PM MODELING: CONTEXT, PRODUCTS, & PROGRESS

Bay Area Air Quality Management District

AGENDA: 4

Advisory Council Meeting

July 11, 2022

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Outline

- Larger context for PM modeling
- Summary of PM modeling work (what, how, why, and when)
- Progress on PM modeling products
- Measuring success

The Larger PM Context

North Star: Reduce PM exposure where it matters most.

Set Policy

Better Understand PM Impacts

Health and equity.

Methods and Models: Local $PM_{2.5}$ Risk Methodology and Combustion Analysis using InMap model and traditional, full-chemistry model.

Revise Priorities

Review current priorities and possibly revise considering what is learned about PM.

Take Action

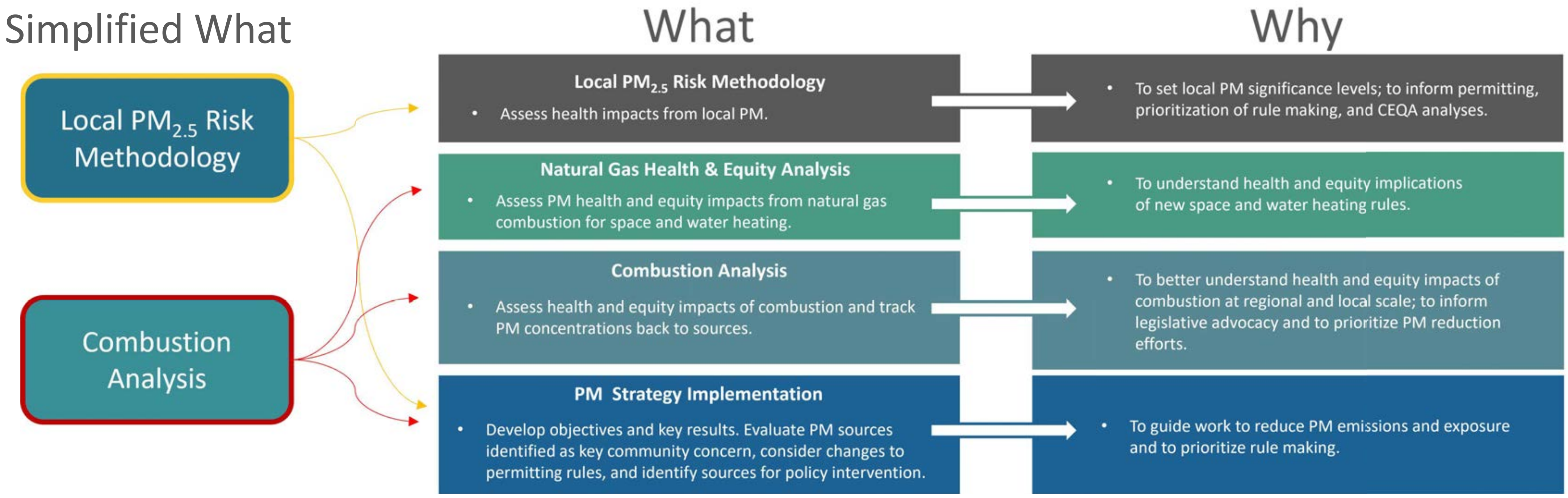
- Rules
- Permitting
- Enforcement
- Incentives
- Community-led actions
- CEQA thresholds & letters
- Advocacy
- Legislation

Assess Progress

- Determine metrics of success
- Assess and report progress

Four Recent Advisory Council Presentations

What	Why
Local $PM_{2.5}$ Risk Methodology • Assess health impacts from local PM.	• To set local PM significance levels; to inform permitting, prioritization of rule making, and CEQA analyses.
Natural Gas Health & Equity Analysis • Assess PM health and equity impacts from natural gas combustion for space and water heating.	• To understand health and equity implications of new space and water heating rules.
Combustion Analysis • Assess health and equity impacts of combustion and track PM concentrations back to sources.	• To better understand health and equity impacts of combustion at regional and local scale; to inform legislative advocacy and to prioritize PM reduction efforts.
PM Strategy Implementation • Develop objectives and key results. Evaluate PM sources identified as key community concern, consider changes to permitting rules, and identify sources for policy intervention.	• To guide work to reduce PM emissions and exposure and to prioritize rule making.



