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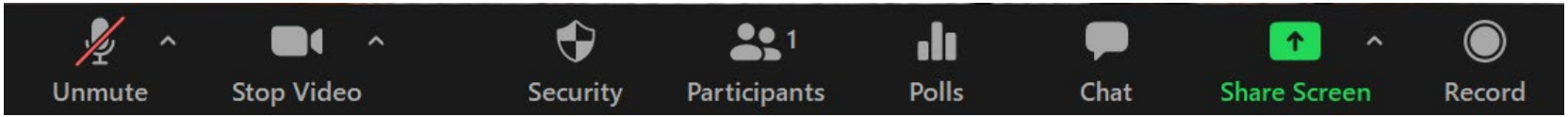
Telehealth & Artificial Intelligence: A Clear Synergy to Increase Effectiveness of Screening in Primary Care

Jorge Cuadros, O.D., Ph.D. | UC Berkeley, Meredith Morgan Optometric Eye Center & EyePACS Inc.

July 18th, 2023

Zoom Tips



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Use Your Video

Please turn on the video for a more collaborative and engaging experience.

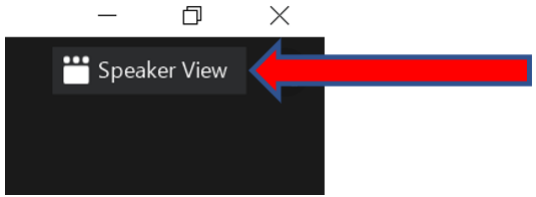
Open the Chat

Please open the chat and use it liberally; we want to hear from you!

Send questions and feedback to **"Everyone"**

Session Recording

We are recording today's session to capture LIVE responses for follow-up material. The recording will not be made public.



Speaker View vs Gallery View

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Before We Get Started

Today's session is purely for informational purposes.

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TELEHEALTH + AI:

A Clear Synergy To Increase Effectiveness of Screening in Primary Care

Jorge Cuadros, OD, PhD

Asst Clinical Professor, University of California, Berkeley

CEO, EyePACS Inc.

Berkeley Herbert Wertheim School of Optometry & Vision Science

What Is This Talk About?
- A Review and Case Study of Telehealth + AI

- Brief history of Telehealth and AI screening in California
- Retinal screening in primary care
- Telehealth benefits and limitations
  - Workforce availability and expertise
- AI benefits and limitations
  - Things that AI can do and humans can't (and vice versa)
- Clinical validation vs. real-world experience
  - Data diversity, data acquisition, and evolving technology
- Sustainability: resource and billing considerations
- Future developments: broadened screening and care everywhere

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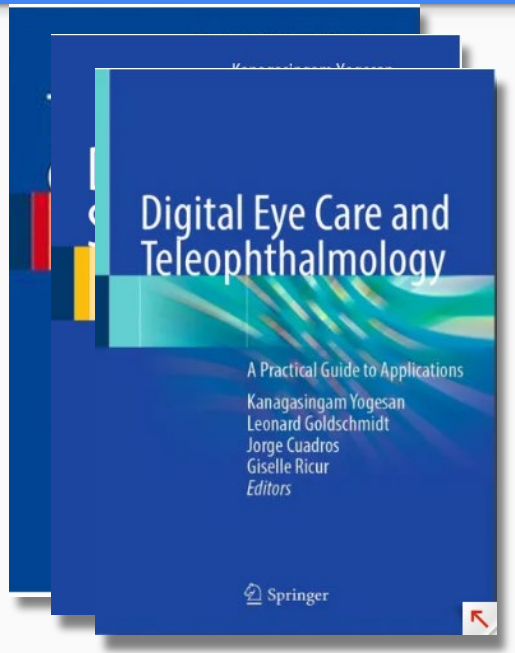
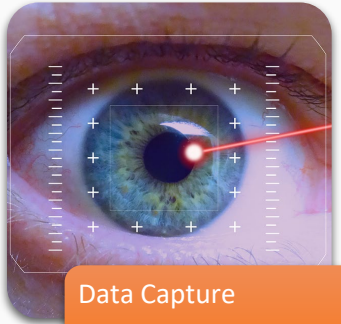
Telehealth for Eye Care in California

- California Telemedicine Development Act of 1996
- Slow growth 1990's to 2010's
  - Grant driven development (CHCF, NIH/NEI, endowments)
  - Commercial initiatives come and go (Innoveon, Digital Healthcare, EyeTel..)
- Reimbursement models take shape for ocular telehealth
  - 92227, 92228, 92250 TC/26, PPS for FQHCs codified
  - HEDIS measures, UDS measures driving adoption in primary care
- Guidelines and best practices
  - ADA screening, ATA guidelines, AAO and professional organizations
- Technology advances
  - Moore's law, Nielsen's law, cloud computing, deep learning..



