

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

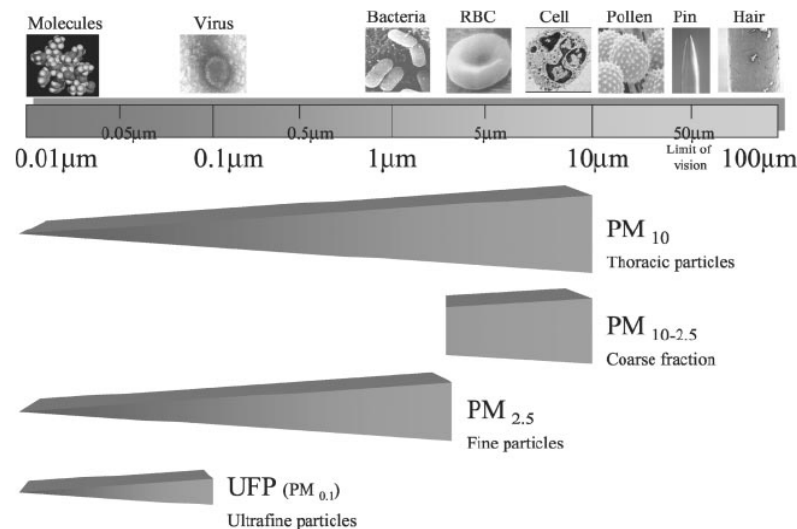
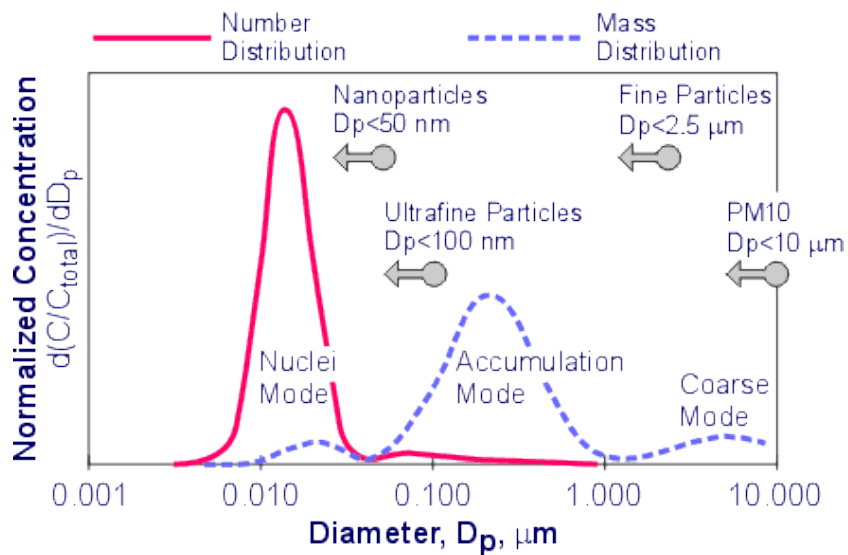
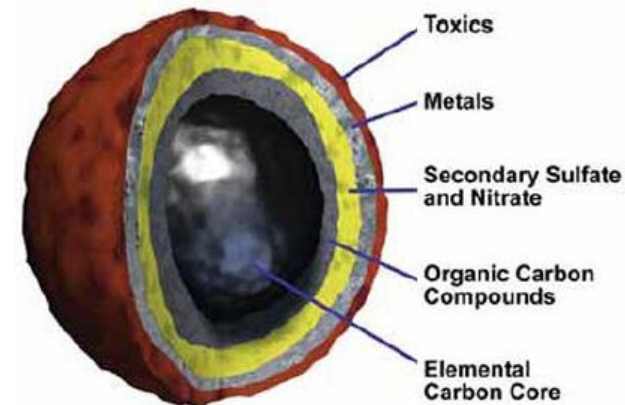
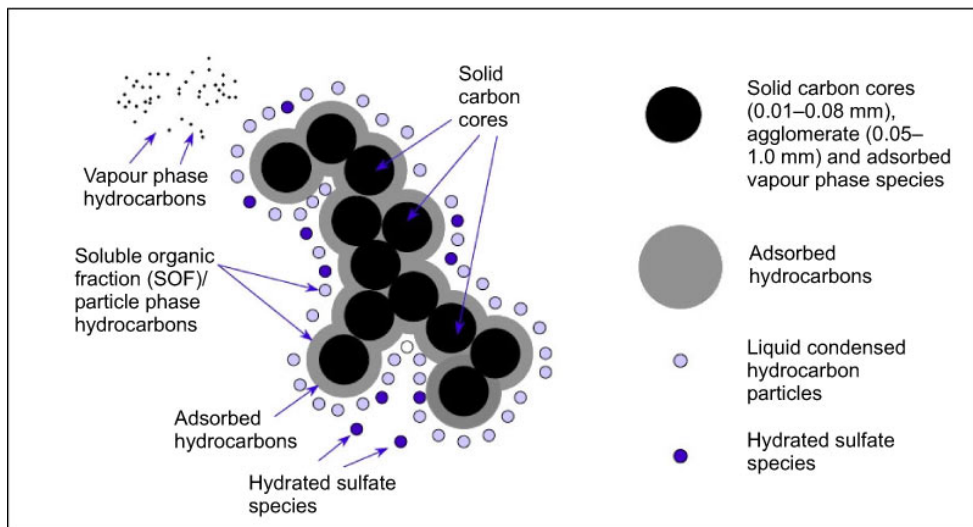
Perry Hystad

