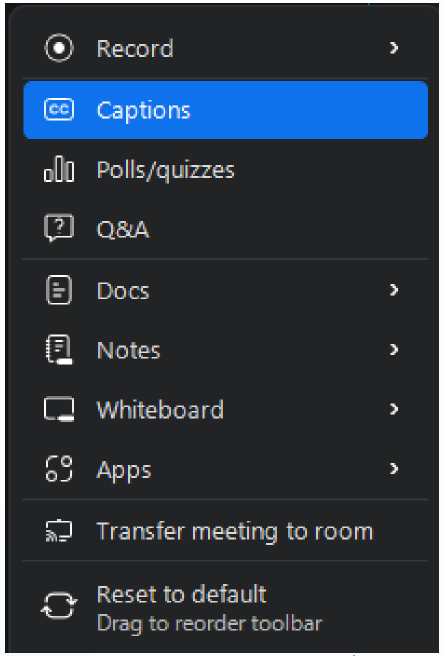
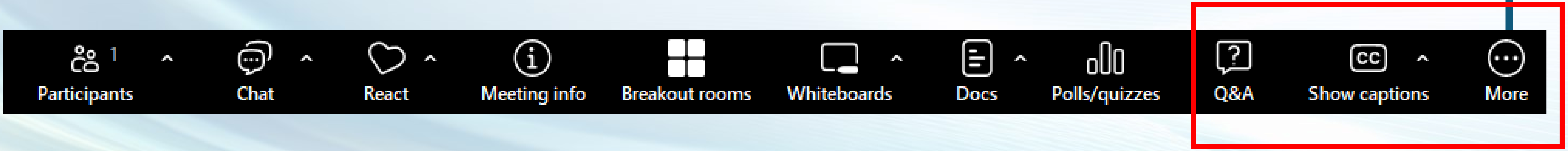
Public Meeting: Health Analysis Consultants' Findings on Environmental Justice in Health Impact Assessments

April 10, 2026

How to Ask a Question

- Meeting is being recorded
- Live, automated captioning available
- We will respond to questions at the end of the workshop
- Submit your questions at any time in the Q&A





Welcome

Opening remarks

Bonnie Holmes-Gen

Chief of the Health & Exposure Assessment Branch

Presenters

Joshua Montefalcon, MPH

Health & Ecosystem Analysis Section

Pradeep Prathibha, PhD

Manager, Health & Ecosystem Analysis Section

Consultants

Max Aung, PhD

USC Keck School of Medicine

Sandrah Eckel, PhD

USC Keck School of Medicine

Marianthi-Anna Kioumourtzoglou, ScD

Brown School of Public Health

Jason Su, PhD

UC Berkeley School of Public Health

Agenda

10:00 - 10:05	Welcome, Housekeeping
10:05 - 10:10	Introduction and Objectives
10:10 - 10:20	Staff overview of methodologies identified by consultants
	Consultants' presentations and discussion
10:20 - 10:50	Population characteristics
10:50 - 11:20	Health endpoints
11:20 - 11:50	Societal factors
11:50 - 12:10	Public comments
12:10 - 12:25	Closing remarks from health consultants
12:25 - 12:30	Next steps and Close

Health Analysis Consultants

Max Aung, PhD
USC Keck School of Medicine

Marianthi-Anna Kioumourtzoglou, ScD
Brown School of Public Health

Sandrah Eckel, PhD
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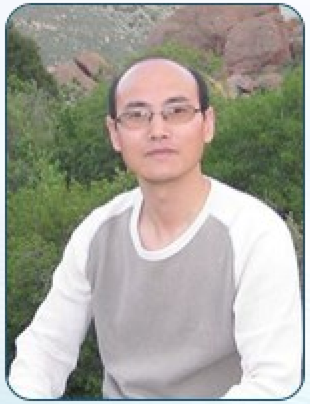


Jason Su, PhD
UC Berkeley School of Public Health

CARB

Max Aung, PhD
USC Keck School of Medicine

Assistant Professor
Division of Environmental Health
Dept of Population and Public Health Sciences
Keck School of Medicine of USC

PhD, Environmental Health Sciences,
University of Michigan, Ann Arbor
MPH, Occupational & Environmental Epidemiology,
University of Michigan, Ann Arbor

Research experience in environmental contaminants and reproductive outcomes across the life course

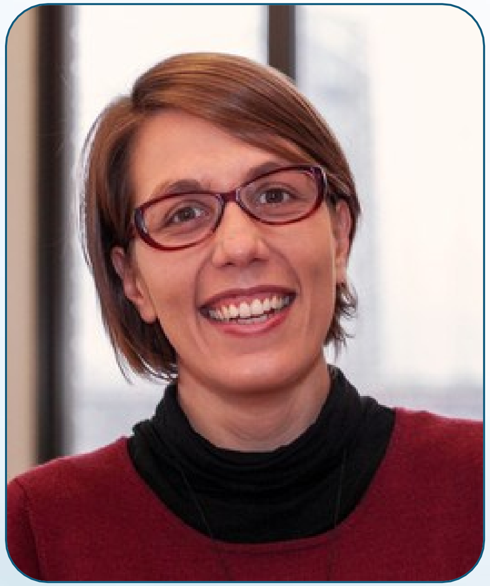
Sandrah Eckel, PhD
USC Keck School of Medicine