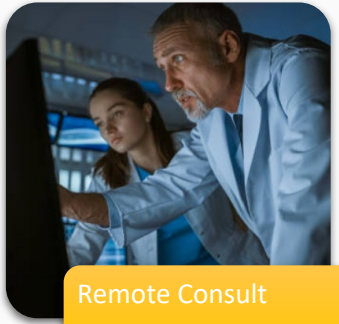
2007 - 2023: Three Teleophthalmology Books

Traditional Asynchronous Telemedicine Screening Workflow:



Data Capture
- Images
- Clinical Info

Data Storage
- Cloud
- Server



Remote Consult
- Web Portal
- VPN

Patient Management
- Report
- Referral

Results of TM Screening 2013 to 2020	Rate
Sufficient quality images (desktop cameras)	91%
Sufficient quality images (robotic cameras)	95%
Any level of diabetic retinopathy	28%
Moderate or worse retinopathy	15%
Sight-threatening retinopathy	6%
Referral for other conditions (cataracts, glaucoma, maculopathy, etc.)	5%
Encourage regular eye care services	100%

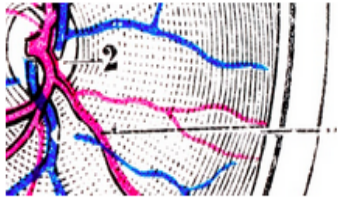
TM DRS USED WITH VALIDATED DEVICES AND VALIDATED IMAGING PROTOCOLS:

- Results of 536,323 encounters over 8 years
- Average turnaround time was about 4 hours
- Turnaround range was 2 minutes to 2 weeks
- Results vary with non-validated systems (i.e. not comparable to gold standard)

2015 - AI for Diabetic Retinal Disease Detection

Kaggle Competition Grand Challenge

- Launched with 100,000 images in February, 2015
- Ended on July 27, 2015
- 661 teams 6,999 entries
- Best quad κ score is .86 – better than humans who have best score of .83
- Kaggle dataset used by thousands of developers, including 3 FDA approved AI
- Nearly 2000 appearances in publications



$100,000 • 268 teams

Diabetic Retinopathy Detection

Tue 17 Feb 2015

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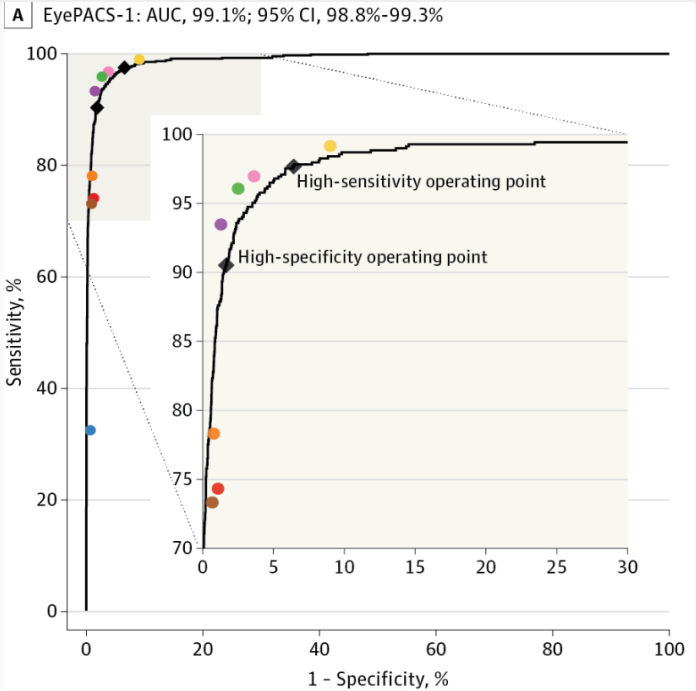
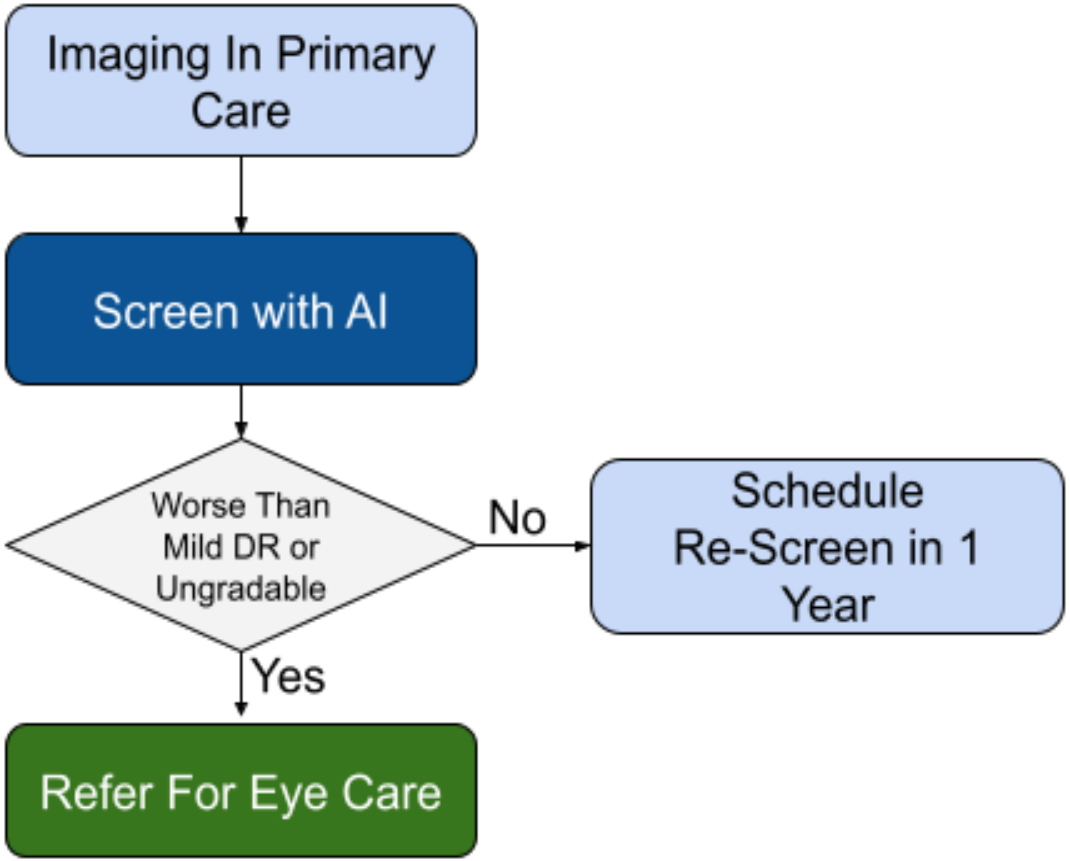
SUPPORTING IDEAS & INNOVATIONS TO IMPROVE HEALTH CARE FOR ALL CALIFORNIANS

