REDUCING HEALTH IMPACT OF DIESEL EXHAUST
Challenge and Opportunities

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Philip Orlando
Why is it difficult to assess health benchmarks for diesel particulate matter?
Nitrogen oxides
Numerous hydrocarbons
Particles < 1μm
Complexities of Diesel Exhaust for Health Impact Assessment

• Diesel exhaust is a complex mixture of gases and suspended particles. Composition depends on vehicle type, fuel, load, lubricant, etc.

• Each potential components carries with it their own health impact.

• Components are not necessarily unique to diesel but perhaps the combination is.

• Health impact studies:
  • Animal studies and cell lines - exposure to diesel exhaust directly
  • Human exposure studies
  • Occupational exposure to diesel
Biology of diesel exhaust effects on respiratory function

Marc Riedl, MD, and David Diaz-Sanchez, PhD Los Angeles, Calif

TABLE I. Direct effects of DEPs and their extracts on multiple cell types

A. Bronchial and nasal epithelial and endothelial cells:
   Increase expression of chemokines and cytokines (IL-8, etoxin, RANTES, GM-CSF, and IL-6)
   Increase expression of histamine 1 receptor
   Upregulate expression of adhesion molecules (ICAM-1)
   Increase phase 2 enzyme expression
B. Eosinophils
   Enhance adhesion to nasal epithelial cells
   Induce eosinophil degranulation
C. Mast cells
   Enhance IgE-mediated histamine release
   Enhance cytokine production (IL-4, IL-6)
D. Basophils
   Induce histamine release in the absence of IgE
   Enhance cytokine production (IL-4)
E. PBMCs
   Induce chemokine production (IL-8, RANTES)
   Synergize with allergen to increases in IL-8, RANTES, and TNF-α production
F. B cells
   Enhance IgE production after IL-4 and anti-CD40 stimulation
G. Monocytes-macrophages
   Modulate cytokine production (eg, inhibits IL-12p40 production)
   Inhibit prostaglandin E2 release
   Increase phase 2 enzyme expression

TABLE II. Clinical effects of diesel exhaust in human controlled exposure studies

A. Diesel exhaust effects on healthy subjects
   Increased number of inflammatory cells (neutrophils, B cells, T cells, mast cells) in the airways
   Increased circulating neutrophils and platelets
   Increased histamine levels
   Increased cytokines (IL-6) and CXC chemokines (IL-8 and GrO-α)
   Increased expression of adhesion molecules ICAM-1 and VCAM-1
   Decreased macrophage function
   Increased airway resistance
B. Diesel exhaust effects on subjects with mild asthma
   Increased hyperresponsiveness to methacholine
   Increased airway resistance
   Increased sputum IL-6 levels
   No apparent airway inflammation
   Increased epithelial staining for IL-10

VCAM-1, Vascular cell adhesion molecule 1.
ORDEQ ABC = 0.1 ug/m³

Diesel Particulates 2017
(OR DEQ Model)

DPM 2017
- 0.2 - 1.0 ug/m³
- 1.0 - 1.3 ug/m³
- 1.3 - 1.6 ug/m³
- 1.6 - 2.2 ug/m³
- 2.2 - 5.5 ug/m³

Meenakshi Rao
PSU July 2016
## ESTIMATES OF HEALTH COSTS OF DPM IN PORTLAND METRO DUE TO LUNG CANCER

<table>
<thead>
<tr>
<th>24</th>
<th>Estimated annual incidence of lung cancer for Portland metro due to DPM exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assuming 90% mortality from lung cancer (Brown et al, 2001). Assuming VSL $7.18 million 2005 USD (EPA VSL)</td>
</tr>
<tr>
<td>$150,088,000</td>
<td></td>
</tr>
<tr>
<td>$17,520,000</td>
<td>At $50,000/per QALY Assuming 14.6 QALYs reduction due to lung cancer (Brown et al 2001)</td>
</tr>
<tr>
<td>$45,760,838</td>
<td>WHO rule of 3x per capita GDP per QALY Assuming 14.6 QALYs reduction due to lung cancer (Brown et al 2001) US 2005 GDP $43,532 USD per capita (World Bank)</td>
</tr>
</tbody>
</table>
### Health Effect