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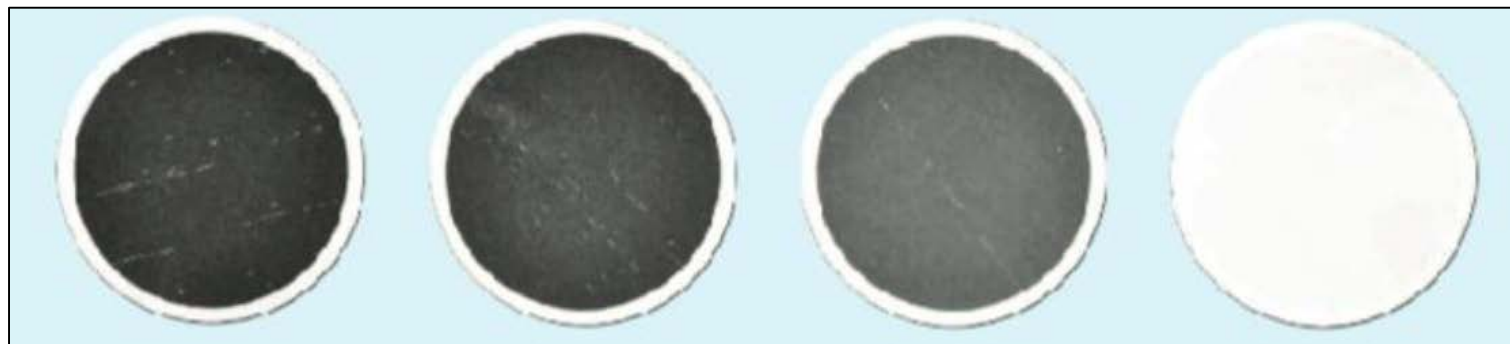
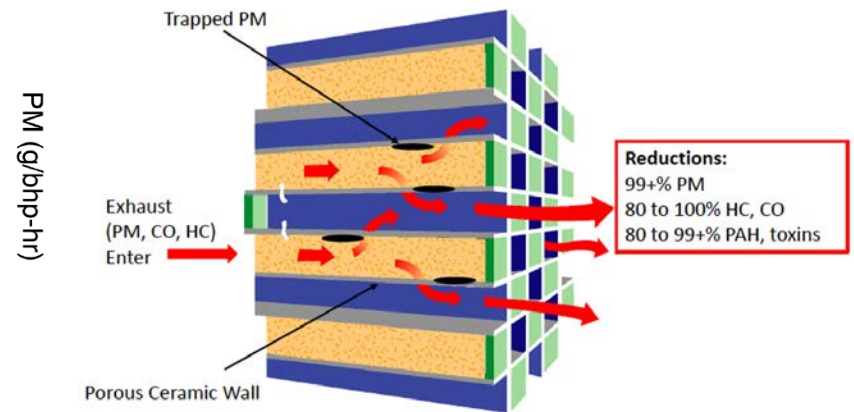
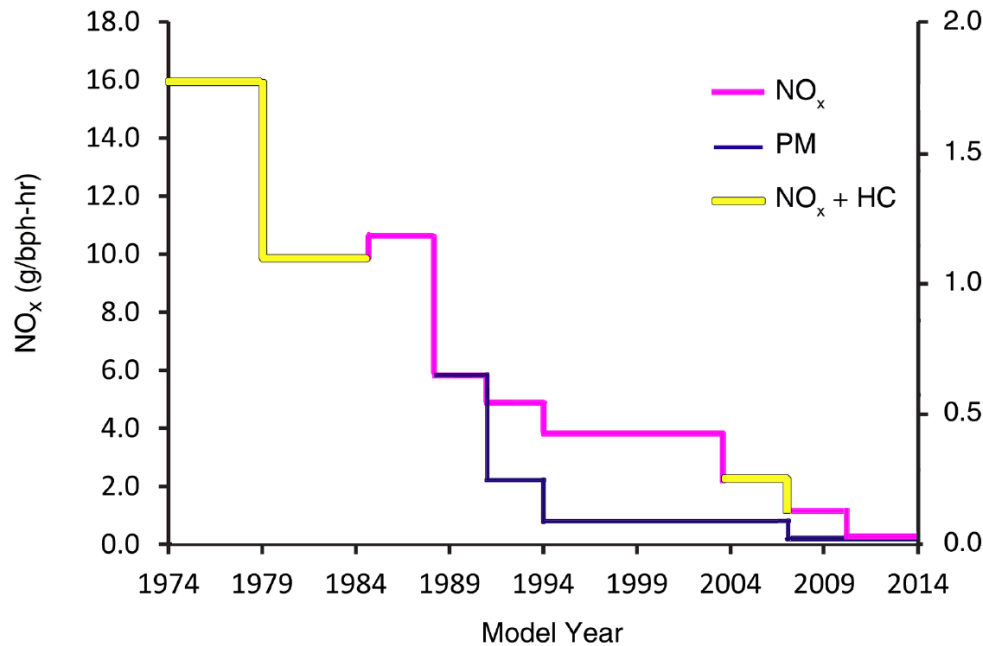
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Diesel Engine Exhaust



