# Artificial Intelligence & Diabetic Retinopathy

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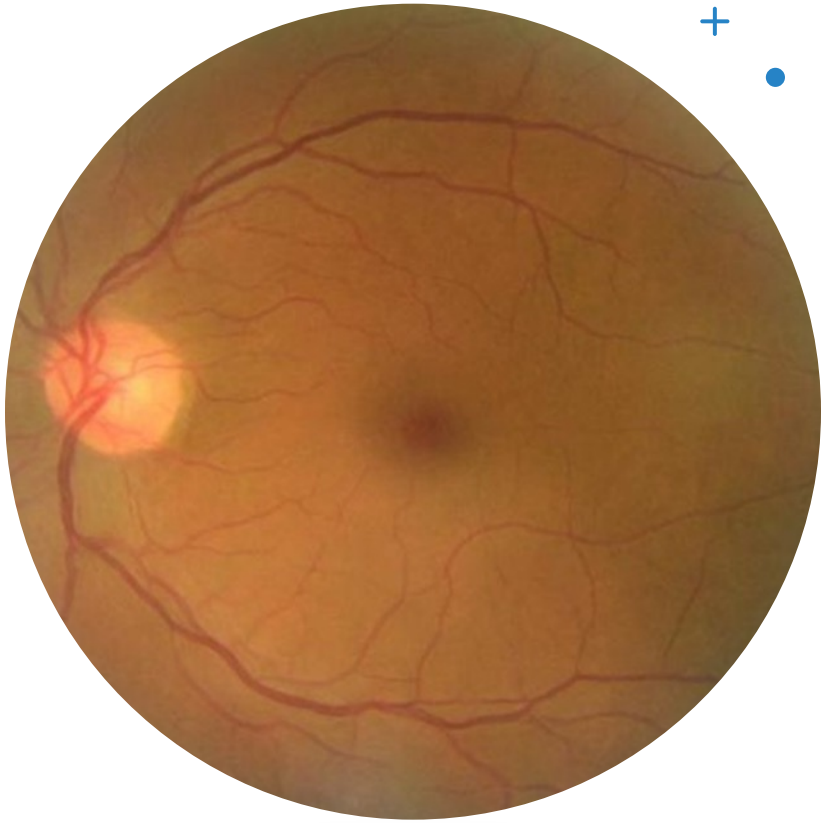
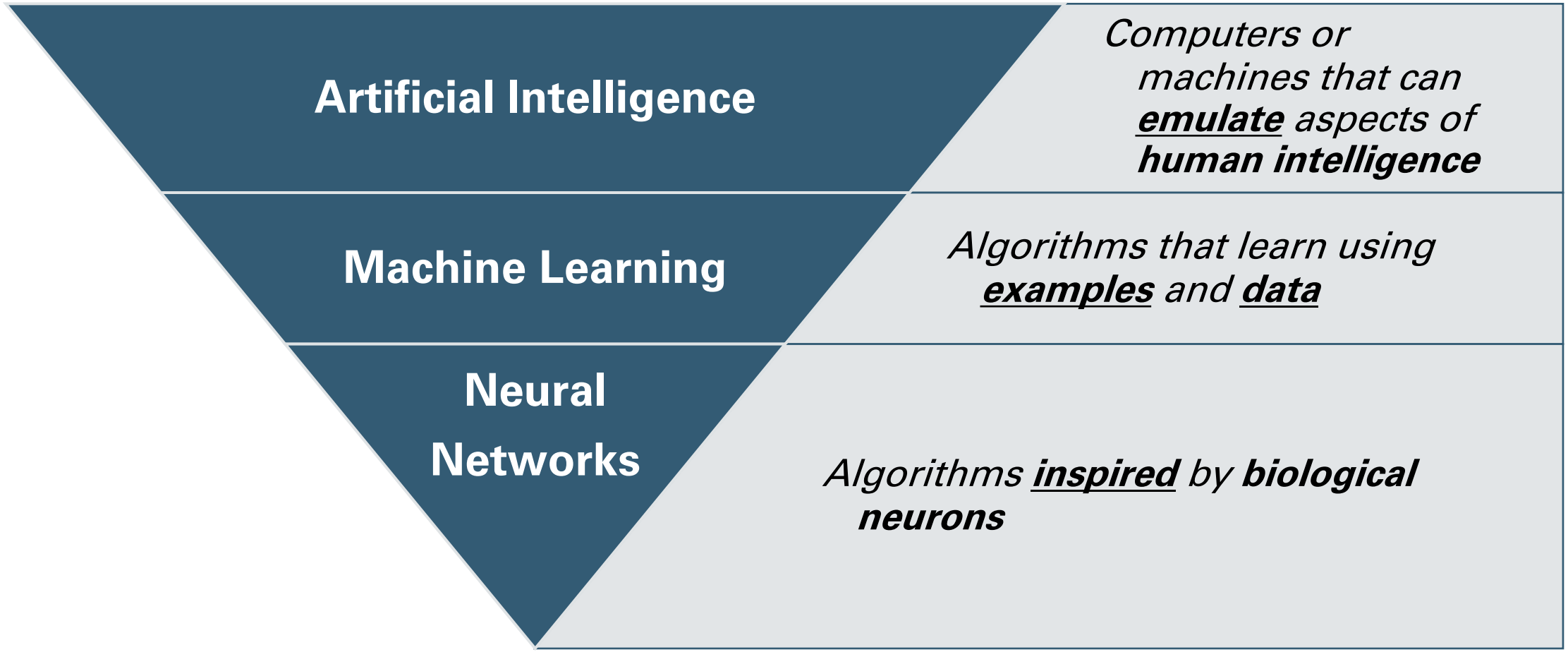
**Conflicts of Interests / Declaration: None**

