CalEnviroScreen

Methodology, Design Principles & Lessons Learned

Bay Area Air Quality Management District Advisory Council
Office of Environmental Health Hazard Assessment
June 15, 2026

~9,100	23	5.0
Census Tracts	Indicators	Tool Versions

What We'll Cover Today

01 **Background & Purpose**

What CES is, who uses it, and why it matters

02 **The CES Model**

Conceptual framework, components, and formula

03 **Indicator Selection**

Criteria, data sources, and the 23 indicators

04 **Normalization & Scoring**

Percentile ranking rationale and aggregation logic

05 **Key Trade-offs**

Specificity vs. generalizability, simplicity vs. rigor

06 **Community Engagement**

Co-design, public process, and iterative refinement

07 **Lessons for Tool Builders**

What we have learned

Background & Purpose

Why CalEnviroScreen exists and how it's used

What It Is

CalEnviroScreen (CES) is a census tract-level composite index that quantifies cumulative environmental and population burdens across California. Developed by OEHHA on behalf of CalEPA, it has been updated through five major versions (1.0–5.0) since 2012.

Policy Applications

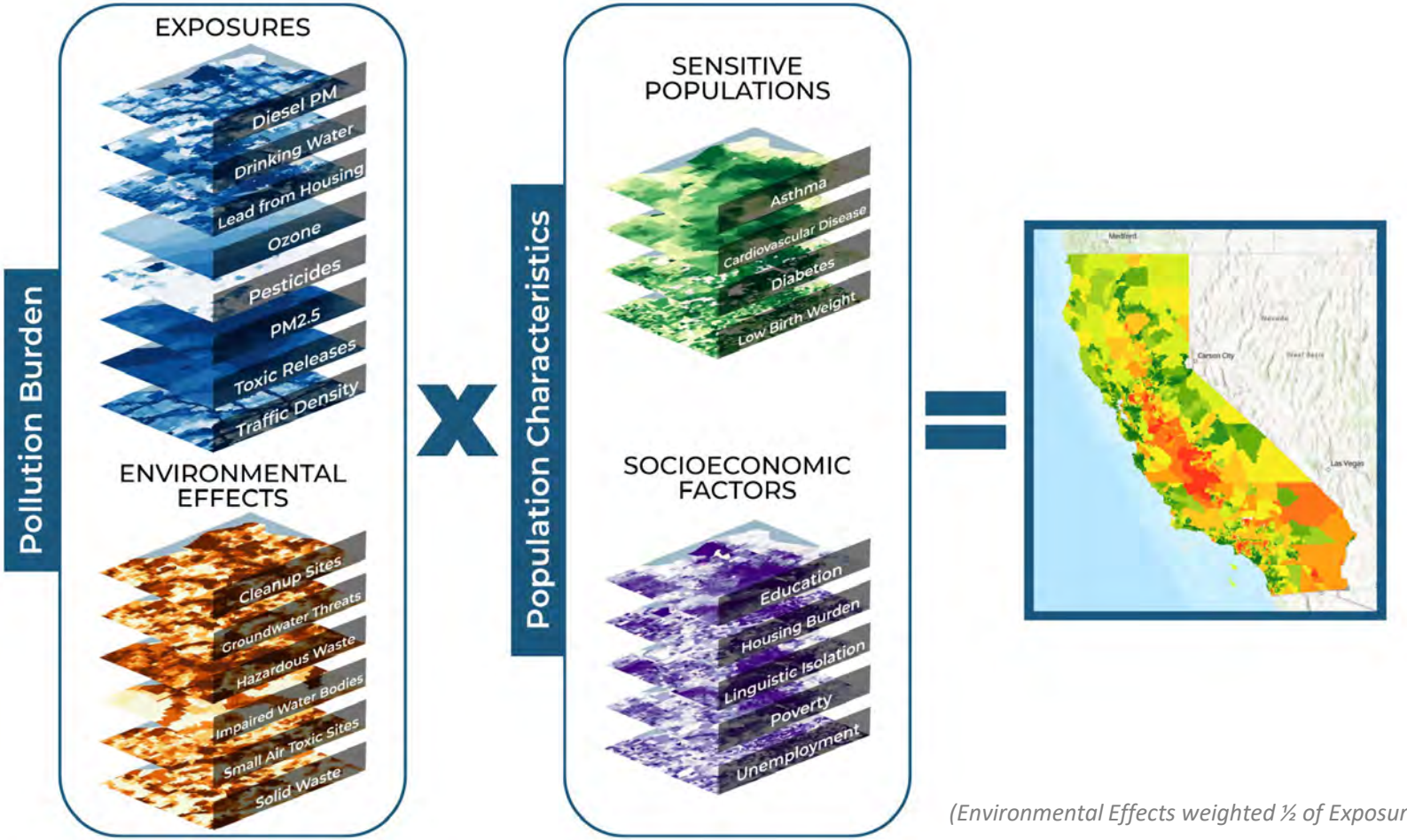
SB 535 / AB 1550 — Identifies Disadvantaged Communities (DACs) for ≥35% of California Climate Investments (~$8.1B invested to date)
SB 1000 — Guides local EJ elements in general plans

- Site cleanup, permitting, enforcement
- Community advocacy and research

Version History

CES 1.0 (2012)	First statewide cumulative impacts tool; foundational framework
CES 2.0 (2014)	Switched from ZIP codes to census tracts; refined indicators; improved data sources
CES 3.0 (2017)	Added border region data; expanded engagement; DAC designations
CES 4.0 (2021)	Added lead in housing indicator; major data refresh; DAC designations
CES 5.0 (2026)	23 indicators (+ Small Air Toxics, Diabetes); 2020 tracts; CBO co-design