Reductions in Diesel Emissions Over Time



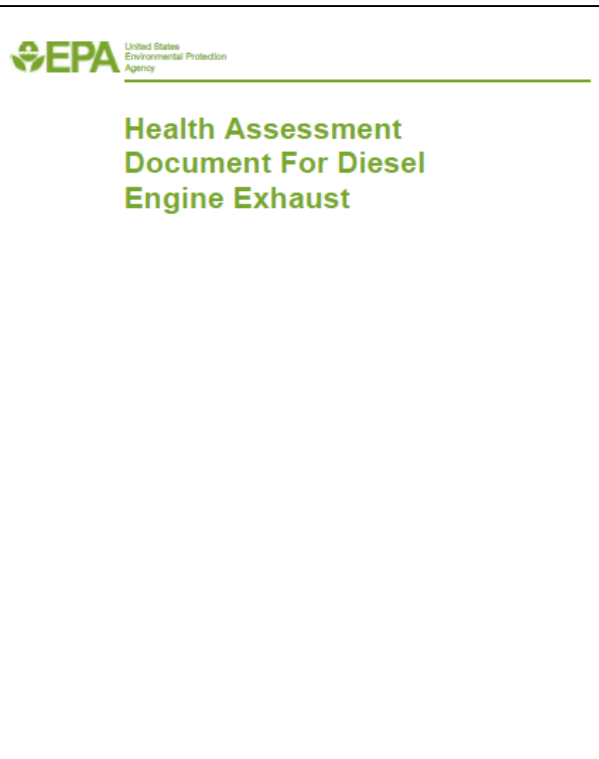
Uncontrolled Diesel Exhaust

Diesel Oxidation Catalyst

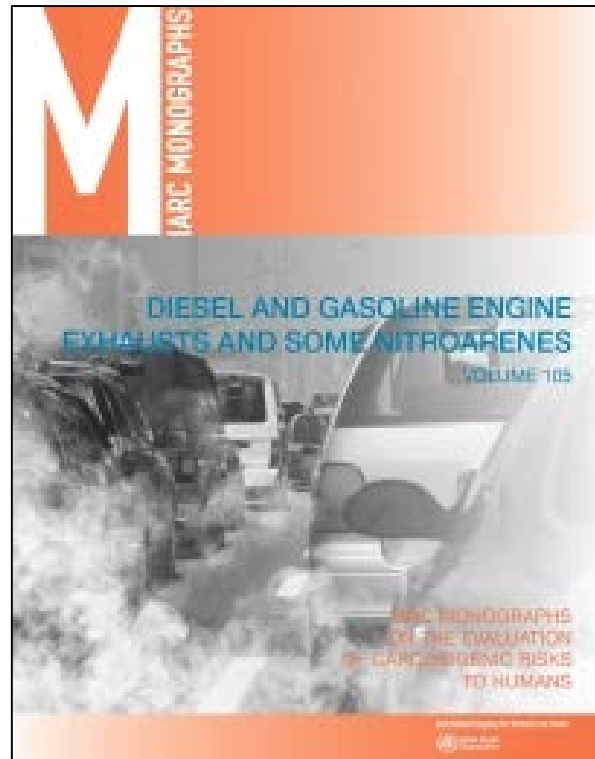
Partial Filter

Diesel Particulate Filter (since 2007)

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



2002 EPA Health Assessment Document for Diesel Engine Exhaust (669 pages)



2012 IARC Monograph, Diesel and Gasoline Engine Exhausts (714 pages)



2015 HEI ACES report on new-technology heavy-duty diesel engines (788 pages)