**Views are my own*

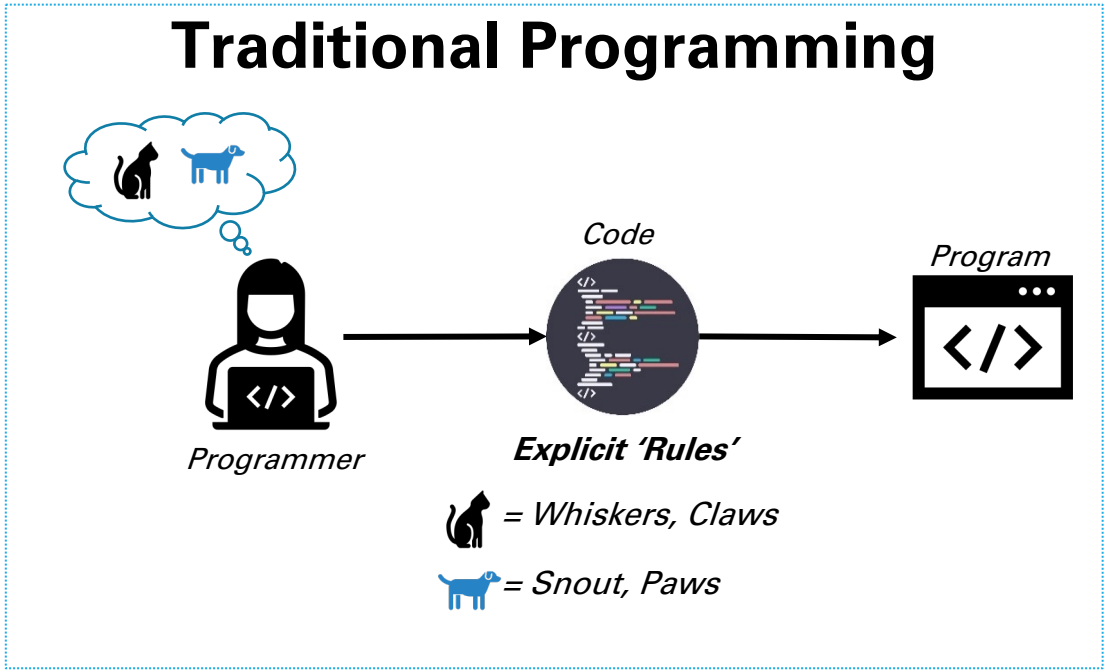


# WHAT IS AI?

# AI | Definitions



# AI | Traditional Programming



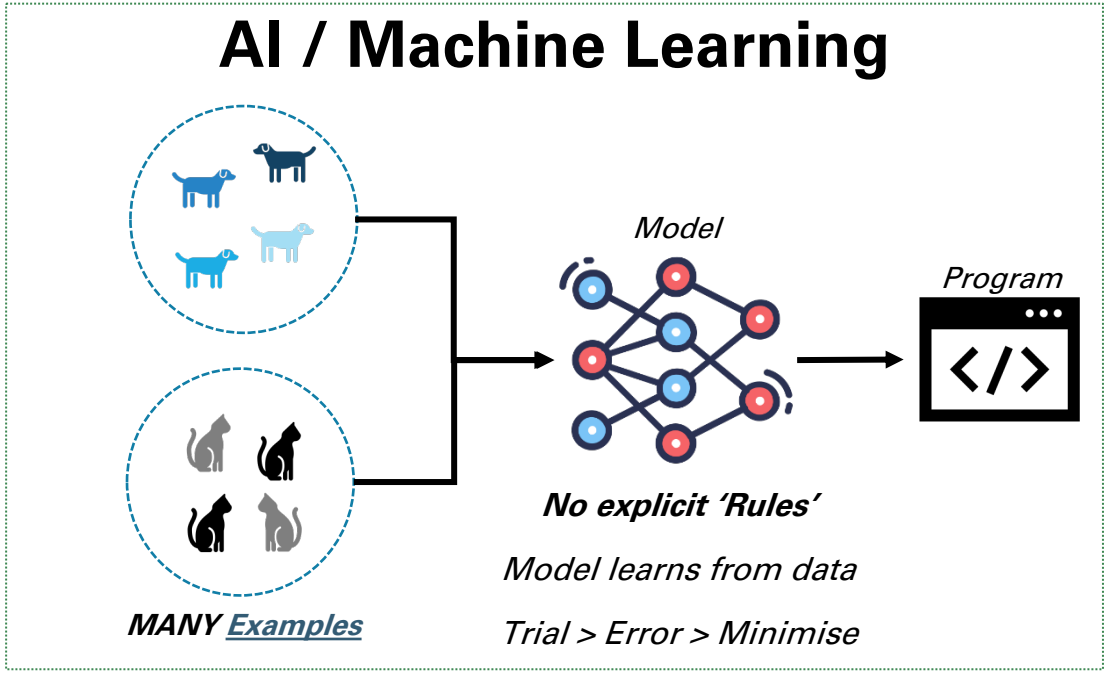
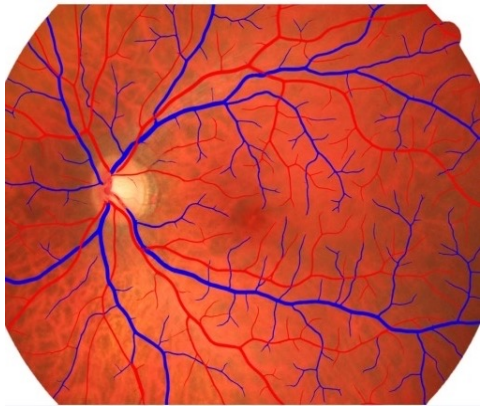