Draft CalEnviroScreen 5.0 Indicators



(Environmental Effects weighted ½ of Exposures)

Selecting the 23 Indicators

A structured, transparent, criteria-driven process

Selection Criteria

- **Relevant**
  Reflects a known pollution burden or vulnerability in California communities
- **Statewide**
  Data available at census tract level for all of California
- **Current**
  Regularly updated from authoritative sources
- **Robust**
  Scientifically defensible; does not introduce significant data gaps
- **Understandable**
  Can be explained to community members and non-technical audiences

The 23 Indicators (CES 5.0)

Exposures (8)

PM2.5 · Ozone · Diesel PM · Drinking Water Contaminants · Pesticide Use · Toxic Releases · Traffic · Children's Lead Risk

Env. Effects (6)

Cleanup Sites · Groundwater Threats · Hazardous Waste · Impaired Waters · Small Air Toxic Sites* · Solid Waste

Sensitive Pop. (4)

Asthma · Cardiovascular Disease · Diabetes* · Low-Birth-Weight Infants

Socioeconomic (5)

Educational Attainment · Housing Burden · Linguistic Isolation · Poverty · Unemployment

** New in CES 5.0*

Normalization & Aggregation

Why percentile ranking, and how scores roll up

Why Percentile Ranking?

Transparent

Percentiles are familiar — analogous to test scores and growth charts.

Distribution-agnostic

Doesn't assume normality. Suitable for CES indicators with skewed, bimodal, or zero-inflated distributions.

Consistent

Applied identically to all 23 indicators across both components.

Emphasizes cumulative burden

Consistently high values across many indicators lead to higher overall scores.

How Scores Are Calculated

1. Each tract gets a percentile score for all 23 indicators (0–100)
2. Exposures percentiles are averaged → Exposures score
   Env. Effects percentiles are averaged → Env. Effects score (weighted ½)
3. Pollution Burden = Average of Exposures and ½ × Env. Effects
4. Sensitive Populations and Socioeconomic Factors percentiles averaged separately, then averaged together → Population Characteristics score.
5. CES Score = Pollution Burden × Population Characteristics (then percentile-ranked statewide)

Note: Zero = no burden present. Missing data excluded from calculation.

Key Trade-offs in CI Tool Design

Deliberate choices that shape every cumulative impacts tool

Specificity ↔ **Generalizability**

Localized tools capture community-specific nuance but aren't equitable across regions. A statewide tool ensures consistent evaluation but may underserve rural areas or Tribes.

Simplicity ↔ **Statistical Rigor**

Percentile ranking and multiplicative aggregation are less sophisticated than z-scores or nonlinear methods, but they are transparent, replicable, and community-legible. Complexity can reduce trust and enable manipulation.

Sensitivity ↔ **Robustness**

Straightforward methods render scores sensitive to model changes. Mitigation: public engagement, documented sensitivity analyses, and transparent documentation of all methodological decisions.

Coverage ↔ **Data Quality**

Additional indicators improve comprehensiveness, but each must meet rigorous quality standards. Data that fall short may be included as non-scored supplemental map layers.

Community Engagement

How OEHHA integrates community voice into every version of CES

1

Collaborative Design

OEHHA worked closely with CBOs to prioritize indicator updates and co-design the public engagement plan. For CES 5.0, CBO partners were central to the design process from mid-2024 through mid-2025.

2

Iterative Feedback

Workshops use the 'World Café' format for inclusive dialogue. Participants a wide range of audiences who provide feedback on data and methodology.

3

Post-Release Input

Each version goes through public comment. For 5.0, written comments were accepted through March 2026. Community feedback directly shapes indicator changes, weights, and data source decisions.

CalEPA also designates all federally recognized Tribal lands as DACs, separate from CES scoring, respecting Tribal data sovereignty while ensuring DAC eligibility.

Geographic Scale & Data Quality

Why census tracts, and what to know about data limitations

Why Census Tracts?

- **Designed for equal population size**
- **Spatially defined & consistent for 10 years**
- **Data availability**

Key Data Limitations

Urban data bias: Air quality monitors denser in cities; rural burdens can be undercounted
Zero vs. missing: zero indicates no burden; missing indicates no data – these have different implications
Temporal lags: Some data (health outcomes, census) lag 2–5 years; exposure data often more current
Border regions: CES added US-Mexico border pollution data to address gaps

Handling Data That Doesn't Meet the Criteria

Supplemental map layers: data included as non-scored, visible layers that inform without affecting official rankings
Indicator expansion: new data incorporated as updates within existing indicators (e.g., additional facility types within Solid Waste)
Documented gaps: publicly noted limitations with a path toward future data source development. Community sensor data (e.g., PurpleAir) could be valuable in supplemental layers.

Lessons for Tool Builders

What a decade of CES development has taught us

- **Transparency over complexity**
- **Engage early and compensate partners**
- **Plan for policy implications**
- **Use supplemental layers**
- **Build an update cycle from the start**
- **Geographic unit shapes all downstream decisions**

Questions & Resources

CES 5.0 Technical Report

Full methodology, indicator rationale, and scoring examples
oehha.ca.gov → CalEnviroScreen 5.0

Ranjbar et al. 2025

"Balancing Act: Trade-offs in Developing Cumulative Impacts Mapping Tools"
Environmental Justice journal

NASEM 2024 Report

"Constructing Valid Geospatial Tools for Environmental Justice"
National Academies guidance document

The core principle:

Prioritize transparency, community trust, and iterative improvement over statistical sophistication. A tool communities trust and understand will drive better policy outcomes than a more technically complex one they don't.