See: https://www.kaggle.com/c/diabetic-retinopathy-detection

JAMA 2016: Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs - *Gulshan et al*

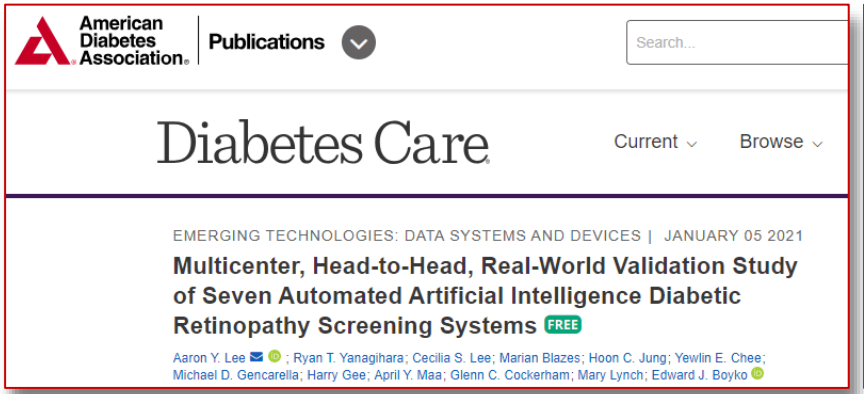
- One of JAMA's 10 most influential publications of the decade (2010 to 2020)
- Google develops highly accurate detection of diabetic eye disease from images
- Key findings:
  - Convolutional Neural Networks, Deep Learning using Inception v3 architecture produces excellent results!
  - Sensitivity of 97.5%
  - Specificity of 93.4%
- High bar for algorithm development → three FDA now approved autonomous AI programs for DR screening





The Promise Of Autonomous Diabetic Retinopathy Screening:

- Reduces demand on eye care providers
- Increases accuracy
- Reduces cost



American Diabetes Association. | Publications

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Diabetes Care

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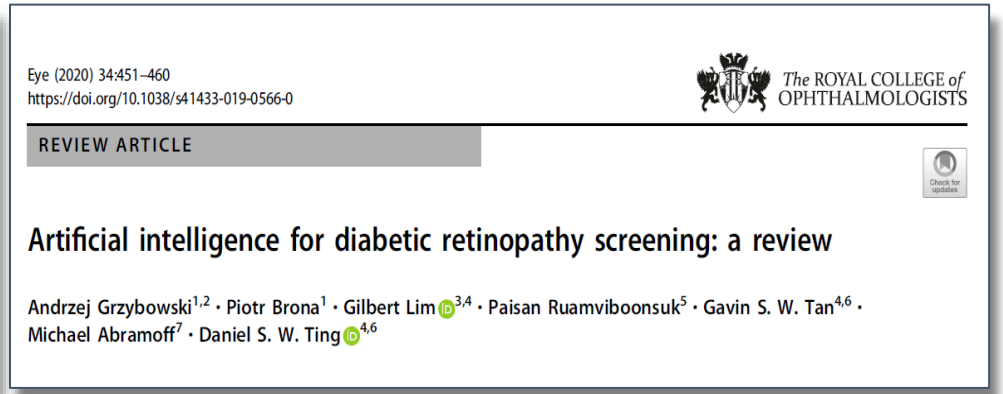
EMERGING TECHNOLOGIES: DATA SYSTEMS AND DEVICES | JANUARY 05 2021

Multicenter, Head-to-Head, Real-World Validation Study of Seven Automated Artificial Intelligence Diabetic Retinopathy Screening Systems FREE

Aaron Y. Lee ✉ ; Ryan T. Yanagihara; Cecilia S. Lee; Marian Blazes; Hoon C. Jung; Yewlin E. Chee; Michael D. Gencarella; Harry Gee; April Y. Maa; Glenn C. Cockerham; Mary Lynch; Edward J. Boyko



