Breakout Session 1: Track A

Strategies for Improving the Readiness of Large-Scale Cohort Data for AI / ML

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"A More Perfect Union: Leveraging Clinically Deployed Models and Cancer Epidemiology Cohort Data to Improve AI/ML Readiness of NIH-Supported Population Sciences Resources"

3U01-CA199277-08S2: J. Lacey & M.E. Martinez, MPIs

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City of Hope

A+ California Teachers Study

Disclosures

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- **NIH grant funding**
  - **MPI on U01-CA199277**
  - **PI on 3U01-CA199277-09S1**
  - **Co-I on NCI & NIEHS R01s**

- **Named co-inventor on pending patent for cohort-selection web application**

Problem Statement

- **Cancer Epidemiology Cohorts (CECs)**: Unique yet underutilized NIH-funded resources
  - *NCI has invested over $1B in over 30 CECs over last few decades*
  - *Millions of high-quality data points on lifestyle, PROs, environment, biospecimens, claims, & more*

- **Three big challenges**: Most* CECs' data are…
  - *Local & siloed, rather than FAIR*
  - *Stored & structured for manual & individual analyses*
  - *"Shared" primarily as limited datasets*

California Teachers Study (CTS)

www.calteachersstudy.org

ABOUT US

The California Teachers Study (CTS) was founded in 1995 when 133,477 teachers, administrators, school nurses, and other members of the California State Teachers Retirement System (CalSTRS) agreed to provide information about their health and behaviors to CTS researchers. In the years that have followed, participants have continued to provide important information about their health and lives.

In addition to enabling widespread research on breast cancer, the data provided by participants has allowed CTS researchers to study the causes of multiple other cancers and diseases.

1995	133,477	4	200+
Year Established	Participants Enrolled	Partner Institutions	Academic Publications

Vast, Diverse, & High-Quality Participant Data

Over 500,000 surveys from 133,477 women
Lifestyle, family history, social support, physical activity, diet, & PROMIS from up to 6 surveys each

25+ year residential history
Linked individual-level geospatial data on the built environment, Census data, air pollution, oil & gas exposures, climate change, & other environmental exposures

Biospecimens from over 23,000 participants
Over 660,000 research-ready aliquots of serum, plasma, RBCs, & clots

Over 1700 WGS, plus genotyping arrays

Over 40,000 cancers
Type, date, tumor details, and initial treatment

Over 780,000 hospital visits
Detailed diagnostic, procedure, and healthcare utilization data from inpatient, emergency department, and ambulatory surgery visits

Over 1 million linked Medicare records
Provider, claims, home health, & skilled nursing for FFS & Medicare Advantage

Over 38,000 linked death records
Date and causes of death

Innovative & Cloud-Based Secure Collaboration Workspace

- Suite of statistical analysis & GIS software
- Custom interactive visualizations
- AI/ML know-how, workflows, tools, & resources
- Secure data warehouse & data lakes
- Integrated project management & tracking
- Self-service cohort-selection tool (Pat. Pend.)

