Diesel Engine Exhaust

Health Effects and Impacts

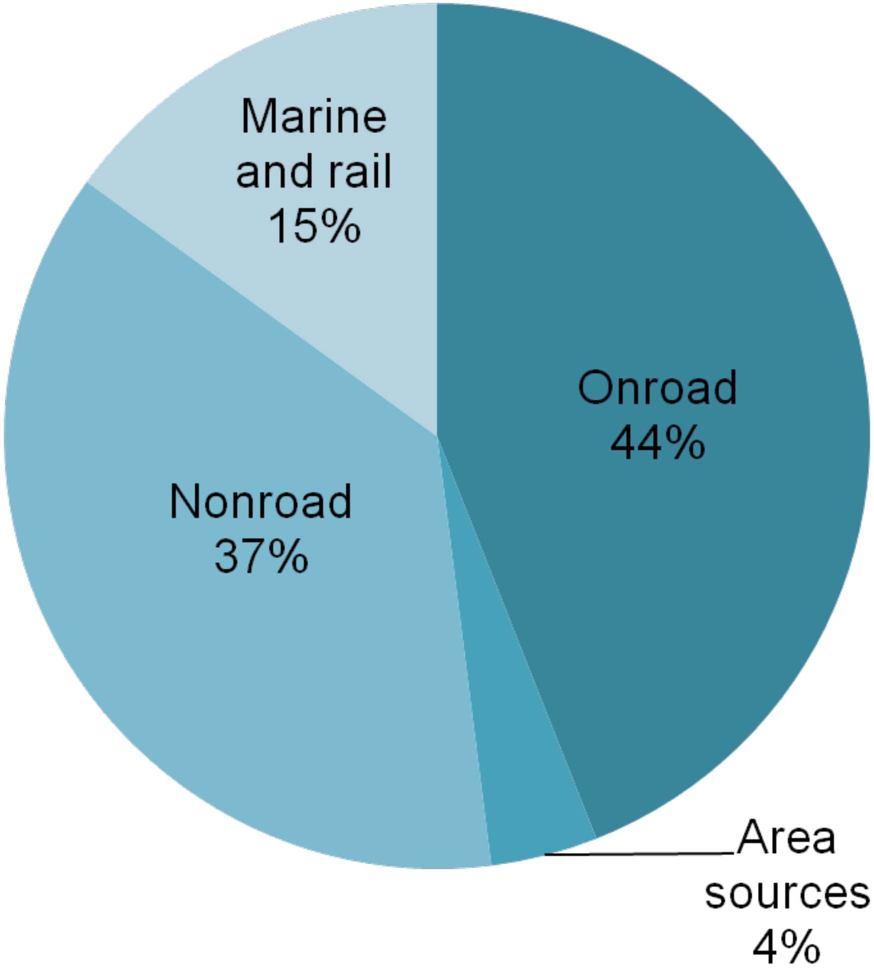
Matthew Davis, MPH

Multnomah County Health Department
Environmental Health Services

Diesel // Small Particles, Big Problems, Easy Solutions

Nuisance or toxic?