The Takeaway

- ***Two major modeling efforts*** will inform regional and community strategies and prioritization:
  - $PM_{2.5}$ Local Risk Method
  - Combustion Analysis

PM Modeling Efforts in Summary

$PM_{2.5}$ Local Risk Method

- **What:** A method to evaluate localized $PM_{2.5}$ health impacts.
- **How:** Local-scale modeling of $PM_{2.5}$ concentrations and exposures using a new method.
- **Why:** To allow consideration of local $PM_{2.5}$ health impacts in new permitting and CEQA thresholds.

Combustion Analysis

- **What:** Assessments of health & equity impacts of $PM_{2.5}$ at regional and local scales.
- **How:** Individual and combined PM sources, including combustion, analyzed using traditional models and reduced complexity InMap model.
- **Why:** To better understand combustion sources which will inform rules, prioritization, community impacts and emission reduction strategies.

Modeling Products & Timeline

$PM_{2.5}$ Local Risk Method

- White paper summarizing evaluation of localized health impacts of $PM_{2.5}$. (Dec '22)
- Rule amendments that consider local PM health impacts. (Beginning 2023)
- Updated CEQA guidelines reflecting new information on local PM health impacts. (Beginning 2023)

Combustion Analysis

- Appendices in staff reports for residential wood burning (Sept '22) and building appliance (Oct '22) rules.
- All-source assessment report on health and equity impacts of $PM_{2.5}$. (Winter '22)
- Richmond-North Richmond-San Pablo community-wide source apportionment and individual source impacts of $PM_{2.5}$ and toxics. (Winter '22)
- East Oakland community-wide source apportionment and individual source impacts of $PM_{2.5}$ and toxics. (Winter '23)

Products Timeline

Fall '22

SPECIFIC SOURCE COMBUSTION ANALYSES

Assess health and equity impacts from residential wood burning and natural gas combustion for space and water heating and power plants.

Dec '22

EVALUATION OF LOCAL $PM_{2.5}$

White paper summarizing evaluation of localized health impacts of $PM_{2.5}$.

Winter '22

ALL SOURCE COMBUSTION

All-source assessment report on health and equity impacts of $PM_{2.5}$.

COMMUNITY $PM_{2.5}$ ASSESSMENT

Richmond area source apportionment and individual source impacts of $PM_{2.5}$ and toxics.

Winter/Beginning '23

RULE AMENDMENTS

Rule amendments that consider local PM health impacts.

CEQA GUIDELINES

Updated CEQA guidelines reflecting new information on local PM health impacts.

COMMUNITY $PM_{2.5}$ ASSESSMENT

East Oakland source apportionment and individual source impacts of $PM_{2.5}$ and toxics.