Open & Democratic Approach

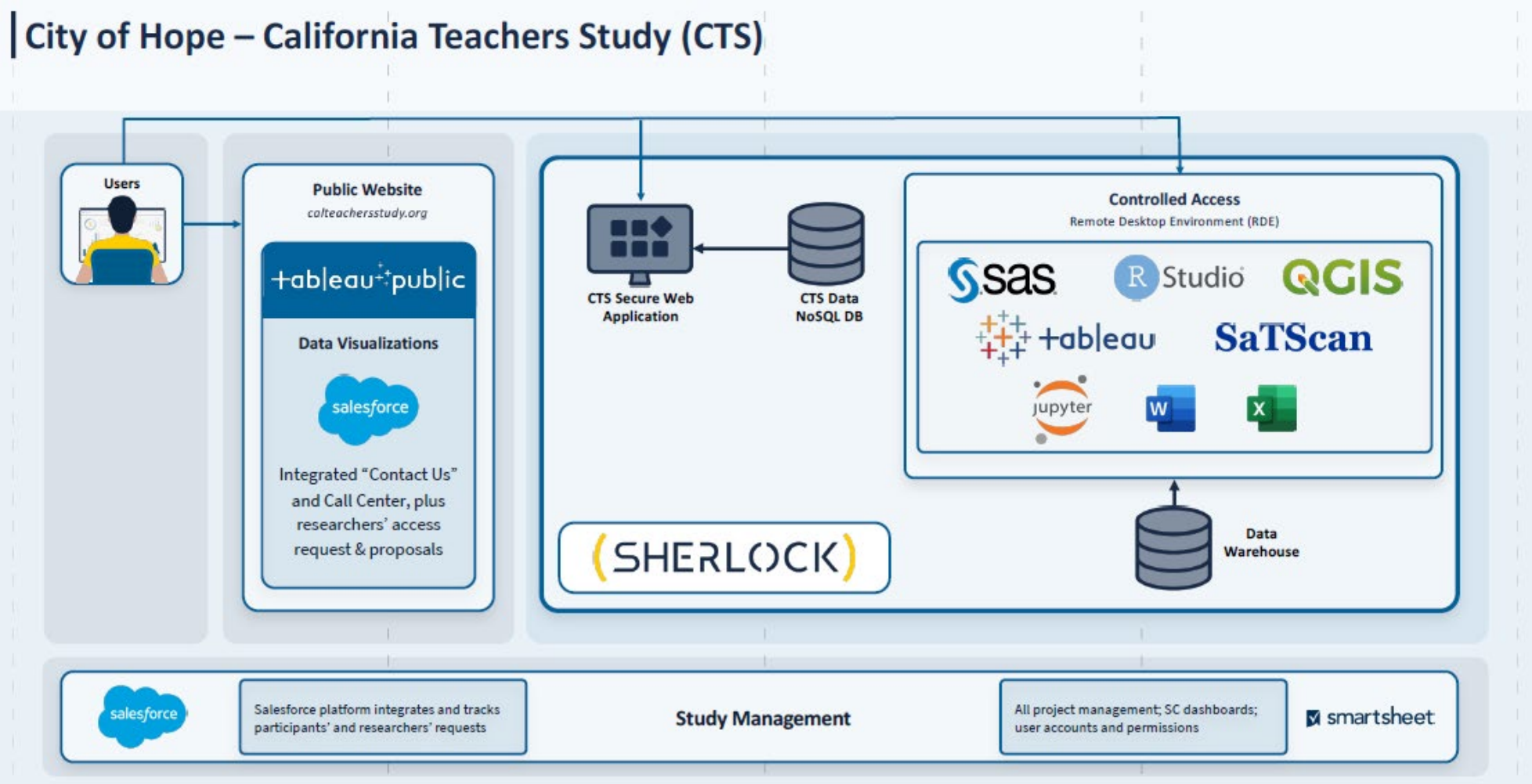
- Equal access for everyone everywhere
- Interactive visualizations on Tableau Public
- Extensive documentation, code, and templates
- User-friendly & efficient data-sharing tools
- Github for broad dissemination & sharing
- Community of over 200 users worldwide

