Impacts of Diesel Engine Exhaust on Human Health: A High-Level Review of the Evidence

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Diesel Engine Exhaust

Solid carbon cores (0.01–0.08 mm), agglomerates (0.05–1.0 mm) and adsorbed vapour phase species

Vapour phase hydrocarbons

Soluble organic fraction (SOF)/particle phase hydrocarbons

Adsorbed hydrocarbons

Hydrated sulfate species

Number Distribution

Mass Distribution

Normalized Concentration $d(C/Total)/dD_p$

Diameter, $D_p$, $\mu$m

Nanoparticles $D_p<50$ nm

Ultrafine particles $D_p<100$ nm

Fine particles $D_p<2.5$ $\mu$m

PM10 $D_p<10$ $\mu$m

Reductions in Diesel Emissions Over Time

Over 60 Years of Research on the Health Impacts of Diesel Engine Exhaust

Thousands of studies examine health impacts from specific air pollutants found in diesel exhaust (e.g. PM$_{2.5}$, NO$_2$, Benzene, PAHs).
Cancer Health Effects

• In 2012, the International Agency for Research on Cancer (IARC) classified diesel engine exhaust as “carcinogenic to human”.
• Driven by 3 epidemiological studies of occupational diesel exhaust exposures among non-metal miners and truck drivers.
• “Sufficient evidence” in animal studies.

Figure 1. Predicted exposure-response curve using relative risk estimates from 3 cohort studies of diesel and lung cancer (Vermeulen et al., 2014).

Figure 2. Lung cancer risk associated with a 10 μg/m³ increase in PM₂.₅ (Hamra et al., 2014).
Respiratory Health Effects

- **Strong evidence** for diesel impacts on lung inflammation, decreased lung function (kids), asthma, acute bronchitis, increased susceptibility to respiratory infections.

**Figure 3.** Associations between truck traffic density and FEV1 in children living <300 m from a motorway. [letters represent study cities].

**Figure 4.** Adjusted associations between levels of exhaled nitric oxide (airway inflammation) and different bus interventions. **Reductions for kids riding on buses switched to ultra-low-sulfur diesel (ULSD).** DOC=Diesel oxidative catalyst; CCV=crankcase ventilating system; B20=biodiesel.
Cardiovascular Health Effects

- Growing evidence for diesel impacts on CVD, concurrent with strong evidence for PM$_{2.5}$.

Ischemic and Thrombotic Effects of Dilute Diesel-Exhaust Inhalation in Men with Coronary Heart Disease

Table 1. Evidence of CVD effects from PM$_{2.5}$, traffic, and combustion-related air pollution (Brook et al., 2010).

<table>
<thead>
<tr>
<th>Health Outcomes</th>
<th>Short-Term Exposure (Days)</th>
<th>Longer-Term Exposure (Months to Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular mortality</td>
<td>↑↑↑↑</td>
<td>↑↑↑↑</td>
</tr>
<tr>
<td>Cardiovascular hospitalizations</td>
<td>↑↑↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Ischemic heart disease*</td>
<td>↑↑↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Heart failure*</td>
<td>↑↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Ischemic stroke*</td>
<td>↑↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Vascular diseases</td>
<td>↑↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Cardiac arrhythmia/cardiac arrest</td>
<td>↑↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Surrogate markers of atherosclerosis</td>
<td>↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Systemic inflammation</td>
<td>↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Systemic oxidative stress</td>
<td>↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Endothelial cell activation/blood coagulation</td>
<td>↑</td>
<td>↑↑↑↑</td>
</tr>
<tr>
<td>Vascular/endothelial dysfunction</td>
<td>↑</td>
<td>↑↑↑↑</td>
</tr>
<tr>
<td>BP</td>
<td>↑↑</td>
<td>↑↑↑↑</td>
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<tr>
<td>Altered HRV</td>
<td>↑↑</td>
<td>↑↑↑↑</td>
</tr>
<tr>
<td>Cardiac ischemia</td>
<td>↑</td>
<td>↑↑↑↑</td>
</tr>
<tr>
<td>Arrhythmias</td>
<td>↑</td>
<td>↑↑↑↑</td>
</tr>
</tbody>
</table>

*↑↑↑↑ Indicates strong overall epidemiological evidence.
*↑↑ Indicates moderate overall epidemiological evidence.
*↑* Indicates some but limited or weak available epidemiological evidence.
Blank indicates lack of evidence.

Figure 5. Myocardial Ischemia during 15-minute intervals of exercise-induced stress and diesel or filtered air exposure (Mills et al., 2007).
Emerging Health Effects

- Some evidence for diesel impacts on birth outcomes (e.g. low birth weight, birth defects), obesity, diabetes, and neurological diseases (e.g. Learning disabilities, Dementia, Alzheimer’s).

Magnetite pollution nanoparticles in the human brain

Barbara A. Maher, I. Mad A. M. Ahmed, Vassil Karloukovski, Donald A. MacLaren, Penelope G. Foulde, David Allsop, David M. A. Mann, Ricardo Torres-Jardon, and Lilian Calderon-Garciduenas

Living near major roads and the incidence of dementia, Parkinson’s disease, and multiple sclerosis: a population-based cohort study

Hong Chen, Jeffrey C Kwon, Ray Copes, Karen Tu, Paul Villeneuve, Aaron van Donkelaar, Perry Hystad, Randall V Martin, Brian J Murray, Barry Jonesman, Andrew S Wilton, Alexander Kopp, Richard T Burnett

Figure 6. Associations between road proximity and Dementia (Chen et al., 2017).

Figure 7. Particle pathways to the brain (ScienceMag, 2017).
Summary

• Substantial evidence of health effects from diesel engine exhaust.
  – Primarily represents engine emissions prior to 2007

• Health effects from new technology diesel engines (post 2007) are unknown.
  – Large reductions in the toxic components of diesel exhaust
  – Animal studies show little impact or impact similar to gasoline emissions (but few studies available)
  – No human studies available
References


• Vermeulen et al. (2014). Exposure-Response Estimates for Diesel Engine Exhaust and Lung Cancer Mortality Based on Data from Three Occupational Cohorts. [https://ehp.niehs.nih.gov/1306880/](https://ehp.niehs.nih.gov/1306880/)