Diesel // Sources

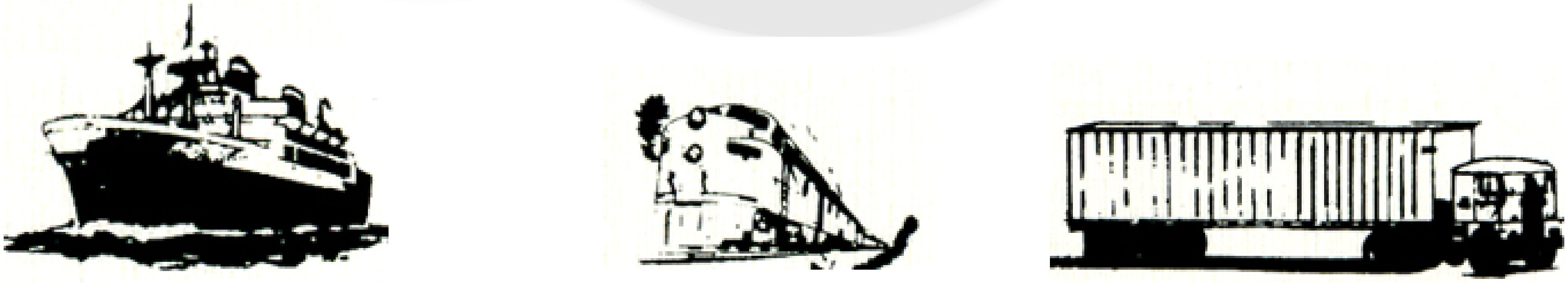


Source: DEQ Emissions Inventory

Diesel // Composition

Diesel // Composition

Biphenyl
Chromium
1,3-butadiene
Chlorine
Cadmium
Toluene
Cobalt
CO$_2$
Chlorobenzene
Benzene
Ethylbenzene
Dioxins
Arsenic
Aniline
CO
Phosphorus
Nitric Acid
Nickel
Manganese
NO$_2$
Phthalates
Trimethylbenzene
Beryllium
SO$_2$
Lead
Styrene
Acetaldehyde
Acrolein
Formaldehyde
Cyanide
PAHs