*Image adapted from*
*N Jaccard @ ORBIS International*

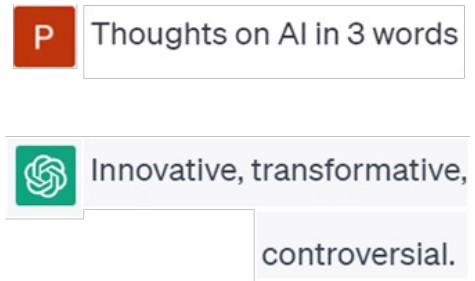
# AI | General Applications

## Computer Vision



- Classification & Regression
- Object Detection
- Segmentation …

## Language

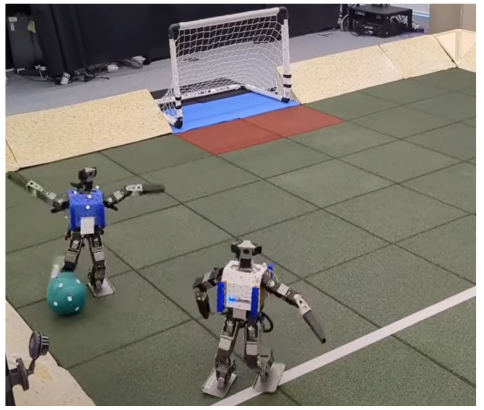



- Translation
- Summarisation
- Generation …

## Multimodal Processes


- Retrieval
- Object Detection
- Generation …

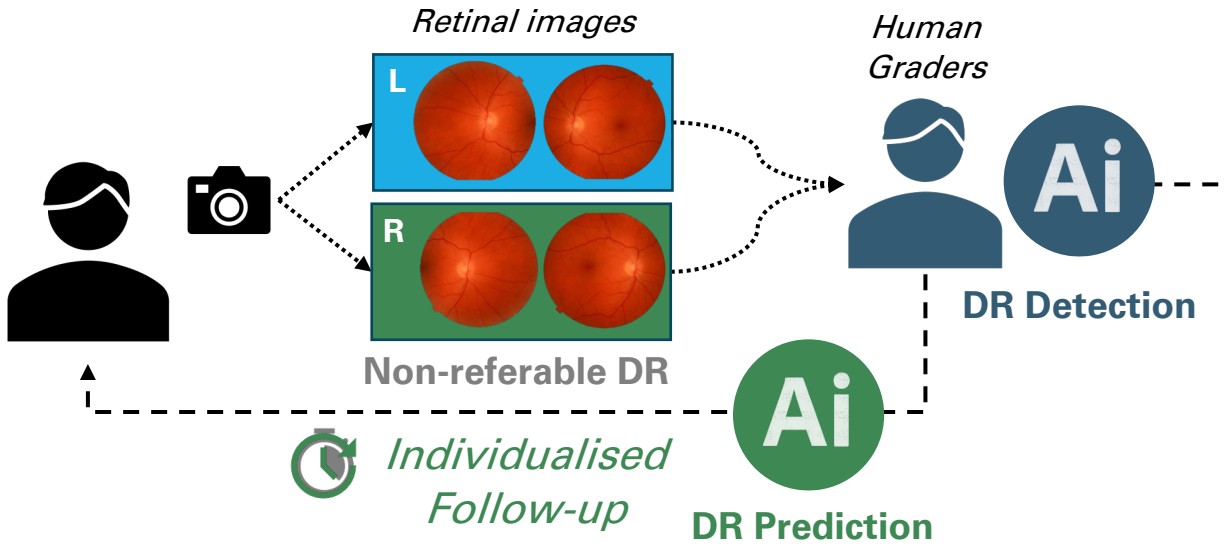
## Robotics



- Self-driving cars
- Healthcare
- Manufacturing
- Football …

# AI | DR Pathway

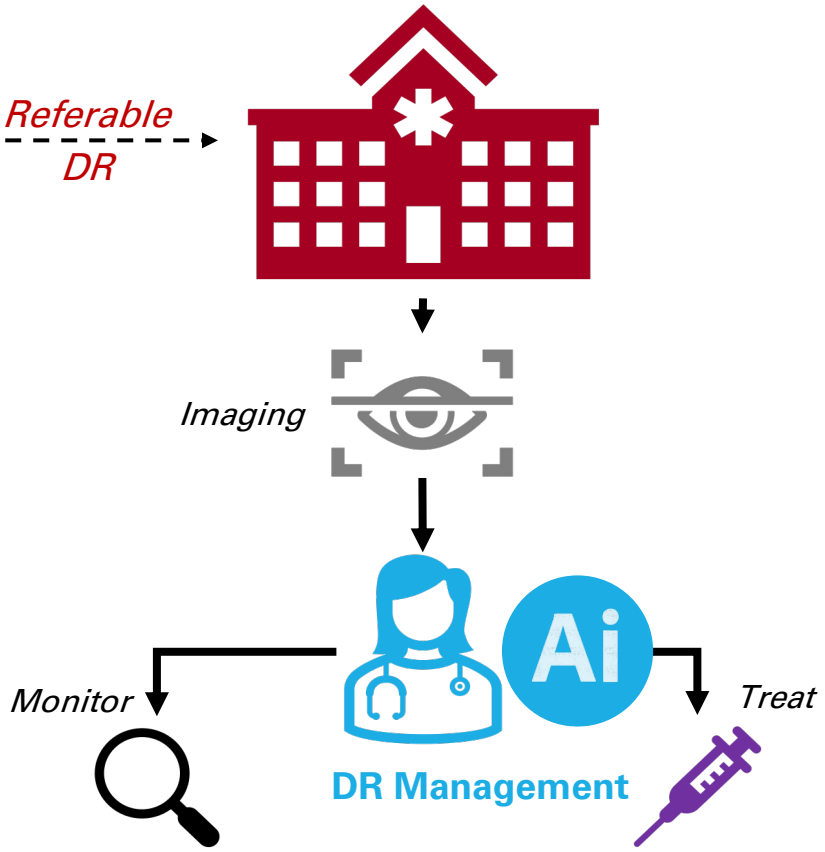
## UK Diabetic Eye Screening Program




### Resource Intensive

- **Staff:** >1,500 highly trained graders
- **Effort:** >13 million images per year
- **Cost:** >£85 million per year *(England alone)*

## Hospital Eye Service



# AI ⇔ Diabetic Retinopathy

DR Detection

DR Prediction

DR Management

Implementation

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# DR DETECTION

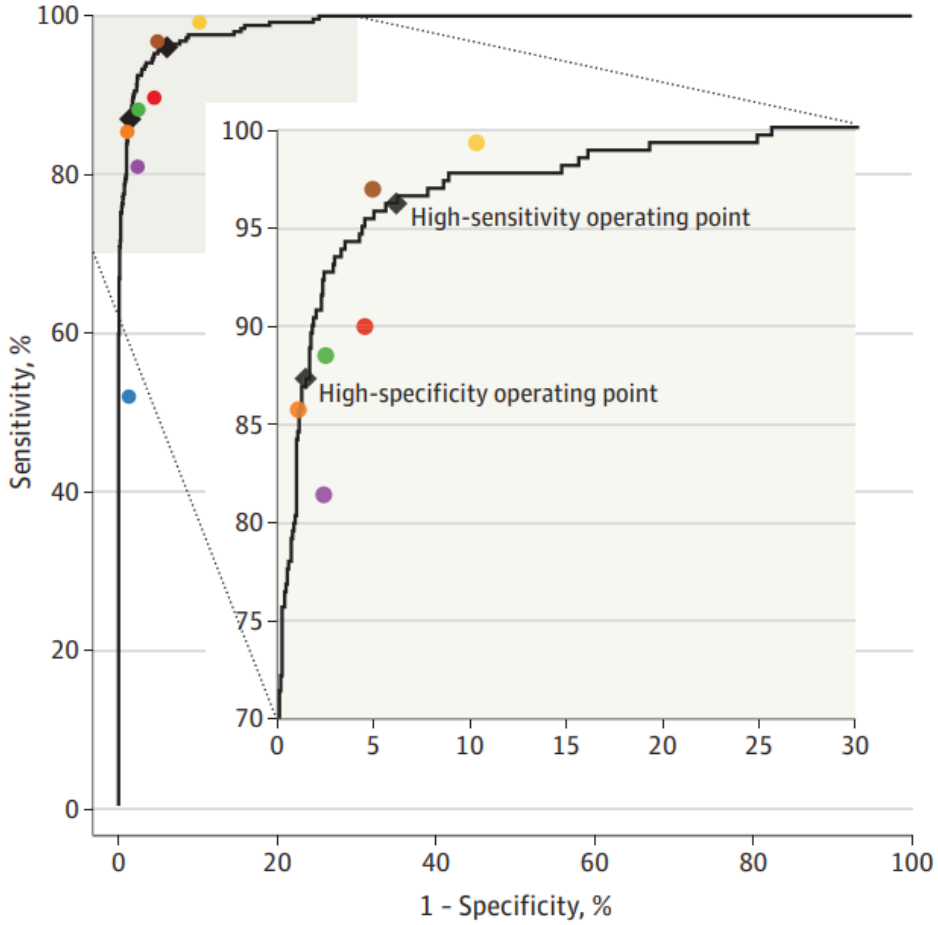
# DR Detection | Evidence

JAMA | Original Investigation | INNOVATIONS IN HEALTH CARE DELIVERY

## Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

Varun Gulshan, PhD; Lily Peng, MD, PhD; Marc Coram, PhD; Martin C. Stumpe, PhD; Derek Wu, BS; Arunachalam Narayanaswamy, PhD; Subhashini Venugopalan, MS; Kasumi Widner, MS; Tom Madams, MEng; Jorge Cuadros, OD, PhD; Ramasamy Kim, OD, DNB; Rajiv Raman, MS, DNB; Philip C. Nelson, BS; Jessica L. Mega, MD, MPH; Dale R. Webster, PhD

- ✓ **Trained using 128,175 retinal images**
- ✓ **Referable DR AUROC: 0.99** (95%CI: 0.986-0.995)
- ✓ **Sensitivity: 87.0%** (95%CI: 81.1%-91.0%)
- ✓ **Specificity: 98.5%** (95%CI: 97.7%-99.1%)