Associate Professor of Population and Public Health Sciences
Division of Biostatistics
Dept of Population and Public Health Sciences
Keck School of Medicine of USC

PhD, Biostatistics, Johns Hopkins Bloomberg School of Public Health

Expertise in statistical methods and applications in environmental epidemiology, especially air pollution health effects

CARB

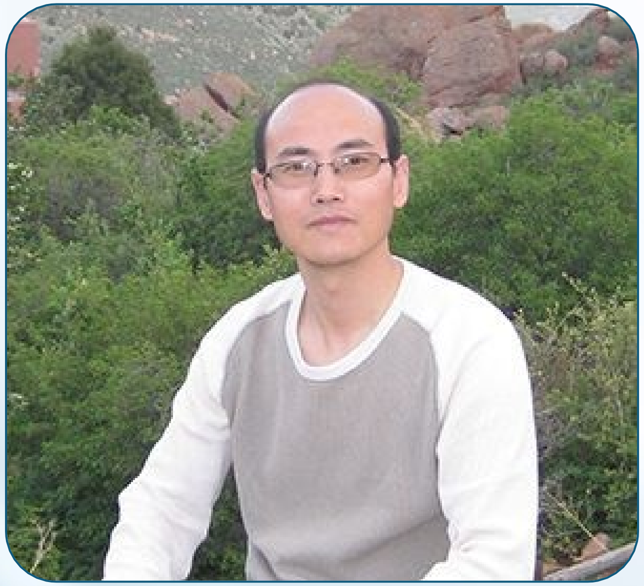


Marianthi-Anna Kioumourtzoglou, ScD
Brown School of Public Health

Professor
Dept of Environmental Health Sciences
School of Public Health
Brown University

ScD, Exposure Assessment, Harvard Chan School of Public Health
MSPH, Dept of Environmental Sciences and Engineering, University of North Carolina, Chapel Hill

Research experience on environmental exposures and health, with additional focus on statistical issues in studies, such as exposure measurement error and uncertainty



Jason Su, PhD
UC Berkeley School of Public Health

Full Researcher & Principal Investigator
Division of Environmental Health Sciences
School of Public Health
University of California Berkeley

PhD, Human and Economic Geography, Chinese Academy of Sciences
PhD, Rangeland and Wildlife Resources Management, University of Alberta (Canada)
MS, Regional Geography, Shaanxi Normal University (China)

Experienced in modeling for environmental exposure and health assessments

CARB's Current Health Impact Analysis

- Performed for all CARB regulations and programs
- Quantifies **small subset of full suite of health benefits** ($PM_{2.5}$ only)
- Based on established peer reviewed methods (i.e. U.S. EPA's BenMAP)

Regulation
↓
Emission Inventory
↓
Health Impacts (IPT)
↓
Economic Impacts

1. Regulatory staff estimate **projected emissions reductions for multiple years** in the future.
2. We use the **incidence-per-ton (IPT) methodology** to relate changes in emissions to estimated changes in health outcomes **statewide** and by **CA air basin**.
3. Economics staff estimate the valuation of the health benefits.

See CARB's Methodology for Estimating the Health Effects of Air Pollution (ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution)

CARB

$PM_{2.5}$: fine particulate matter; EPA: U.S. Environmental Protection Agency

How does BenMAP estimate health impacts?

Environmental Benefits Mapping and Analysis Program

Concentration Response Function (CRF):

$(1 - e^{-\beta \times \text{change in pollutant concentration}})$ × Population × Baseline incidence rate = Change in health outcome

Modeled or monitoring change in air quality

Population

Baseline rates of disease incidence

Estimate of how change in air pollution changes disease rates (concentration response functions, CRFs)

Adapted from U.S. EPA's how BenMAP-CE Estimates the Health and Economic Effects of Air Pollution (epa.gov/benmap/how-benmap-ce-estimates-health-and-economic-effects-air-pollution)

CARB's Methodology for Health Impact Analysis

Δ Emissions $\propto$ Δ Concentrations $\propto$ Δ Health Outcomes

U.S. EPA's Benefits-per-ton (BPT) method

Time- & resource-intensive approach (e.g., CMAQ) to associate reduced emissions to health outcomes

Change in $PM_{2.5}$ and NO_x Emissions

↓

Change in ambient concentrations

↓

Monetized benefit ($ per ton)

CARB's Incidence-per-Ton (IPT) method

California-specific, air basin level approach when air quality data (in concentrations) are not available

Change in $PM_{2.5}$ and NO_x Emissions

↓

IPT factors
(proportionality between emissions and health outcome by air basin)

↓

Avoided health burden (cases per ton)

CARB

CMAQ: Community Multiscale Air Quality model; NO_x: oxides of nitrogen

Health endpoints in CARB’s methodology

12 health outcomes from exposure to $PM_{2.5}$

In use until 2023
Cardiopulmonary Mortality
Cardiovascular Hospital Admissions
Respiratory Hospital Admissions
Asthma Emergency Room Visits

Added in 2023
Cardiovascular Emergency Room Visits
Respiratory Emergency Room Visits
Acute Myocardial Infarction, Nonfatal
Asthma Onset
Asthma Symptoms / Exacerbation
Lung Cancer Incidence
Work Loss Days
Alzheimer’s Disease
Parkinson’s Disease

Proposed in 2026
Cardiac Arrest
Stroke
Allergic Rhinitis (Hay Fever)
Minor Restricted Activity Days

