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Using statistical modelling and machine learning algorithms for osteoporosis prediction: a systematic review and meta-analysis

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ADMINISTRATIVE INFORMATION

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Review Stage at time of this submission - Data analysis.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 12 January 2026 and was last updated on 12 January 2026.

INTRODUCTION

Review question / Objective The aim of this study is to systematically review, synthesize and evaluate the prediction performance of current prediction algorithms for OP and explore whether the current algorithm could be further optimized with respect to current and novel risk factors.

Condition being studied Osteoporosis (OP) is a significant global health concern, affecting an estimated 200 million people worldwide, particularly postmenopausal women and older adults. With the acceleration of global population aging, an increasing number of individuals with OP are confronted with high treatment costs, fracture-related disability, psychological distress, and long-term care needs. Because the early symptoms of OP are insidious, it is often diagnosed after the occurrence of fragility fractures. Therefore, there is an urgent need to improve early detection and precise risk stratification in order to address this growing public health challenge. In recent years, with the development of artificial intelligence and machine learning, researchers have been exploring a variety of prediction algorithms to improve the recognition ability of OP. These algorithms range from traditional statistical models (such as logistic regression, Cox regression) to machine learning methods (such as random forests, support vector machines, gradient boosting trees) to more complex deep learning models (such as artificial neural networks, deep neural networks). However, the existing results are difficult to cross-compare and clinical promotion. In addition, some studies have problems such as small sample size, lack of external validation, and insufficient model generalization ability, which limit its reliability and credibility in practical application. Therefore, it is

necessary to conduct a systematic review and meta-analysis to synthesize the current recent evidence on the diagnostic accuracy in predicting osteoporosis.

METHODS

Participant or population Osteoporosis patients with mean ages more than 18 years.

Intervention Prediction algorithms.

Comparator F1 value, AUC, ACC.

Study designs to be included Cohort and cross-sectional researches.

Eligibility criteria Cohort and cross-sectional studies were included if they were published. The following criteria were predefined for inclusion: (a) full-text availability; (b) population: mean ages more than 18 years; (c) intervention: prediction algorithms; (d) comparator: F1 value, area under curve, and accuracy; (e) study design: cohort or cross-sectional study. Studies were excluded based on the following pre-determined exclusion criteria: (a) Researches on other topic; (b) Comparison of other interventions; (c) Study lacking available data; (d) Review, abstract, duplicate publication.

Information sources We searched electronic databases including PubMed, Embase, Scopus, Web of Sciences, Google Scholar and Cochrane Library for all OP prediction models between January 2020 and October 2025.

Main outcome(s) F1 value, AUC, ACC.

Quality assessment / Risk of bias analysis Using the Newcastle-Ottawa scale (NOS) method, we assessed the studies' quality and the possibility of bias.

Strategy of data synthesis Data for effect sizes of continuous outcomes were extracted or recalculated as standard mean difference (SMD) with 95% CI. Data for the rate of events were extracted or recalculated as proportions. The pooled event rate (PER) with 95% CI was calculated as the summary measure.

Subgroup analysis To reduce confounding bias, we performed subgroup analyses for each outcome based on the type of variables included in the model, sample size, final feature count, algorithm used, race, and research design.

Sensitivity analysis To explore possible sources of heterogeneity, the leave-one-out method was used. Publication bias for the primary endpoint of osteoporosis prediction was assessed using Egger's regression test and a funnel plot.

Language restriction Without language restrictions.

Country(ies) involved China - Shanxi Medical University School of Public health.

Keywords Osteoporosis, Convolutional neural network, Radiomics, metabolomics, Meta-analysis.

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