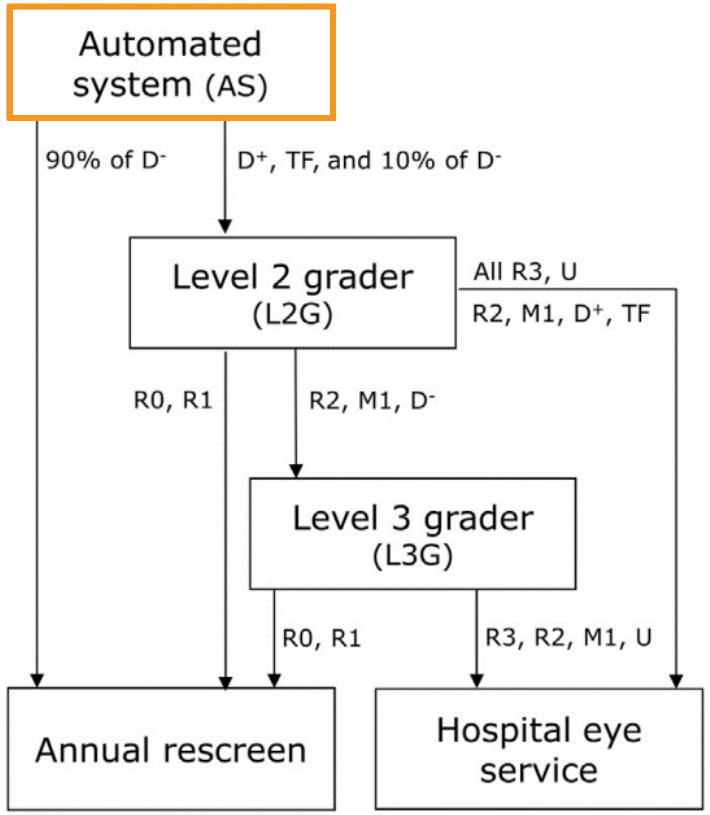
# DR Detection | Evidence

## Prospective evaluation of an artificial intelligence-enabled algorithm for automated diabetic retinopathy screening of 30 000 patients

Peter Heydon [1], Catherine Egan [1,2], Louis Bolter [3], Ryan Chambers [3], John Anderson [3], Steve Aldington [4], Irene M Stratton [4], Peter Henry Scanlon [4], Laura Webster [5], Samantha Mann [5], Alain du Chemin [5], Christopher G Owen [6], Adnan Tufail [1,2], Alicja Regina Rudnicka [6]

- ✓ **Evaluated on 30,405 patients from x3 DESP**
- ✓ **EyeArt™ System** (V2.1.0, EyeNuk, CA)
- ✓ **DR+ Sensitivity | Specificity: 90.7% | 67.9%**
- ✓ **Save £0.5 million / 100,000 screening episodes**
- ✓ **~50% reduction in grading workload**

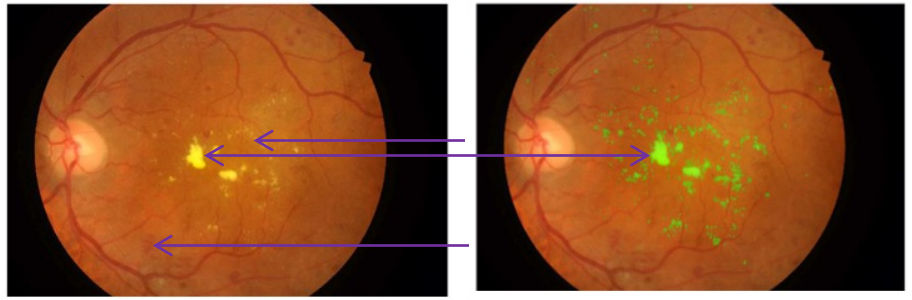
Replacing L1G by an automated system



# DR Detection | Evidence

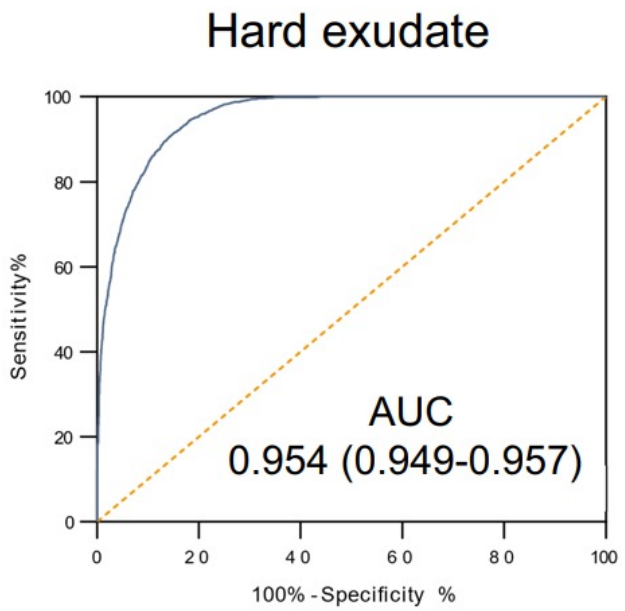
## A deep learning system for detecting diabetic retinopathy across the disease spectrum

Ling Dai[1,2,3,9], Liang Wu[2,9], Huating Li[2,9], Chun Cai[2,9], Qiang Wu[4,9], Hongyu Kong[4], Ruhan Liu[1,3], Xiangning Wang[4], Xuhong Hou[2], Yuexing Liu[2], Xiaoxue Long[2], Yang Wen[1,3], Lina Lu[5], Yaxin Shen[1,3], Yan Chen[4], Dinggang Shen[6,7], Xiaokang Yang[8], Haidong Zou[5]✉, Bin Sheng[1,3]✉ & Weiping Jia[2]✉



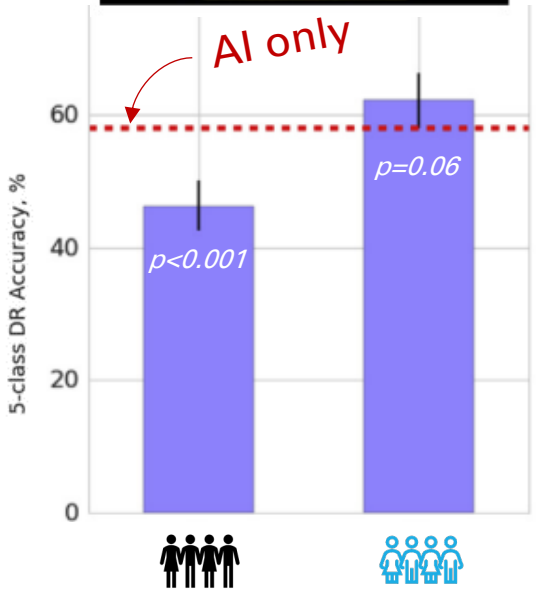
Original Hard exudate

- ✓ **Trained on 466,247 fundus images**
- ✓ **Lesion level detection & DR classification**
- ✓ **Microaneurysm AUROC: 0.90** (95%CI: 0.894-0.906)
- ✓ **Haemorrhage AUROC: 0.97** (95%CI: 0.965-0.969)
- ✓ **Exudate AUROC: 0.95** (95%CI: 0.949-0.957)