CARB Board Directed Expansion of Health Analysis
Board Resolution 20-13

Goal: Develop Methods for More Comprehensive Evaluation of Health Benefits

- New qualitative and quantitative approaches
- Assess health impacts in disadvantaged communities
- Quantify additional pollutants
- Update health endpoints from pollution exposure
- Assess and communicate GHG reduction benefits

GHG: green house gas

Ongoing and Longer-Term Work

CARB-FUNDED STUDIES OF CALIFORNIA POPULATIONS

- **Metabolic Health** and criteria pollutants
  Diabetes incidence, medication use, ED visits, hospitalizations, death
- **Birth Outcomes** and criteria pollutants
  Pre-term birth, low birth weight, Autism Spectrum Disorder
- **Neurodegeneration** and criteria pollutants
  Parkinson and Alzheimer's Diseases, cognitive decline
- **Neurodevelopment** and criteria pollutants
  Student standardized test performance
- **Life Expectancy** and $PM_{2.5}$
  Change in life expectancy over time
- **Respiratory Symptoms** and train, port emissions
  Use of medication puff and ED visits in Southern California

EXPANDING CARB ANALYSES

Qualitative Health Analysis

- Complement quantitative assessments with comprehensive evaluation of additional impacts, co-benefits, and cumulative burdens, integrating racial equity and community insights.

Health Equity analysis

- Develop methods to quantify differences in health outcomes for subpopulations

Health consultants

- Review available community-focused health analysis methods
- Recommend approaches to expand CARB's health impact analyses

ED: emergency department

Health Consultants: Objective

- Review CARB's current health analysis methodology for evaluating health benefits of air pollution reduction programs
- Review existing science and methodologies related to air pollution health impacts in diverse communities and subgroups
- Provide independent, individual recommendations* on options to integrate scientific findings and methods into CARB's current approach

* Recommendations do not reflect the views of CARB staff and do not consider legal and resource constraints.

Tasks

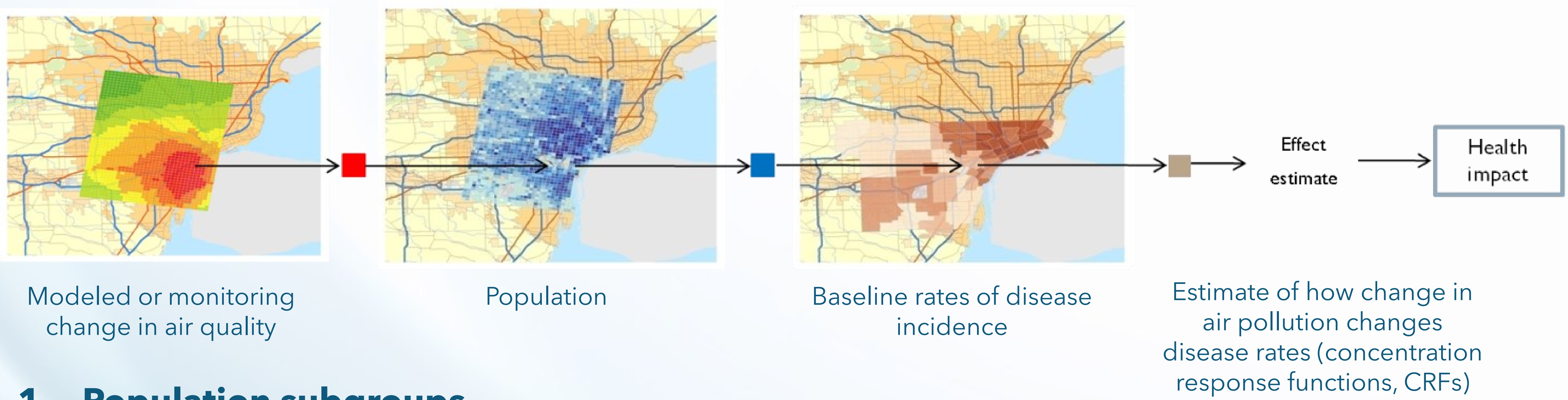
Step 1. Literature Review

- Identify and summarize existing literature and new approaches related to environmental justice (EJ) analysis methodologies

Step 2. Develop <u>individual recommendations</u> on health analysis approaches to account for community factors like increased vulnerability and pollution exposure

- Offer options at multiple complexities
  - Low: can be implemented using existing resources
  - Moderate: can be implemented using existing resources and significant staff time
  - High: can require more resources and complexity (external resources, computational support)
- For each recommendation:
  - Specify individual-level or area-level factors
  - Recommend appropriate spatial resolution

Focus Areas for Health Consultant Recommendations



1. **Population subgroups**
   Race, ethnicity, or overburdened communities at greatest risk for health effects of air pollution
2. **Health outcomes** of high concern for tracking and health analysis in overburdened communities
3. **Societal factors** (e.g. income, education attainment) impacting health outcomes from air pollution

Key Points from Consultants' Review (Step 1)

Population subgroups

- Need finer spatial resolution data (e.g., census tract-level)
- Need to capture intersectionality across subgroups
- Need community engagement to define and prioritize populations

Health outcomes

- Use disease risk estimates specific to subgroups
- Expand beyond mortality to community-relevant endpoints
- Consider co-morbidity and cumulative health burden

Societal factors

- Expand to include structural and environmental factors
- Account for dynamic changes (e.g., migration, displacement)
- Capture effect modification from social and environmental stressors

Workshop Goals

Health consultants will present their **individual ideas and recommendations** (Step 2) on methodologies to incorporate community vulnerabilities and disparate exposures in three aspects of health assessments.

