Exposures in the Trucking Industry

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National Jewish Health
Science Transforming Life®

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Trucker Demographics

- 83% Caucasian
- Median age: 46
- 73% married w/children
- 50% with at least some college
- 14 years driving experience
- Drive 118,000 miles/year
- 47% run more than 1,000 miles/trip
- Median income
  - $61,000 for owner-operators
  - $41,000 for drivers
- 43% are regular tobacco users
- Average smoker 1.5 packs/day
- 66% overweight
- < 25% exercise on the road
- Typical OTR Trucking Company has >100% employee turnover per year
- Local drivers work about 50 hours per week
- OTR drivers work up to 70 hours per week

(Profile of the Interstate Trucker, 1999)
Occupational Exposures in Trucking

- Diesel exhaust
- Other transportation related particles
- Fuel vapors
- Noise
- Carbon monoxide in warehouse operations
- Asbestos for maintenance workers
- Cargo related exposures
What factors affect trucker exposures?

• Traffic/Congestion
• Long work hours
• Loading and unloading
• Idling
• Truck condition
What are diesel emissions?

- Complex mixture
  - 1,000s of constituents
- Gases
  - NO\textsubscript{x}, SO\textsubscript{2}, CO\textsubscript{2}, CO
- Vapors
  - VOCs, PAH, aldehydes
- Particles
  - DPM
  - Metals
    - Ca, Al, Na, Ba, Zn, Fe, Se, Mg
Is there anything special about DPM?

- Toxic substances, such as PAHs
- Metals
- Secondary sulfate and nitrate
- Organic carbon compounds
- Elemental carbon core
Is DPM a nanoparticle?
Why worry about DPM?

- Very small particles – deep lung penetration
- 1000’s of compounds can be adsorbed on surface of particle
  - Many of these cytotoxic, carcinogenic, or mutagenic
- Particles stable in lung fluid – retained for long periods of time
- Early studies suggested 90% of mutagenic potency of whole diesel exhaust associated with the particle phase
What factors affect DPM output?

- Fuel type and composition
- Speed
- Ambient temperature
- Humidity
- Engine load
  - More chemical components adhered to particles generated at low loads
  - High load mostly elemental carbon
Can you measure diesel exposure?

- Must pick a surrogate and assume it provides a good relative measure

- Surrogates
  - NO$_2$
  - CO
  - PM$_{2.5}$
  - Carbon
    - Total Carbon = Elemental Carbon + Organic Carbon
    - Elemental Carbon is most specific, but not without problems
How do truckers’ exposures compare?

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>GM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008 MSHA Standard</td>
<td>n/a</td>
<td>160 ug/m³</td>
</tr>
<tr>
<td>Residential Bkgd</td>
<td>23</td>
<td>1.1 ug/m³</td>
</tr>
<tr>
<td>Highway Bkgd</td>
<td>21</td>
<td>2.5 ug/m³</td>
</tr>
<tr>
<td>Long Haul Drivers</td>
<td>72</td>
<td>3.8 ug/m³</td>
</tr>
<tr>
<td>Local Drivers</td>
<td>56</td>
<td>4.0 ug/m³</td>
</tr>
<tr>
<td>Mechanics</td>
<td>80</td>
<td>12.1 ug/m³</td>
</tr>
<tr>
<td>Dock workers</td>
<td>75</td>
<td>13.8 ug/m³</td>
</tr>
</tbody>
</table>

*Geometric mean of elemental carbon in ug/m³
(Zaebst et al. 1991)
More Recent Data

- **Long Haul (non-smokers)**
  - 1.1 ug/m³ EC
- **Local (non-smokers)**
  - 1.4 ug/m³ EC
- **Background (terminal upwind)**
  - 0.5 ug/m³ EC
- **All truckers**
  - Windows open: 1.2 ug/m³ EC
  - Windows shut: 1.0 ug/m³ EC

(Davis et al. 2007)
DPM is decreasing with better control technologies

(Davis et al. 2007)
What about total small particles?

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Typical Denver Day</td>
<td>5-15 ug/m³</td>
</tr>
<tr>
<td>EPA AAQS 24-hr Avg</td>
<td>35 ug/m³</td>
</tr>
<tr>
<td>EPA AAQS Annual Avg</td>
<td>15 ug/m³</td>
</tr>
<tr>
<td>Tunnel Construction Workers\textsuperscript{a}</td>
<td>230 ug/m³</td>
</tr>
<tr>
<td>Diesel Mechanics\textsuperscript{a}</td>
<td>42 ug/m³</td>
</tr>
<tr>
<td>Construction Equip Operators\textsuperscript{a}</td>
<td>28 ug/m³</td>
</tr>
<tr>
<td>Bus Drivers\textsuperscript{a}</td>
<td>16 ug/m³</td>
</tr>
<tr>
<td>Taxi Drivers\textsuperscript{a}</td>
<td>17 ug/m³</td>
</tr>
<tr>
<td>Local Truck Drivers\textsuperscript{b}</td>
<td>16 ug/m³</td>
</tr>
<tr>
<td>Long Haul Drivers\textsuperscript{b}</td>
<td>19 ug/m³</td>
</tr>
</tbody>
</table>

(All geometric mean PM\textsubscript{2.5})

\textsuperscript{a}Lewne et al. 2007, \textsuperscript{b}Davis et al. 2007
What about NO$_2$?