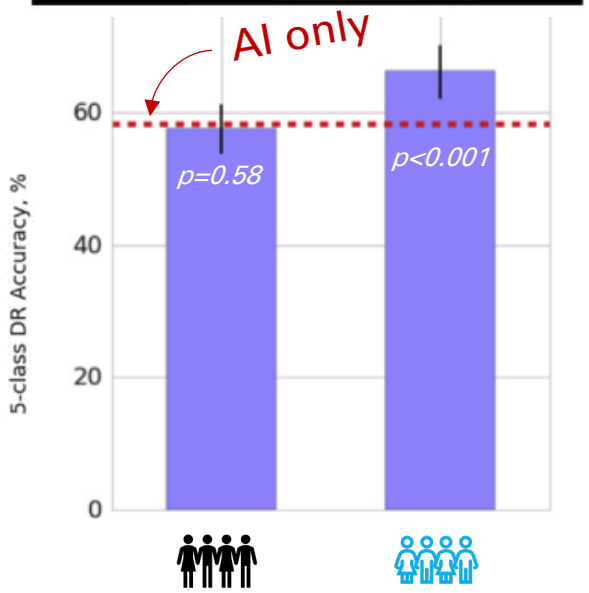


# DR Detection | Evidence

**Unassisted**




**AI-assisted**

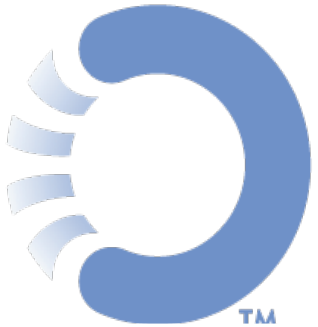




General ophthalmologists

Retinal specialists

✓ Synergy between AI & human graders

# DR Detection | AI Systems



**LumineticsCore**

*FDA Cleared & CE Marked*


**EyeArt**

*FDA Cleared & CE Marked*


**Retmaker**

*CE Marked*

**AEYE Health**

*FDA Cleared*

**ARDA**

*CE Marked, FDA Clearance Pending*


**Galaxy**

*FDA Clearance Pending*

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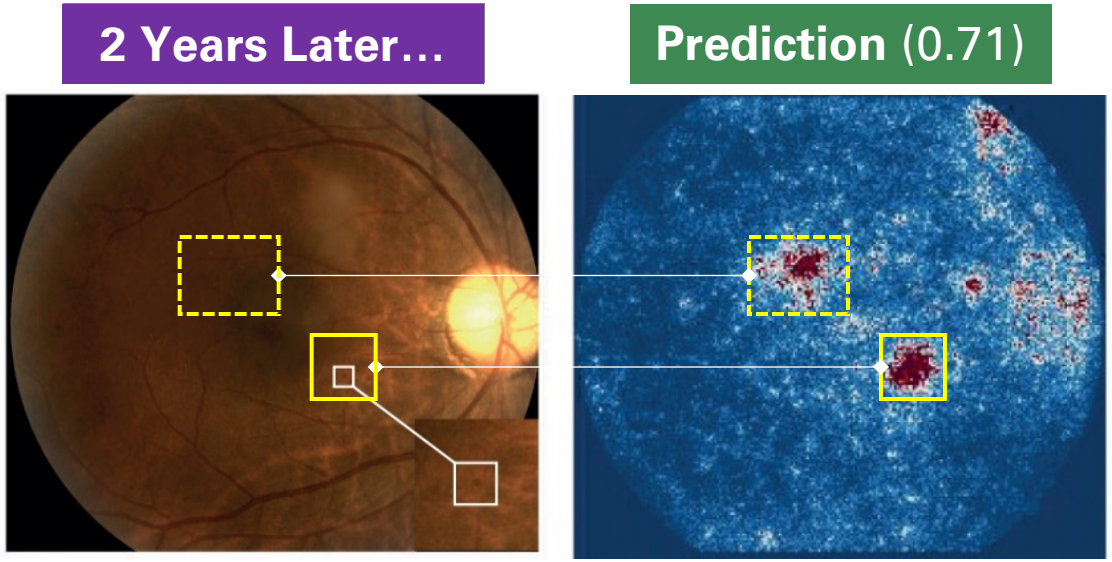
# DR PREDICTION

# DR Prediction | Evidence

## Predicting the risk of developing diabetic retinopathy using deep learning

*Ashish Bora, Siva Balasubramanian, Boris Babenko, Sunny Virmani, Subhashini Venugopalan, Akinori Mitani, Guilherme de Oliveira Marinho, Jorge Cuadros, Paisan Ruamviboonsuk, Greg S Corrado, Lily Peng, Dale R Webster, Avinash V Varadarajan, Naama Hammel, Yun Liu*, Pinal Bavishi**

- ✓ **Trained using 575,431 retinal images**
- ✓ **Predict incident DR+ at 2 years**
- ✓ **Using retinal images alone**
- ✓ **Incident DR+ AUROC: 0.79** (95%CI: 0.75-0.82)
- ✓ **Could predict areas of future DR lesions**