Eye (2020) 34:451–460
https://doi.org/10.1038/s41433-019-0566-0

The ROYAL COLLEGE of OPHTHALMOLOGISTS

REVIEW ARTICLE

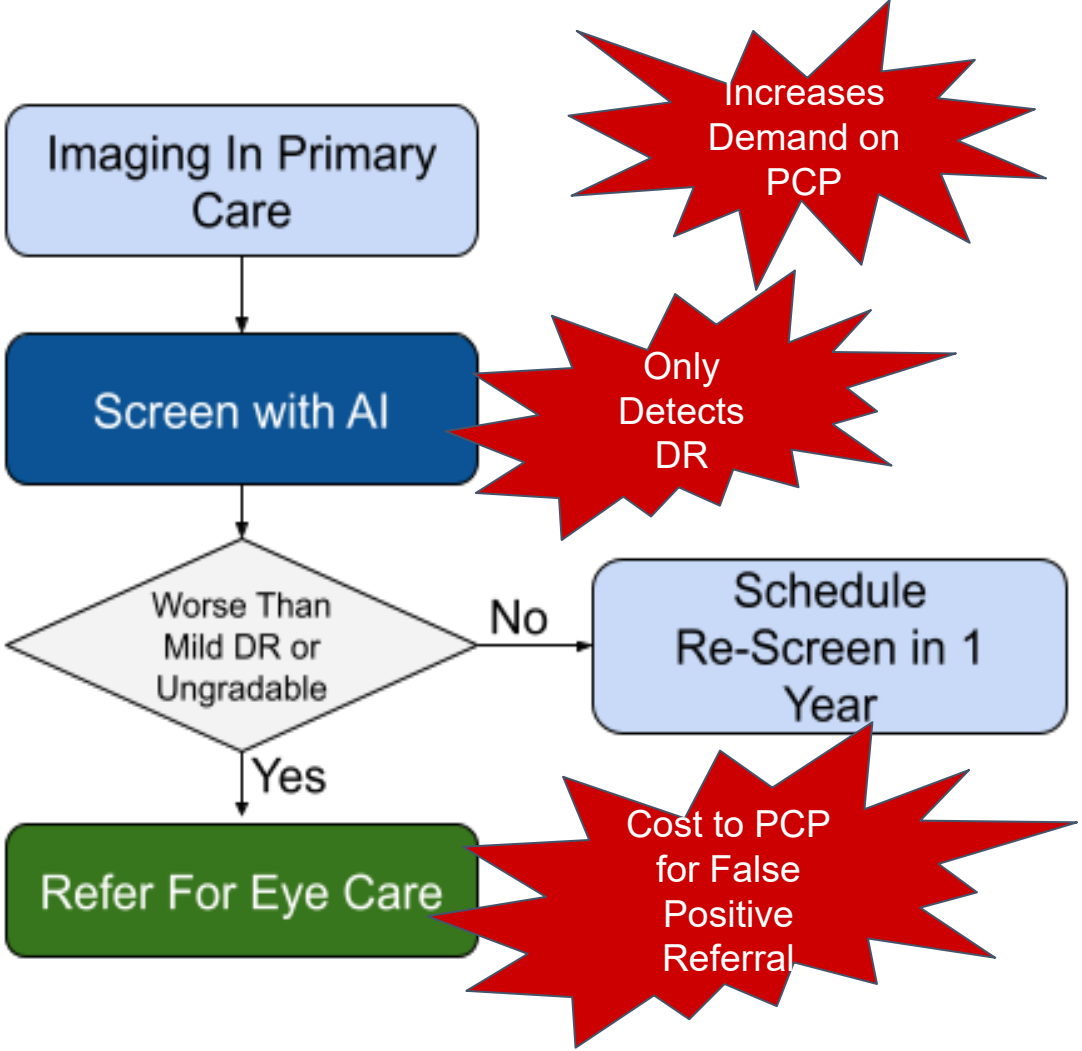
Artificial intelligence for diabetic retinopathy screening: a review

Andrzej Grzybowski[1,2] · Piotr Brona[1] · Gilbert Lim[3,4] · Paisan Ruamviboonsuk[5] · Gavin S. W. Tan[4,6] · Michael Abramoff[7] · Daniel S. W. Ting[4,6]

- 23,724 teleretinal DR screening Atlanta Veterans
  - 95% Male, 28% African American, 60% Caucasian, 62 yr. average age
- Sensitivity: 50.98 to 85.90%, Specificity: 60.42 to 83.69%
- Human graders: Sensitivity 82.22%, Specificity 84.36%