OEHHA
SCIENCE FOR A HEALTHY CALIFORNIA

Program on Reproductive Health and the Environment

The cumulative impact of social stressors and particulate matter (PM) on child cognitive ability: a Navigation Guide systematic review

Ruwan Thilakaratne, PhD, MPH

Office of Environmental Health Hazard Assessment

June 15, 2026

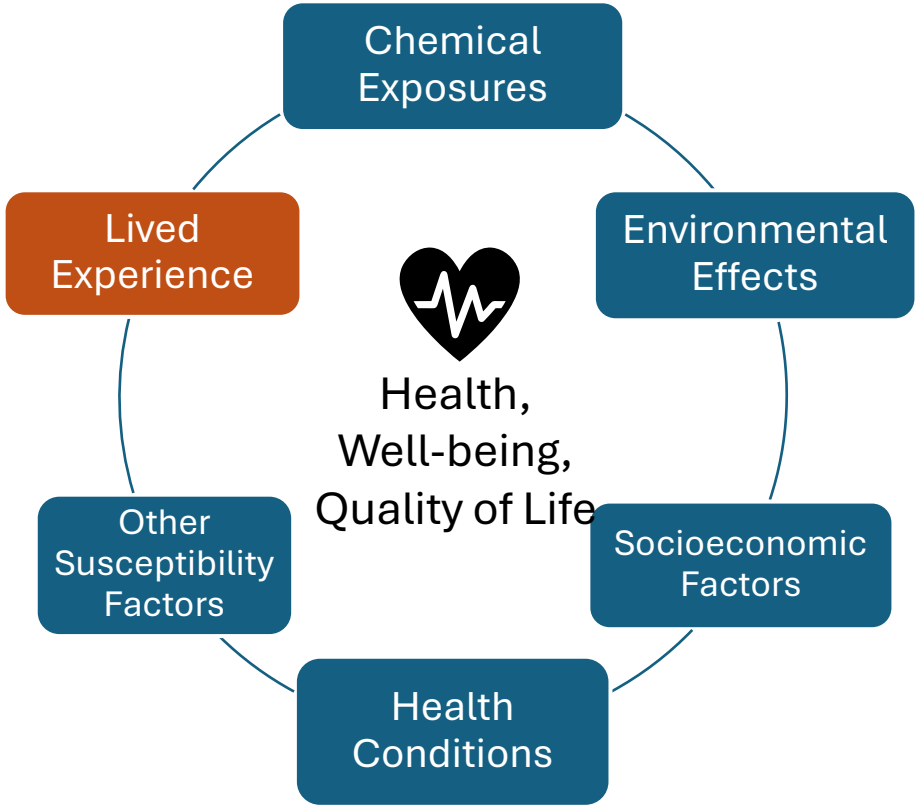
Image from LA Times

Disclaimer

- Statements, data, and results presented here do not necessarily represent the views of OEHHA or CalEPA
- Results are **preliminary and not yet peer-reviewed – please do not share publicly, nor treat as final/authoritative***

**Clarifying note added to packet 6/15/2026 1:00PM: The intent of the red text "please do not share publicly" is to request that the statements, data, and results not be republished as final, since they are not.*

Background: Cumulative Impacts (CI)



Environmental injustice = Disproportionate cumulative impacts

Cumulative Risk Assessment (Non-cancer)