Diesel // Layers of Toxics

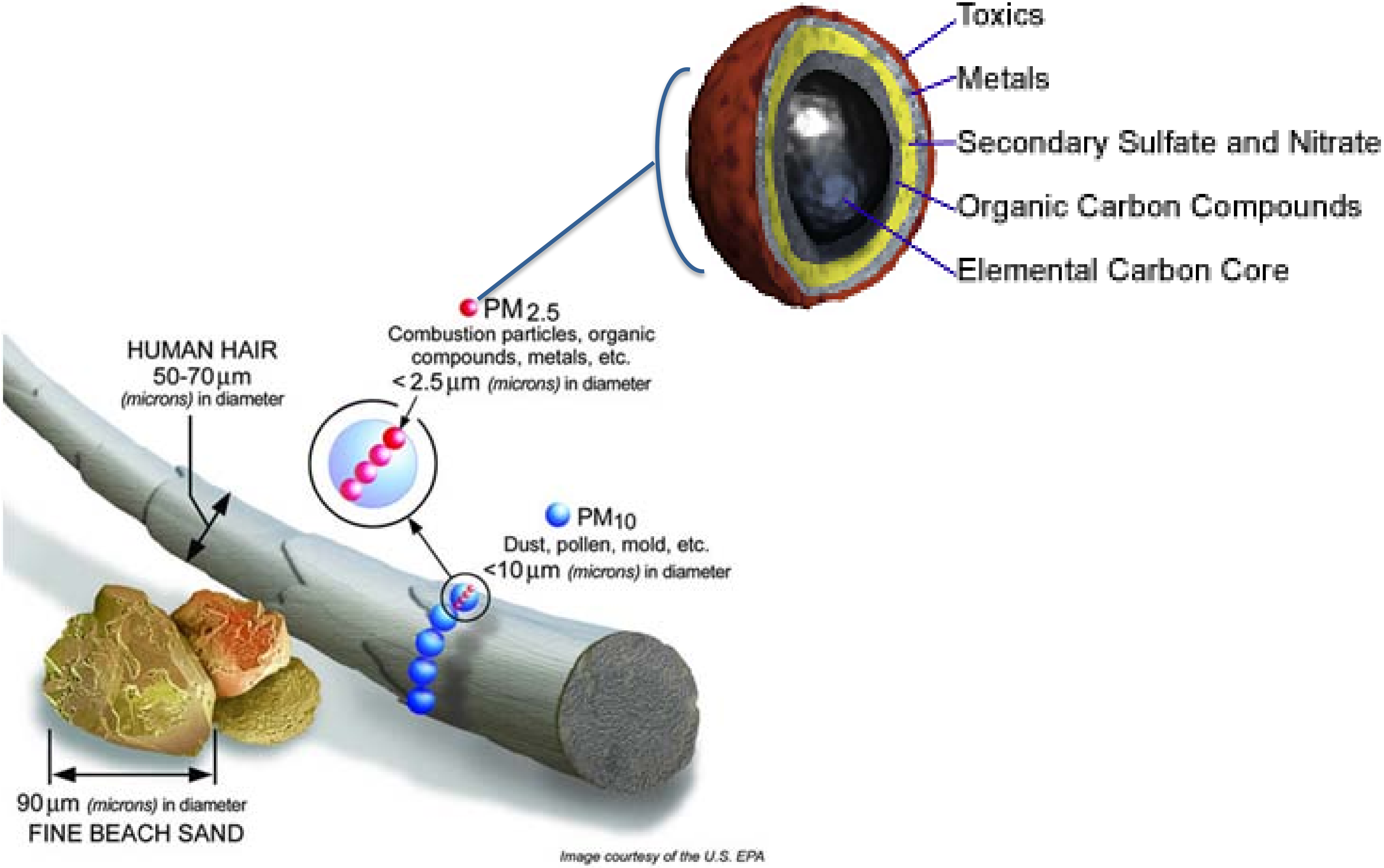