<table>
<thead>
<tr>
<th>Health Effect</th>
<th>Estimated Annual Number of Cases*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiopulmonary Death</td>
<td>1,400 (1,100 – 1,800)</td>
</tr>
<tr>
<td>Cardiovascular Hospitalization</td>
<td>100 (0 – 250)</td>
</tr>
<tr>
<td>Respiratory Hospitalization</td>
<td>120 (30 – 250)</td>
</tr>
<tr>
<td>Respiratory Emergency Room Visits (Including Asthma)</td>
<td>600 (400 – 800)</td>
</tr>
</tbody>
</table>

DPM is estimated to increase statewide cancer risk by 520 cancers per million residents exposed over a lifetime.

http://www.arb.ca.gov/research/diesel/diesel-health.htm
ORDEQ ABC = 0.1 μg/m³

Diesel Particulates 2017
(OR DEQ Model)
INVESTIGATING THE POTENTIAL OF LAND USE MODIFICATIONS TO MITIGATE THE RESPIRATORY HEALTH IMPACTS OF NO₂
A CASE STUDY IN THE PORTLAND-VANCOUVER METROPOLITAN AREA

MEENAKSHI RAO, PHD
SCHOOL OF THE ENVIRONMENT

Portland State UNIVERSITY
Summer & winter sites

Summer only sites

Winter (82 sites): 13\textsuperscript{th} – 27\textsuperscript{th} Feb 2014
Summer (174 sites): 23\textsuperscript{rd} Aug – 6\textsuperscript{th} Sep 2013
Portland summer-time NO2
200m res. predictive model
<table>
<thead>
<tr>
<th>Health Impact</th>
<th>Incidence</th>
<th>Incidence rate (per 100,000)</th>
<th>Valuation (2013 USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma Exacerbation, Missed school days (4-12 year olds)</td>
<td>34,189</td>
<td>14,455</td>
<td>$7,289,729</td>
</tr>
<tr>
<td>Asthma Exacerbation, One or More Symptoms (4-12 year olds)</td>
<td>99,740</td>
<td>42,171</td>
<td>$21,266,297</td>
</tr>
<tr>
<td>Cough (7-14 year olds)</td>
<td>24,134</td>
<td>12,070</td>
<td>$3,219,017</td>
</tr>
<tr>
<td>Emergency Room Visits, Asthma (75 years and older)</td>
<td>20</td>
<td>22</td>
<td>$7,171</td>
</tr>
<tr>
<td>HA, Asthma (younger than 30 years)</td>
<td>6</td>
<td>1</td>
<td>$64,785</td>
</tr>
<tr>
<td>HA, Asthma (30 years and older)</td>
<td>7</td>
<td>1</td>
<td>$76,749</td>
</tr>
<tr>
<td>HA, Chronic Lung Disease (less Asthma) (65 years and older)</td>
<td>143</td>
<td>64</td>
<td>$2,633,286</td>
</tr>
<tr>
<td>HA, All Respiratory (65 years and older)</td>
<td>307</td>
<td>137</td>
<td>$7,752,000</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td><strong>$39,598,999</strong></td>
</tr>
</tbody>
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ORDEQ ABC = 0.1 ug/m³

Diesel Particulates 2017 (OR DEQ Model)

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Meenakshi Rao
PSU July 2016
Diesel particulate matter assessment in Portland
(partially funded by METRO grant to NCA)

Aethalometer
PM 2.5 Particulate Monitor
Ultrafine particle counter
Filter EC/OC

Preliminary data
Black carbon PM assessment, preliminary data, P. Orlando, B. Bennett & L. George July 2016

DPM ABC = 0.1 ug/m³

NAAQS standard
ORDEQ ABC = 0.1 \mu g/m^3

Diesel Particulates 2017
(OR DEQ Model)

DPM 2017
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- 2.2 - 5.5 \mu g/m^3

Meenakshi Rao
PSU July 2016
“Overall, these results indicate that rats exposed to one of three levels of NTDE [new technology diesel exhaust] from a 2007-compliant engine for up to 30 months, for 16 hours per day, 5 days a week, with use of a strenuous operating cycle that more accurately reflected the real-world operation of a modern engine than cycles used in previous studies, showed few exposure-related biologic effects. In contrast to the findings in rats chronically exposed to TDE [traditional technology diesel exhaust], there was no induction of tumors or pre-cancerous changes in the lung and no increase in tumors that were considered to be related to NTDE in any other tissue.”
CALIFORNIA

Statewide DPM Ambient Concentration

- Reformulated Diesel Program
- PSIP
- Transit Bus
- HDV - Off road
- HDV Engine STD
- Port rule

Year

Ambient DPM μg/m^3