Traffic-Related Air Pollution: 
A Critical Review of the Literature on Emissions, Exposure, and Health Effects

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Goals of the Review

Summarize and synthesize relevant information on air pollution from traffic and its health effects, linking:

- Emissions and exposure to traffic air pollution
- Exposure to traffic air pollution and health effects
- Toxicological data and epidemiologic associations

A preprint of the report was released in May 2009
The final Report, following extensive QA/QC, will be published in fall 2009
**HEI Traffic Review Panel**

Ira Tager—UC Berkeley, *Chair*
Kenneth Demerjian—SUNY, Albany
Mark Frampton—U Rochester
Michael Jerrett—UC Berkeley
Frank Kelly—King’s College
Lester Kobzik—Harvard SPH
Nino Künzli—IMdM, Barcelona
Brian Leaderer—Yale SPH
Thomas Lumley—U of Washington SPH
Frederick Lurmann—Sonoma Tech. Inc
Sylvia Richardson—Imperial College
Jon Samet—Johns Hopkins
Michael Walsh—Consultant

**Emissions from Motor Vehicles**

*The Current Context*

*Significant progress* has been made in reduction of pollutant emissions from motor vehicles despite increases in number of vehicles and vehicle miles traveled.

Increased urbanization and urban populations have:
- Increased dependence on motor vehicles and traffic congestion
- Changed land use patterns such that *more people are near traffic sources of pollution*
There are many studies (over 400) that have attempted to look at traffic exposure and effects

• However, they are not all of equal quality
1. How should we assess Exposure?

- Who is likely to be exposed?
- What exposure assessment methods used in epidemiologic studies?
  - Pollutant surrogates for traffic exposures (e.g., NO₂, EC/BS, CO, UFPM, benzene, etc.)
  - Distance from and/or length of roadways
  - Estimate of traffic density or intensity
  - Modeling of primary traffic-generated pollutant exposure

Who is Likely to be Exposed?
Highest levels within 300 – 500 meters of a major road

Toronto, Beckerman et al. (2008)
Near Roadway Exposure Can Include Large Populations
Toronto Example: ~45% (within 500 meters of an expressway; 100 meters of a major road)

Los Angeles Example: (~44%)
What Markers or Surrogates?

- Pollutant surrogates for traffic exposures (e.g., NO\textsubscript{2}, EC/BS, CO, UFPM, benzene, etc.)

- Criteria for what is a good surrogate:
  1. Traffic as the major source
  2. Emissions vary with other motor vehicle constituents
  3. Can be measured at low concentrations by reasonably inexpensive and accurate methods
  4. Not have independent health effects
**NO₂ as a surrogate**

- There is substantial variability in average concentrations by locations.
- NO₂ is a potential surrogate for vehicle emissions if it is measured on a fine spatial resolution.

**PM₂.₅ as a Surrogate**

- Use of PM₂.₅ as a surrogate is of limited value because many sources contribute to urban PM₂.₅ and PM₂.₅ concentrations are well mixed within a region.
- Current central monitors do not provide sufficient spatial resolution for assessing the contribution of traffic to ambient PM₂.₅.
What Markers or Surrogates?

- Pollutant surrogates for traffic exposures (e.g., NO₂, EC/BS, CO, UFPM, benzene, etc.)
- Criteria for what is a good surrogate:
  1. Traffic as the major source
  2. Emissions vary with other motor vehicle constituents
  3. Can be measured at low concentrations by reasonably inexpensive and accurate methods
  4. Not have independent health effects
- Can provide useful information but none meet all these criteria…

Can We Use Exposure Models?