Thousands of studies examine health impacts from specific air pollutants found in diesel exhaust (e.g. PM_{2.5}, NO₂, 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.

Exposure-Response Estimates for Diesel Engine Exhaust and Lung Cancer Mortality Based on Data from Three Occupational Cohorts

Roel Vermeulen,¹ Debra T. Silverman,² Eric Garshick,³ Jelle Vlaanderen,^{1,4} Lützen Portengen,¹ and Kyle Steenland⁵

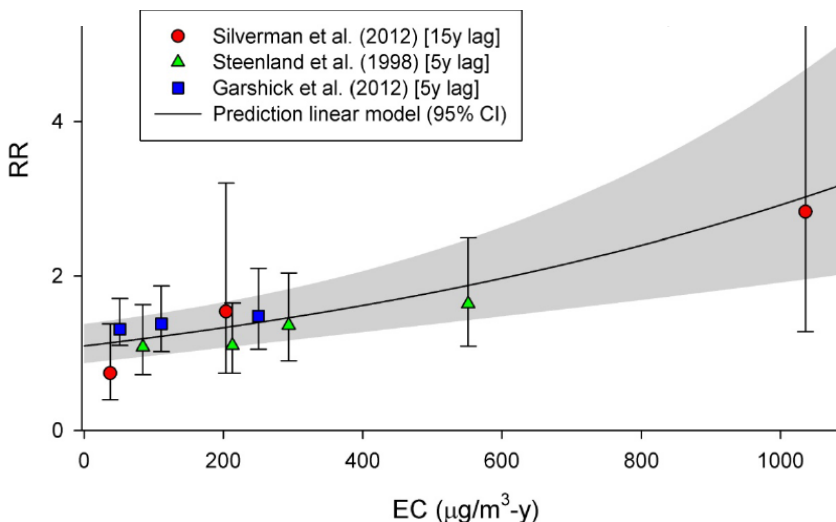


Figure 1. Predicted exposure-response curve using relative risk estimates from 3 cohort studies of diesel and lung cancer (Vermeulen et al., 2014).

