Welcome

Grace Wickerson
Science Policy Fellow,
Federation of American Scientists
Please navigate to the Google doc linked to on the agenda for our interactive reflection

https://bit.ly/3DK0KDA
Keynote:

“Open Oximetry: Designing a Better Pulse Oximeter”

Gregory Leeb
Fellow, Center for Health Equity in Surgery & Anesthesia, UCSF
The Open Oximetry Project

Harmonized approach to address data transparency, device performance, and regulatory challenges.

Join the Collaboration

www.openoximetry.org
Part 1: Understanding The Consequences of Bias
“Small Biases Can Translate Into Large Differences: An Example From COVID-19”

Tianshi David Wu
Assistant Professor, Pulmonary and Critical Care Medicine, Baylor College of Medicine
Pulse Oximetry as a Gatekeeper of COVID-19 Therapies

- Among 6,673 patients with COVID-19 treated at Johns Hopkins hospitals, we estimated that 29% had delayed recognition of eligibility for COVID-19 therapies because of pulse oximetry inaccuracy.
- An observed ~1.2 percentage point bias in accuracy resulted in Black patients having a 29% higher risk of delayed recognition.
- 451 patients never had severe COVID-19 recognized, and more than half were Black.

Fawzy and Wu, et al, JAMA Int Med 2022
“Racial Disparities in Pulse Oximetry Cannot Be Fixed With Race-Based Correction”

Neal Patwari
Professor, Electrical and Systems Engineering, Washington University in St. Louis
Race correction won’t fix occult hypoxemia discrimination

- Used eICU dataset, as [Sjoding 2020]
  - SpO2 error = SpO2 - paired SaO2
    - Patients racialized as Black see higher variance vs. racialized as white
- Detect hypoxemia: SpO2 < X, for some X
  - Performance on + & - cases on two axes
  - Vs. any possible threshold X
  - May use different X (race-based)
- No correction can achieve equal results
  - Response to [Philip 2021]
- We have to repair the sensor itself
  - Race ≠ skin color, so…
- The reason pulse ox isn’t fixed is racism

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Part 2: How to Build an Evidence-Base for Bias-Free Oximetry
“Using Big Data Sets to Assess Medical Technologies”

Jackie Gerhart
Vice President, Clinical Informatics,
Epic Cosmos

Sam Butler
Senior Vice President, Clinical Informatics,
Epic Cosmos
“Understanding Skin Tone Bias in Pulse Oximetry: The Roles of Measurement and Regulatory Standards”

Ellis Monk
Associate Professor, Sociology,
Harvard University
Dichotomous sex categories make simple orienting frames, but by the same token they are too diffuse to define behavior adequately in most contexts” (Ridgeway & Smith-Lovin 1999: 193).
“Race,” Color, and Education (U.S.)

Race, Skin Tone, and the CJS

Arrest

<table>
<thead>
<tr>
<th>Skin Tone</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blacks</td>
<td>0.36</td>
</tr>
<tr>
<td>Whites</td>
<td>0.21</td>
</tr>
<tr>
<td>Very Light</td>
<td>0.24</td>
</tr>
<tr>
<td>Medium</td>
<td>0.34</td>
</tr>
<tr>
<td>Very Dark</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Health disparities in black and white?

- Health disparities between blacks and whites often remain even after controlling for SES and health behaviors (Das 2013).

- Health disparities within-race are often as large or even larger than between-race health disparities (Williams & Sternthal 2010).

- The lightest-skinned blacks have 44% higher odds of perceiving more color discrimination.

- The darkest-skinned blacks have 62% higher odds of perceiving more color discrimination.

- Medium-tone blacks have 26% lower odds of perceiving more color discrimination.
Unique consequences of intraracial discrimination

- Intraracial skin color discrimination may be an analytically and empirically distinct form of discrimination that has consequences for health above and beyond everyday and/or major lifetime discrimination.

- Rejection from the ingroup is likely to be extremely damaging for health. It takes away a common coping mechanism (e.g. friends and family). It catches its victims with their “guards down,” unlike interracial discrimination (see Keyes on ‘flourishing’).