For each focus area:

- Consultants will present recommendations by complexity
- Guided discussion on specific, actionable items with CARB staff

Population subgroups

Race, ethnicity, or overburdened communities at greatest risk for health effects of air pollution




	Dr. Aung	Dr. Eckel	Dr. Kioumourtzoglou	Dr. Su
Population subgroups	×	×	×	
Health outcomes	×	×		×
Societal factors			×	×

Aung: Recommendations on Population Subgroups

Low Complexity Recommendation

- Identify trends in air pollution exposures and health outcomes among 2-way combinations of population subgroups
- CARB is exploring exposure disparity analysis and health disparity analysis approaches, which could generate combined statistics for 2-way combinations of subgroup variables

  1. Percent people of color
  2. Income/poverty
  3. Unemployment
  4. Educational attainment
  5. Linguistic isolation
  6. Aging populations
  7. Proportion of population with disabilities

- Relevance to CARB health impact analysis: Potentially improves understanding of exposures and health risks in marginalized communities

Eckel: Recommendations on Population Subgroups

- Low Complexity Recommendation

  Use **census-tract resolution** 5-yr rolling estimates from U.S. Census American Community Survey (ACS)

- Moderate Complexity Recommendation

  Prioritize **concentration-response functions** (CRF) most relevant to California conditions and populations

[prioritize activities to reduce spatial scale]

Eckel: Recommendations on Population Subgroups

#1 Recommendation: Prioritize Census Tract Resolution

- Air basin & county resolution obscure hyperlocal disparities
  - South Coast Air Basin: ~17 million people, or 44% of CA's population
  - LA county: ~10 million people, or 25% of CA's population
- Census tracts (~4,000 people): best balance of **statistical stability**, **data availability**, and **EJ relevance**
  - More precise exposure characterization near localized sources (e.g., ports, freeways, refineries)
  - Use of key population and vulnerability metrics (e.g., 5-year American Community Survey estimates)
  - Use of subgroup-specific concentration-response functions (CRFs)
- Note: Zip codes unsuitable; but crosswalk to ZCTAs only if necessary

ZCTA: ZIP code tabulation area

Eckel: Recommendations on Population Subgroups

<u>How</u> to move towards census tract resolution?
Develop Intermediate-Complexity, Spatially Resolved Health Analysis Approach

- Reminder: CARB's current approach to Health Analysis:
  - **<u>Simple</u>: Reduced form Incidence Per Ton (IPT) analysis,** assumes proportionality of change in emissions and in health at air basin scale

    Key limitation: Coarse air basin-level resolution masks EJ disparities

  - **<u>Complex</u>: "Full" health analysis**
    1. Translate emissions into air pollution exposure surfaces with CMAQ
    2. Estimate health impacts of these exposure changes with BenMAP-CE

    Key limitation: Computationally intensive / resource intensive

- **Recommendation**: develop an **<u>intermediate complexity</u>** approach leveraging reduced-complexity model to maintain spatial resolution

CMAQ: Community Multiscale Air Quality model

Eckel: Recommendations on Population Subgroups

How to move towards census tract resolution?

Develop Intermediate-Complexity, Spatially Resolved Health Analysis Approach

- **Key barrier: full CMAQ model** of emissions to exposure surfaces is too computationally intensive for routine EJ analysis at CARB

- Recommendation: leverage **reduced-complexity models** (e.g., InMAP)
  - Use to generate (approx.) fine-scale $PM_{2.5}$ surfaces for regulatory scenarios
  - Use BenMAP-CE at census-tract resolution
    - Baseline and change in exposure concentrations at census-tract resolution
    - Population data (e.g., age, sex, race/ethnicity) at census-tract resolution (e.g., 5-yr ACS)
    - Baseline health incidence data at finest resolution possible (may be county-level)
    - Appropriate (possibly nonlinear) concentration-response function (CRFs)

InMAP: Intervention Model for Air Pollution (www.caces.us/inmap);
ACS: American Community Survey

Eckel: Recommendations on Population Subgroups

How to move towards census tract resolution?
Develop Intermediate-Complexity, Spatially Resolved Health Analysis Approach

