Air Quality Research Seminar

Overview and Introduction

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Objectives:

1. Evaluate current understanding of role of PM components in explaining health effects of PM
2. How new PM and air pollution health data fit in with regulatory timelines, needs, and processes?
3. What else needs to be done?
What This Is Not

• A comprehensive review of what is known about air pollution components and health impacts
• Recommendations for standards
• Debate about standard setting process, current standards
Why Is EPRI Sponsoring This Meeting?

• Help resolve the health-air pollution issue
  – Public benefit mission
• EPRI has done considerable work on this issue
  – How can it be used?
  – What else is needed?
• What are others doing?
• How can all research be better coordinated and integrated?
Organization

Pivotal presentation:
- Consideration of alternative regulatory paradigms; toxicology, human clinical studies, epidemiology, CAPs, exposure

Presentations:
- React to pivotal presentation
- Evaluate current state of knowledge
- Identify greatest achievable needs

Panels:
- Integrate what we know with pivotal presentation
- Comment on preceding presentation
- Discuss how to advance science/proceed further
EPRI Research and Insights

- Began Aerosol Research Inhalation and Epidemiology Study (ARIES) program in 1998
- Measured over 200 compounds on a daily (+) basis
  - little guidance
  - selected criteria pollutants
  - PM sizes
  - sulfates, nitrates, ions, EC (elemental carbon), OC (organic carbon)
  - organic species: PAHs, later particles
  - pollen, mold spores
- Related measures to several endpoints
- Set a priori methods, models, hypothesis
- Secondary sensitivity analysis
Speciated VOC and PM$_{2.5}$ Carbon

• Daily canister sample in Atlanta (8/98-12/08)
  – Analysis by GC-FID, GC-MS (R. Rasmussen)
    • 78 VOCs
    • 12 Oxygenated VOCs

• Daily Quartz filter in Atlanta (3/06-Present)
  – Analysis by TD-GC-MS (DRI)
    • c. 140 organics (n-HCs, PAHs, hopanes, steranes, etc.)

*Slide courtesy of Eric S. Edgerton
ARIES Cities

- Atlanta
- St. Louis
- Birmingham
- Pittsburgh
- Dallas
- Detroit*
- New York*
ARIES Limitations

• Central monitor
  – Limited use of additional monitors for more common pollutants
• Caveats with respect to measurement error, usual times series assumptions
• Personal monitoring
  – One study in Atlanta
  – Detroit, limited use of component data to date, but work is underway
• Indoor data for New York, one Atlanta study
ARIES: What Have We Found?

• Results primarily for Atlanta (1998-2006)
• There is no “unique” pollutant responsible for health effects
• Different endpoints are associated with different pollutants
• ARIES design was not appropriate for pollen, mold spores, ultrafine particles
ARIES Results

• Strongest, most consistent results occur with pollutant gases, especially CO, NO$_2$, ozone
• PM$_{2.5}$ associated with many endpoints
• Components of PM$_{2.5}$ generally more important than PM$_{2.5}$
• Components at greatest concern: EC, OC, some metals
• Issue of multiple comparisons, grouping
  – source-receptor models
  – alternative groupings
What Can We Say About PM Components

Atlanta ARIES: FRM Measurements

OM = 1.4 * OC
ARIES Results

Metal Oxides

- Some evidence of cardiovascular disease hospital admissions
- Biggest associations for childhood asthma
  - Zn, especially coarse Zn, stands out
  - Confusion about traffic association
- ? Fingerprint, marker
ARIES Results

Sulfates

• Largely non-significant associations with health
• Strongest for respiratory emergency department (ED) visits
  – a priori hypothesis not significant
  – Significant, positive lag 0
  – Significant, negative lag 2
ARIES Results

**EC:**

- Important for CVD emergency department visits, especially for congestive heart failure (CHF)
- Evidence for heart rate variability parameters and personal exposure
- Important for pediatric asthma: emergency department visits and unscheduled physician visits
ARIES Results

- EC fractions: EC₁, EC₂, EC₃

- Note correlation between EC₁ and EC₂, EC₃ is near zero

- Strongest pediatric asthma unscheduled physician visits associated with EC₂, EC₃
ARIES Results

• **OC**: Important for CVD ED visits, especially for CHF, (N.B. total carbon performance in multi-pollutant models)