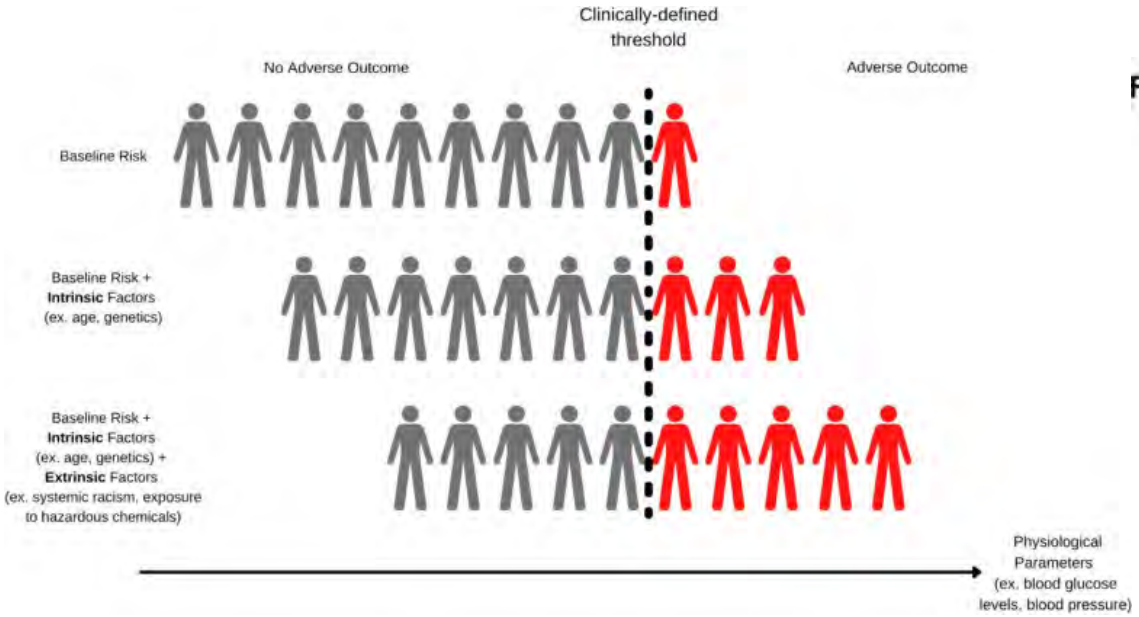


Figure 2 from Varshavsky et al. 2023

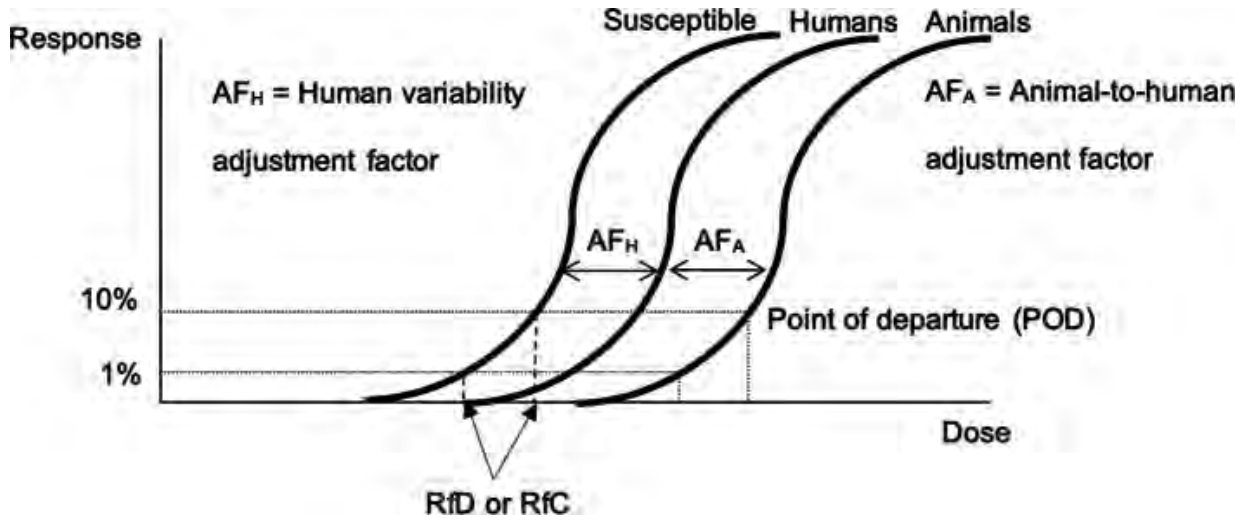


Figure 3 from Varshavsky et al. 2023

Susceptibility is incompletely characterized

Table 2 Examples of increased susceptibility in the human population

Factor	Example	Susceptibility[a]	Reference
Examples from *Science and Decisions* 2009 report			
Genetic	Increased copper susceptibility among Wilson's heterozygotes (~ 1% population).	> 10:1	NRC 2000 [78]
Predisposing exposure	Increased susceptibility among smokers to arsenic-induced lung cancer.	20:1	CDHS 1990 [76]
	Increased susceptibility among smokers to radon-associated lung cancer.	10–20:1	ATSDR 1992 [79]
	Increased susceptibility among low-iodide female smokers to perchlorate-induced thyroid hormone disruption.	20–100:1	Blount et al. 2006 [77]
Preexisting disease	Increased susceptibility among people with hepatitis to liver cancer from aflatoxin.	10–30:1	Wu-Williams et al. 1992 [80]
Physiologic and Pharmacokinetic	Difference in susceptibility to 4-aminobiphenyl (median vs upper 2 percentile) due to physiologic and pharmacokinetic differences (modeled).	> 10:1	Bois et al. 1995 [81]
Overall	Increased heterogeneity in lung and colorectal cancer risk (95th percentile vs median) from age-specific incidence curves.	50:1	Finkel 1995, 2002 [82, 83]

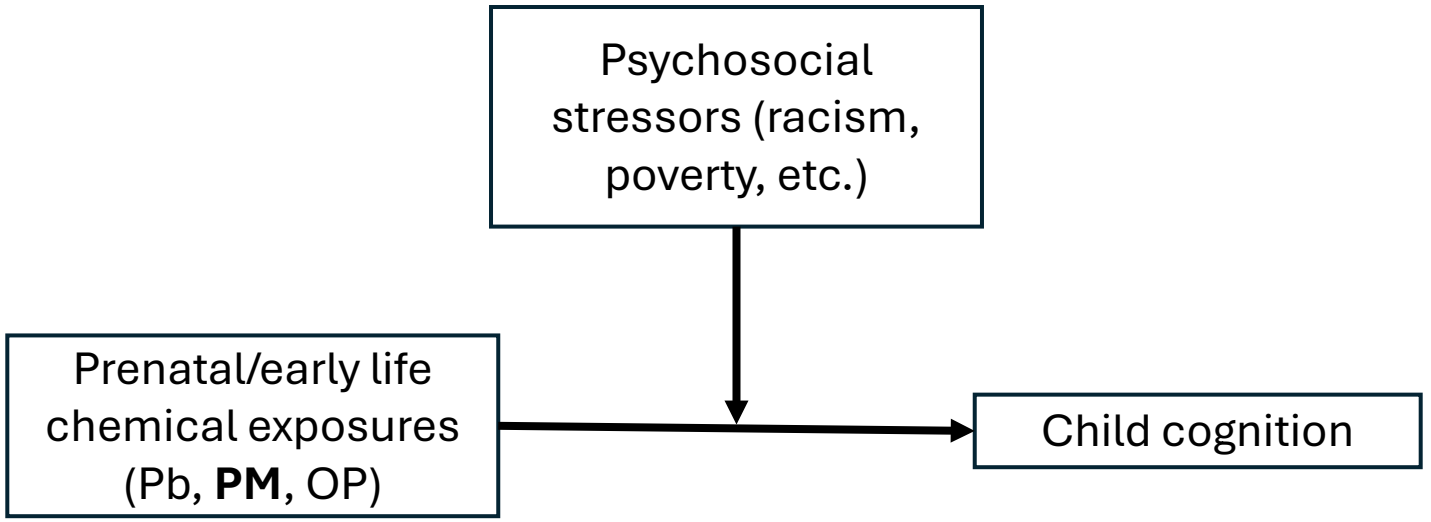
Fragment of Table 2 from Varshavsky et al. 2023

