Use of machine learning in the detection and prediction of glaucoma progression: A systematic review

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Aims/ Purpose

Glaucoma is the leading cause of irreversible blindness worldwide. Effective assessment of glaucoma progression could facilitate timely interventions and improve prognosis. This systematic review aims to evaluate the use of machine learning (ML) in the detection and prediction of longitudinal glaucoma progression.

Methods

As outlined in the protocol (PROSPERO CRD42021272728), an online search of MEDLINE, EMBASE, Cochrane Controlled Register of Trials, and ClinicalTrials.gov was conducted on 31.12.2022. Papers addressing the review's primary outcome were included: ML algorithm detection or prediction of Glaucomatous Optic Neuropathy progression. Outcome data collected included ML algorithm type, maximum sensitivity, specificity, and area under the receiver operating characteristic curve (AUROC), with the QUADAS-2 tool used to assess risk of bias.

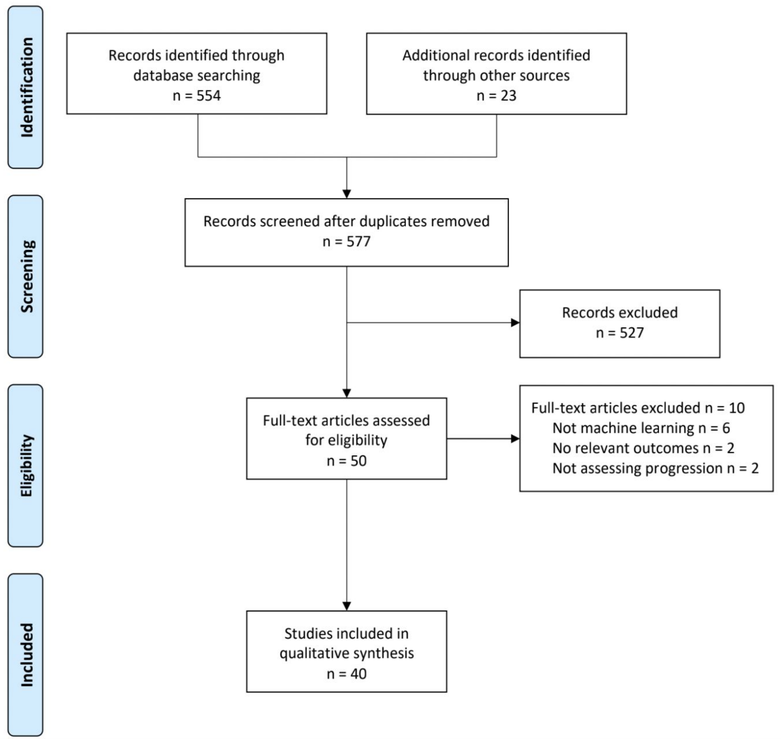
Results

Of the 577 records initially identified, 40 studies with over 156,000 eyes were included. Overall, 30 studies included traditional ML methods, and 13 studies included representational methods. 28 studies used supervised ML, whilst 12 studies used unsupervised ML. 24 studies performed classification analysis, 13 studies included regression analysis and 3 studies included both classification and regression analysis.

11 studies evaluated structural glaucoma data, including retinal nerve fiber layer thickness. Six studies detected glaucoma progression, with mean pooled maximum sensitivity, specificity, and AUROC of 68.9% (range 36.9-86.0%), 80.5% (49.0-94.0%) and 0.80 (0.60-0.91), respectively. Five studies predicted glaucoma progression, with mean pooled maximum sensitivity, specificity, and AUROC of 84.9% (range 81.0-93.0%), 73.5% (59.0-91.7%) and 0.82 (0.71-0.90), respectively. 23 studies evaluated functional visual field data. 10 studies detected glaucoma progression, with mean pooled maximum sensitivity, specificity, and AUROC of 74.8% (range 3.8-95.0%), 94.3% (90.0-98.1%) and 0.89 (0.82-0.94), respectively. Four studies predicted glaucoma progression, with mean pooled maximum sensitivity, specificity, and AUROC of 52.2% (range 20.0-72.0%), 72.3% (49.0-95.0%) and 0.73 (0.44-0.86), respectively.

Eight studies combined structural and functional data. Two studies detected glaucoma progression and six studies predicted glaucoma progression, with mean pooled maximum sensitivity, specificity, and AUROC of 66.6% (range 44.2-83.7%), 90.0% (85.0-100%) and 0.79 (0.61-0.88), respectively.

PRISMA Flow Diagram



Conclusions

This systematic review found that ML algorithm detection and prediction of longitudinal glaucoma progression is highly accurate. However, there is significant heterogeneity in ML methodologies. Standardization is needed for robust evidence of the clinical utility of ML.