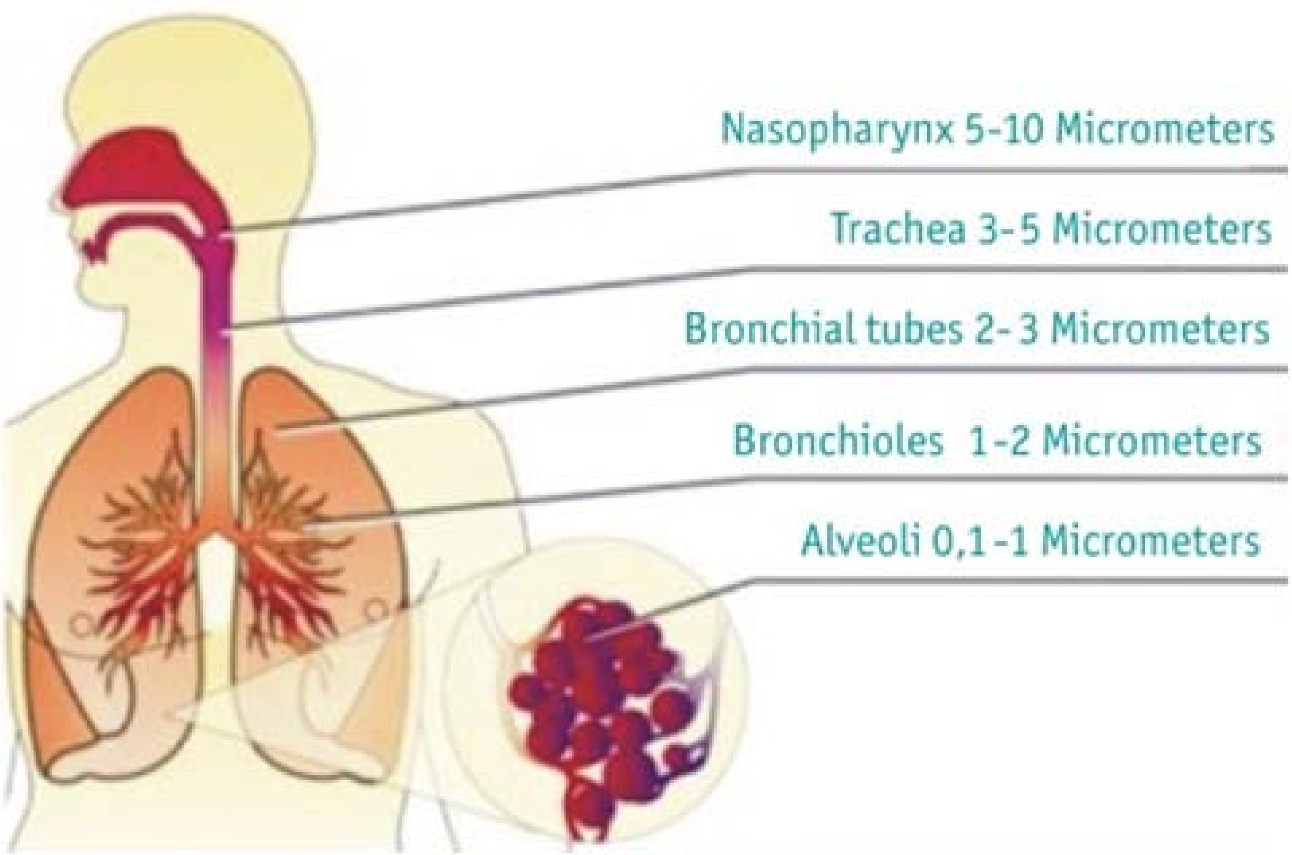
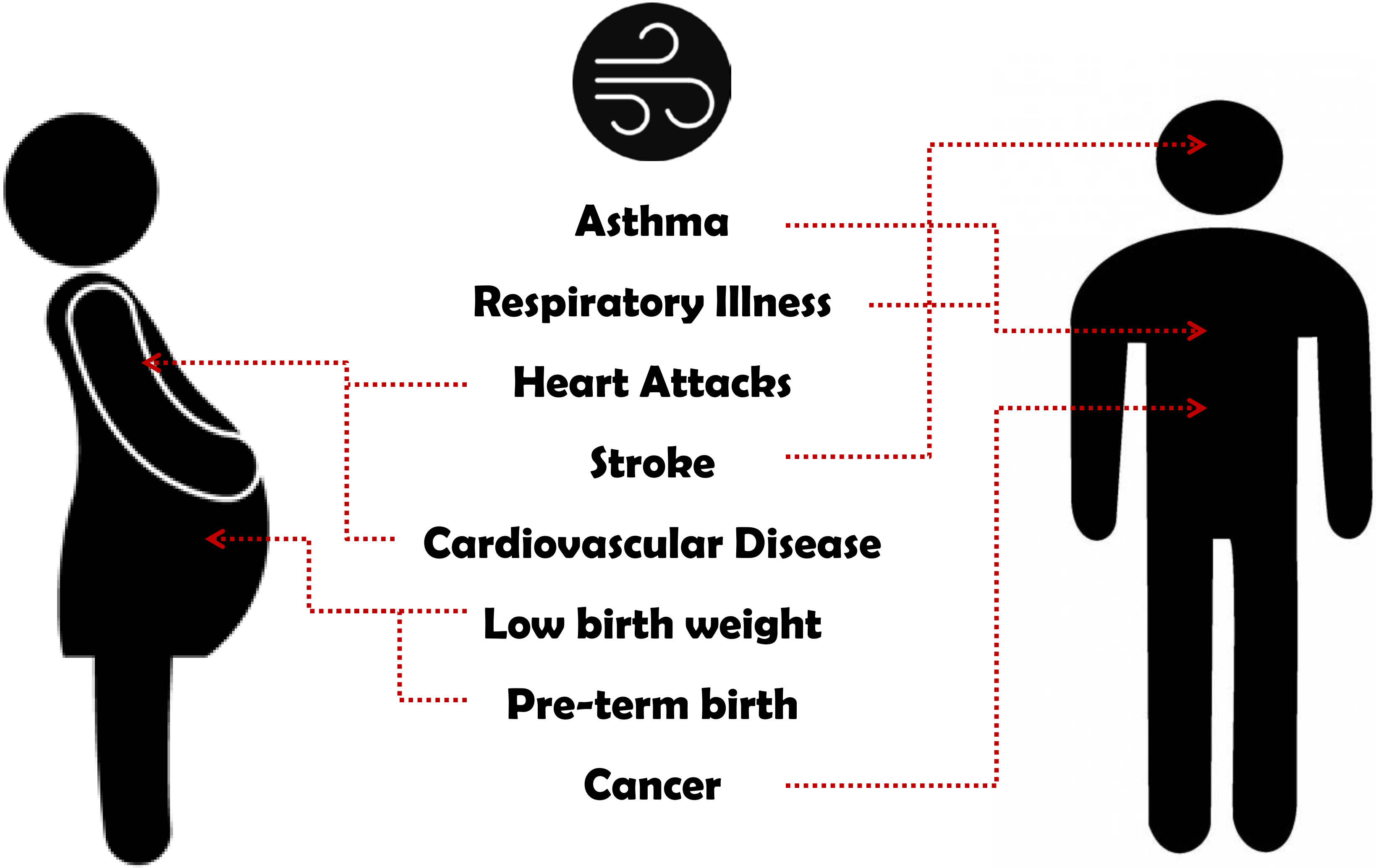