Outdoor Particulate Matter Exposure and Lung Cancer: A Systematic Review and Meta-Analysis

Ghassan B. Hamra,¹ Neela Guha,¹ Aaron Cohen,² Francine Laden,^{3,4,5} Ole Raaschou-Nielsen,⁶ Jonathan M. Samet,⁷ Paolo Vineis,⁸ Francesco Forastiere,⁹ Paulo Saldiva,¹⁰ Takashi Yorifuji,¹¹ and Dana Loomis¹

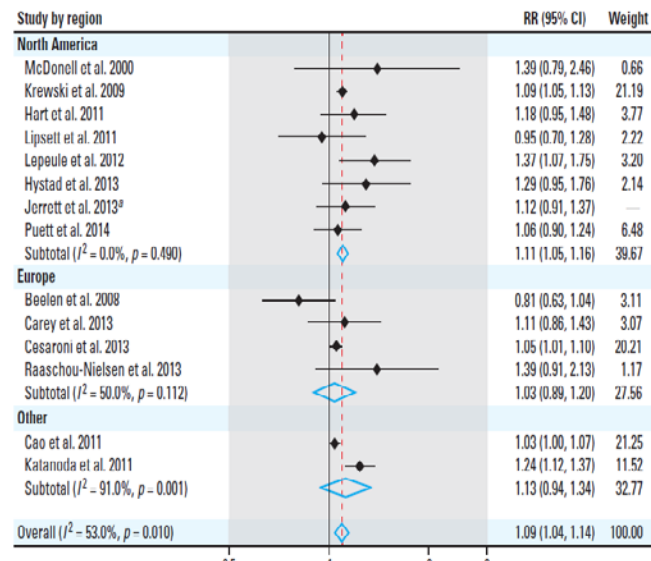


Figure 2. Lung Cancer risk associated with a 10 µg/m³ increase in PM_{2.5} (Hamra et al., 2014).

Respiratory Health Effects

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

Air Pollution from Truck Traffic and Lung Function in Children Living near Motorways

Bert Brunekreef,¹ Nicole A. H. Janssen,² Jeroen de Hartog,¹ Hendrik Harssena,² Mirjam Knape,² and Patricia van Vliet²

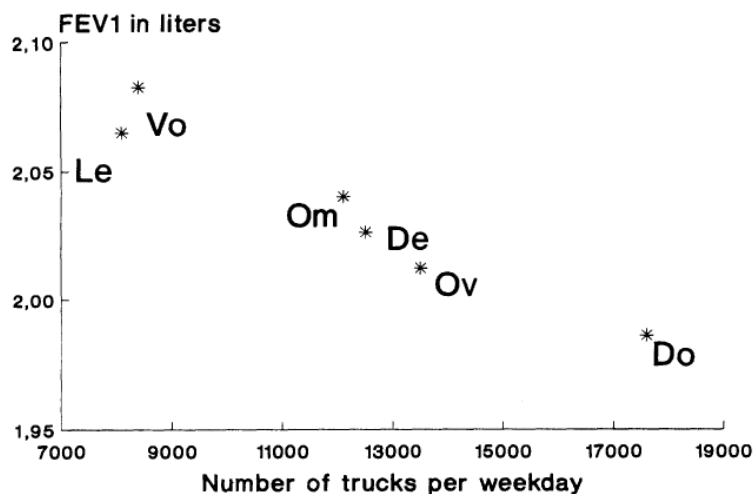


Figure 3. Associations between truck traffic density and FEV1 in children living <300 m from a motorway. [letters represent study cities].

ORIGINAL ARTICLE

Adopting Clean Fuels and Technologies on School Buses Pollution and Health Impacts in Children

Sara D. Adar¹, Jennifer D'Souza¹, Lianne Sheppard^{2,3}, Joel D. Kaufman^{2,4,5}, Teal S. Hallstrand⁴, Mark E. Davey⁶, James R. Sullivan², Jordan Jahnke⁷, Jane Koehn², Timothy V. Larson^{2,8} and I. J. Sally Gun^{2,6†}

