



BAY AREA
AIR QUALITY
MANAGEMENT
DISTRICT

AGENDA: 4

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”).

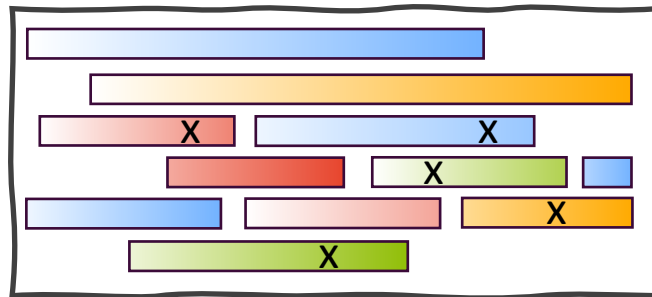
† In this framework, accounted for via $\Delta x / \Delta C$ (C = annual average ambient concentration; x = annual average exposure intensity).

‡ In this framework, accounted for via adjustment factor F.

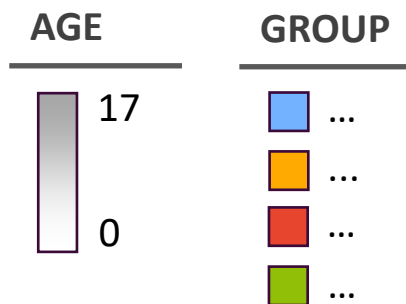
Shared Foundation, Complementary Goals



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



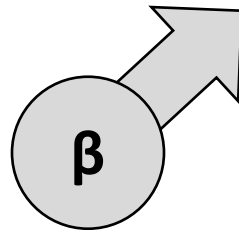
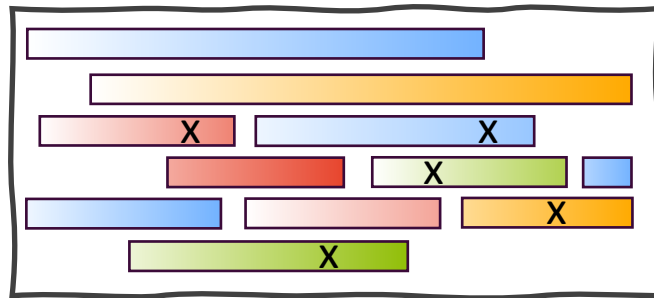
β



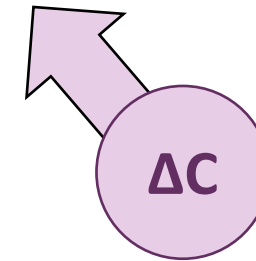
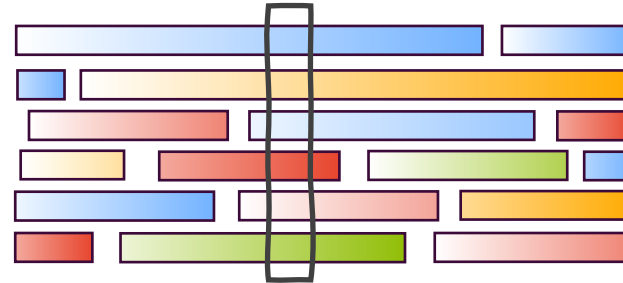
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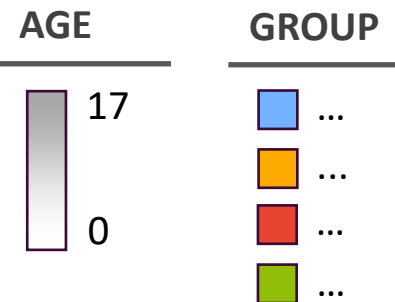
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Goal for BenMAP: Estimate change in **annual rate** of outcome **across Bay Area population** due to some ΔC



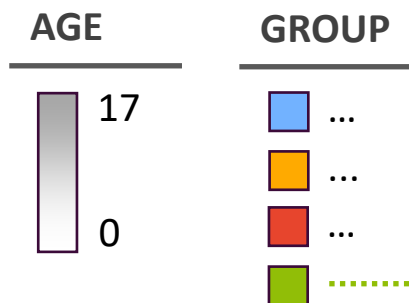
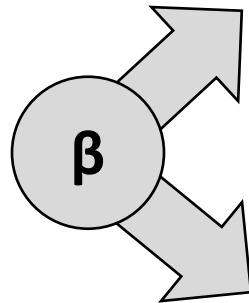
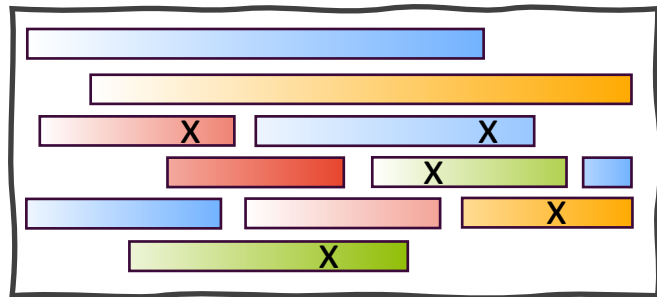
ΔC = increase in annual average concentration attributed to modeled source