Project Summary and Goals

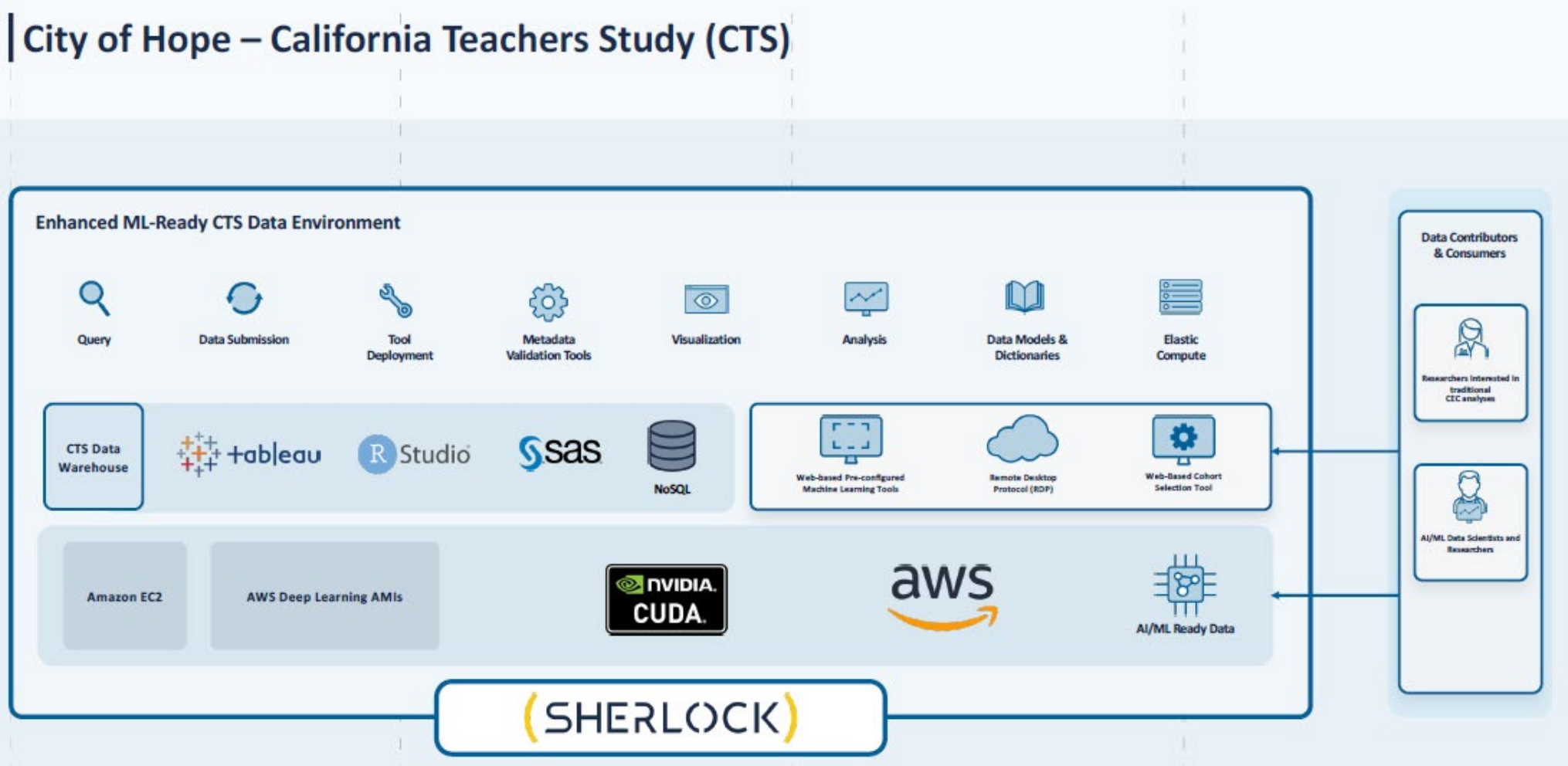
- **Objective**: Increase the AI/ML readiness of CTS data

- **Specific Aim #1**: Deploy a secure and scalable computing environment for CTS data
  - With partners at the San Diego Supercomputer Center's (SDSC) Sherlock Cloud, expand our CTS data commons to include an AWS SageMaker environment for AI/ML applications
    - *Goal: Increase the readiness of our CTS environment for AI/ML*
- **Specific Aim #2**: Generate low-dimensional latent representations, or embeddings, for complex CTS survey data
  - Visualize clusters from over 5000 data columns for over 133,477 participants
    - *Goal: Identify additional phenotypes and help inform cohort discovery*
- **Specific Aim #3**: Test a City of Hope readmissions model in CTS data
  - Revised: Train two new models focused on participants' survey response & lifespan
    - *Goal: Real-world model training on CTS data in new environment by data scientists*

Highlights: Aim #1

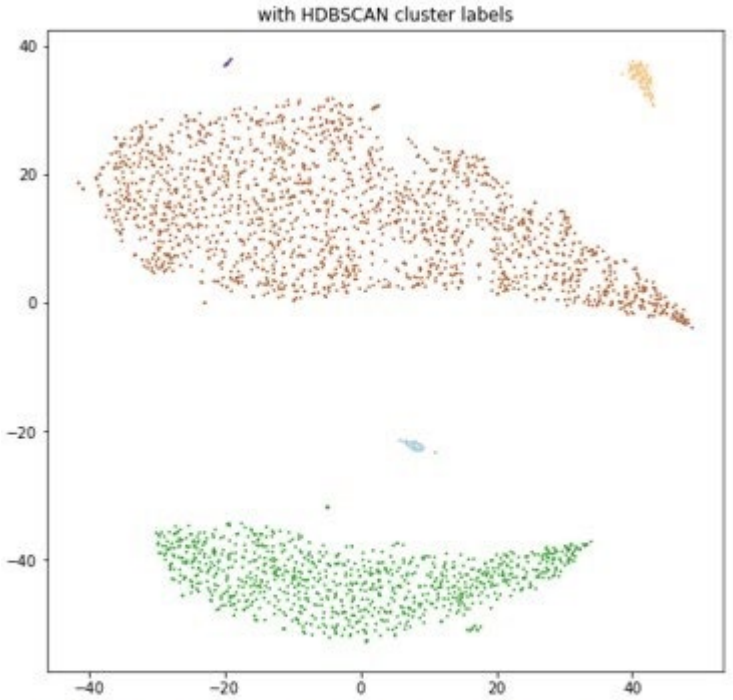


Expanded and Enhanced Analytics Infrastructure



Highlights: Aim #2

- Focused on subset of CTS population with minimum amount of missing data
  - Over 27,500 participants (observations) who completed all 6 CTS surveys
  - 89 data columns (features) that were completed by all participants



Visualization of distinct groups discovered within high-dimensional, complex data.

