AGENDA: 4

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Fine Particulate Matter Local Risk Methodology Update

Advisory Council Meeting
September 11, 2023

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Overview

1. Review and illustrations of key points
2. Remarks on completeness
3. Next steps

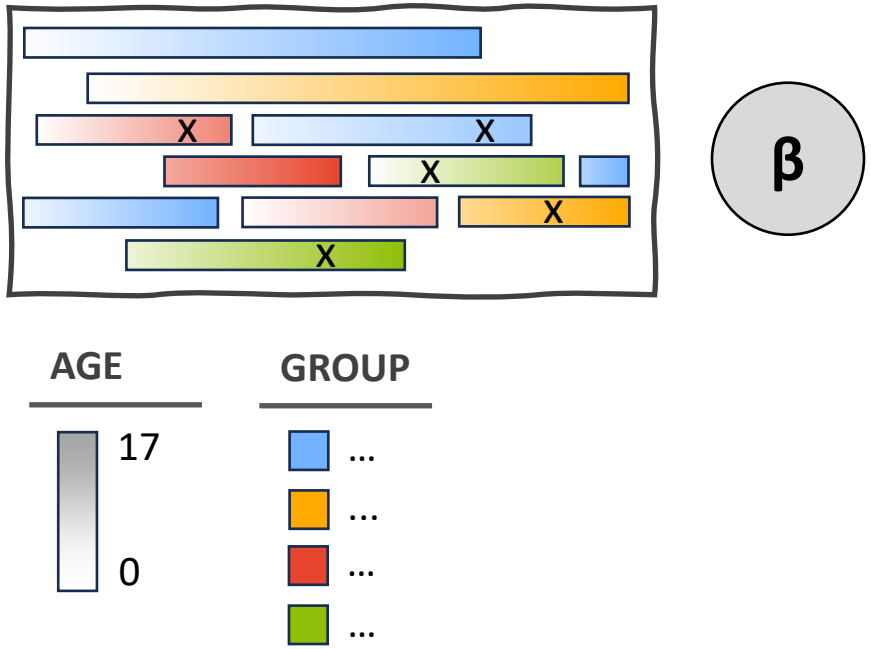
Frameworks Compared

	BenMAP, for $PM_{2.5}$	This methodology (v2.0), for $PM_{2.5}$
Target for estimation	Large population w/ spatially varying density; typical composition & time-activity patterns	Discrete receptors represent potential risk scenarios: residents 24/7, students exposed at school; etc.
Result (ΔY)	Y = annual incidence (events per year)	Y = P(event occurring during long-term risk window)
$PM_{2.5}$ level	Uses continuous modeled surface	Uses maximally impacted receptor locations
Exposure duration	Annual (1 year)	Long-term (up to 30 years)
Exposure timing	Cross-sectional demographics *	Worst-case (young or old), same-age cohort
Co-presence / locality	n/a: source always influencing receptor	Can have "time away" from influence of local source †
Sensitive groups	n/a: typical mixture in population; some more sensitive, others less *	Sensitive group = 3x average effect size ‡
Exposure modification	n/a: typical protection from buildings *	No protection = 1.5x (inverse of typical protection) ‡
Intake modification	n/a: typical intake / breathing rates *	Higher-intake situation = 2x (relative breathing rate) ‡

* β reflects the distribution of this in the populations & contexts/activities that the underlying study(ies) observed.
For maximum validity, should match the target characteristics (e.g. "under age 18, typical shelter, full range of daily activities").
† In this framework, accounted for via Δx/ΔC (C = annual average ambient concentration; x = annual average exposure intensity).
‡ In this framework, accounted for via adjustment factor *F*.

Shared Foundation, Complementary Goals

Epi Study → Effect Size (β) for study population, comprising varying ages and defined groups, per ±1 ug/m^3 in outdoor annual average concentration (C)



Shared Foundation, Complementary Goals (cont.)

