?] was used to assess risk of bias and applicability across four domains: participants, predictors, outcome, and statistical analysis.

Results

2.1 Literature Screening

A total of 1,486 records were initially identified. After removing duplicates and screening, 13 studies [?] were ultimately included.

[Figure 1: see original paper]

2.2 Basic Characteristics

All 13 studies were conducted in China and utilized retrospective designs. Sample sizes ranged from 165 to 1,294 cases, with renal involvement incidence between 26.67% and 63.75% .

2.3 Model Development and Performance

Twelve studies utilized logistic regression [?, ?], while others incorporated machine learning algorithms like XGBoost, Random Forest, and SVM. AUC values ranged from 0.55 to 0.956. Only six studies reported model calibration [?, ?, ?], and only five performed external validation [?, ?] .

2.4 Predictive Factors

The five most frequent predictors were age, recurrent purpura, persistent purpura, D-dimer, and serum albumin .

2.5 Quality Assessment Results

The overall risk of bias was high. Bias in the statistical analysis domain was particularly noted due to inadequate sample sizes and poor handling of missing data .

Discussion

3.1 Analysis of High-Risk Factors

Age is a consistent independent risk factor [?, ?, ?, ?, ?, ?, ?, ?]. Older children may have more intense IgA-related immune responses. Recurrent or persistent purpura facilitates the long-term deposition of immune complexes in the glomerular mesangium. Elevated D-dimer indicates activation of the coagulation-fibrinolysis system, associated with microthrombus formation in glomerular capillaries [?].

3.2 Analysis of Bias in Existing Models

The high risk of bias is attributed to: (1) Retrospective designs and inconsistent definitions of renal injury. (2) Small sample sizes leading to overfitting. (3) Non-standardized handling of missing data (e.g., simple listwise deletion). (4) Lack of external validation across different institutions.

3.3 Implications for Future Research

Future studies should: (1) Conduct multicenter prospective studies. (2) Use robust methods like multiple imputation for missing data. (3) Adhere to TRIPOD guidelines for reporting. (4) Integrate multi-omics data to improve model interpretability.

Conclusion

This scoping review identified 13 studies on HSP renal injury prediction models. While high-frequency predictors like age and D-dimer were identified, the models suffer from high risk of bias. Improving methodological rigor and external validation is essential for clinical translation.

参考文献 (References)

[**?**] (As listed in the original text)

Note: Figure translations are in progress. See original paper for figures.