OculoCardio

"An eye into the heart"

IMPERIAL

Celine NG†, Cho Fung Woody TAI† | St Michael's School, Llanelli | United Kingdom

†These authors contributed equally to this work and share first authorship

The Problem?

Cardiovascular disease (CVD) accounts for one in four premature deaths in the UK [1]. There is a profound disparity in cardiovascular care and outcomes among socially disadvantaged populations —including low-income individuals, ethnic minorities, rural residents, and marginalized communities. [2]

CVD risk factors:

- Chronic stress (financial insecurity, unstable housing, or discrimination) triggers a prolonged fight-or-flight response in the body. This continuous elevation of cortisol and adrenaline leads to chronic inflammation, increasing risk of atherosclerosis and high blood pressure. [3]
- Socially disadvantaged neighbourhood's frequently lack safe spaces for physical activity and have a higher density of fast-food outlets compared to grocery stores selling affordable, fresh produce. This environment heavily drives modifiable risk factors like obesity and type 2 diabetes. [4][5]

The Science Behind Our Method

Video Capture:
A perfect photo is near impossible using current mobile camera technology, instead we will record a short, high-frame-rate video clip while sweeping across the eye.

Frame Selection & Stitching:
The video is cut frame by frame and the brightness, hue and saturation are normalised by AI and the blurry frames caused by eye twitching (micro-saccades) are removed. The sharpest frames, are stitched together to produce a single, crystal-clear 2D map of the retina.

Tech Stack:
Light, compressed deep-learning models run directly on the phone's internal neural processing unit (NPU).

Vessel Tortuosity τ:
The exact curvature and twisting of the blood vessels, which increases with chronic hypertension. Caliber Ratios: The precise pixel-width ratio between venules (veins) and arterioles (arteries). Microvascular Texture: Subtle changes in background retinal tissue and pixel density that correlate with systemic inflammation and endothelial dysfunction. [6]

Our 2 AI Models:
Different phones have different sensors, flash brightness levels, and lens qualities, AI models must be aggressively trained to normalise colours and contrast. The app will feature 2 models to deliver this function.

More on our normalisation AI model

First, the video's frames are isolated and landmark-based Homography Estimation Models are used to re-centre the eye based on canthi (corners of the eye), brow and nose apex to centre the eye segmentation below.

Then, Semantic (interpretation and segmentation of an image) and Instance Segmentation (object detection) is needed to isolate the eye to ensure pixel perfect isolation of the image for diagnostic modelling. This process is also aided by Data Augmentation by randomly shifting brightness, contrast, and adding artificial shadows to the training images so the model learns to look at texture boundaries rather than light levels. This allows for the final model to be 'tuned' to the same condition for AI diagnostics.

More on our diagnostic AI model: Proprietary KNN Model

Our diagnostic AI model relies on the low energy and easy to train and update K-Nearest Neighbour classification algorithm for the initial tier of risk stratification.

KNN was chosen not just because for the low cost and ease of updating the model, they are an intuitive instance based learning algorithm that allows for constant update of the 'vector' base. By not relying on complex, highly resource-intensive mathematical models, it instead classifies a patient's current cardiovascular health status based on how closely their data matches known historical patient profiles.

When the patient performs a scan, the app plots their data set (normalised image, demographic and Social Determinants of Health) into a new point as a vector in the feature space.

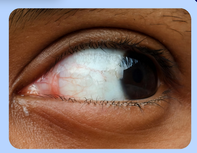
Design Thinking

Hypertension doesn't have obvious daily symptoms

How might we create an *intuitive*, *encouraging* AI assistant that helps individuals seamlessly monitor their daily cardiovascular metrics, making invisible risks visible without causing anxiety or user burnout?

Eye Photoplethysmography (PPG): Instead of requiring expensive equipment, the app can use the smartphone's camera and flash against the user's eye to detect micro-changes.

The app is tested to see how easily it generates a clean, readable PDF report.



Biological Pathways

Systemic chronic hypertension, leads to continuous sheer injury of the endothelial cells lining the vessels near the eye leading to vessel damage of the ocular structure. [7]

The bulbar conjunctiva sitting on top of the sclera undergo architectural remodelling to sustain the long term stress, therefore the vessel narrows progressively and the arteriolar-to-venule (diameter) ratio reduces significantly. [7][8]

The lipid deposition, capillary pruning and microvascular branching complexity are architectural markers that are not quantifiable by manual human ophthalmoscopy.

How is "Risk" scored?

Demographic and Social Determinants of Health (SDoH)
The patient's image is placed against aggregated data from demographics which are most similar to them. Factors such as age, genetics, and whether they smoke or not, would be taken into consideration. [2][9]

AI
The image taken undergoes normalisation and is then passed through a diagnostics model to determine the discrete risk level (limitation of KNN) such as low medium or high.

