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Oculomics for cardiovascular disease: A review of artificial intelligence applications using retinal imaging for screening and risk stratification

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Background:

Oculomics is a novel field aimed at identifying ocular biomarkers of systemic disease, often with the use of artificial intelligence models.

Aim:

Evaluate the use of AI in RFP / OCT/ OCT-A for the prediction and risk stratification of cardiovascular disease (CVD).

Methods:

Literature search was conducted on:

- PubMed, Web of Science, Scopus, IEEE Xplore, medrXiv

✓ Published between 31/01/2014 – 31/01/2024

✓ RFP, OCT, or OCT-A images

✓ Utilise AI models

✓ Endpoint – predicting or stratifying risk for CVD

✗ Technical-only papers

Study selection:

Search Results: 527 → Relevant studies: 31 → Included studies: 15*

*Inclusion of the final 15 studies based on main themes identified from relevant studies

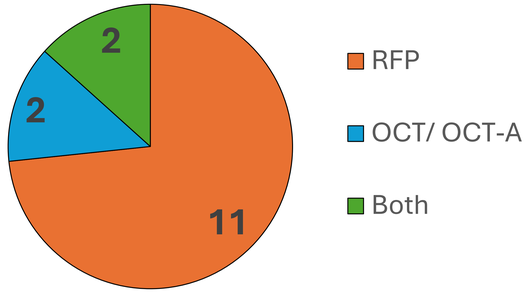
Main Themes:

Prediction of CVD markers

Prediction of CVD risk factors and risk scores

Prediction and risk stratification for incident CVDs, CVD events, and CVD mortality

Image modalities in reviewed studies



Conclusion:

- Models generally demonstrated **good performance, especially RFP models**.
- Further studies with larger, more heterogenous datasets and external validation are needed for stronger evidence and generalisability, particularly in OCT/OCT-A models.

Results:

Prediction of CVD markers

- **Retinal vessel-calibre, Retinal vasculometry, Retinal age gap**
  - Excellent agreement shown via intraclass correlation coefficients (ranging 0.823-0.948), Bland-Altman plots, and mean average error (3.55).
- **RetiCAC, Reti-CVD, DL-FAS – Author-proposed markers for predicting coronary arterial calcium scores and atherosclerosis**
  - Moderate to high AUROC (ranging 0.729-0.843)

Prediction of CVD risk factors and risk scores

- Both RFP and OCT/OCT-A models demonstrated comparable accuracy (ranging 0.605-0.863) and AUROCs (ranging 0.686-0.970) against traditional risk calculators.

Prediction and risk stratification of incident CVDs, CVD events and CVD mortality

- Moderate to high AUROCs (ranging 0.662-0.720) and C-statistics (ranging 0.543-0.810).
- Hazard ratios (95% CI; ranging 1.12-8.83) also showed positive associations between model predictions and CVD outcomes.

Additional findings

- **RFP models performed consistently well, but OCT/OCT-A models yielded inconsistent findings**.
  - One study reported poor AUROCs (ranging <0.5-0.59) for prediction of CVD events, whilst another demonstrated good prediction rates (63.05–96.23%) for classifying patients into clinical CVD risk categories stratified by established risk scores
- **Convolutional neural network** was the most prominent architecture (12 out of 15 studies) employed.
- Other deep learning architectures include **masked autoencoder, variational autoencoder, and fully convolutional network.**