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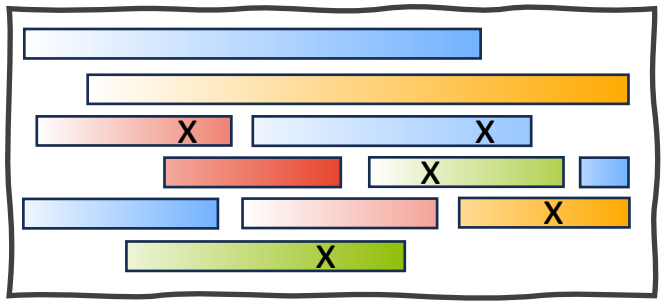
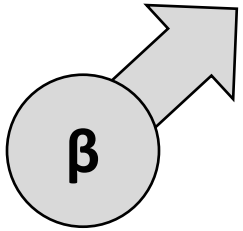
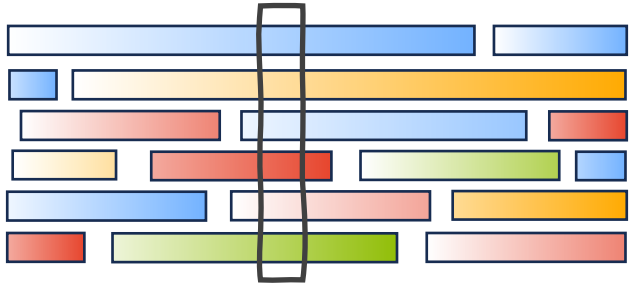
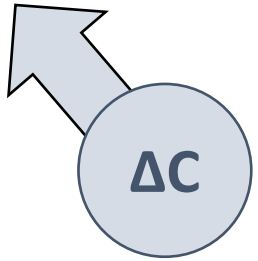


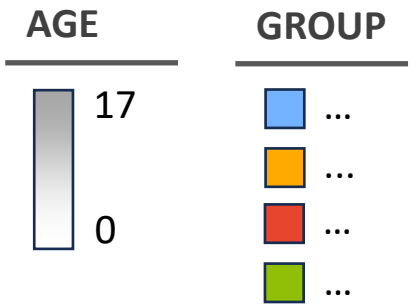


Goal for BenMAP: Estimate change in ***annual rate*** of outcome ***across Bay Area population*** due to some ΔC





ΔC = increase in annual average concentration **attributed to modeled source**



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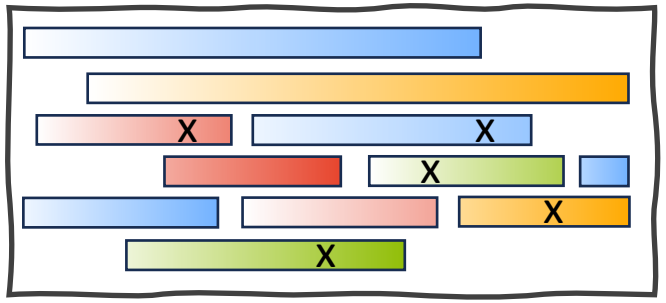