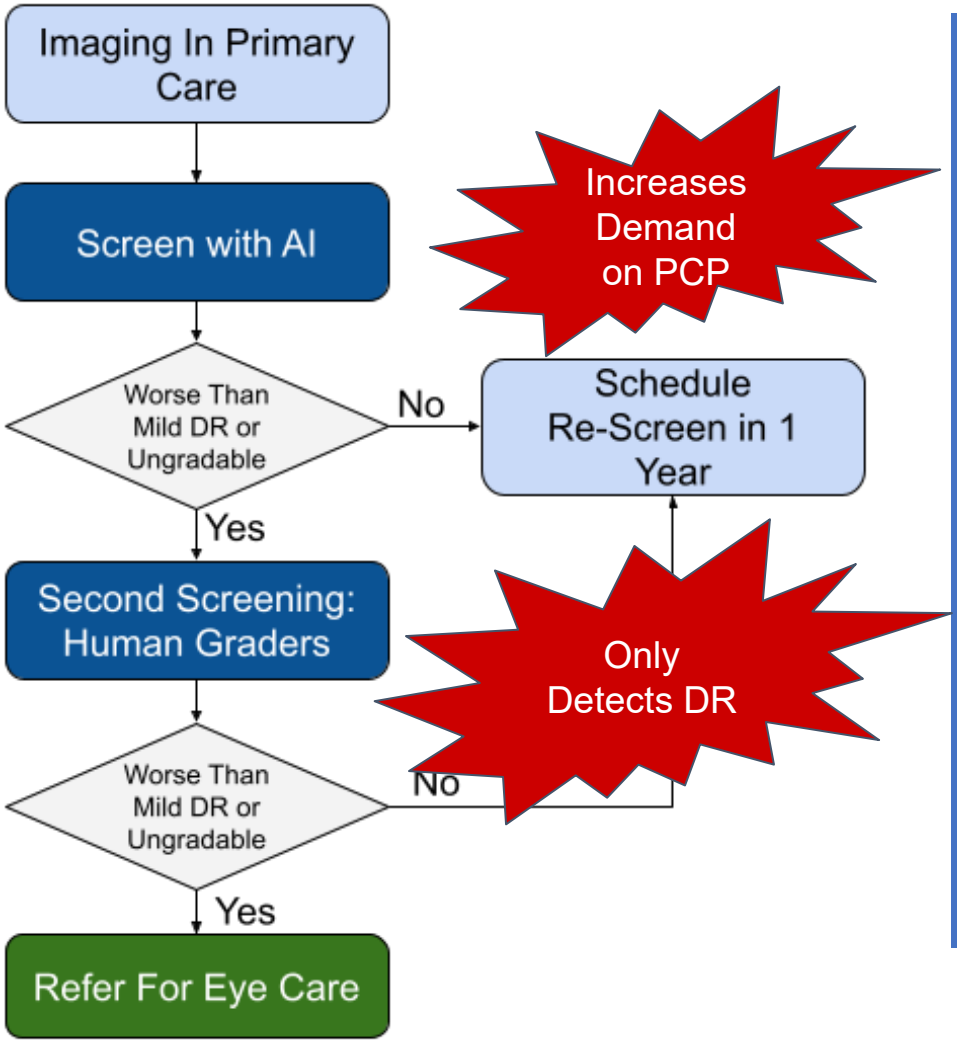
* (Cuadros J. The Real-World Impact of Artificial Intelligence on Diabetic Retinopathy Screening in Primary Care. J Diabetes Sci Technol. 2021 May;15(3):664-665. doi: 10.1177/1932296820914287. Epub 2020 Apr 24. PMID: 32329352; PMCID: PMC8120063)

- Review of Major AI programs
  - IDxDR, EyeArt, ARDA, RetMarker, Retinalyze, Bosch, and others
- Ungradable rates vary by AUC (lower AUC, higher gradability)
- Ex 1: 17% ungradable: sensitivity/specificity of 91%/84%;
- Ex 2: 2% ungradable: sensitivity/specificity 86%/54%
- Real World approximation: 15% ungradable, sensitivity 90%, specificity 90% → PPV ~ 20%* (4 of 5 false positives)



The Promise Of Autonomous Diabetic Retinopathy Screening:

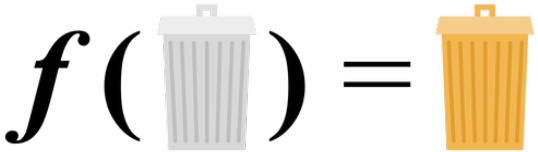
- Increases demand on primary care to manage program, improve image quality
- Increases accuracy, but can't screen other conditions
- Increases referral costs due to false positives



Alternative Workflow with Human TM Consultants to Refine Intervention:

- Improves precision of referral
- What to do with ungradable images?
- Still doesn't catch other conditions

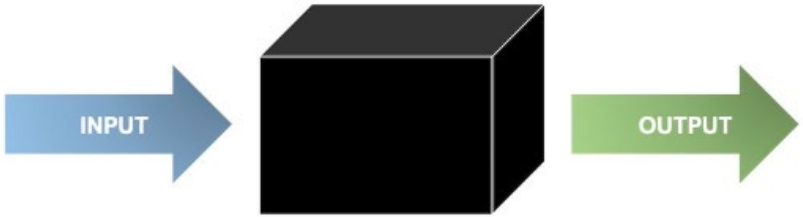
Other Concerns With AI :



Ground truth may not represent real world experience*

- Racial, gender, social bias
- Inequality of opportunity
- Inequality of odds

- Generative AI might address bias in the future



"Black box" processing: We can't see how deep learning makes decisions

- Use explainable AI to show what features led to decision
- Mark regions of interest in images
- Allows for greater human interaction

*Burlina P, Joshi N, Paul W, Pacheco KD, Bressler NM. Addressing Artificial Intelligence Bias in Retinal Diagnostics. Transl Vis Sci Technol. 2021 Feb 5;10(2):13. doi: 10.1167/tvst.10.2.13. PMID: 34003898; PMCID: PMC7884292.