Shared Foundation, Complementary Goals

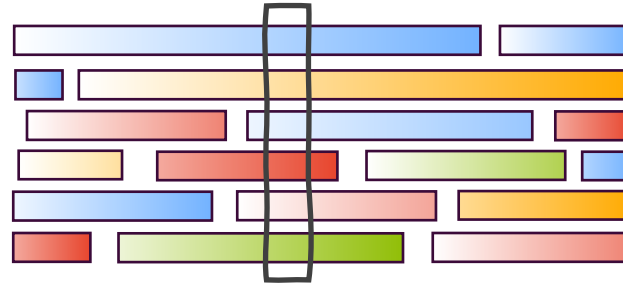


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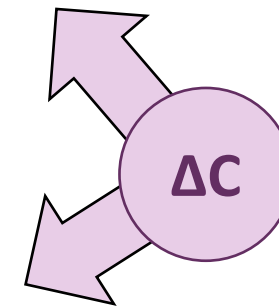


especially sensitive (vulnerable) group

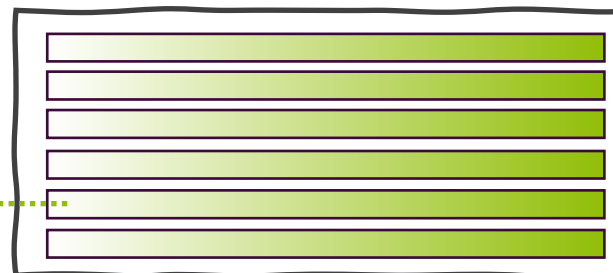
Goal for BenMAP: Estimate change in **annual rate** of outcome **across Bay Area population** due to some ΔC



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



ΔC = increase in annual average concentration attributed to modeled source



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

Linearity and Adjustments



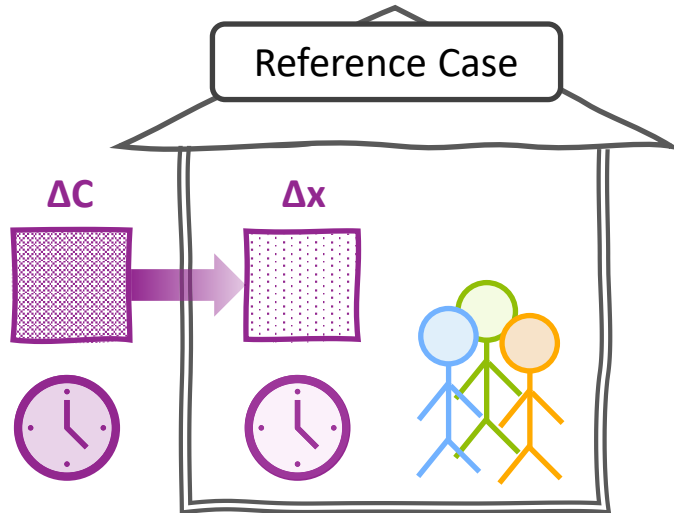
Version 2.0:

- 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



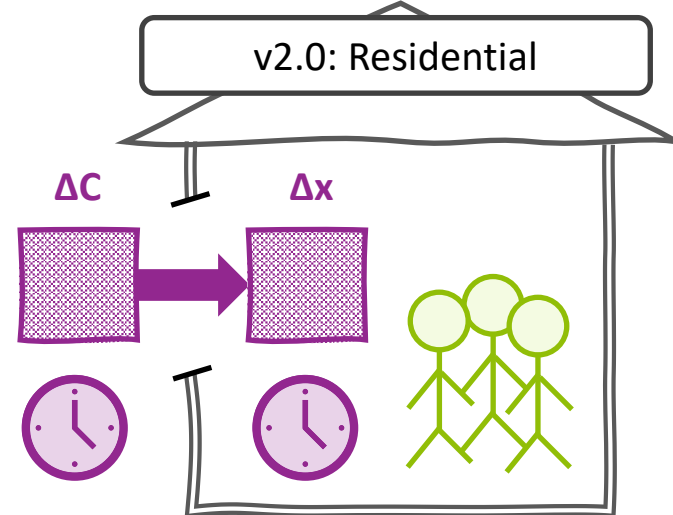
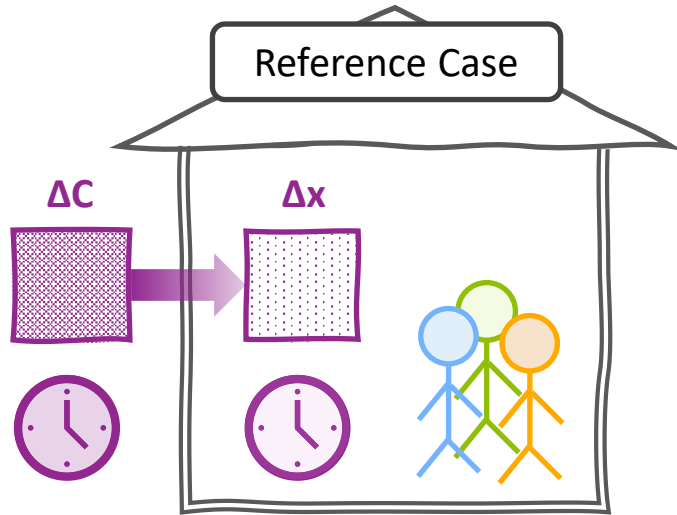
“Reference Case” / BenMAP Method