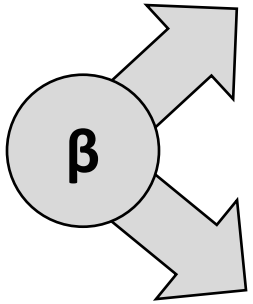

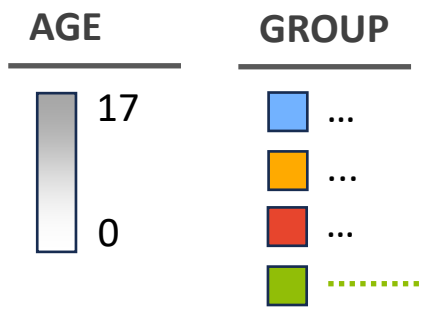

especially sensitive (vulnerable) group

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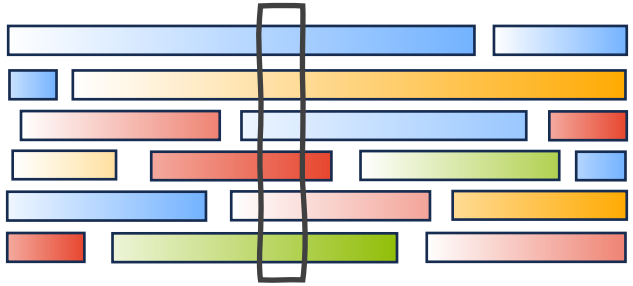
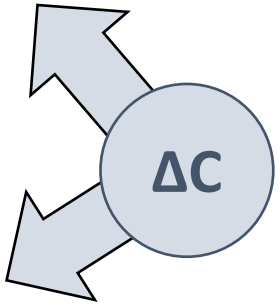
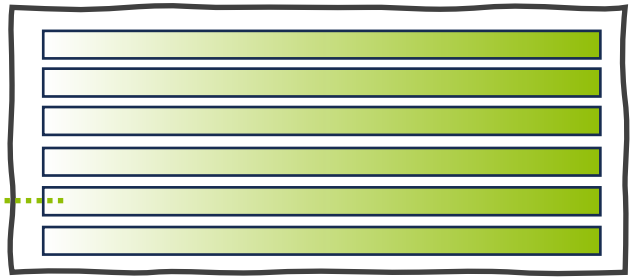




ΔC = increase in annual average concentration **attributed to modeled source**

Goal for this method: Estimate change in ***probability*** of outcome (long term) due to ΔC under a ***"worst case" scenario***



Scenario parameters: especially sensitive group; highly adverse exposure duration & timing (younger for asthma, older for mortality)

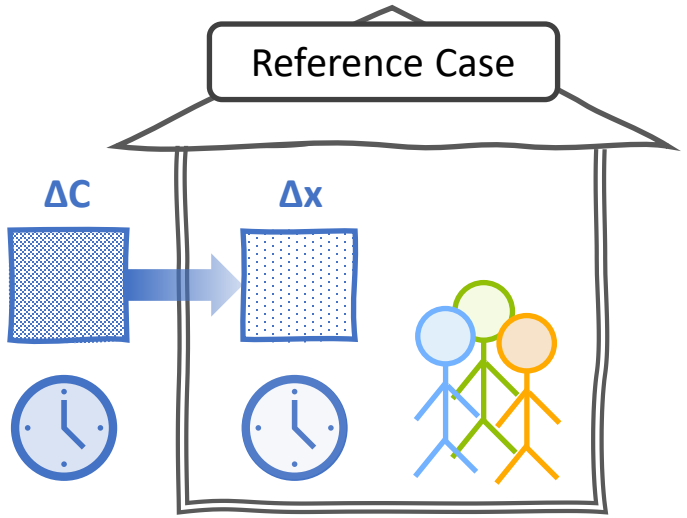
Linearity and Adjustments

Version 2.0:

- Within the range of conditions being considered by this methodology, there are approximately linear relationships between small changes (“deltas”) in concentration, exposure, intake, and effect at a group level.
- Adjustments (relative to BenMAP) bring us into alignment with the established linear-risk, local-source approach used for toxic air contaminants.

Adjustments for Higher Risk

Δx = increase in annual average exposure intensity due to source



"Reference Case" / BenMAP Method

- Some epi study serves as our basis for an **overall effect size β**
- Observed a distribution of human activities, attributes, contexts, etc.
- Reference case: target population / context has similar distribution of factors (e.g., both epi study and target are children-only, but diverse otherwise)

Adjustments for Higher Risk (cont.)