Photography, Retinal Reading, and Quality Assurance: SimulARDA

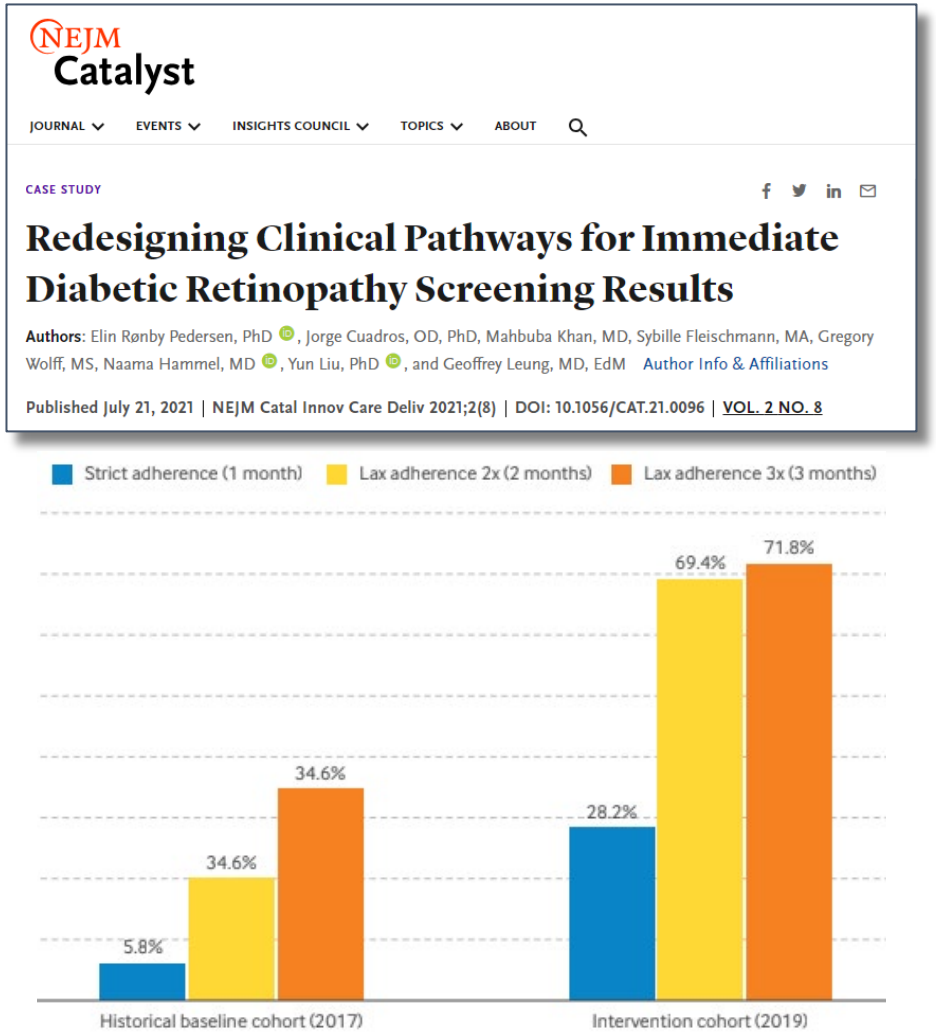
- n= 15,839
- 51 RUHS photographers certified using AI certification program.
- 26 Certified and credentialed image readers (selected UC Berkeley Optometry Faculty)
- Average turnaround time is 5 minutes 49 seconds
- In addition to Diabetic Retinopathy level, graders systematically identify Cataract, Glaucoma, Non-diabetic maculopathy, and Other conditions requiring referral
- Less than 2% false negative rate in the matrix .

Clinician Grade	Algorithm No DR	Algorithm Mild DR	Algorithm Moderate DR	Algorithm Severe DR	Algorithm PDR or Dme
no_dr	44.85%	21.54%	1.45%	0.55%	0.09%
mild_dr	3.13%	3.99%	0.50%	0.01%	0.01%
moderate_dr	0.62%	6.18%	6.29%	1.00%	0.07%
severe_dr	0.01%	0.10%	0.51%	0.68%	0.11%
pdr_dme	0.24%	0.37%	1.22%	2.93%	1.26%

