PM MODELING: CONTEXT, PRODUCTS, & PROGRESS

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**

- **Local PM$_{2.5}$ Risk Methodology**
  - Assess health impacts from local PM.

- **Natural Gas Health & Equity Analysis**
  - Assess PM health and equity impacts from natural gas combustion for space and water heating.

- **Combustion Analysis**
  - Assess health and equity impacts of combustion and track PM concentrations back to sources.

- **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.

**Why**

- To set local PM significance levels; to inform permitting, prioritization of rule making, and CEQA analyses.

- To understand health and equity implications of new space and water heating rules.

- To better understand health and equity impacts of combustion at regional and local scale; to inform legislative advocacy and to prioritize PM reduction efforts.

- 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 Model 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.
The Larger PM Context

North Star: Reduce PM exposure where it matters most.

Set Policy
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  - Methods and Models: Local PM$_{2.5}$ Risk Methodology and Combustion Analysis using InMap model and traditional, full-chemistry model.
- Revise Priorities
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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

Modeling Products & Timeline

**PM$_{2.5}$ Local Risk Method**
- White paper summarizing evaluation of localized health impacts of PM$_{2.5}$ (Dec 22)
- Recommendations for local PM$_{2.5}$ thresholds (uncertain)

**Combustion Analysis**
- Appendices in staff reports for residential wood burning (Dec 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)
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 Modelng 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)
Fine Particulate Matter Local Risk Methodology: Update and Key Questions

Advisory Council Meeting
July 11, 2022

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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
I. With assumptions, a long-term increment of $+0.1 \mu g/m^3$ PM$_{2.5}$ $\approx$ excess risk (multiplicative) of 0.07%

II. For a “statistically average” Bay Area adult, this would be an excess risk (additive) of $6\times10^{-6}$ death/yr

**Table:**

<table>
<thead>
<tr>
<th>Risk Component</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure increment ($\Delta c$)</strong></td>
<td>+0.1 $\mu g/m^3$ PM$_{2.5}$</td>
</tr>
<tr>
<td><strong>Effect estimate ($\beta$)</strong></td>
<td>0.007 (0.7%)</td>
</tr>
<tr>
<td><strong>Excess risk (multiplicative)</strong></td>
<td>0.0007 (0.07%)</td>
</tr>
</tbody>
</table>

**Equations:**

I. $\text{risk ratio} \approx \Delta c * \beta$

II. $\text{risk difference} \approx \text{baseline risk} * (\text{risk ratio})$

**Baseline risk**

<table>
<thead>
<tr>
<th>Baseline risk</th>
<th>9×10^{-3} death/yr</th>
</tr>
</thead>
</table>

**Excess risk (additive)**

| Excess risk (additive) | 6×10^{-6} death/yr |
• 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
Group B is exposed to 10 $\mu$g/m$^3$ more PM$_{2.5}$ than Group A. Relative risk = 1.07 per 10 $\mu$g/m$^3$. 

Illustration
• 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
Table 1. Modeled PM$_{2.5}$ increments and corresponding risk scores for different receptor types and health endpoints.

<table>
<thead>
<tr>
<th>Annual Average Concentration</th>
<th>Asthma Onset</th>
<th>Adult Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daycare (0-4)</td>
<td>Student (5-17)</td>
</tr>
<tr>
<td>$3 \times 10^{-1} \mu g/m^3$</td>
<td>$1 \times 10^{-3}$</td>
<td>$9 \times 10^{-4}$</td>
</tr>
<tr>
<td>$1 \times 10^{-1} \mu g/m^3$</td>
<td>$5 \times 10^{-4}$</td>
<td>$3 \times 10^{-4}$</td>
</tr>
<tr>
<td>$3 \times 10^{-2} \mu g/m^3$</td>
<td>$1 \times 10^{-4}$</td>
<td>$9 \times 10^{-5}$</td>
</tr>
<tr>
<td>$1 \times 10^{-2} \mu g/m^3$</td>
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</table>

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)
• Medicare cohort
  • Age 65 and up
  • 460M person-years

• Relative risk = 1.073 per 10 ug/m³ PM$_{2.5}$
  • 1x for Medicaid-eligible
  • 3x for African-American/Black
  • 2x for subset below 12 ug/m³

• 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


• 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:
  • \[2\times\] if estimated at 10 \(\mu\)g/m\(^3\) when relying on all studies
  • \[4\times\] when relying only on studies with average exposure < 10 \(\mu\)g/m\(^3\)

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)
• 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?
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)