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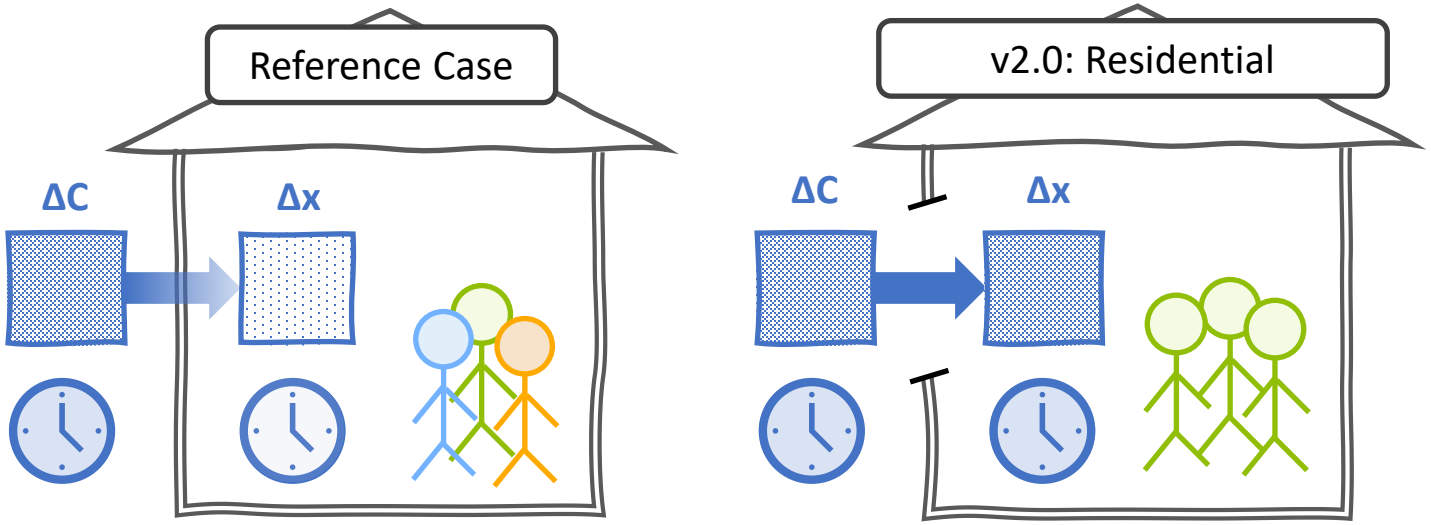

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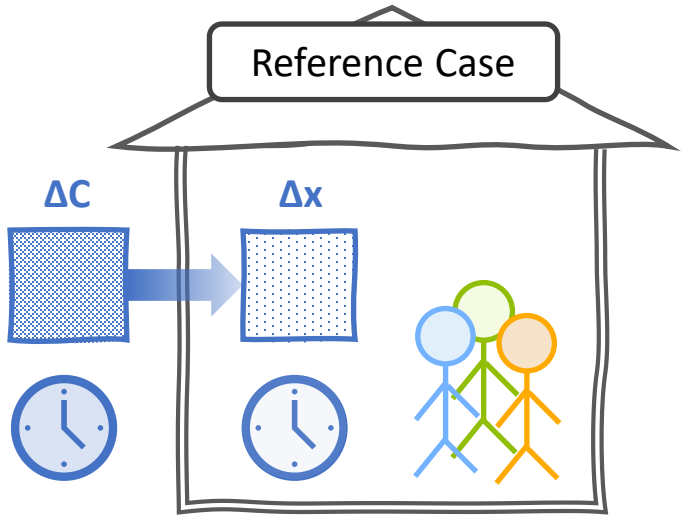
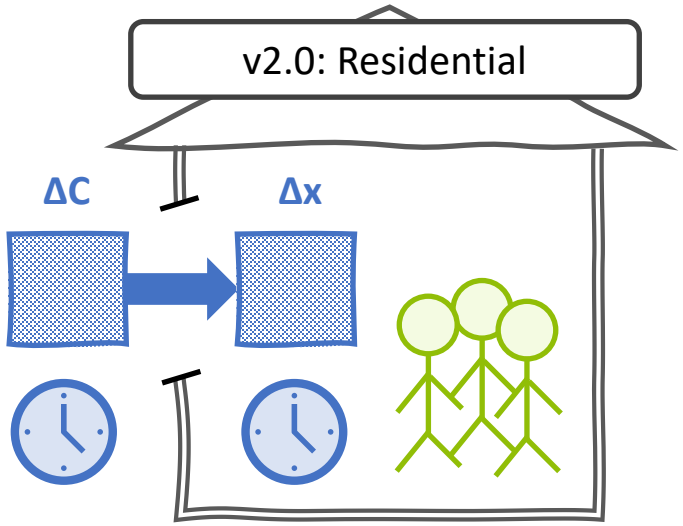
Residential Receptor / Scenario