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Typical Denver Day</td>
<td>10-30 ppb</td>
</tr>
<tr>
<td>EPA AAQS 1-hr Avg</td>
<td>100 ppb</td>
</tr>
<tr>
<td>EPA AAQS Annual Avg</td>
<td>53 ppb</td>
</tr>
<tr>
<td>ACGIH TLV 8-Hr Avg</td>
<td>3,000 ppb</td>
</tr>
<tr>
<td>Tunnel Construction Workers</td>
<td>185 ppb</td>
</tr>
<tr>
<td>Diesel Mechanics</td>
<td>49 ppb</td>
</tr>
<tr>
<td>Construction Equip Operators</td>
<td>23 ppb</td>
</tr>
<tr>
<td>Bus Drivers</td>
<td>28 ppb</td>
</tr>
<tr>
<td>Taxi Drivers</td>
<td>24 ppb</td>
</tr>
</tbody>
</table>

(All geometric mean NO$_2$)
Regulations Changing Diesel Emissions

- Low sulfur fuels – reduce SO₂
- Anti-idling laws – reduce both community and trucker exposures to diesel exhaust
Other Transportation Related PM

• Brake wear particles
  - Up to 20% of traffic related particulate
  - Particles high in Fe, Cu, Ba, Sb
  - Larger than combustion related particles
  - Have been associated with inflammatory responses in lung epithelial cells in-vitro
  - No data on exposure levels
Other Transportation Related PM

• Tire particles
  - Constitute >10% of PM10 in areas with heavy traffic
  - Consist of natural rubber, organic compounds, and metals including zinc, selenium, lead, and cadmium
  - Latex allergy??
Other Transportation Related PM

• Mineral dusts
  – Produced by sanding roads, damage to roads by studded tires
  – Dominates PM10 in Spring in areas where sand is used
  – Also contributor to ultrafine particles
  – No data on personal exposures
  – Some data suggest inflammatory potential in vitro
Tanker Driver Exposures

- 20% of tanker drivers reported acute symptoms of solvent exposure during load and unload situations (Hakkola et al. 1997)

- Benzene exposures
  - ACGIH TLV 0.5 ppm
  - Tanker drivers: 0.21 ppm (Javelaud et al. 1998)
  - Tanker drivers: 0.08 ppm (Verma et al. 2004)
  - Car mechanics: 0.04 ppm (Javelaud et al. 1998)

- Total hydrocarbons
  - ACGIH TLV 300 ppm
  - Tanker drivers: 5.9 ppm (Verma et al. 2004)
Carbon Monoxide Exposure in Warehouses

- Use of propane forklifts in enclosed spaces can cause elevated CO
- Forklifts not properly maintained emit high levels of CO
- Extremely dangerous in cold storage and unventilated spaces
- Proper tuning of forklifts to reduce CO often increases NO$_2$ concentrations
Asbestos Exposure in Truck Maintenance Workers

- Asbestos still found in aftermarket brake replacement parts
- Mostly drum brakes
- Imports of asbestos brake materials totaled $124 million in 2003
- OSHA advises all brakes should be treated as containing asbestos
- Use of wet methods for cleaning and prohibiting the use of compressed air
Noise and Trucking

- Engine noise (piston slap)
- Exhaust noise
- Gear noise
- Aerodynamic noise
- Tire/Road noise
- Open windows
- Radio/CB
- “Jake” brakes
How high are truckers’ noise exposures?

- Study of 400 drivers*
  - 10% > 90 dBA (TWA)
  - 53% > 85 dBA (TWA)
- Window open and radio on, nearly always exceeded 85 dBA
- Cabs mounted over engine slightly quieter (2.6 dB)
- 4 lane highways noisier than 2 lane highways (1.6 dB)
- Radios add 3 to 8 dB
- Closing window reduces noise by 4 dB
- Estimated 13% prevalence of hearing loss in transportation industry

*(Seshagira 1998)
Other Potential Trucker Exposures

- Pesticides from hauling produce
- Animal allergens, ammonia, and endotoxin from hauling animals
- Chemicals
- Silica among concrete mixer drivers
Potential Health Effects

• Lung cancer
• COPD
• Asthma
• Heart disease
• CO poisoning
• Solvent/fuel related CNS issues
Lung Cancer Increased in Truckers

- **U.S. trucking mortality study** (Laden et al. 2007)
  - Lung cancer SMR=1.10 (1.02-1.19)

- **Lung cancer mortality study** (Garshick et al. 2008)
  - Smoking adjusted hazard ratios for 20 year working history
    - Long haul drivers, HR=1.40 (0.88-2.24)
    - Local drivers, HR=2.21 (1.38-3.52)
    - Dockworker, HR=2.02 (1.23-3.33)
COPD Associated with Diesel Exposure

- **Railroad workers mortality study** (Hart et al. 2009)
  - N=21,234
  - 2.5% increase in COPD mortality/year working in diesel exposed job

- **Case-control study** (Weinmann et al. 2008)
  - 346 cases, 298 controls
  - Ever smokers: OR: 1.7 (1.1-2.7)
  - Never smokers: OR: 6.4 (1.3-31.6)
Heart Disease Increased in Truckers

• U.S. trucking mortality study (Laden et al. 2007)
  – Ischemic heart disease SMR=1.49 (1.40-1.59)
Bottom Line

• Truckers respiratory exposures to diesel and other traffic related particles are remarkable for their length of exposure, but not necessarily their magnitude of exposure

• Other potential exposures can be very significant depending on the cargo hauled

• Significant potential for acute exposures in the event of an accident
Questions?

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