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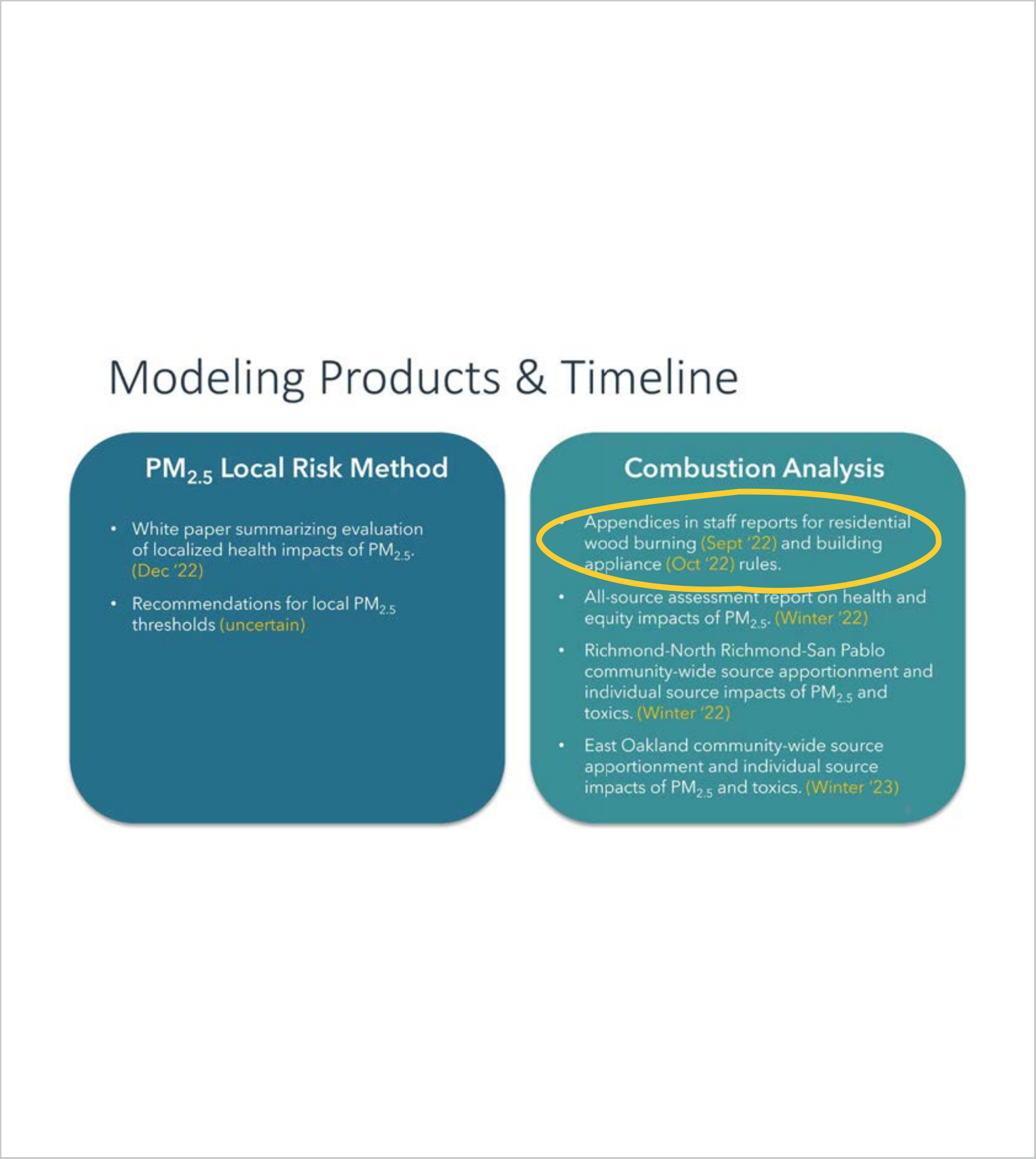
Combustion Analysis Progress:
Building Appliances