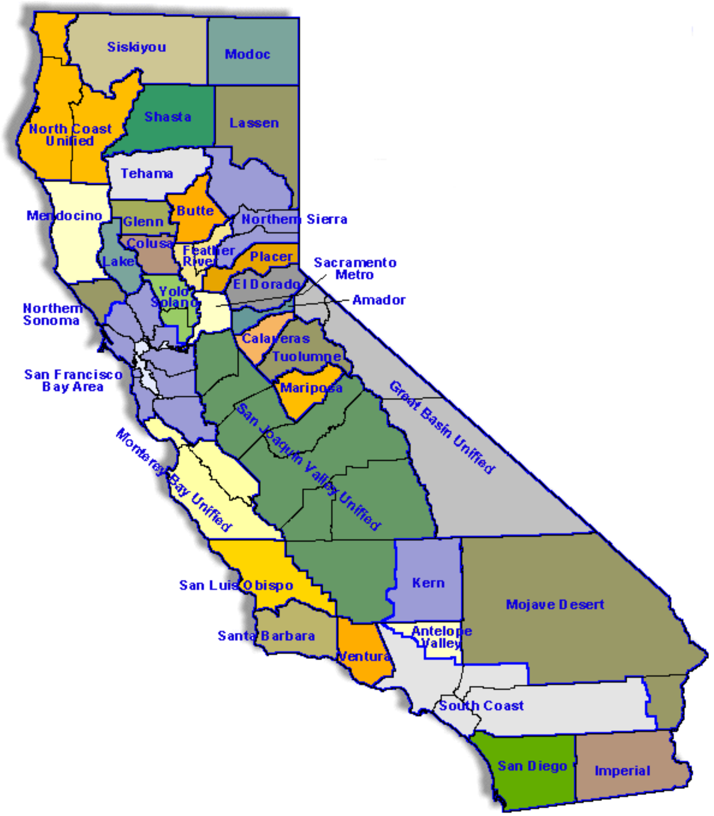
- **Key barrier: full CMAQ model** of emissions to exposure surfaces is too computationally intensive for routine EJ analysis at CARB
- Recommendation: leverage **reduced-complexity models** (e.g., InMAP)
- **Result: scenario evaluation at finer spatial resolution → EJ relevance**
  - Tradeoffs in **complexity**:
    reduce exposure model complexity to gain spatial resolution
  - Tradeoffs in **computational burden/staff time**:
    - Faster than full health analysis but still produces EJ-relevant fine spatial scale result
    - Slower than simple IPT, but IPT is not EJ relevant

EJ: Environmental Justice

Kioumourtzoglou: Recommendations on Population Subgroups

Low Complexity Recommendation: Neighborhood-Level Mapping

- Transition from large "Air Basin" averages to "Census Tract" (neighborhood) analysis.
- Illustrative example: Instead of one average score for the entire South Coast Air Basin, look at the ~4,000 individual neighborhoods to see which specific ones are most impacted.
- Relevance to CARB: Large spatial units can mask significant local diversity; neighborhood data capture the granular disparities essential for environmental justice.

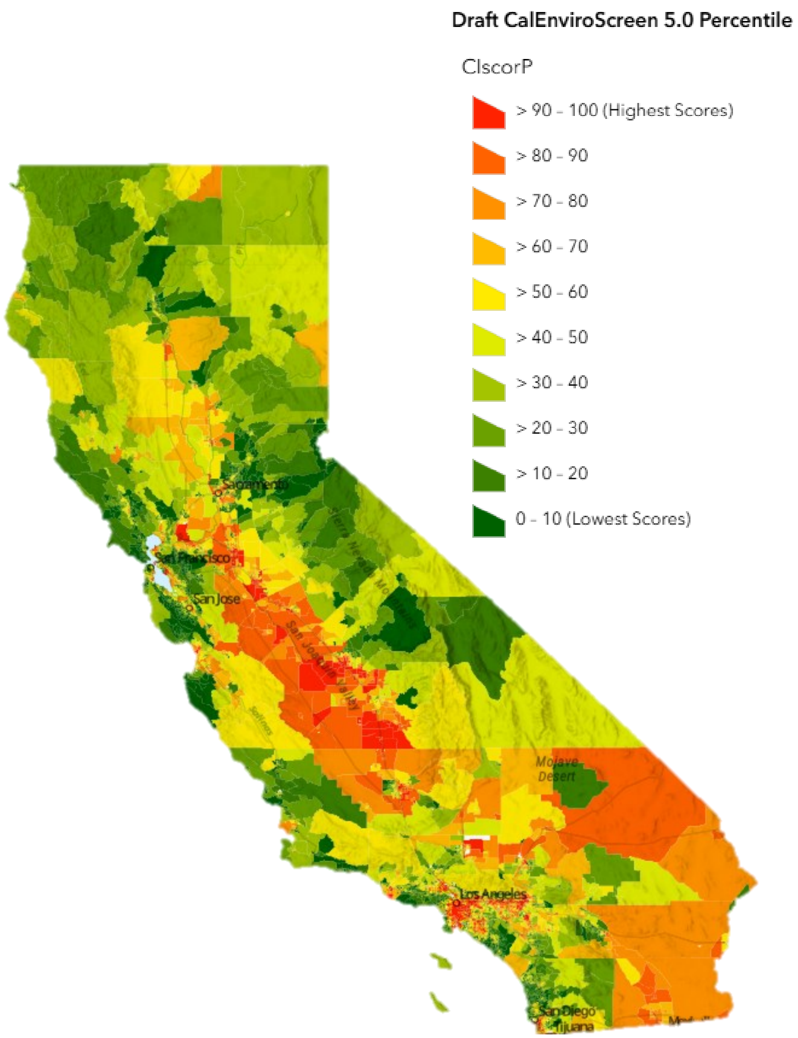


School of Public Health
BROWN UNIVERSITY

Kioumourtzoglou: Recommendations on Population Subgroups

Moderate Complexity Recommendation: Tailored Community Profiles

- Move beyond just a single total ranking score; use data to group communities by their specific vulnerability drivers.
- Illustrative example: Two neighborhoods might have the same high score, but one is driven by heavy-duty diesel traffic while the other is driven by high rates of poverty and unemployment.
- Relevance to CARB: By pairing these data with direct community engagement, CARB can co-design policies that are culturally and logistically more likely to succeed.