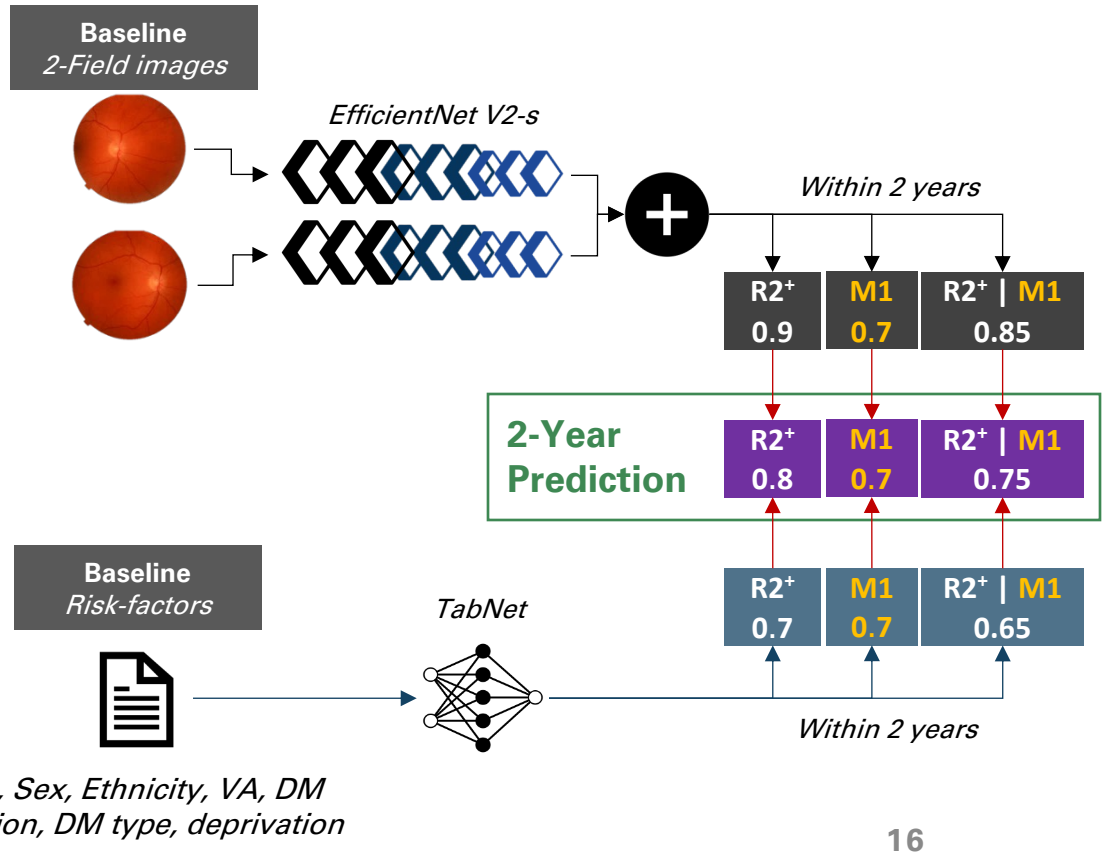


# DR Prediction | Evidence

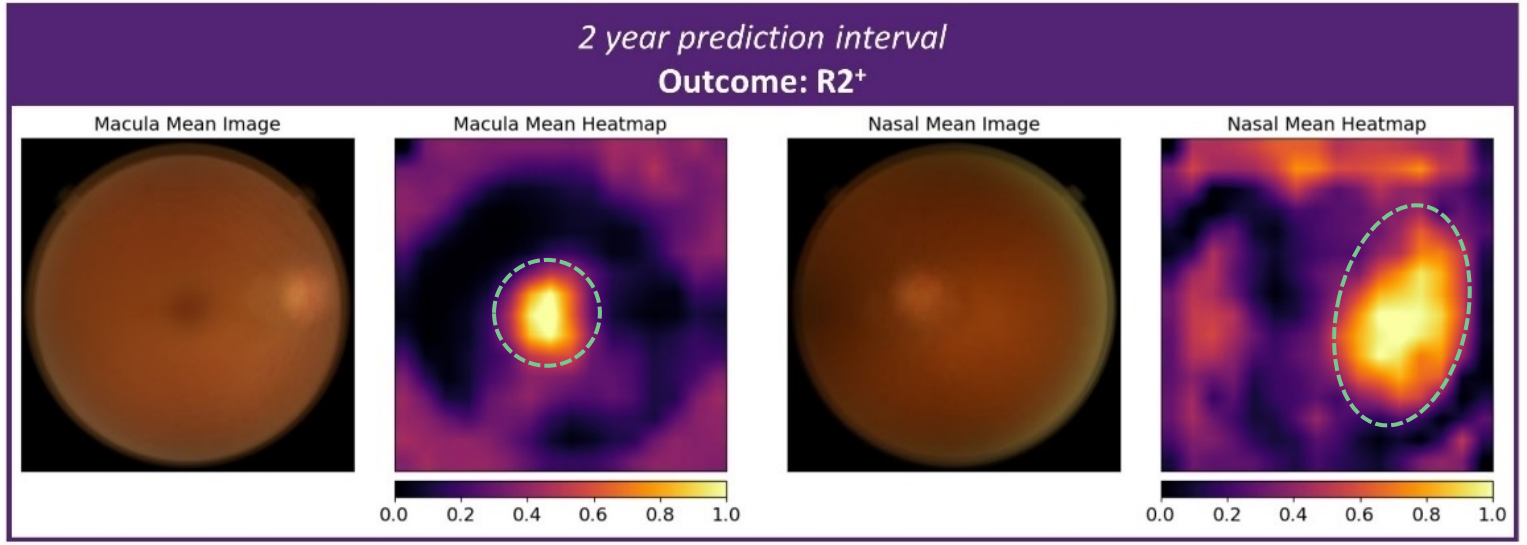
## Predicting progression to referable diabetic retinopathy from retinal images and screening data using deep learning

Paul Nderitu; Joan Nunez do Rio; Laura Webster; Samantha Mann; David Hopkins; Jorge Cardoso; Marc Modat; Christos Bergeles; Timothy L Jackson

- ✓ **Training: 162,339 eyes** (SEL-DESP)
- ✓ **External Validation** (Birmingham-DESP)
- ✓ **Incident R2⁺ or M1 over 1, 2 and 3 years**
- ✓ **2-year R2⁺ AUROC: 0.93** (95%CI: 0.89-0.97)
- ✓ **2-year M1 AUROC: 0.79** (95%CI: 0.74-0.84)