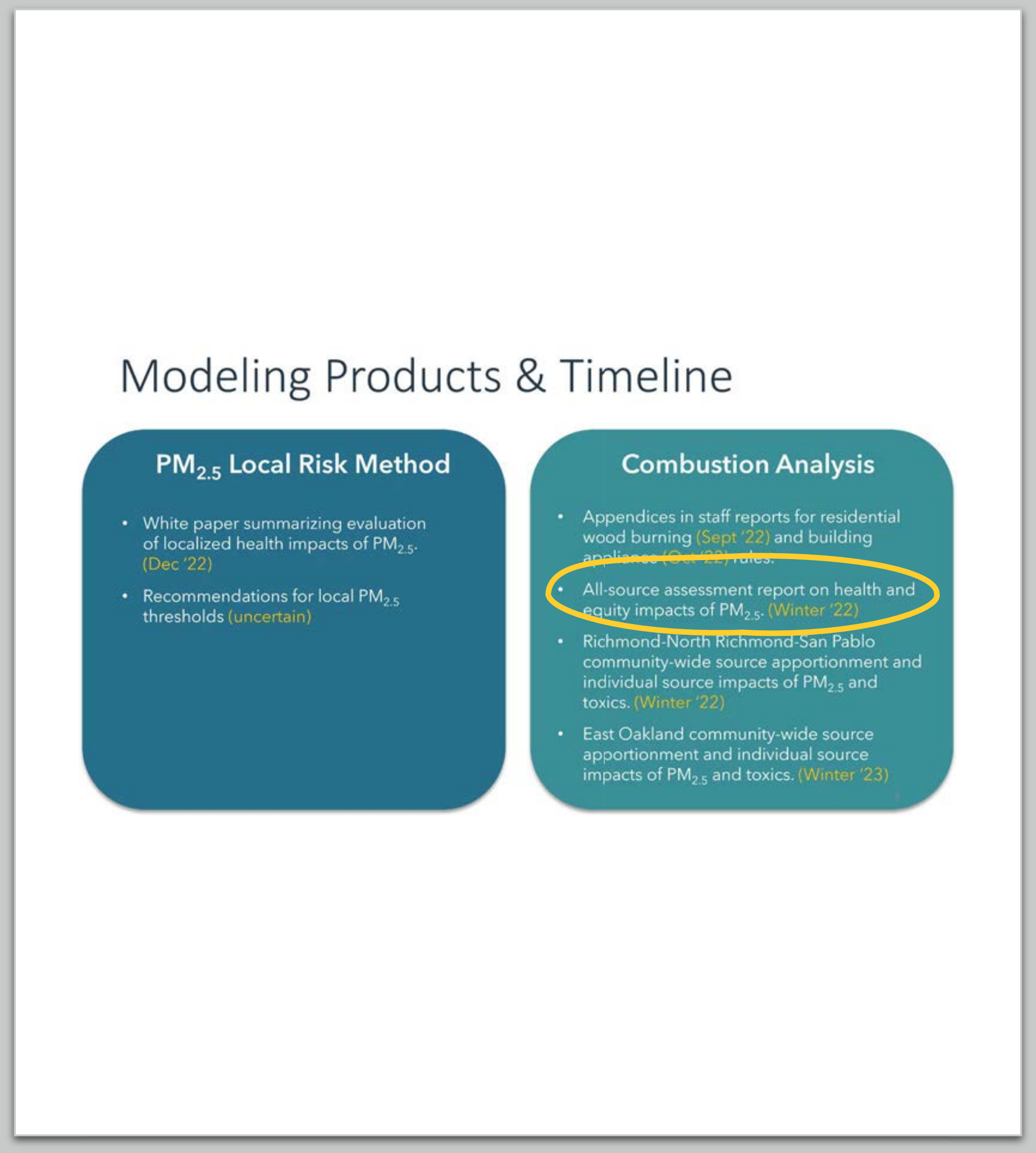
- Modeling health impacts of emissions from power plants
    - Incorporating consultant work on potential additional electrical power demand
- Work 80% complete
- Draft rule to be presented to Air District Board Oct ’22



Combustion Analysis Progress:

All Source Assessment: Application of InMAP

- Intervention Model for Air Pollution (InMAP)
- Links PM exposures to sources of PM and PM precursors
- Major outstanding task: data format translation → Air District regional modeling to InMAP
- About 30% complete, expect more progress this summer



PM Modeling Next Steps

$PM_{2.5}$ Local Risk Method

- Update Advisory Council on progress and key questions since April. (July '22)
- Finalize draft whitepaper with updates and circulate for comments. (Sept '22)
- Summarize and address comments received. (Nov '22)

Combustion Analysis

- Report to Advisory Council on wood burning impacts and on updates to building appliance rule assessments. (Nov '22).
- Report to Advisory Council on all-source assessment report on health and equity impacts of $PM_{2.5}$. (Dec '22)

AGENDA: 5

Fine Particulate Matter Local Risk Methodology: Update and Key Questions

Advisory Council Meeting
July 11, 2022

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Bay Area Air Quality Management District

