Vehicle Emissions and Health: A Global Perspective on Effects, Placed in an Indian Context

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The Health Effects Institute

• Non-profit institute providing trusted science on the health effects of air pollution for over 30 years

• Joint core support from
  • Government (US EPA) and Industry (Worldwide Motor Vehicle)
  • Partnerships with WHO, ADB, CAI-Asia, EU, US DOE, other industries, Hewlett foundation

• Independent Board and Expert Science Committees
  • Including international experts (e.g. India (AIIMS), China, Thailand)

• Over 270 studies, scientific reviews, reanalysis conducted around the world, including:
  • Public Health and Air Pollution in Asia (PAPA) program
  • Comprehensive Review of Asian Health Science (2010)

• HEI delivers science
  • no policy positions taken

Understanding local impacts in a global context
Particulate Matter (PM)

- Sources:
  - wide range of combustion sources;
  - vehicles are significant, though not only, contributor
- High levels of PM (> 500 μg/m³) known to cause premature death
  - e.g. London 1952
- Studies in US, Europe, elsewhere have found association of PM with mortality at much lower levels (<50 μg/m³)
  - no evidence of a “threshold” (safe level)
Asia in a Global Context
(Risk of Premature Mortality with Increased Exposure to PM10)
Effects of pollution in India and Asia are similar to results around the world.
New HEI PAPA Studies in India
Find Similar Results to Global Science

- Three studies chosen competitively and overseen by international experts
- Major new HEI Report, March 2011:
  - Chennai – Dr. Kalpana Balakrishnan et al, Sri Ramachandra University
  - Delhi – Dr. Uma Rajarathnan, TERI
- Also,
  - Ludhiana – Dr. Rajesh Kumar, PGI Chandigarh
  - Published in the Indian Journal of Public Health
VEHICLE CONTRIBUTIONS ARE LARGELY ULTRAFINE PM (<100 nanometers)

Typical Diesel Particle Size Distributions, Number, Surface Area, and Mass Weightings

- **Nuclei Mode** - Usually forms from volatile precursors as exhaust dilutes and cools
- **Nanoparticles** - Dp < 50 nm
- **Ultrafine Particles** - Dp < 100 nm
- **Fine Particles** - Dp < 2.5 μm
- **PM10** - Dp < 10 μm
- **Accumulation Mode** - Usually consists of carbonaceous agglomerates and adsorbed material
- **Coarse Mode** - Usually consists of reentrained accumulation mode particles, crankcase fumes

In some cases this mode may consist of very small particles below the range of conventional instruments, Dp < 10 nm

These modes will be nearly eliminated by filtration
Fractional Deposition of Inhaled Particles in the Human Respiratory Tract
(ICRP Model, 1994; Nose-breathing)

Figure courtesy of J.Harkema
Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects

HEI Expert Panel
Dr. Ira Tager, UC Berkeley, Chair
January 2010
There are many studies (over 700) that have attempted to look at traffic exposure and traffic effects. However, they are not all of equal quality.
Who is Likely to be Exposed?
Highest levels within 300 – 500 meters of a major road

VOC (TraceAir) Distance Decay Around Highway 401, Toronto

Toronto, Beckerman et al. (2008)
The Traffic Impact Area in Delhi:
New HEI Analysis: 55% of the Population within 500 meters of a Freeway; 50 meters of a Major Road
Overall Traffic Conclusions

- The data are incomplete on emissions, their transformations, and exposure assessment
- There were enough studies to find:
  - **Sufficient** evidence that exposure to traffic can cause exacerbation of asthma, especially in children
  - **Suggestive** evidence for other health effects (premature mortality, lung function, respiratory symptoms, and others)
  - But only **limited evidence** of effects for: Adult onset asthma; Health care utilization; COPD; Non-asthmatic allergy; Birth outcomes; Cancers
Overall Traffic Conclusions II

- 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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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...)

[Graph showing the impact of traffic exposure on lung function over time for participants in Hyde Park and Oxford Street.]
Nitrogen Dioxide (NO2)

- Sources: vehicles a significant source; also thermal power plants
- Known, like many “oxidants” to cause inflammation
- May cause serious problems at lower levels and short, high doses
- Also may be a “marker” for other pollutants (e.g. fine PM)
Nitrogen oxide levels are rising in almost all locations in Delhi.

NOx also contributes to the problem of ozone pollution

Source: CSE analysis based on CPCB air quality data
Childhood lung function development reduced in those exposed to higher NO2

Community-specific average growth in FEV1 among Girls and Boys for the period 1993 to 2001 plotted against average nitrogen dioxide (NO2) levels from 1994 to 2000 (Gauderman 2004)
New NOx Results from India: HEI Study in Delhi

• Delhi study also tested Nitrogen Oxide associations
  • Independently and with PM10
• Found higher estimates of risk for NOx (0.65%/10 \(\mu g/m^3\)) than for PM10