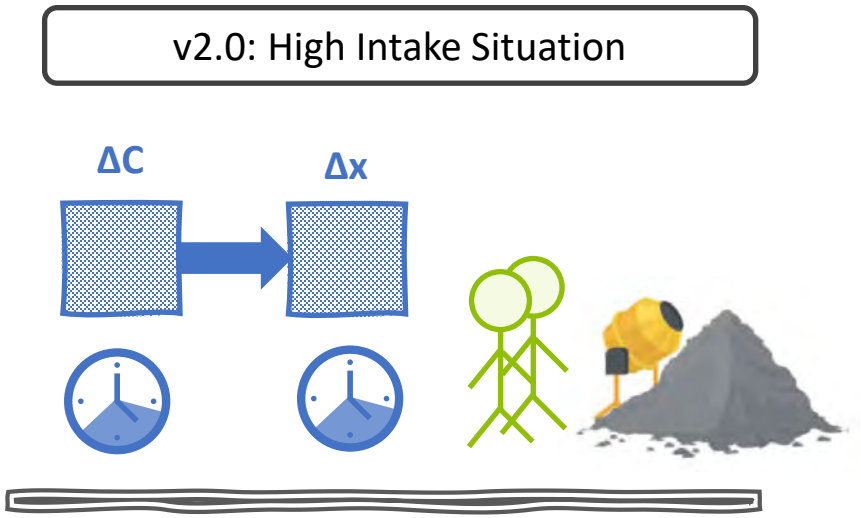
- **More sensitive group** (3x), in terms of, e.g., race/ethnicity, income, comorbidities, etc.
- **Negligible shelter & filtration** (1.5x)
- **F = composite adjustment = 5x**

Δx = increase in annual average exposure intensity due to source

Adjustments for Higher Risk (cont.)







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Example: Off-Site **Worker** Receptor / Scenario

- Same as previous composite adjustment F = 5x in terms of (a) more sensitive group and (b) lack of shelter while exposed to source
- Also **higher intake** (2x) given same exposure (Δx), due to substantially higher activity level while exposed; inhalation rate ≈ 2x average
- **F = composite adjustment = 10x**

Completeness

At the last Advisory Council meeting (June 12, 2023):

- $PM_{2.5}$ has broad effects, so an array of endpoints could be considered (e.g. neurological & reproductive as well)
- Multiple considerations likely to play roles in threshold-setting
- Co-chair requested staff to look into effect sizes for other endpoints

Review of Effect Sizes for Other Endpoints

- Key studies selected with OEHHA assistance, emphasizing:
  - Irreversible binary outcomes, suitable for long-term risk-oriented approach
  - Large follow-up and/or more recent studies
  - Overlap with Bay Area or California
  - Relied on by EPA or CARB
- 21 studies reviewed, 35+ reported risk ratios
- Not a formal literature review

Relative Risks and Baseline Rates

Notable Endpoints and Key Studies	Age Ranges	Baseline Rates (y_0, annual)*	Effect Sizes (β, per µg/m³)
Pediatric asthma onset (Tetréault 2016)	0–17	0.4% to 2%	4.4×10^{-2}
All-cause adult mortality (multiple key studies)	55–84	1% to 6%	1.0×10^{-2}
Alzheimer's disease, first admission (Shi 2020) †	55–84	0.004% to 0.1%	3.5×10^{-2}
Ischemic heart disease mortality (Alexeeff 2023)	55–84	0.04% to 1%	1.9×10^{-2}
Preterm birth (Basu 2017)	15–44	0.1% to 1% ‡	2.2×10^{-2}

* Rates vary by age; ranges given. Sources: BenMAP and CDC (WONDER/NCHS/DVS).
† For exposures < 12 ug/m3. In terms of β, Kioumourtzoglou et al (2016) reported ~4x this effect size, but with much less precision. Five of those co-authors contributed to Shi (2020).
‡ Annual US rate ≈ 10 to 100 per 1,000 women age 15–44. About 10–15% of births are preterm.

$$\Delta y = y_0\,[\exp(\beta\,\Delta x) - 1]$$
$$\approx y_0\,\beta\,\Delta x \quad \text{(for small } \beta\Delta x\text{)}$$

Risk difference (Δy)
If the baseline rate (y_0) is relatively low, Δy may not be large, even if β is large

Baseline rate (y_0) has defined scope & unit of denominator; receptor definitions must be consistent w/those

Next Steps

- Formal endorsement
- Method goes to Air District Board of Directors with Council endorsement
- California Air Pollution Control Officer Association (CAPCO) Toxics symposium - Oct 24
- Case studies

Thank You

Questions and comments