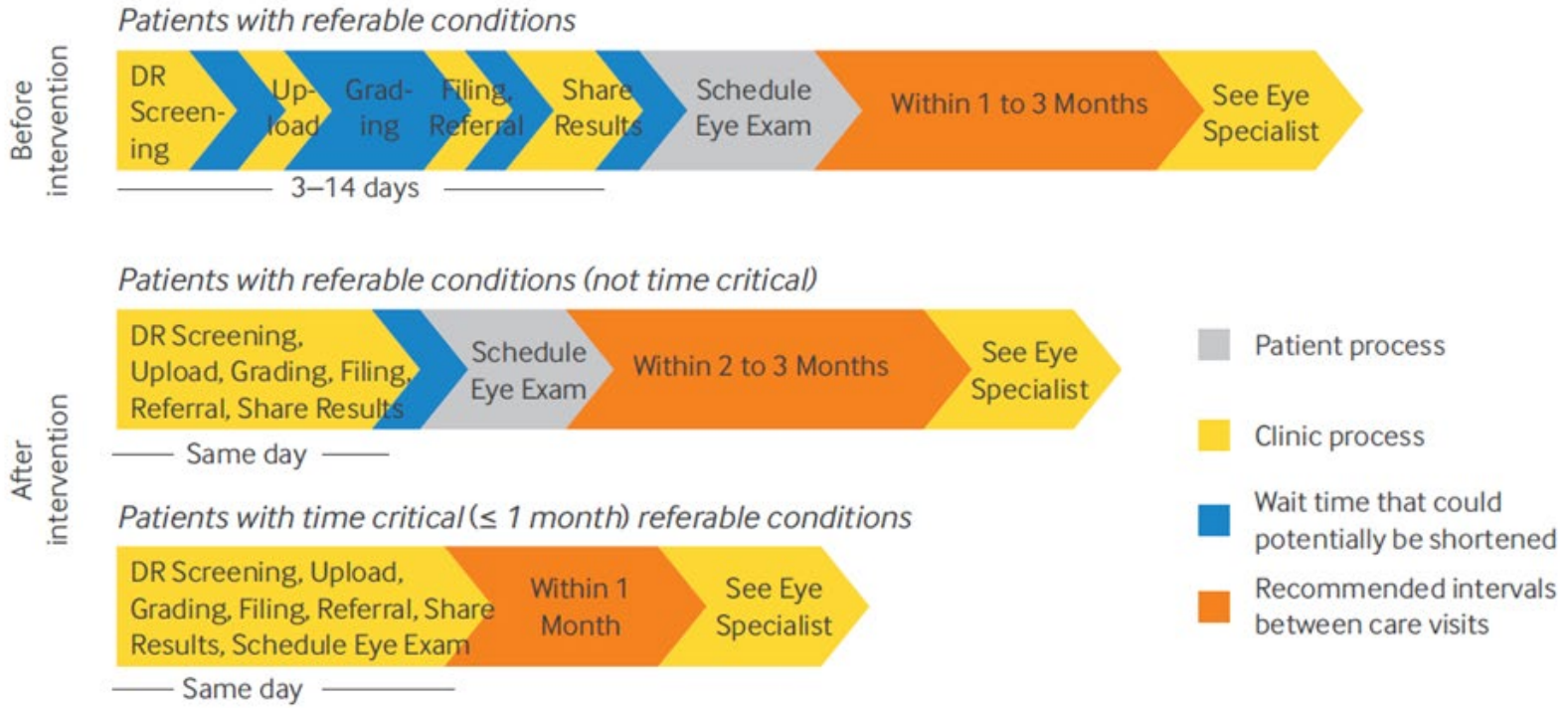
Confusion Matrix of Human vs. Retinal Algorithm grades.

Immediate Triage: The Best Feature of AI + TM

- N = 215 out of 1629 (7.5%) patients screened and detected to have sight-threatening diabetic retinopathy
- Half followed from screening to treatment before redesign
- Half followed after co-designing primary care workflow:
    - Immediate appointment given to ophthalmology
    - Patient education and engagement provided at POC
- Up to 4 fold increase in adherence to referral recommendations



Co-design of Workflow



Why Do We Screen In Primary Care Clinics?

- **Quality Measures:**
  Improve Rate of Screenings → incentives/pay-for-performance
- **Referral Effectiveness:**
  Detect and Triage Conditions Before It's Too Late
- **Self-Management:**
  Improves Patient Education And Engagement About Their Conditions

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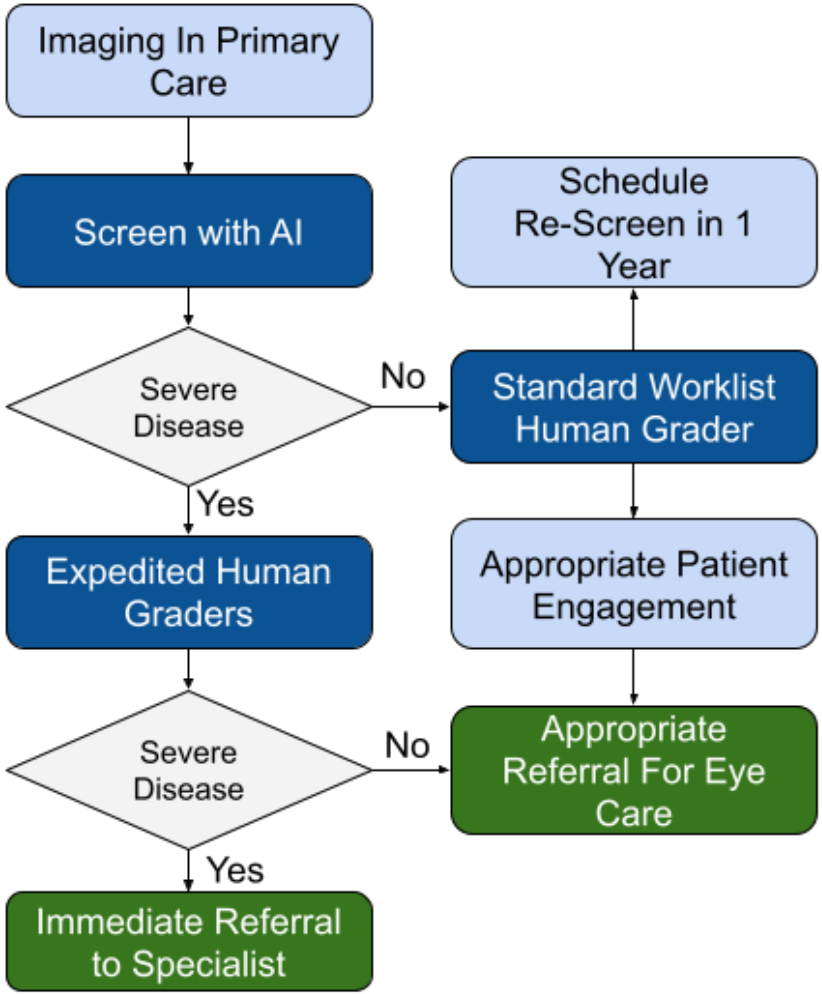