CalEnviroScreen (CES): Mapping tool with environmental, health, and socioeconomic information that helps identify California communities that are most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects. (oehha.ca.gov/calenviroscreen)

Kioumourtzoglou: Recommendations on Population Subgroups

High Complexity Recommendation: CA-specific Risk Data

- Develop subgroup-specific health risk estimates (i.e. CRFs) and track predictive indicators of inequity.
- Illustrative example: Instead of using national averages or studies conducted in other states, CARB could conduct original studies to see how pollution impacts specific CA groups (e.g., by race/ethnicity or income).
- Relevance to CARB: This ensures that health impacts are grounded in the most accurate risk assessments for CA unique population.

CRF: concentration response function

Population Subgroups: Discussion Questions

1. How should CARB identify and prioritize population subgroups for inclusion in health impact analyses?
2. Which **recommendations would have the greatest impact** on improving EJ in CARB's health impact analyses?
3. What are the **challenges or barriers** for implementing these recommendations? Is this feasible?
4. What **data, methodological, and research gaps** need to be addressed?
5. How do these recommendations advance CARB's current approaches?

Health Outcomes

of high concern for tracking and health analysis in overburdened communities




	Dr. Aung	Dr. Eckel	Dr. Kioumourtzoglou	Dr. Su
Population subgroups	×	×	×	
Health outcomes	×	×		×
Societal factors			×	×

CARB

Aung: Recommendations on Health Outcomes

Low Complexity Recommendation

- Estimate exposure-response functions and subgroup specific baseline health outcome rates
- Building on epidemiologic studies in the CARB Health Endpoints Bulletin, CARB can modify IPT analysis for sensitivity analysis with beta effect estimates for subgroups and intercepts for baseline health outcome rates. This includes the following outcomes: cardiovascular outcomes; respiratory outcomes; and nervous system outcomes
- Relevance to CARB health impact analysis: Potential improvement of estimating health risks in population subgroups

Aung: Recommendations on Health Outcomes

Low Complexity Recommendation

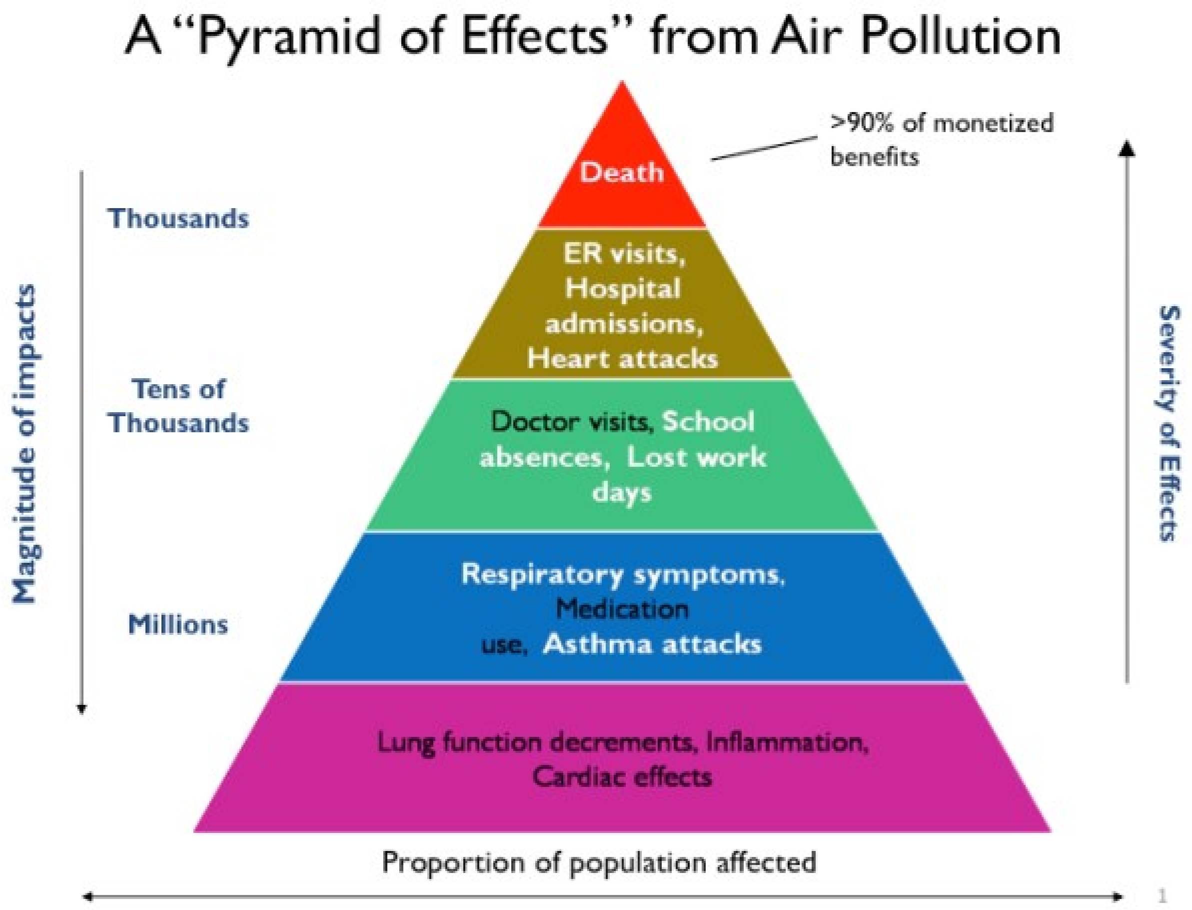
- Estimate exposure-response functions for incidence of multiple-chronic conditions
- Building on CA-based health statistics, CARB can modify IPT analysis for sensitivity analysis with beta effect estimates for multiple chronic conditions and intercepts for baseline multiple chronic conditions (combinations of cardiovascular, respiratory, and nervous system outcomes)
- Relevance to CARB health impact analysis: Potential improvement of estimating health risks for populations experiencing multiple chronic conditions