Overall Score:
The analysis of the results would be obtained from comparison of image with the data. The above measures are concancated to create a overall risk score and confidence factor.

Phase I: Pre-Clinical Optimisation (Month 1-12)

We will train the AI on diverse biobank data [10] and use data augmentation to ensure consistent microvascular extraction across varying smartphone optics and sensor resolutions. Additionally, poor photos will be rejected by the system and a rescan will be needed.

Phase II: Clinical Trial Validation (Months 12 - 24)

OculoCardio will be validated by testing asymptomatic patients to compare its accuracy against traditional blood/pressure risk calculators, and mathematically prove that smartphone-captured data achieves the same diagnostic performance Area Under the Receiver Operating Characteristic Curve(AUROC) as clinical-grade cameras.

Phase III: Regulatory Approach & NHS System Integration (Months 24-36)

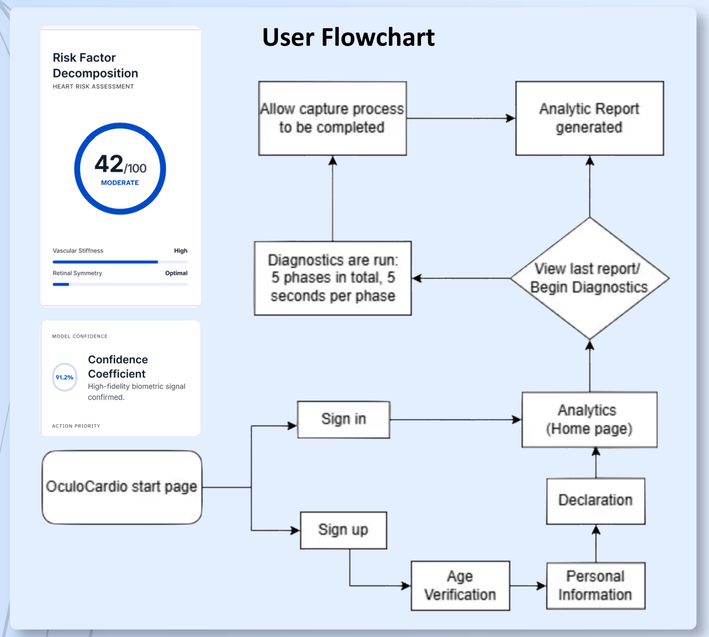
Compiling clinical performance dossiers to file for a Class II Medical Device Certification under the UK Medicines and Healthcare products Regulatory Agency (MHRA) framework.

Clinical Trials

Market Composition:

1. Patients who are 45–75 years old with high risk/managing risk, or patients with high anxiety regarding "invisible" symptoms such as hypertension;
2. Prevention seekers with family history who are 40-44 years old;
3. Low to middle income levels where easy access to regular health checkups is hard.

User Flowchart



Potential Setbacks	Frequency	Cause	Solution
Unreadable Image Quality	High	Hand tremors, poor lighting, or rapid blinking during macro-capture.	The software actively blocks substandard frames, showing user-friendly alignment rings on screen until clear data is found.
Algorithmic Drift	Low	Lack of internet access prevents regular security patches and network updates.	The local database triggers a soft lock every 30 days if an internet connection isn't briefly made to verify code integrity.

NHS Cost Savings

CVD costs the UK economy approximately £15.8 billion annually, with healthcare costs alone comprising £7.4 billion. Early preventative screening reduces the emergency acute care, surgical intervention, and post-stroke rehabilitation cost burden by an estimated £2,700 per high-risk patient.

Because the solution requires no hardware manufacturing, zero specialized clinic space, and zero clinical staff overhead, the scaling cost per additional user is virtually none. [11]

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Step 1: User downloads the app and completes a secure ID verification check (restricting use to individuals over 18).

Step 2: The smartphone flash illuminates the pupil for a few seconds. The local device normalises the frame and extracts vascular dimensions.

Step 3: The *Analytics* tab populates with raw data, a risk factor score out of 100 based on biomarker trends, and a confidence coefficient.

Step 4: If an elevated cardiovascular profile is flagged, the app pulls local geographic data to display the contact information of the nearest available primary care GP surgeries.

Step 5: The user can instantly export a PDF clinical dossier of their retinal metrics, allowing them to provide immediate data directly to their GP.

Rollout Process

Pilot Launch
Local community health centers & specific wards

B2B Intergration
Business-to-Business
Partnering with clinics & health insurance plans

Public Health
Scaling nationwide via national health frameworks

Link to → supplementals