• Lag 0 significant results for upper respiratory infection (URI) ED visits

• OC TOR fractions highly correlated with each other, EC$_1$
Volatile Organic Compounds (VOCs)

Groupings Based on Principal Components Analysis
NMHCs = Non-methane hydrocarbons
OHCs = Oxygenated hydrocarbons

NMHCs
- Toluene (anthropogenic)
- Isoprene (biogenic)

OHCs
- Benzaldehyde
- 2-butanone (? biogenic)
- Octanal
All Cardiovascular Disease ED Visits

RR (per standard deviation)

NMHCs

OHCs

NMHC
Aromatic
Toluene
Alkenes
Isoprene
OHC
2-Butanone
Octanal
Benzaldehyde
Summary: Cardiovascular ED Visits

• Significant positive effects between cardiovascular ED visits and 24-hr VOC concentrations

• Associations highest for
  – Ischemic heart disease (IHD), myocardial infarction (MI) and congestive heart failure (CHF) ED visits
  – NMHCs: aromatics (toluene), alkenes
  – OHCs: 2-butane

• No significant associations for urgent care visits

• Mortality associations only at extended lags
Emergency Department Visits
Respiratory Disease and VOCs

• Total respiratory: none
• Asthma: none
  Summer: NMHCS, EC*
• Upper respiratory disease
  Winter: NMHCS
• Pneumonia: none
• Chronic Obstructive Pulmonary Disease (COPD): several significant associations
  – Non-methane hydrocarbons
    • Alkanes
    • Aromatic compounds
    • Toluene
    • Alkenes (not isoprene)
  – Benzaldehyde

*EC also significant for childhood urgent care visits
The Veterans Cohort Study

- 67,000 males, recruited in 1975-76, with indications of hypertension
- 35% African-American, 81% current or former smokers
- Average age at recruitment: 51 years
- Nationally representative (44% in Northeastern US)
- 66% died through 2001
- Followed since mid 1970’s
- Hypertensive diagnosis, but …
- Homogeneous socioeconomic status
PM$_{2.5}$ Constituents; Speciation Trends Network-Chemical Speciation Network (STN-CSN) Data

**Single Pollutant Model**

Statistically significant pollutants:

EC, NO$_3^-$, V, Ni

**In Model with Traffic Density**

None remained significant and traffic density was statistically significant, except for model with EC
Extension of Analyses: Hazardous Air Pollutants (HAPs) Data

• 188 substances; subset chosen
• EPA modeled ambient concentrations at county (sub-county level)
• Use of 50th percentile for each county
  – Metals: As, Pb, Mn, Hg, Ni
  – Traffic-related compounds: benzene, diesel particulate matter
  – Others: formaldehyde, POMs, HCl, polypropylene
  – Also added sulfates, NO$_x$
Example: Cohort Study

Air Quality Variables Extended to Estimated HAPs Concentrations

Significant in single pollutant models:

- Benzene*
- Formaldehyde*
- Diesel PM*
- NOx*
- EC*
- Nickel*
- Polycyclic organics*
- Hg
- Pb
- SO₂
- Cl*
- Arsenic*

* Remains significant with traffic density in model
Difference Between ARIES Data and Speciation Network

• Speciation network more widespread, considers EC, OC, sulfates, metal ions
• ARIES has additional organic speciation data
• Need largest database possible to aid any interference about components
• How to reconcile?
What Do EPRI Results Say About STN-CSN Measurements?

- Some support for NAAQS gases especially CO, NO₂, ozone
- Stronger support for some PM components than for PM₂.₅
- Metals: some support especially for Zn, Ni;
- ? interpretation
- A role for organics
Organics

• ARIES, Veterans Study find some evidence for organic gases
  – More monitoring in support of public health
  – HAPs data as a resource for cohort studies
• OC, EC issue is complex
  – Both are mixtures
  – Different morphologies
  – Components likely have different toxicities
  – Components of OC can correlate more highly with EC or OC or TC
### Correlations Between Organic Compounds and OC, EC, Total Carbon (TC)

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Concluding Thoughts

• Air pollution health effects are being observed today
• Pollutant gases, including organic gases, appear to play a role in observed health effects
• Health effects results differ for different PM, pollution components
• Results from ARIES and other studies need to be examined systematically, and comprehensively
• There is a need to develop a concomitant toxicology agenda
• Mixtures and synergisms can be important
• A coordinated research agenda is needed
• There is a need to monitor for public health considerations