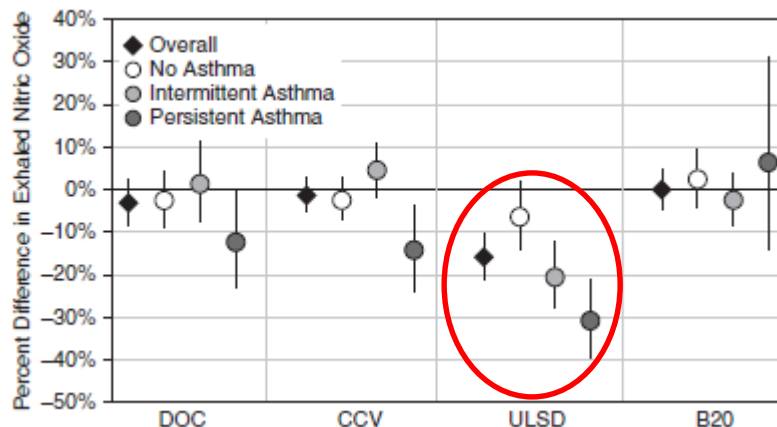


Figure 4. Adjusted associations between levels of exhaled nitric oxide (airway inflammation) and different bus interventions. Reductions for kids riding on buses switched to ultra-low-sulfur diesel (ULSD). DOC=Diesel oxidative catalyst; CCV=crankcase ventilating system; B20=biodiesel.

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

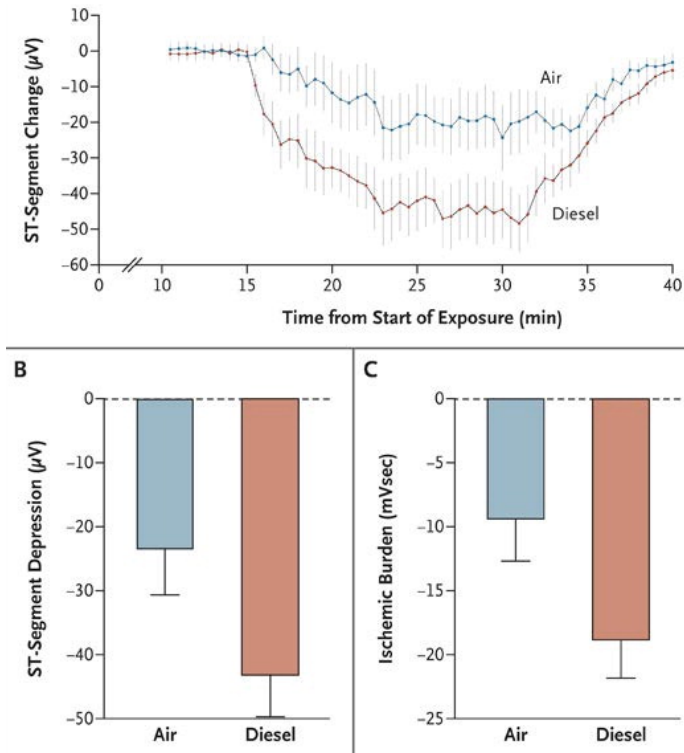


Figure 5. Myocardial Ischemia during 15-minute intervals of exercise-induced stress and diesel or filtered air exposure (Mills et al., 2007).

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

Health Outcomes	Short-Term Exposure (Days)	Longer-Term Exposure (Months to Years)
Cardiovascular mortality	↑ ↑ ↑	↑ ↑ ↑
Cardiovascular hospitalizations	↑ ↑ ↑	↑
Ischemic heart disease*	↑ ↑ ↑	↑ ↑ ↑
Heart failure*	↑ ↑	↑
Ischemic stroke*	↑ ↑	↑
Vascular diseases	↑	↑ †
Cardiac arrhythmia/cardiac arrest	↑	↑
Surrogate markers of atherosclerosis	N/A	↑
Systemic inflammation	↑ ↑	↑
Systemic oxidative stress	↑	
Endothelial cell activation/ blood coagulation	↑ ↑	↑
Vascular/endothelial dysfunction	↑ ↑	
BP	↑ ↑	
Altered HRV	↑ ↑ ↑	↑
Cardiac Ischemia	↑	
Arrhythmias	↑	