Immediate Read Workflow with Human TM Consultants to Refine Intervention:

- Expedites triage of patients at risk of vision impairment
- Readers engage with primary care staff
- Refines referral and return recommendations
- Detects other diseases

Future Efforts

- AI can see things that humans can't in retinal images:
  - CVD risk, nephropathy, hyperlipidemia
  - Future risk of systemic disease and cognitive disorders
- Detection of systemic disease from external images of the eye ("eye selfie")
- AI can review EMR and improve triage of those who are at-risk *
- One of the fastest areas of growth: remote eye exams due to shortages of both ophthalmologists and optometrists.

*Ogunyemi O, Kermah D. Machine Learning Approaches for Detecting Diabetic Retinopathy from Clinical and Public Health Records. AMIA ... Annual Symposium proceedings. AMIA Symposium. 2015;2015:983-990. PMID: 26958235; PMCID: PMC4765709.

nature biomedical engineering

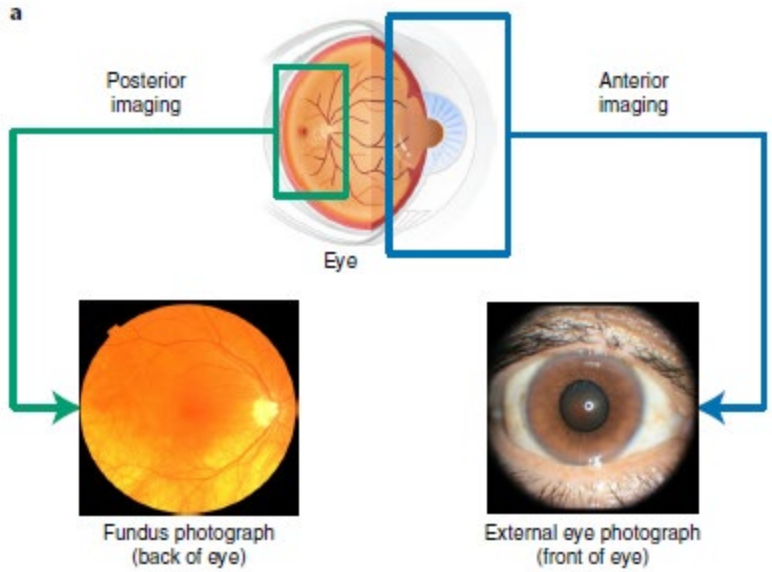
ARTICLES

https://doi.org/10.1038/s41551-022-00867-5

Check for updates

Detection of signs of disease in external photographs of the eyes via deep learning

Boris Babenko[1,7], Akinori Mitani[1,2,7], Ilana Traynis[3], Naho Kitade[1], Preeti Singh[1], April Y. Maa[4,5], Jorge Cuadros[6], Greg S. Corrado[1], Lily Peng[1], Dale R. Webster[1], Avinash Varadarajan[1], Naama Hammel[1]✉ and Yun Liu[1]✉



Key Takeaways for AI Screening:

- Use validated, effective interventions to target and triage patients at risk, not just to meet quality measures.
- AI won’t help to prevent complications without a change to workflows and clinic processes
- Best scenario for screening in primary care is AI + Telehealth for greater depth and breadth
- Screening interventions are as much triage and patient engagement as they are diagnostic tests - AI should assist this view

Thank You!

jcuadros@berkeley.edu

The Future is Virtual Care – But How Do We Get There, Sustainably?

August 15th @ 12 Noon PT

By now it's obvious to everyone that virtual care is here to stay. The key question though is: how can health centers, health systems, hospitals, and behavioral health agencies make virtual care an integral part of their care delivery? How can we achieve financial sustainability, clinical sustainability, and strategic sustainability? What approaches can we take to increase clinician buy-in and commitment by leadership?

Based on 15+ years of experience implementing virtual care services, Christian Milaster will share a set of pragmatic approaches, mindset models, and tactics to enable those who care about virtual care to make it stay. Sustainably.

The presentation will present approaches and tactics:

- to create clinician buy-in and leadership commitment
- to build the business, financial, and clinical case for virtual care
- to increase your organization's virtual care maturity
- for telehealth optimization: workflows, technology, and policy
- to create a virtual care and digital health strategy
- to manage virtual care performance

Presented by: Christian Milaster, MS| Founder, President & CEO of Ingenium Digital Health Advisors

https://ochinhq.zoom.us/meeting/register/tJUkdeCoqD4tHtb9yQzZdmHeT-qhbjZ0R1dN

Thank **You**

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