Aung: Recommendations on Health Outcomes

High Complexity Recommendation

- Estimate exposure-response functions for 2-way combinations of population subgroups
- Building on findings from the population subgroup recommendations, and epidemiologic studies from the health endpoint bulletin, CARB can modify IPT analysis for sensitivity analysis with beta effect estimates for 2-way combinations of population subgroups
- Relevance to CARB health impact analysis: Potential improvement of estimating health risks in intersecting population subgroups

Eckel: Recommendations on Health Outcomes



https://www.epa.gov/benmap/how-benmap-ce-estimates-health-and-economic-effects-air-pollution

- Air pollution impacts health in many ways, with the most severe tending to be simpler to quantify, with stronger epidemiological evidence
- CARB's current list of health endpoints is already well-aligned with the health endpoints in BenMAP-CE, i.e., the subset of health endpoints deemed "causal" or "likely to be causal" in the U.S. EPA's Integrated Science Assessments (ISAs) for $PM_{2.5}$ and O_3.

Eckel: Recommendations on Health Outcomes

- **Low Complexity Recommendation**
  - Keep current list of health endpoints
    [prioritize activities to reduce spatial scale]
- **Moderate Complexity Recommendation**
  - Update health endpoints regularly, at each update to EPA ISAs or every few years if no updates to ISAs to review new literature
  - For each regulation under consideration, engage local communities to identify any key endpoints of concern beyond CARB's current list
  - Develop a "library" of concentration-response functions (CRFs) most relevant to California conditions and populations
- **High Complexity Recommendation**
  - Incorporate nonlinear CRFs as appropriate because EJ communities may have higher exposures and linear CRFs may mischaracterize health impacts
  - Use CRFs that parse toxicity of wildfire-related vs non-wildfire $PM_{2.5}$

Su: Recommendations on Health Outcomes

Low Complexity Recommendation

- Brief description
  - Add EJ-critical, underrepresented endpoints using existing CRFs
  - Focus on endpoints already supported by epidemiologic evidence
- Illustrative example
  - Adverse birth outcomes (low birth weight, preterm birth)
  - Metabolic outcomes (Type 2 diabetes incidence)
  - Cancer risk (air toxics–related lifetime risk)
- Relevance to CARB health impact analysis
  - Uses existing log-linear framework
  - Aligns with CARB/OEHHA practices
  - Expands coverage to high-priority EJ outcomes

CRF: concentration response function
OEHHA: Office of Environmental Health Hazards Assessment (oehha.ca.gov/)

Su: Recommendations on Health Outcomes

Moderate Complexity Recommendation

- Brief description
  - Use HIA tools (e.g., BenMAP-CE) with age-, sex-, and SES-stratified population counts, baseline incidence, and concentration–response functions for key health endpoints.
- Illustrative example
  - Quantify attributable asthma ED visits, cardiovascular hospitalizations, and birth outcome risks by SES and CalEnviroScreen strata, including sensitivity analyses
- Relevance to CARB health impact analysis
  - Supports subgroup-specific quantification of health benefits and standardized reporting for ISORs and endpoint bulletins.

SES: socioeconomic status;
ISOR: Initial Statement of Reasons
(CARB document outlining rationale for regulatory actions)

Su: Recommendations on Health Outcomes

High Complexity Recommendation

- Brief description
  - Apply multivariate and multi-pollutant exposure–response models to estimate joint burdens across respiratory, cardiovascular, metabolic, birth, cancer, and cognitive outcomes. Include interactions with SES and other stressors.
- Illustrative example
  - Estimate life expectancy and morbidity losses from $PM_{2.5}$, ozone, NO_2, and air toxics, modified by SES, neighborhood deprivation, and access to care; report both component-specific and cumulative burdens.
- Relevance to CARB health impact analysis
  - Enables comprehensive, equity-oriented assessments of regulatory scenarios, facilitating prioritization of interventions that maximize health benefits in socially vulnerable communities.

Health Outcomes: Discussion Questions

1. How should CARB decide which **co-morbidities** to consider?
2. How should CARB determine which **additional health endpoints** to include to improve health impact analyses?
3. Which **recommendations would have the greatest impact** on improving EJ in CARB's health impact analyses?
4. What are the **challenges or barriers** for implementing these recommendations? Is this feasible?
5. What **data, methodological, and research gaps** need to be addressed?
6. How do these recommendations advance CARB's current approaches?