Overview

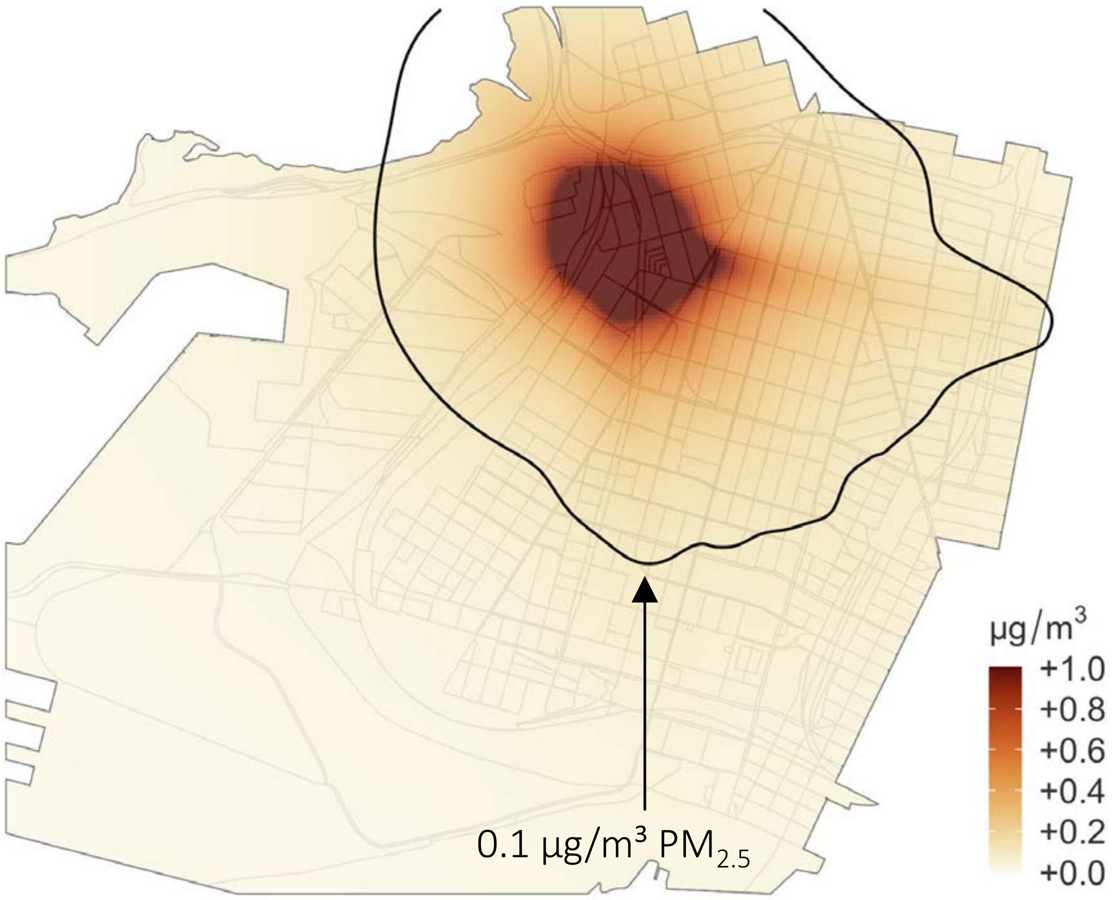
- Provide updates responsive to Council feedback
- Consider key questions concerning safety/uncertainty factors

Key Questions

In light of available evidence, is a safety/uncertainty factor of three (3x) justified/defensible for:

1. Premature mortality
   a. Older seniors
   b. Younger seniors
   c. Workers
2. Asthma onset
   a. Young children
   b. Students

Recap: Average Annual Impact



risk ratio $\approx \Delta c * \beta$

I

Exposure increment *(Δc)*	+0.1 µg/m³ $PM_{2.5}$
Effect estimate (β)	0.007 (0.7%)
Excess risk (multiplicative)	0.0007 (0.07%)