Models used
- Proximity models
- Geostatistical interpolation models
- Dispersion models
- Land-use regression models
- Hybrid models
  - Combine a model with time-activity data, or personal/microenvironmental monitoring
- Proximity models are least effective:
  - Can be confounded by Socioeconomic Status, Noise, other factors
- Newer models of exposure are better
  - But should be validated against some real-world data.
Criteria for Inclusion of Toxicology and Epidemiology Studies

• Quality of exposure assessment was key…
• Studies had to include 1 or more of the following exposure methods:
  • Distance from and/or length of roadways
  • Estimate of traffic density or intensity
  • Modeling of primary traffic-generated pollutant exposure
  • Studies of occupations characterized by exposure to traffic
  • Pollutant surrogates for traffic exposures (e.g., NO₂, EC/BS, CO, benzene, etc.) only if data provided to validate the pollutant as a reasonably specific surrogate for such exposure

2. What Can We Learn from Toxicology?
(Example from a somewhat limited database):

Effects of Traffic Exposure on Asthmatics (Zhang HEI 2009)
Lung function decline in asthmatics comparing Hyde Park and Oxford Street, London
(although symptoms did not increase...)
3. What can we learn from epidemiology?
Criteria for Causal Inference

Four categories to test whether traffic causes effects, based on:
- how well studies controlled for confounding
- consistency of the findings with other studies
- quality of the method to estimate exposure

• Sufficient evidence
• Suggestive but not sufficient
• Inadequate and insufficient evidence
• Suggestive of no association

Epidemiology
Health Outcomes Evaluated

• Mortality (all cause, cardiopulmonary)
• Cardiovascular morbidity
• Respiratory disease
  • Asthma—childhood/adult
  • General respiratory symptoms
  • Lung function-childhood/adult/COPD
  • Health care utilization
• Non-asthmatic allergy
• Birth Outcomes
• Cancer
Exacerbation of Asthma Symptoms

Increase in Wheeze Per Increment NO2

**Synthesis of Evidence**

Exacerbations with asthma—**Sufficient** for causal association

**Reasons**

Large number of studies with adequate control for confounding and mostly precise effect estimates

Traffic Exposure and Doctor-Diagnosed Asthma Incidence in Children

**Synthesis of Evidence**

**Sufficient OR suggestive** evidence

**Reasons**

Studies that included both traffic-specific pollutants and density measures most consistent
Long-Term Traffic Exposure and Cardiopulmonary Mortality

**Synthesis of Evidence**

Suggestive to infer causal association but not yet sufficient

**Reasons**

Too few studies
Relative imprecision of most estimates

Effects of Traffic Exposure on Birth Outcomes

- **Synthesis of Evidence**
  - Insufficient evidence

- **Reasons**
  - Only 4 studies met criteria for inclusions
Conclusions

Exposure

- Traffic-related pollutants impact ambient air quality on a broad spatial scale ranging from roadside, to urban, to regional background.

- Based on synthesis of evidence, 300 to 500 meters from major road was identified as the near-source area most impacted by traffic;
  - variations exist depending on meteorology, background pollution, and local factors.
Issues for Exposure Assessment

• None of the pollutant surrogates considered met all criteria for an ideal surrogate
  • CO, benzene, and NOx [NO₂] found in on-road vehicle emissions are also major components of emissions from all sources
  • UF PM has not been used in epidemiologic studies so far. It is difficult to model them because there are no emission inventories
• Exposure models are important, but have various degrees of utility to health studies
  • The proximity model is the most error-prone
  • Other models are better:
    • Dispersion models (need adequate data)
    • Land use regression models
    • Several approaches together (hybrid)

Overall Conclusions

• The data are incomplete on emissions, their transformations, and exposure assessment
• There were, however, enough studies to find
  • Sufficient evidence for a causal association with exacerbation of asthma
  • Suggestive evidence for a number of other health effects (mortality, lung function, respiratory symptoms, and others)
**Overall Conclusions II**

- Limited evidence of effects but *inadequate and insufficient* to infer causal associations:
  - Adult onset asthma
  - Health care utilization
  - COPD
  - Non-asthmatic allergy
  - Birth outcomes
  - Cancers

**Overall Conclusions III**

- *A caution*: epidemiology studies are based on past estimates of exposure
  - they may not provide an accurate guide to estimating health associations in the future
- However, given the large number of people living within 300-500 meters of a major road, the Panel concluded that exposures to primary traffic generated pollutants are likely to be of public health concern and deserve attention.
Thank You!

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