Societal Factors

(e.g. income, education attainment) impacting health outcomes from air pollution




	Dr. Aung	Dr. Eckel	Dr. Kioumourtzoglou	Dr. Su
Population subgroups	×	×	×	
Health outcomes	×	×		×
Societal factors			×	×

Kioumourtzoglou: Recommendations on Societal Factors

Moderate Complexity Recommendation: Shifting to Modifiable Factors

- Shift the paradigm from simply quantifying harm based on factors that cannot change (like race or income) to evaluating modifiable community assets.
- Illustrative example: Evaluate the health benefits of specific interventions CARB or partners can influence, such as increasing urban tree canopy or improving access to healthy foods.
- Relevance to CARB: This would give CARB the scientific proof to invest in local improvements to reduce the health gap between neighborhoods.

Kioumourtzoglou: Recommendations on Societal Factors

High Complexity Recommendation: Simulating Solutions

- Use computer simulations (modeling) to test which interventions can help a specific neighborhood the most.
- Illustrative example: Before spending money, run a digital test to see if adding a park or a new bike path reduces the health burden for a specific group of residents near a railyard.
- Relevance to CARB: Ensures CARB targets its resources toward the most efficient and effective solutions for physical and mental well-being.

Su: Recommendations on Societal Factors

Low complexity recommendation

- Brief description
  - Adjust exposure and health metrics using tract- or neighborhood-level SES indicators such as income, educational attainment, or composite deprivation indices.
- Illustrative example
  - Report average $PM_{2.5}$ exposure levels by CalEnviroScreen deciles or by median household income categories.
- Relevance to CARB health impact analysis
  - Identifies communities disproportionately affected by air pollution and aligns with screening-level EJ analysis in Scoping Plan and ISORs.

SES: socioeconomic status;
ISOR: Initial Statement of Reasons
(CARB document outlining rationale for regulatory actions)

Su: Recommendations on Societal Factors

Moderate complexity recommendation

- Brief description
  - Incorporate multivariable regression or subgroup stratification to examine how SES indicators (income, education, housing burden) modify pollution-related health risks.
- Illustrative example
  - Use BenMAP-CE to quantify asthma ED visits stratified by SES proxies, CalEnviroScreen scores, and age/race subgroups.
- Relevance to CARB health impact analysis
  - Enables more accurate estimation of health impacts across populations/social factors and supports subgroup-specific benefit analysis in regulatory applications.

Su: Recommendations on Societal Factors

High complexity recommendation

- Brief description
  - Model air pollution jointly with multiple social stressors (crime, deprivation, access to healthcare) and environmental co-stressors to estimate cumulative, non-additive health burdens.
- Illustrative example
  - Develop multilevel models predicting life expectancy losses incorporating SES, neighborhood deprivation, air pollution, heat, and noise exposures.
- Relevance to CARB health impact analysis
  - Supports equity-focused regulations and prioritizes mitigation strategies for the most socially vulnerable populations using advanced EJ and cumulative impact modeling.

Societal Factors: Discussion Questions

1. How should CARB handle variability in spatial resolution of societal factors (e.g., income is household-level, greenness is neighborhood-level)?
2. Which **recommendations would have the greatest impact** on improving EJ in CARB's health impact analyses?
3. What are the **challenges or barriers** for implementing these recommendations? Is this feasible?
4. What **data, methodological, and research gaps** need to be addressed?
5. How do these recommendations advance CARB's current approaches?

Public Comments

1. Raise your hand to be added to the speaking queue: **each speaker will have 2 minutes**
   - Click **Raise Hand**
   - If using a phone, **Dial *9**
2. Type your questions at any time in the Q&A

Closing Remarks

Eckel: Closing Remarks

Key Recommendation:
Prioritize fine spatial resolution (census tract) for EJ-relevant health analyses.
Requires new intermediate complexity approach to health analysis

Recommendations on Other Areas and Future Directions

- Enhance **transparency & dissemination**: standardized public repository of analyses
- Strengthen **accountability**: post-implementation evaluations
- Multipollutant analyses are important, but put efforts towards fine spatial resolution first
- Potential to use causal inference approaches to estimate impacts of policy-relevant exposure changes using observed exposure-hospitalization/mortality data (HCAI or CDPH)
- Anticipate future roles of **AI/deep learning**:
  - Automating key steps of health analyses
  - Next generation exposure modeling, including data fusion
  - Digital twins of pollution sources and/or California population

Conclusion: Recommendations prioritized to help CARB deliver accurate, equitable, and transparent assessments that reflect California's evolving air pollution sources/exposures and the lived realities of disproportionately burdened communities

HCAI: California Department of Health Care Access and Information;
CDPH: CA Department of Public Health

Su: Recommendations on Health Outcomes

EJ-critical and currently underrepresented:

- **Adverse birth and early-life outcomes** (Low birth weight, preterm birth, infant mortality)
- **Metabolic outcomes** (Type 2 diabetes incidence and complications)
- **Cancer risk** (Air toxics–related lifetime cancer risk [consistent with CARB/ practice])

Emerging but policy-relevant:

- **Neurologic and cognitive outcomes** (Dementia, cognitive decline)
- **Mental health** (Stress, anxiety, depression linked to environmental + social burden)

Cross-cutting / integrative endpoints:

- Life expectancy / life-table impacts
- Multi-endpoint burden comparison (relative contribution across disease pathways)

Conclusion and Next steps

To provide public comments:

- Online by April 24, 2026: https://ww2.arb.ca.gov/public-comments/public-meeting-health-analysis-consultants-findings-environmental-justice-health

Questions: please email healthimpacts@arb.ca.gov