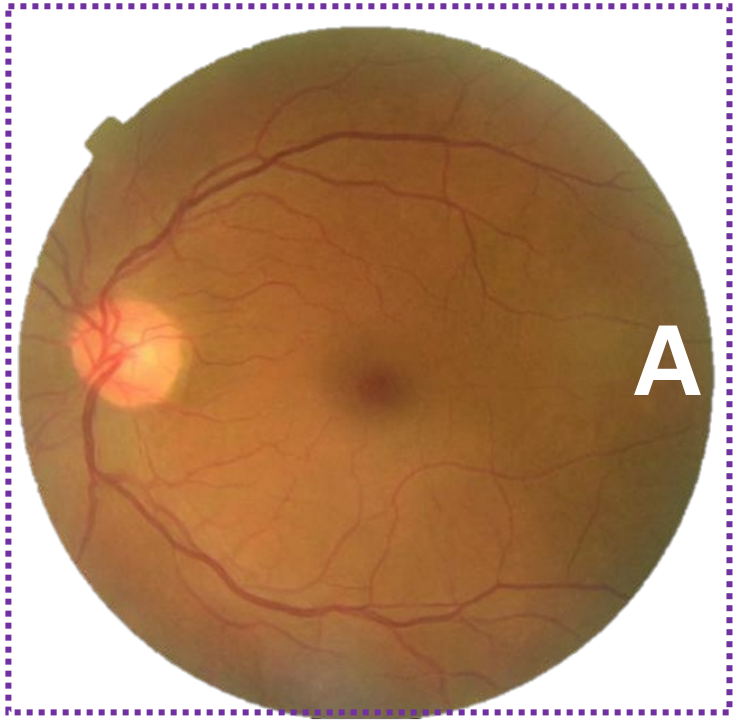


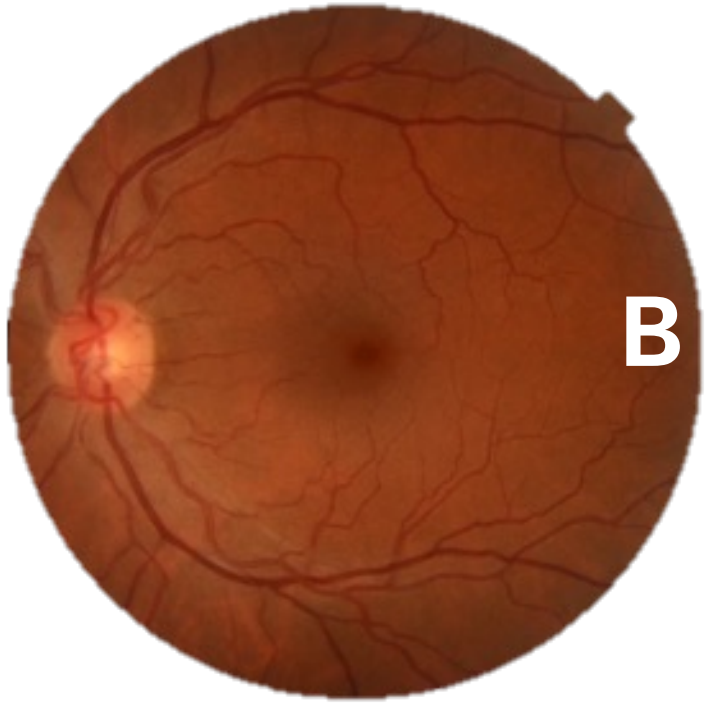
# DR Prediction | Explainability



# DR Generation | Example

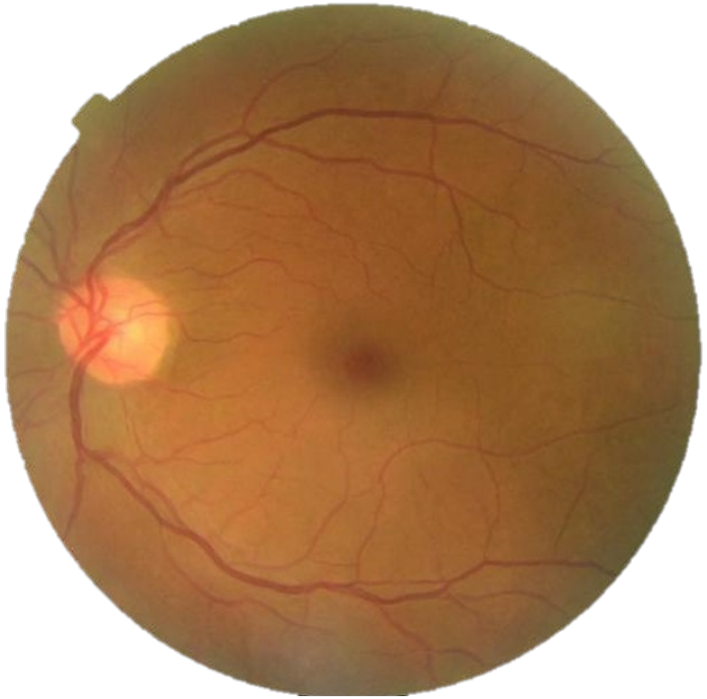
## Which macula does not exist?



# DR Generation | Conditioning

*Generated Image*



*Generated Image*

***Characteristics***

**50-70y Male White**

***Change characteristics***

**50-70y Male Black**

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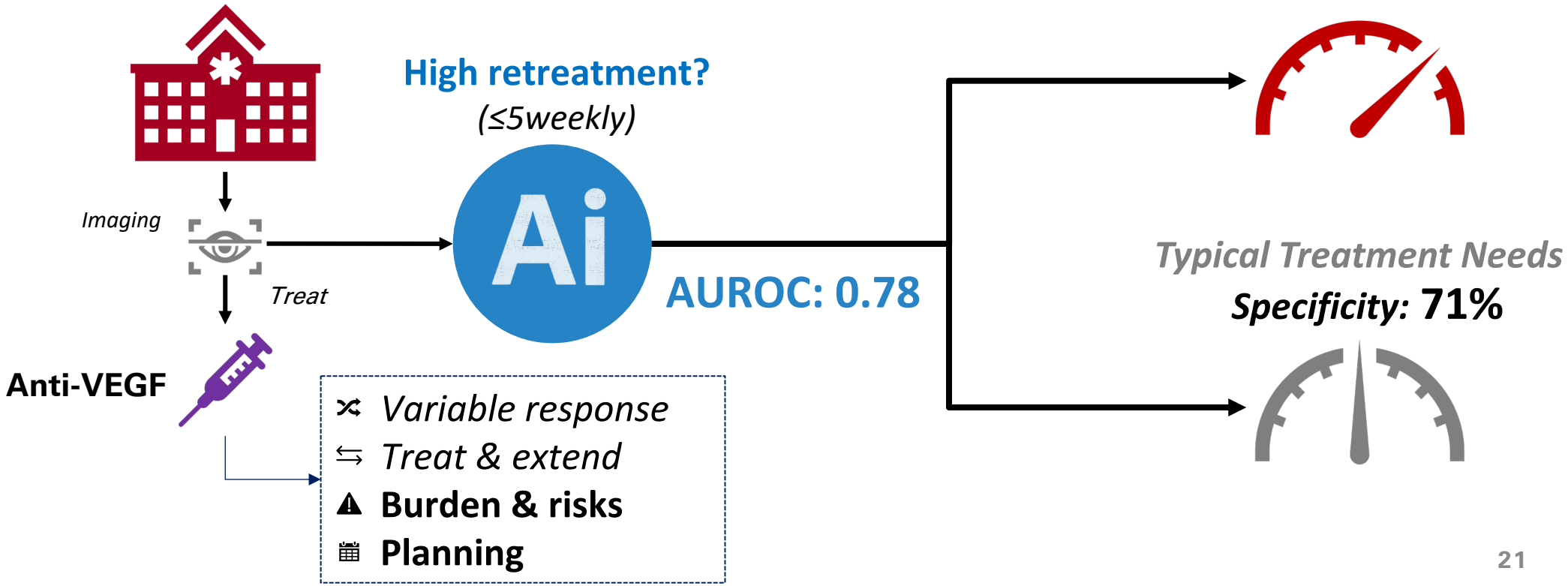
# DR MANAGEMENT

# DR Management | Evidence

## Machine Learning Can Predict Anti–VEGF Treatment Demand in a Treat-and-Extend Regimen for Patients with Neovascular AMD, DME, and RVO Associated Macular Edema