- 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)



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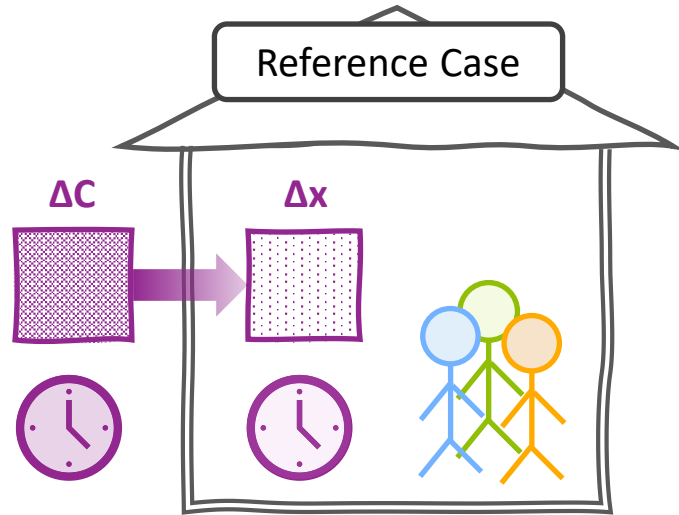
Residential Receptor / Scenario

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



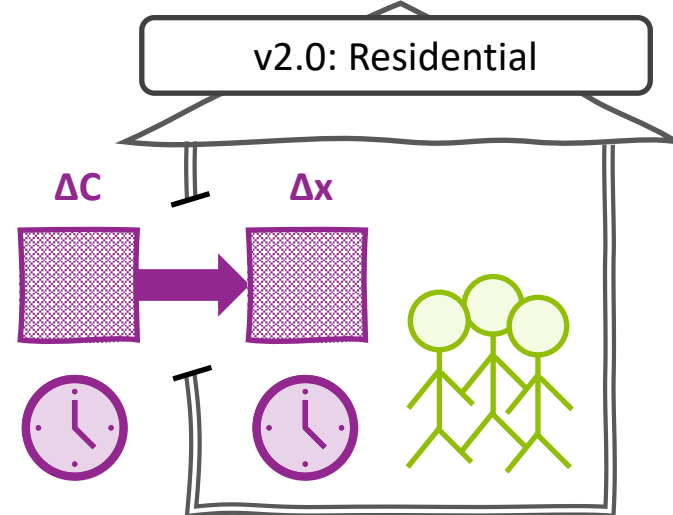
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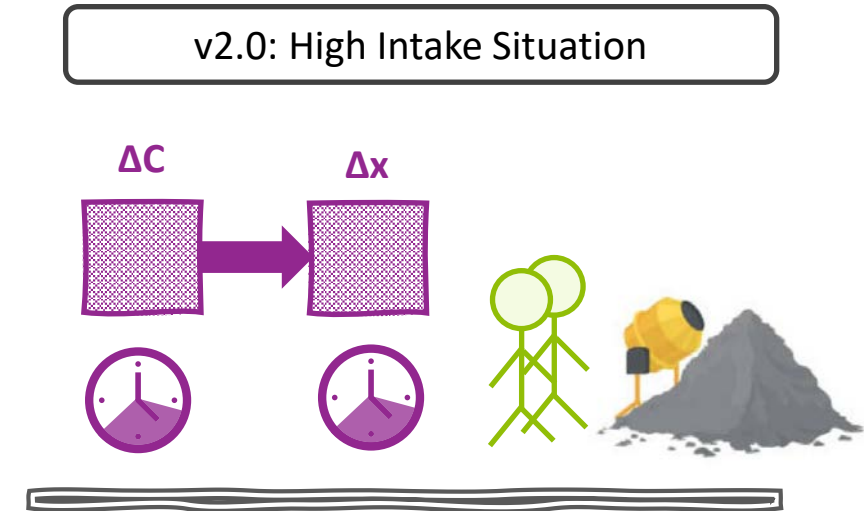
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Example: Off-Site **Worker** Receptor / Scenario

- 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 $\approx 2x$ 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 $\mu\text{g}/\text{m}^3$) |
|---|------------|-----------------------------------|---|
| 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} |

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

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

* Rates vary by age; ranges given. Sources: BenMAP and CDC (WONDER/NCHS/DVS).

† For exposures < 12 $\mu\text{g}/\text{m}^3$. 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 \approx 10 to 100 per 1,000 women age 15–44. About 10–15% of births are preterm.

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