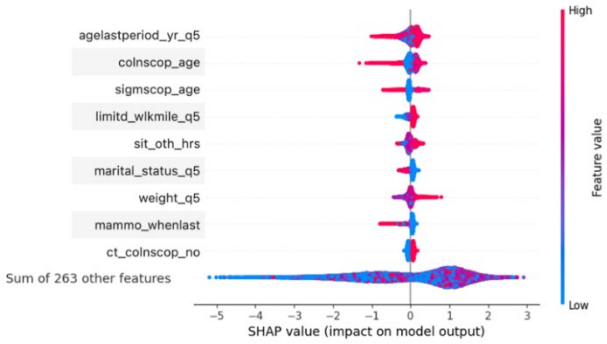
- t-SNE: t-distributed stochastic neighbor embedding on 10% sample
  - Hierarchical density-based clustering to partition 2D t-SNE embedding into spatial groups
  - Used learned cluster labels to train a random forest classifier to predict labels in validation set
  - Trained classifier then interpreted using SHAP values

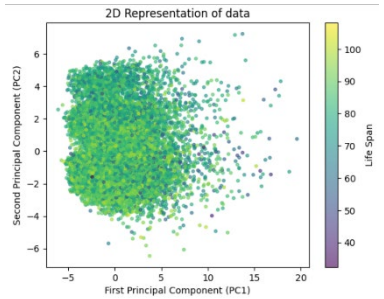
Highlights: Aim #3

- Demonstrate potential downstream use of CEC data by training 2 models: participant survey response & life expectancy
  - Split dataset into 80:20 training & testing sets; reweighted b/c of class imbalances

- Who completes next mailed surveys?
  - Separate models for all 5 follow-up surveys; including gradient boosting classifier

- Can diet & smoking predict death during follow-up?
  - 3 models: 1) age-based, 2) XGBoost regression, & 3) DNN
  - Transformed data into principal components (PC)

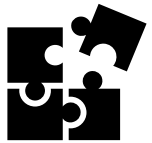




Challenges & Lessons Learned

Environment & Data

- Extensive & sensitive CEC data
- Valuable to surface heretofore hidden data & compute costs



Missing Data

- By design vs. data flaws
- CEC documentation subpar; need CDMs, CDEs, & standards

Data Diversity in CECs

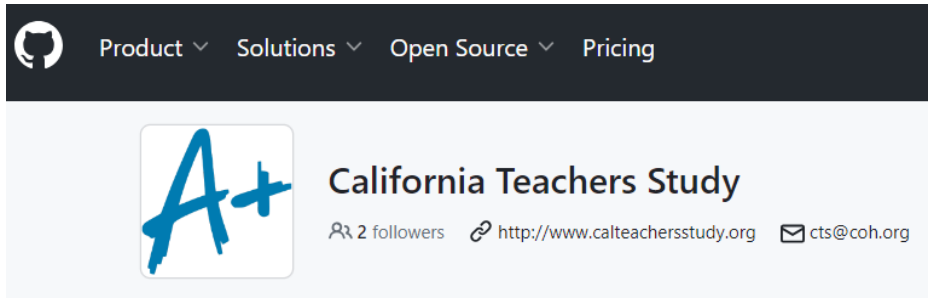
- A strength & AI/ML weakness
- Organize & document in ways that convey context better