risk difference $\approx$ *baseline risk* $*$ *(risk ratio)*

II

Baseline risk	9×10^{-3} death/yr
Excess risk (additive)	6×10^{-6} death/yr

I. With assumptions, a long-term increment of +0.1 µg/m³ $PM_{2.5}$ ≈ excess risk (multiplicative) of 0.07%

II. For a "statistically average" Bay Area adult, this would be an excess risk (additive) of 6×10^{-6} death/yr

Advancements

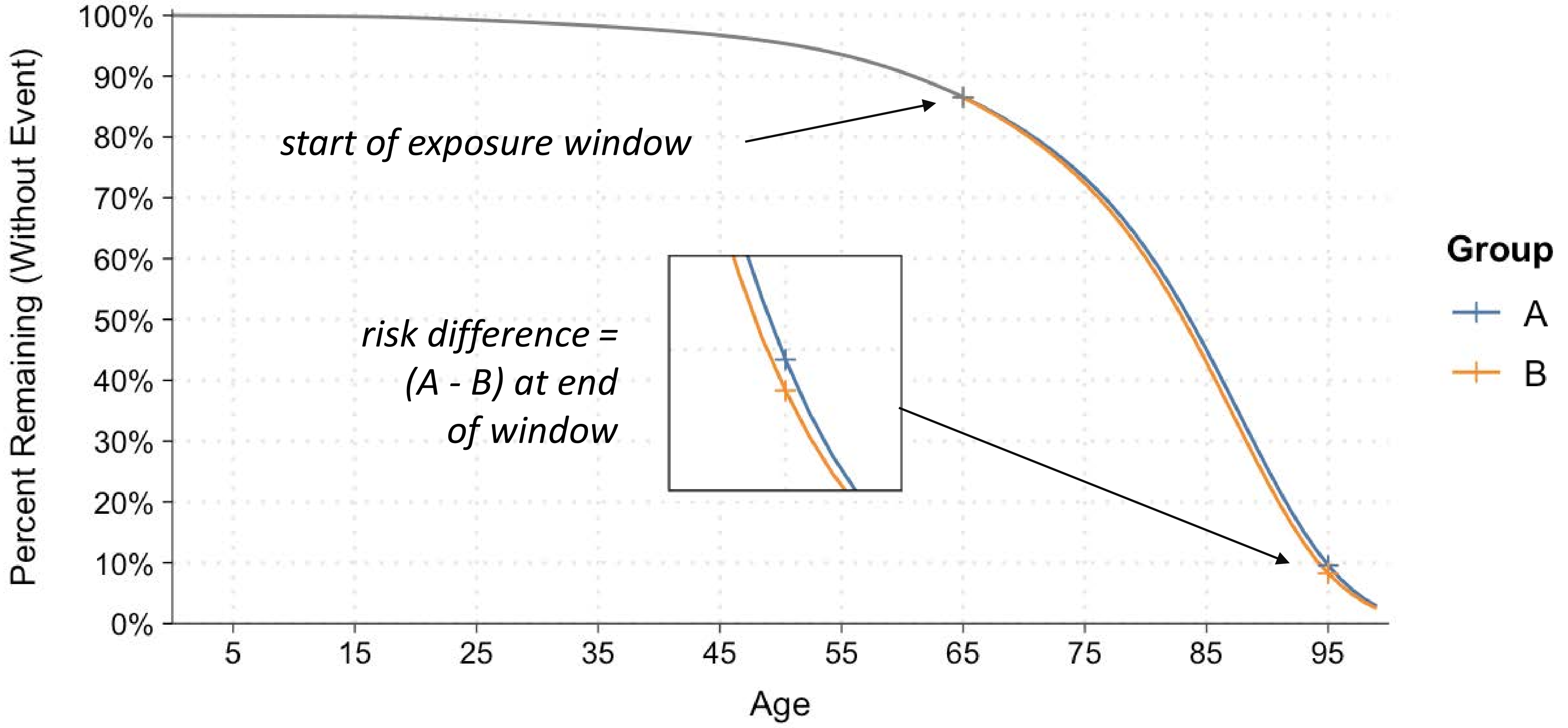
- At-risk populations
  - ✓ *Seniors, people of color, children*
- Dimensions for safety/uncertainty factor(s)
  - ✓ *Age, race/ethnicity*
  - ❑ *SES: low income, Medicaid eligible, …*
  - ❑ *Lower baseline concentrations (less than 10 or 12 µg/m³)*
- Chronic disease endpoint(s)
  - ✓ *Asthma onset*

Revised Approach

- **Maximally exposed individual** (MEI) receptor
- Multi-year **exposure window**
- **Risk difference** post-exposure
  - Population perspective = expected excess *incidence*
  - Individual perspective = excess *probability* of adverse event

Illustration

Group B is exposed to 10 μg/m³ more $PM_{2.5}$ than Group A.
Relative risk = 1.07 per 10 μg/m³.



Exposure Window

- Constraint: **max 30 yr co-presence** of source & receptor
  - OEHHA (2015) and BAAQMD (2020)
  - Worker: 25 yr; student: 13 yr; daycare: 5 yr

- Principle: select **most health-protective** window
  - Cancer: early life
  - Mortality: later life
  - Asthma: early life

Points of Reference

Table 1. Modeled $PM_{2.5}$ increments and corresponding risk scores for different receptor types and health endpoints.