Social non-chemical stressors (SNCS)

- Variety of socially-mediated stressors and resources
- Heightened stress associated with greater susceptibility to chemical effects according to animal studies (Vesterinen 2017)
- **How to quantify?**
  - Insufficiency of animal and *in vitro* models
  - Observational epidemiologic studies needed

Research question

To what extent do SNCS modify the effects of prenatal or postnatal exposure to key chemicals (Pb, **particulate matter**, organophosphate chemicals) on child cognition?



Methods

Systematic review

1. Define research question (PECO)
2. Literature search
3. Title/abstract screening
4. Full text screening
5. Data extraction (ongoing)
6. Risk of bias assessment (ongoing)
7. Qualitative/quantitative synthesis (ongoing)

Program on Reproductive Health and the Environment

NAVIGATION GUIDE

Methods

Population

Children ages 0-18.

Exposure

Prenatal or childhood exposure to higher levels of Pb, PM, or OP; and SNCS.

Comparator

Lower levels of the above exposures.

Outcome

Quantitative measures of cognitive function (e.g., IQ tests, standardized academic tests).

$$SF_{ratio} = \frac{\beta_H}{\beta_L}$$

- **Susceptibility factor (SF)**, the contrast in chemical effect (β) between higher-SNCS (β_H)and lower-SNCS (β_L) subgroups
- SF is estimated within-study and is comparable between studies as a general measure of effect amplification/diminishment

Preliminary results (PM)

Qualitative

- N=20 studies met inclusion criteria
  - PM2.5 exposure range: 9.1-18.7 mcg/m^3 (central tendencies)
  - 15/20 individual-level analyses (not ecologic)
  - 5/20 U.S. studies (other countries: Brazil, Italy, Spain, Australia, Denmark)
  - 4/20 prenatal exposure (rest postnatal)
  - 10/20 used standardized tests to assess cognition (rest 1:1 neuropsychological tests)
  - Most common SNCS: maternal education (N=6)
    - Others: household income, maternal race/ethnicity, composite SES measures, urbanicity

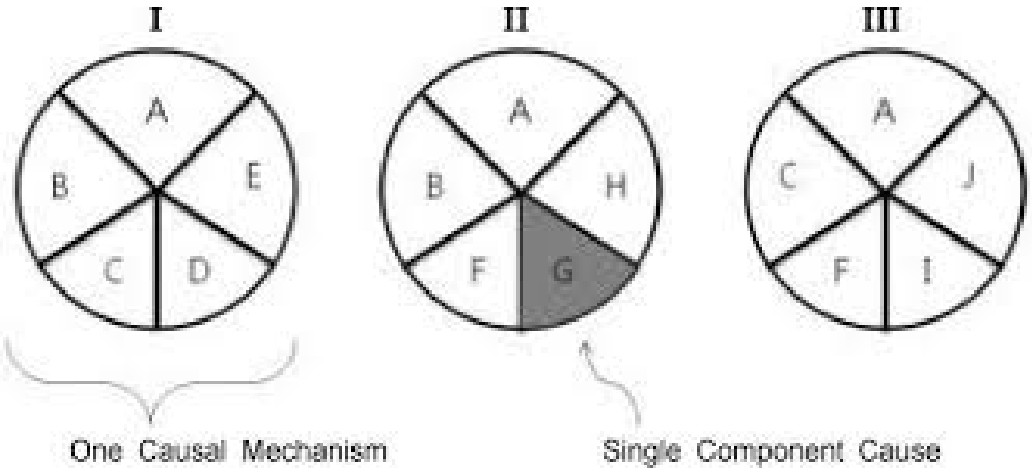
Preliminary results (PM)

Quantitative

- **(Looking only at: individual-level PM2.5 studies)**
- Roughly 20% stronger effect (ratio=1.2) in “high-stress” subgroup vs. “low-stress” subgroup
- Egger’s test (funnel plot asymmetry) supports null (p=0.89), i.e., no evidence of publication bias

Interpretation

- Evidence supports cumulative impact of PM2.5 and psychosocial stress on child cognition
- On average, psychosocial stress amplifies adverse effect of PM2.5 on child cognition
- Both directions are biologically plausible
  - Ratio <1: saturation of disease-causing pathway by other exposures results in reduced apparent effect