After controlling for sociodemographic factors, and everyday, major lifetime, and skin color (from whites) discrimination:

- Cardiovascular and cardio-metabolic disorders: IRR=1.07 [Everyday discrimination NS]
- Pain: OR=1.12
- Sensory dysfunction: OR=1.23
- Morbidity: OR=1.10 [Everyday discrimination NS]
Needed foundational research needs standards for skin tone measurement

- **“Subjective”:** Fitzpatrick, von Luschan, Massey-Martin, Monk.
  - May be subject to inter-coder reliability issues, scales may not cover the right range of skin tones (e.g., Fitzpatrick).

- **“Objective”:** Colorimeters, Spectrophotometers, etc.
  - Expensive, no consensus on which ‘objective’ standard is the standard, questions remain over global versus site specific skin tone.

- We cannot move forward with fixing ethnoracial and skin color bias in pulse oximetry without settling on standards for skin color measurement.
- The measurement of skin color drives the recruitment of patients and volunteers into research.
- The measurement of skin color is a prerequisite for adequate testing of existing and future pulse oximeters (and similar devices).
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Part 3: Approaches to Building More Equitable Devices
“Futures of Equitable Design”

Amy Moran-Thomas
Associate Professor, Anthropology, MIT
How to Continue Learning from Interdisciplinary Perspectives to Remake Unequal Health Devices

- Makeshift interdisciplinary collaborations (including among doctors, engineers, STS & medical humanities scholars) were necessary for this issue to receive overdue federal scrutiny. How can such socio-technical dialogues be expanded, funded, and sustained ahead?

- There is an extraordinary amount of data available today. What is often missing are meaningful social questions to reframe this data with fresh eyes and unorthodox perspectives. Bridges allowing for cross-disciplinary exchange of ideas are vital to this ongoing work ahead.

- Practitioners & technologists should continue engaging with key socio-technical insights provided by fields like STS, anthropology, sociology, and history – in order to more robustly learn from past and present dilemmas as we face new futures of computing & healthcare.
“Equitable Optics: the UCLA Pulse Oximeter and Plethysmograph”

Achuta Kadambi, PhD
Assistant Professor, Electrical Engineering & Computer Science,
UCLA

Joint work with Dr. Laleh Jalilian, MD and Pradyumna Chari
The UCLA Pulse Oximeter

Demonstrate equitable pulse oximetry at UCLA through computational imaging and light transport

Light Transport: Algorithm and Sensor Techniques to Interpret the Flow of Light
[Kutulakos16 Communications of the ACM]
Reducing oximetry bias (a step toward equity)

Preliminary results show that the UCLA oximeter approaches skin tone equity.
Application to Remote PPG

Cropped Face Frame

Estimated Waveform from Camera - 74.2

Pulse Oximeter Ground Truth - BPM 83.1

Vilesov, Chari, Armouti et al. SIGGRAPH 2022
Device Circuitry Relies on Computational Light Transport

**Hardware**

**Computational Light Transport**

- **Physical bias**
- **Computational bias**
- **Interpretation bias**

*Figure from “Achieving Fairness in Medical Devices”, Science 2021*
Algorithms, Sensor Diagrams, and Data will be available at visual.ee.ucla.edu post publication

Collaboration Opportunities:
Cross-Institute Dataset Validation
Collaboration on papers with UCLA
Additional axes of light transport to achieve better equity/perf.
“Tracking Bias in Pulse Oximetry through a Complex Healthcare System”

Harriet Nembhard
Dean and Professor, College of Engineering, University of Iowa
If medical devices are fair, they support the ability of caregivers to deliver better care for their patients.
However, if medical devices are not fair, the bias they create puts a higher burden on patients and creates the need for other (sometimes unmet) healthcare interventions.
The illumination of racial bias presents opportunities to counter its pernicious effects through policy and through the marketplace.
Engineers and engineering education has a very important role: “The best way to eliminate a medical device is to replace it with a better device.”
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Closing Remarks

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