	Asthma Onset		Adult Mortality	
Annual Average Concentration	**Daycare (0-4)**	**Student (5-17)**	**Resident (65-94)**	**Worker (40-64)**
3×10^{-1} µg/m³	1×10^{-3}	9×10^{-4}	4×10^{-4}	2×10^{-4}
1×10^{-1} µg/m³	5×10^{-4}	3×10^{-4}	1×10^{-4}	6×10^{-5}
3×10^{-2} µg/m³	1×10^{-4}	9×10^{-5}	4×10^{-5}	2×10^{-5}
1×10^{-2} µg/m³	5×10^{-5}	3×10^{-5}	1×10^{-5}	6×10^{-6}
3×10^{-3} µg/m³	1×10^{-5}	9×10^{-6}	4×10^{-6}	2×10^{-6}

No safety/uncertainty factors *applied*

Safety/Uncertainty Considerations

Holding aside age, we have seen evidence of larger impacts on adult mortality—given the same increase in annual average $PM_{2.5}$—depending on:

1. **Attributes of individual/group** (race & ethnicity, Medicaid eligibility, low-income ZIP code, …)

2. **Baseline $PM_{2.5}$ level** (at or below current NAAQS)

Di et al (2017)

- Medicare cohort
  - Age 65 and up
  - 460M person-years
- Relative risk = 1.073 per 10 ug/m^3 $PM_{2.5}$
  - **1x** for Medicaid-eligible
  - **3x** for African-American/Black
  - **2x** for subset below 12 ug/m^3

Di Q, Wang Y, Zanobetti A, Wang Y, Koutrakis P, Choirat C, Dominici F, Schwartz JD. Air pollution and mortality in the Medicare population. New England Journal of Medicine. 2017 Jun 29;376(26):2513-22.

Yazdi et al (2021)

- Subset of Medicare cohort
  - Always below 12 ug/m^3
- **2x** our provisional relative risk of 1.07 per 10 ug/m^3
  - **4x** for Medicaid-eligible
  - **0.8x** for African-American/Black
  - **5x** for lowest income quartile

Yazdi MD, Wang Y, Di Q, Requia WJ, Wei Y, Shi L, Sabath MB, Dominici F, Coull B, Evans JS, Koutrakis P. Long-term effect of exposure to lower concentrations of air pollution on mortality among US Medicare participants and vulnerable subgroups: a doubly-robust approach. The Lancet Planetary Health. 2021 Oct 1;5(10):e689-97

Vodonos et al (2018)

- Meta-regression of 59 previous studies
  - Modeled relative risk parameter itself
  - As a smooth function of average exposure
  - Each study's main estimate was a data point
- Compared to our provisional relative risk:
  - **2x** if estimated at 10 ug/m^3 when relying on all studies
  - **4x** when relying only on studies with average exposure < 10 ug/m^3

Vodonos A, Awad YA, Schwartz J. The concentration-response between long-term PM 2.5 exposure and mortality: a meta- regression approach. Environ Res 2018; 166: 677–89.

Safety/Uncertainty Factor(s)

- What should we do with the weight of available evidence?
- Is a generic factor appropriate?
- If so, how large should that factor be? (3x, 10x, ...)
- Should there be more than one factor?
- To what receptor(s) and endpoint(s) should factor(s) apply?

Receptors to Consider

- Senior at a residence (age 65+ or 55+)
- Worker at a workplace (age 40-65)
- Student at a school (age 5-17)
- Child at a daycare (age 0-4)

Senior at a Residence

- Provisionally: age 65-95
  - 30-year exposure window that conveniently aligns with Medicare cohort
- What if we shift the exposure window by 10 years?
  - To ages 55-85 instead
  - This age range seems more relatable to more people, particularly in communities with lower-than-average life expectancies
  - Increases the corresponding risk score

Worker at a Workplace

- On the one hand:
  - Healthy worker effect (HWE)—selection of vulnerable out of an exposed population—cited in arguments for ”resilience” of workers
  - Empirical support for this age range (40-65)

- On the other:
  - Precautionary principle
  - Modeled worker receptor is offsite, may not be in “dusty trades”
  - HWE is actually what we want to prevent

Child at a School or Daycare

- Pediatric asthma onset
- To apply a safety/uncertainty factor, or not? On what basis?
- This is newer to us
- Guidance from Council?

Key Questions

In light of available evidence, is a safety/uncertainty factor of three (3x) justified/defensible for:

1. Premature mortality
    a. For older seniors (65-95)
    b. For younger seniors (55-85)
    c. For workers (40-65)
2. Asthma onset
    a. For young children (0-4)
    b. For students (5-17)