Rothman's causal pies: a conceptual model for disease causation

Implications/Next Steps

- Supports lower threshold for chemical effects in low-socioeconomic status populations
  - Potentially an additional uncertainty factor (UF) is warranted
- Risk of bias to be performed for remaining studies
- Integration with Pb and organophosphate chemicals for overall conclusions – forthcoming

Acknowledgements

- OEHHA colleagues
  - Erin Delker, Laura August, Alvaro Alvarado, Keita Ebisu, May Wu, Amal Syed, Tessa Wardle
  - Chloe Ortiz (graduated student)
  - Others
- UCSF PRHE colleagues
  - Jessica Trowbridge, Nicholas Chartres, Rashmi Joglekar, Tracey Woodruff

References

1. Varshavsky JR, Rayasam SDG, Sass JB, et al. Current practice and recommendations for advancing how human variability and susceptibility are considered in chemical risk assessment. *Environ Health*. 2023;21(Suppl 1):133. Published 2023 Jan 12. doi:10.1186/s12940-022-00940-1
2. Vesterinen HM, Morello-Frosch R, Sen S, Zeise L, Woodruff TJ. Cumulative effects of prenatal-exposure to exogenous chemicals and psychosocial stress on fetal growth: Systematic-review of the human and animal evidence. *PLoS One*. 2017;12(7):e0176331. Published 2017 Jul 12. doi:10.1371/journal.pone.0176331

AGENDA: 3C

Bay Area Air District

Regulatory Design Theory

Advisory Council Meeting

June 15, 2026

Kelly Crawford
Deputy Executive Officer
Engineering & Compliance

Kelly Crawford
@ClimateKelly
#minidiva raised her voice @EPA @EPAair #CleanerTrucks hearing. "I am painfully aware of the #airquality concerns within the city I call home and that the color of my skin makes me and my peers more likely to suffer from health issues like asthma." @DCISchool
Zoom
Leave
12:29 PM · 14 Apr 22 · Twitter Web App

Purpose

Socialize a conceptual framework to support Advisory Council discussions on cumulative impacts and regulatory frameworks

Establish shared understanding before program and policy design decisions are made

What We Know

What We Measure Matters

If we measure activity → we get **activity**

If we design for reducing harm → we get **impact**

Air Regulatory Design Foundations

Air Quality Management:

- Polluters pay & self-report
- Technology evolves
- Anti-backsliding
- Regulatory cooperation

Current Operating Conditions:

- Large number of regulatory requirements
- Increasing facility complexity
- Shrinking resources
- Growing public expectations

Core Insight:

- Implementation will become increasingly difficult to enforce effectively

Connection to Cumulative Impacts

Supports both:

1. Place-based approaches (near-term)
2. Risk-based improvements (longer-term)

Near-term path:

1. Use prioritization and design tools with existing data
2. Improve analytical tools over time

Core Principles: Regulatory Design & Justice

Regulatory design focuses on how systems are structured to reduce harm, not simply enforce rules

Success is defined by outcomes (harm reduction), not activity (inspections, violations)

Core Principles: Regulatory Design & Justice

Regulatory Design:

- Harms
- Focusing Bias
- Cycle Time Reduction
- Coverage vs. Impact
- Perverse Incentives

Energy and Environmental Justice Principles

- Procedural Justice
- Recognition Justice
- Distributive Justice
- Restorative Justice

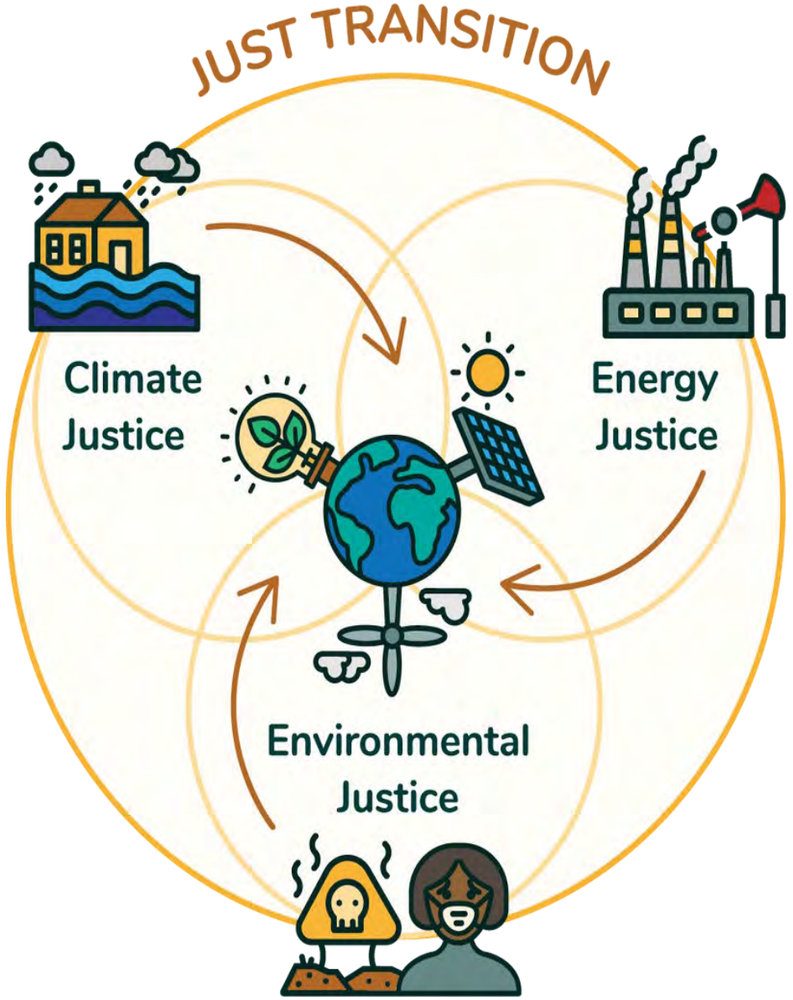


Image Credit: Initiative for Energy Justice Section 1 - Defining Energy Justice: Connections to Environmental Justice, Climate Justice, and the Just Transition - Initiative for Energy Justice (iejusa.org)