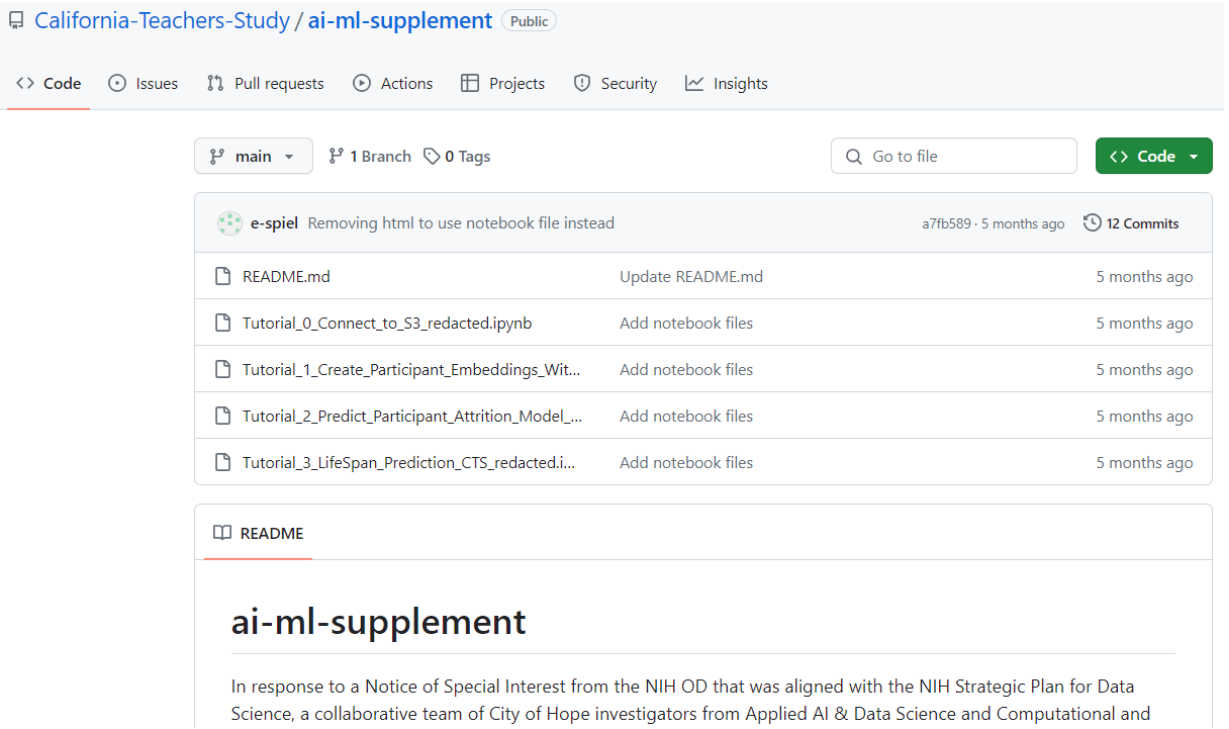
Closed vs. Open Cohorts

- CECs don't replenish population
- Major questions about models over time & age in CEC data

Links & Future Work

- 4 tutorial notebooks on CTS GitHub: github.com/California-Teachers-Study/ai-ml-supplement





- Incorporating embeddings into ongoing CTS work, e.g., geospatial exposures
- With SDSC Sherlock, accelerating transition of CTS infrastructure to AWS
- Strategic AI/ML plans for new cohorts

The CTS: A different approach

Equal access for everyone to the same CTS data & resources

All users, data, tools, software, & documentation in **one place**

Thorough security framework for all users, data, & the environment

Standardize, automate, & **eliminate barriers** to success

Thank You


Kingson Man, PhD


Alec Wong, PhD


Mohsen Nabian, PhD

Commitment to Diversity, Equity, and Inclusion

The California Teachers Study team is committed to equity, diversity, and to honoring our participants' contributions through excellence in research. We are dedicated to creating an inclusive and equitable research environment in which all CTS researchers, staff, partners, and participants can participate fully.

Public health research is often at the intersection of science and social justice, and those who work in this discipline recognize racism as a public health crisis. The California Teachers Study acknowledges that social and institutional inequalities experienced based on race, ethnicity, gender identity, and sexual orientation continue to disproportionately affect the health outcomes of marginalized groups.

Actively addressing disparities and racism is essential in our roles as health researchers. The California Teachers Study investigators and research staff are committed to advancing equity in research through:

- Continued internal education and discourse about diversity and inclusion
- Collaborating with other researchers to advance research on cancer and health conditions that disproportionately affect underrepresented populations
- Actively building partnerships to increase the diversity of researchers who use CTS data or join the CTS team


Caroline Thompson


Sophia Wang


Jim Lacey


Elena Martinez


Cheryl Anderson


Jennifer Benbow


Sandeep Chandra


Jessica Clague DeHart


Christine Duffy


Hannah Lui Park


Kristen Savage


Emma Spielfogel