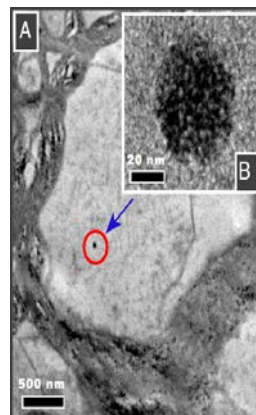
↑ ↑ ↑ Indicates strong overall epidemiological evidence.
 ↑ ↑ Indicates moderate overall epidemiological evidence.
 ↑ Indicates some but limited or weak available epidemiological evidence.
 Blank Indicates lack of evidence.

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^{a,1}, Imad A. M. Ahmed^b, Vassil Karloukovski^b, Donald A. MacLaren^c, Penelope G. Foulds^d, David Allsop^e, David M. A. Mann^e, Ricardo Torres-Jardón^f, and Lilian Calderon-Garciduenas^{g,h}



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

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

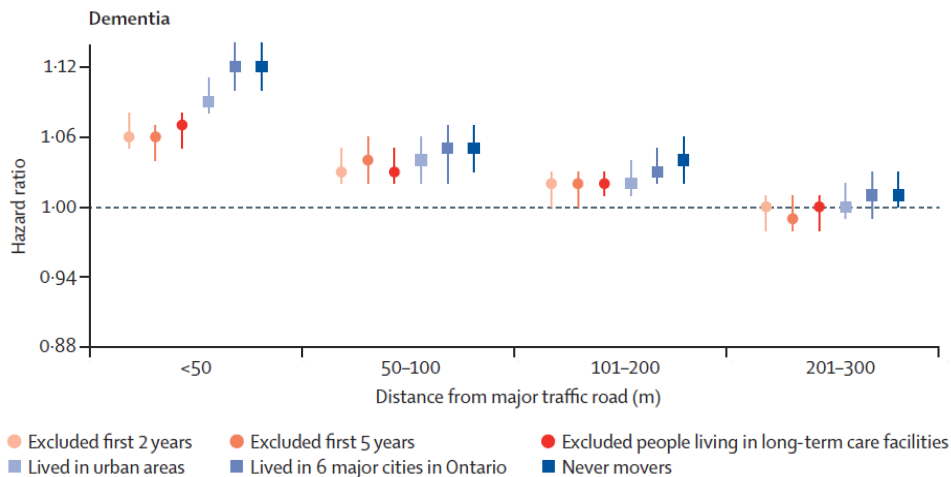


Figure 6. Associations between road proximity and Dementia (Chen et al., 2017).

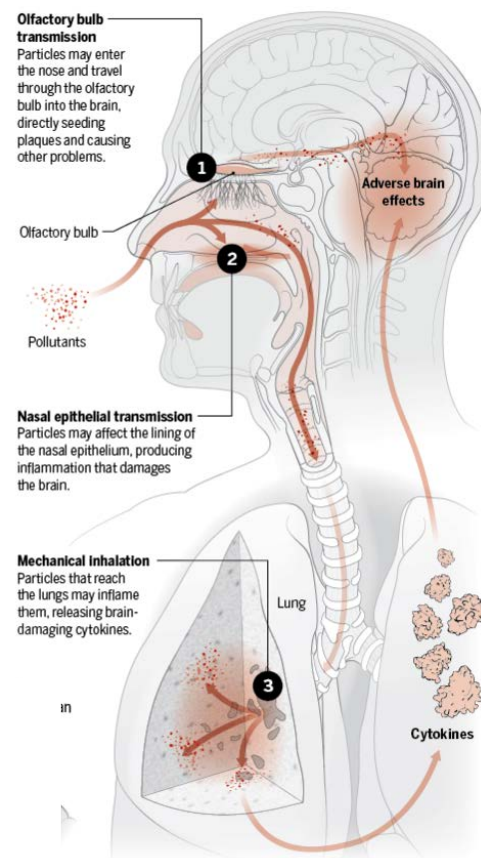


Figure 7. Particle pathways to the brain (ScienceMag, 2017).

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

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