Reframing the Core Question

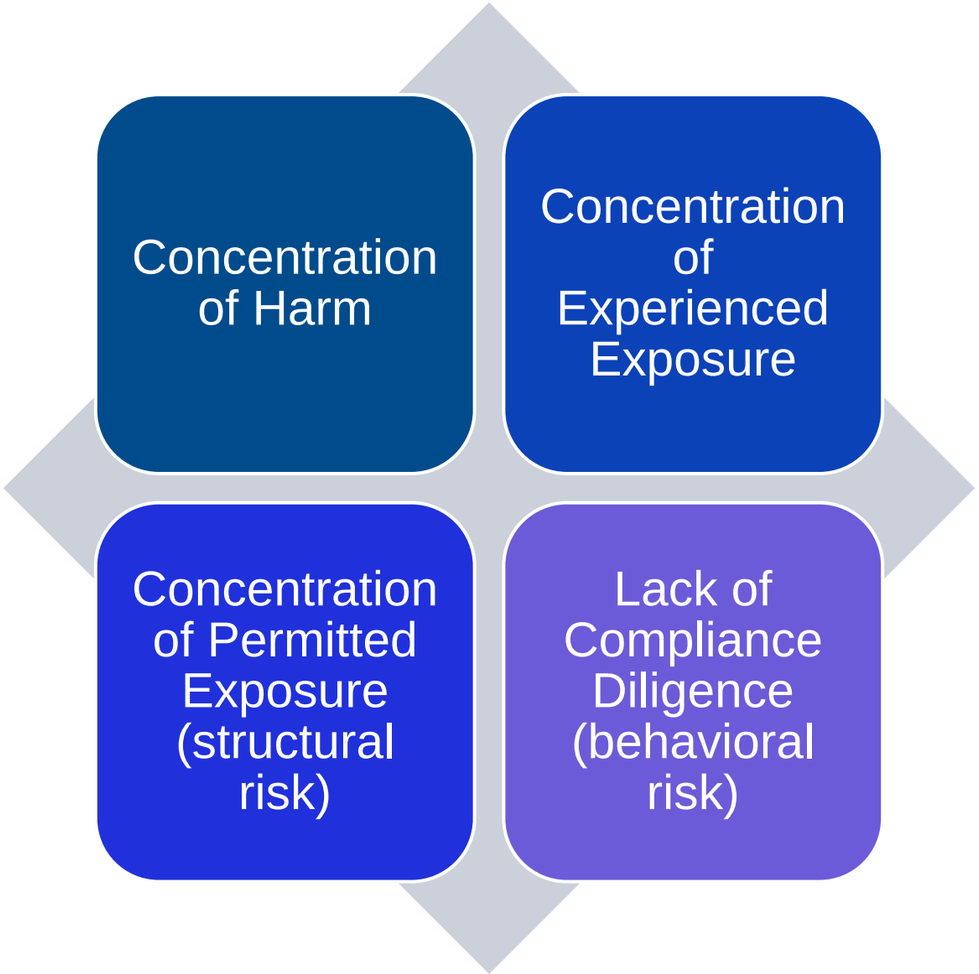
From … *Who is in compliance?*

To … *Where is preventable harm occurring?*

Requires:

1. Integration of community experience
2. Balancing certainty vs. urgency
3. Moving design decisions into process, not only rulemaking

Decision-Making As A Design Choice



Questions & Discussion

For more information:

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DRAFT
Recommendations to Address Cumulative Impacts

Bay Area Air District Advisory Council

June 15, 2026
Advisory Council Meeting
Phil Martien, PhD, Chair

Draft Document Outline

- Introduction
- Background
- Methods
- Findings and Recommendations
- Summary
- Appendix

Focus Area for Recommendations

Cumulative impacts in permitting

New and modified facilities

A priority for community groups

Recommendation Goals

Minimize added burden to areas already suffering cumulative impacts

Reduce differential exposure to air pollution

Consider non-chemical stressors

Reflect community concerns and understanding

Recommendations: Place-based vs. Region-wide

Place-based	Region-wide
Maps of Overburdened Communities (Explicit)	Tailored to Overburdened Communities (Implicit)