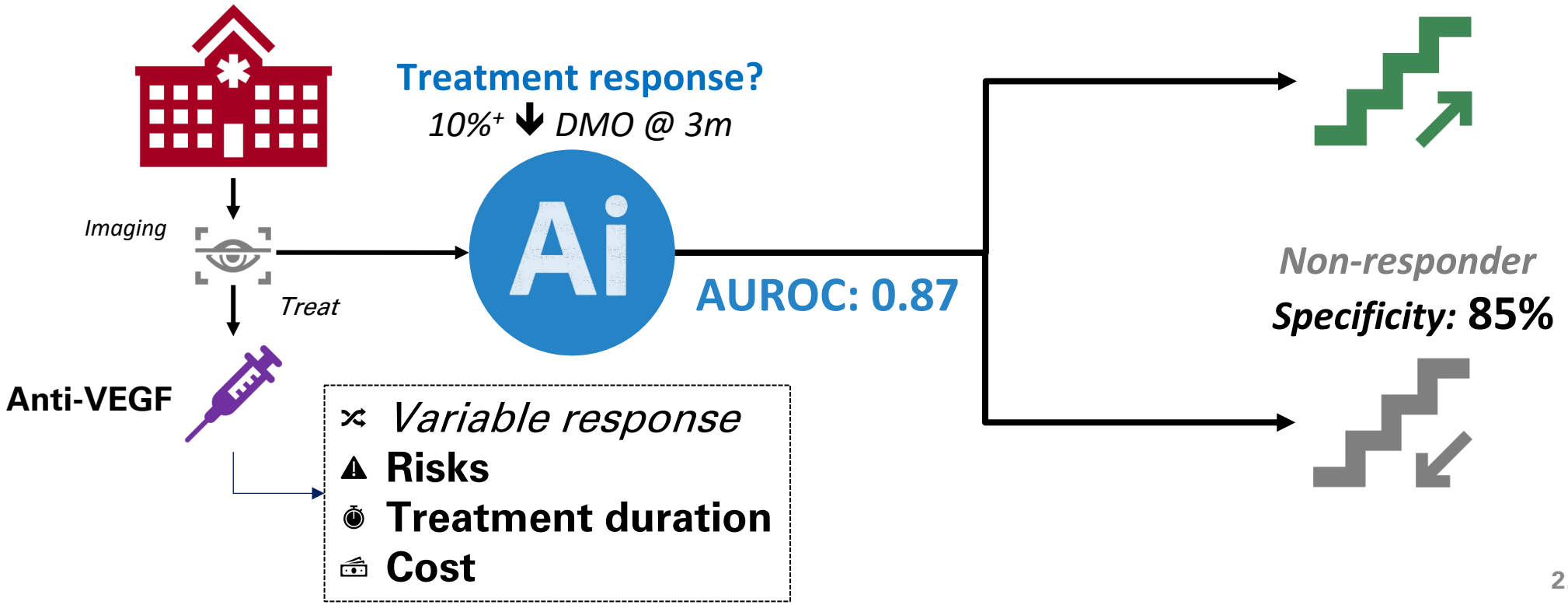
Mathias Gallardo, PhD,[1] Marion R. Munk, MD, PhD,[2] Thomas Kurmann, PhD,[1] Sandro De Zanet, PhD,[5] Agata Mosinska, PhD,[3] Isil Kutlutürk Karagoz, MD, PhD,[2] Martin S. Zinkernagel, MD, PhD,[2] Sebastian Wolf, MD, PhD,[2] Raphael Sznitman, PhD[1]



# DR Management | Evidence

## Deep learning-based single-shot prediction of differential effects of anti-VEGF treatment in patients with diabetic macular edema

Reza Rasti,[1,*] Michael J. Allingham,[2] Priyatham S. Mettu,[2] Sam Kavusi,[3] Kishan Govind,[2] Scott W. Cousins,[2] and Sina Farsiu[1,2]



# IMPLEMENTATION

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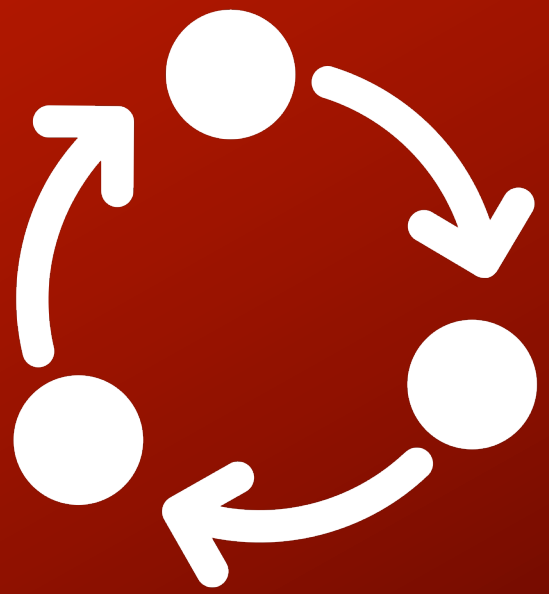
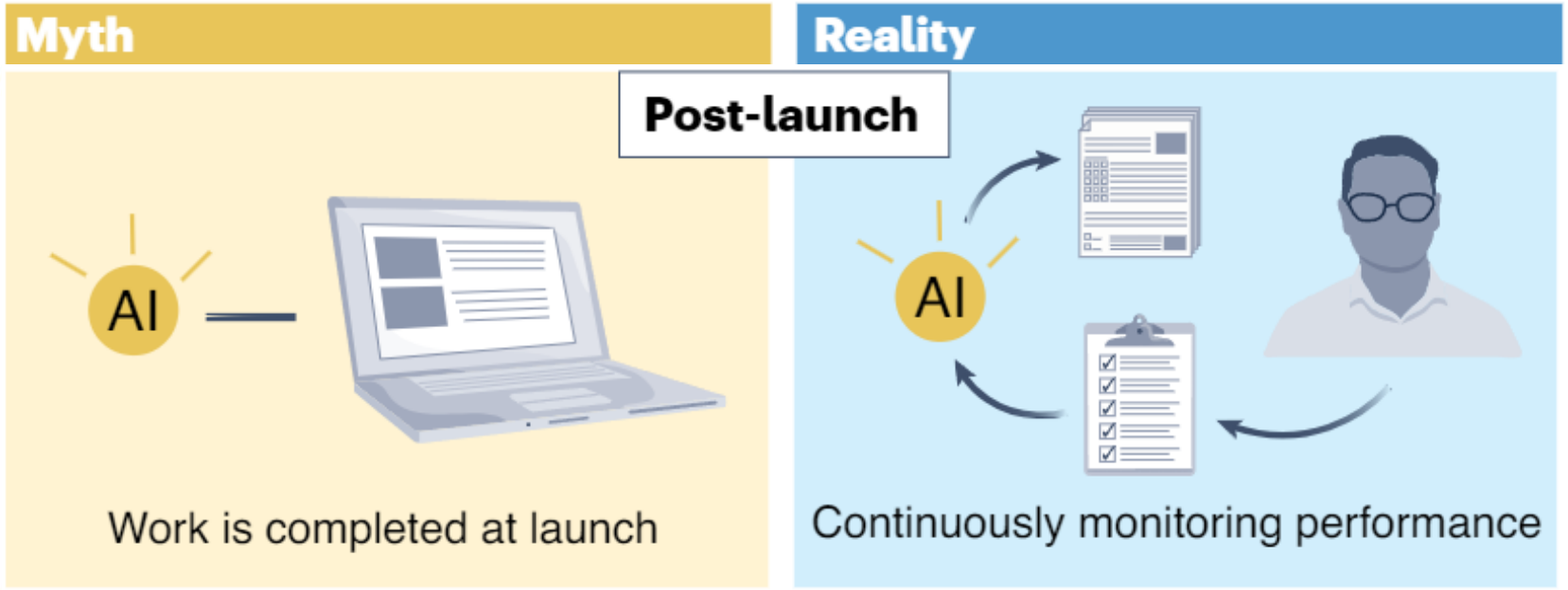


# AI | Myths vs Realities

## Lessons learned from translating AI from development to deployment in healthcare

Kasumi Widner, Sunny Virmani, Jonathan Krause, Jay Nayar, Richa Tiwari, Elin Rønby Pedersen, Divleen Jeji, Naama Hammel, Yossi Matias, Greg S. Corrado, Yun Liu, Lily Peng & Dale R. Webster



# AI | Potential

## Short Term

- Automated DR grading
- Individualised follow-up
- AI-enabled telemedicine
- Multi-disease detection

## Medium to Long Term

- Wider access to DES
- Handheld & widefield retinal imaging
- Treatment decision support systems

# THANK YOU

## *QUESTIONS?*

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