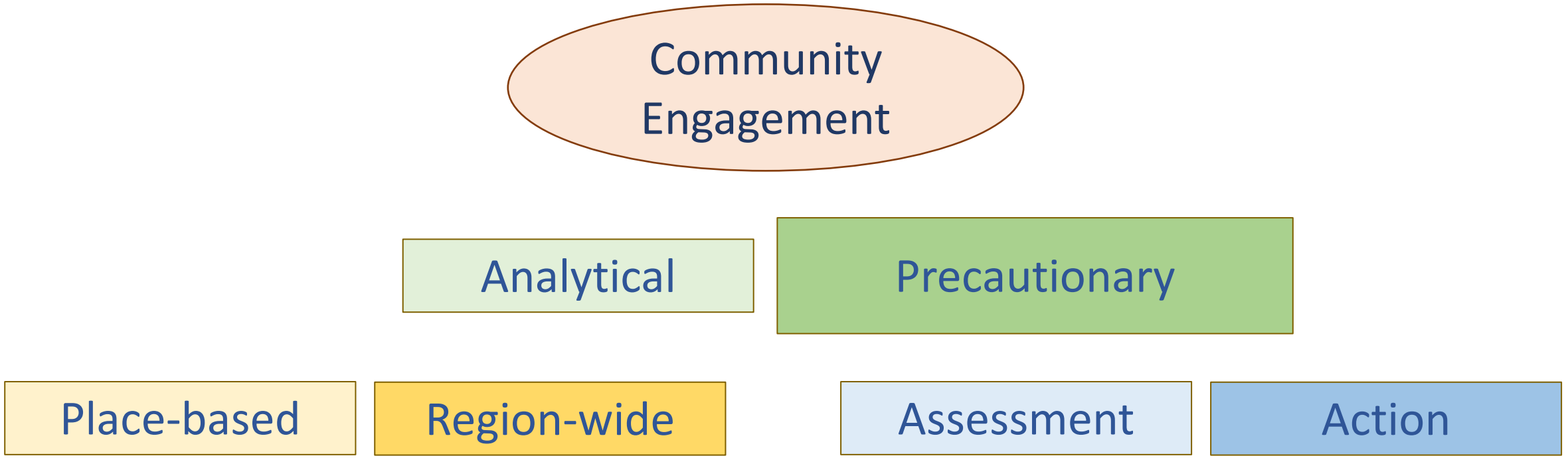
Recommendations: Assessment vs. Action

Assessment (Risk Identification)	Action (Risk Management)

Recommendations: Analytical vs. Precautionary

Analytical	Precautionary
Calculated Impact (Risk-based)	Potential for Harm (Hazard-based)

Recommendations Big Picture



Top-Level Recommendations

1. Adopt precautionary approaches that move more directly to action without quantification of harm, especially where harm might be reasonably assumed.
2. Continue to engage community partners to help gather support and to identify important aspects of both assessments and actions, reflecting lived experiences.

Adopt Place-Based Approaches

3. Apply place-based approaches to identify communities for more health-protective actions. However, a place-based approach alone is insufficient.
    a. Use CalEnvironScreen, at least initially, to identify overburdened communities in place-based approaches.
    b. Explore options for modifying and/or expanding CalEnvironScreen.

Expand the Scope of Impact Assessments

4. Expand the scope of impact assessments:
   a. Using both monitoring and modeling, estimate ambient toxic air contaminant emissions and concentrations throughout the region, with an initial focus on AB 617 communities.
   b. Use measures of population burden to characterize impacts of toxic air contaminants, in addition to measures of peak exposure.
   c. Account for the existing background pollutant levels in assessments that compare source contributions to a reference concentration.

Expand the Scope of Impact Assessments (continued)

4. Expand the scope of impact assessments:
    d. Develop an approach to calculate hazard indices using multiple target organ systems rather than just the most sensitive organ system.
    e. Quantify the contributions of non-chemical stressors in estimates of air pollutant impacts.
    f. Develop and apply methods to account for local, near-source impacts of fine particulate matter ($PM_{2.5}$), especially in overburdened communities.

Add Protections, Move to Action

5. Adjust thresholds, limits, and trigger levels to reduce cumulative impacts:
   a. Tighten limits for cancer risk in overburdened communities when conducting health risk assessments. (e.g., Air District Rule 2-5).
   b. Tighten limits for non-cancer health risk in overburdened communities when conducting health risk assessments.
   c. Reduce near-source impacts of fine particulate matter (PM2.5) from new and modified sources, especially in overburdened communities.
   d. Lower emissions thresholds for best available control technology (BACT) in overburdened communities.

Add Protections, Move to Action (continued)

5. Adjust thresholds, limits, and trigger levels to reduce cumulative impacts:

   e. Use emissions limits as triggers for requiring best available control technology for toxics (TBACT) in overburdened communities.

   f. Set lower emission thresholds and tighten other screening criteria to trigger an environmental review in overburdened communities.

   g. Set lower trigger levels for public notification for projects inside overburdened communities for some source types.

Adopt Precautionary Approaches

6. Adopt precautionary approaches to move more directly to action:
   a. Consider a facility's compliance history in issuing permits.
   b. Explore facility-emission caps for toxic air contaminants and $PM_{2.5}$. This could entail calculating an emissions budget for facilities in overburdened communities.
   c. Consider prohibiting select categories of permits, for some new and modified source types, in overburdened communities.

Explore New Models to Reduce Impacts

7. Protect frontline communities and promote harm reduction by focusing Compliance and Enforcement resources on communities near polluting facilities.
8. Track community benefit agreements within other agencies/jurisdictions—productive examples may emerge.

Questions

- Corrections, changes to goals?
- Recommendations consistent with goals?
- Corrections, changes to recommendations?
- Additional recommendations?
  - More focus on precautionary approaches?
  - Additional hazard-based triggers for action?

Next Steps

- Discuss and refine draft recommendations (today, and via ad hoc)
- Discuss draft recommendations with the Community Advisory Council, if possible (summer/fall)
- Complete draft final recommendations document (Advisory Council meeting, fall)
- Present draft final recommendations to Board of Directors (fall/winter)
- Complete final recommendations document (Advisory Council meeting, winter)