Image courtesy of the U.S. EPA

Diesel // Small Particles = Big Problems



Diesel // Health Effects



Asthma

Respiratory Illness

Heart Attacks

Stroke

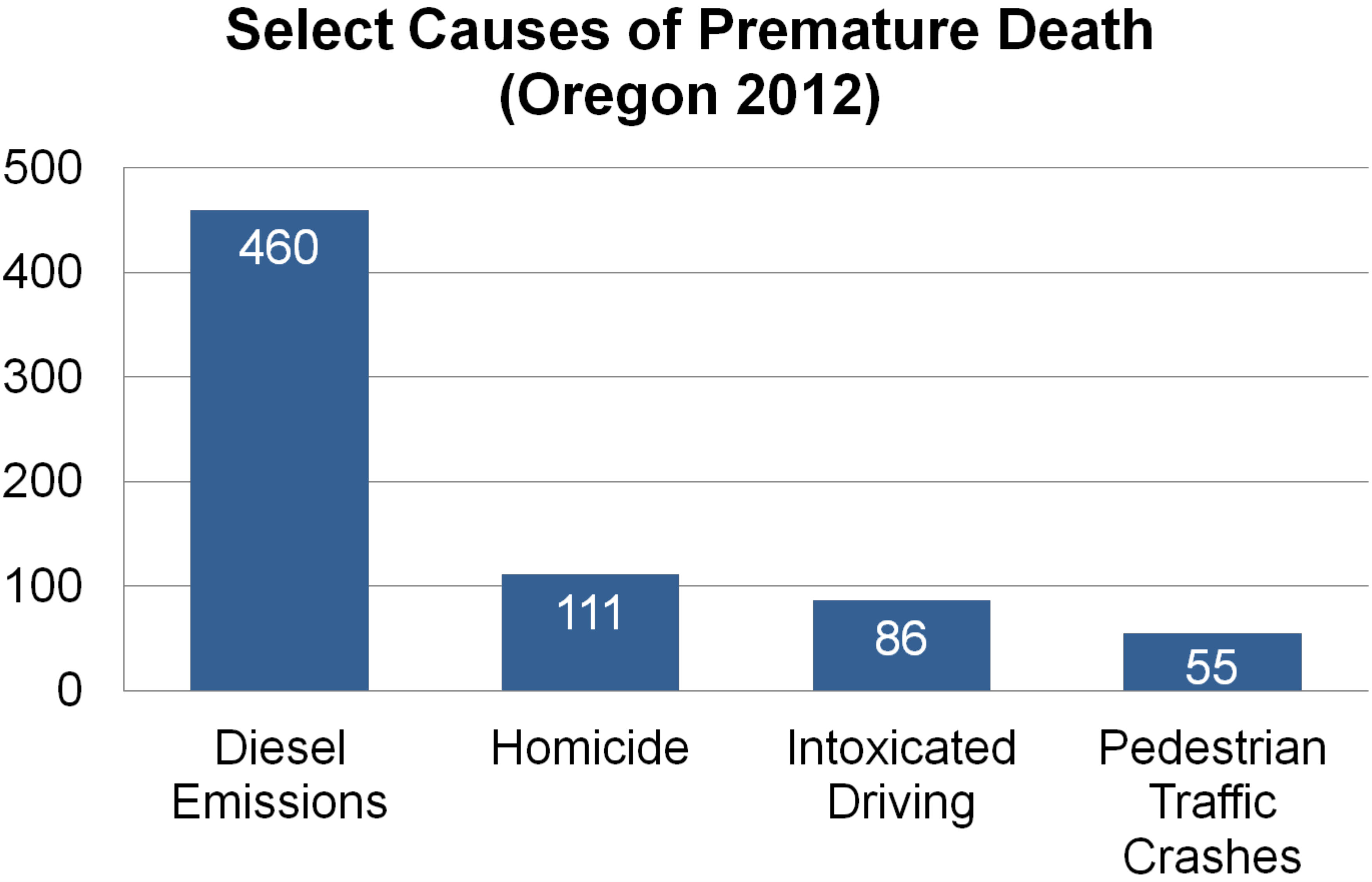
Cardiovascular Disease

Low birth weight

Pre-term birth

Cancer

Diesel // Health Impacts



Diesel // Health Impacts

Adults

- 145 non-fatal heart attacks
- 25,910 Work Loss Days
- 151,000 Minor Restricted Activity Days

Children

- 119 Asthma ED visits
- 250 Acute Bronchitis
- 3,200 lower respiratory symptoms
- 5,300 Asthma Exacerbations

Annual Impact: $ 3,500,000,000

Diesel // Neurodevelopmental Effects

Diesel // Neurodevelopmental Effects

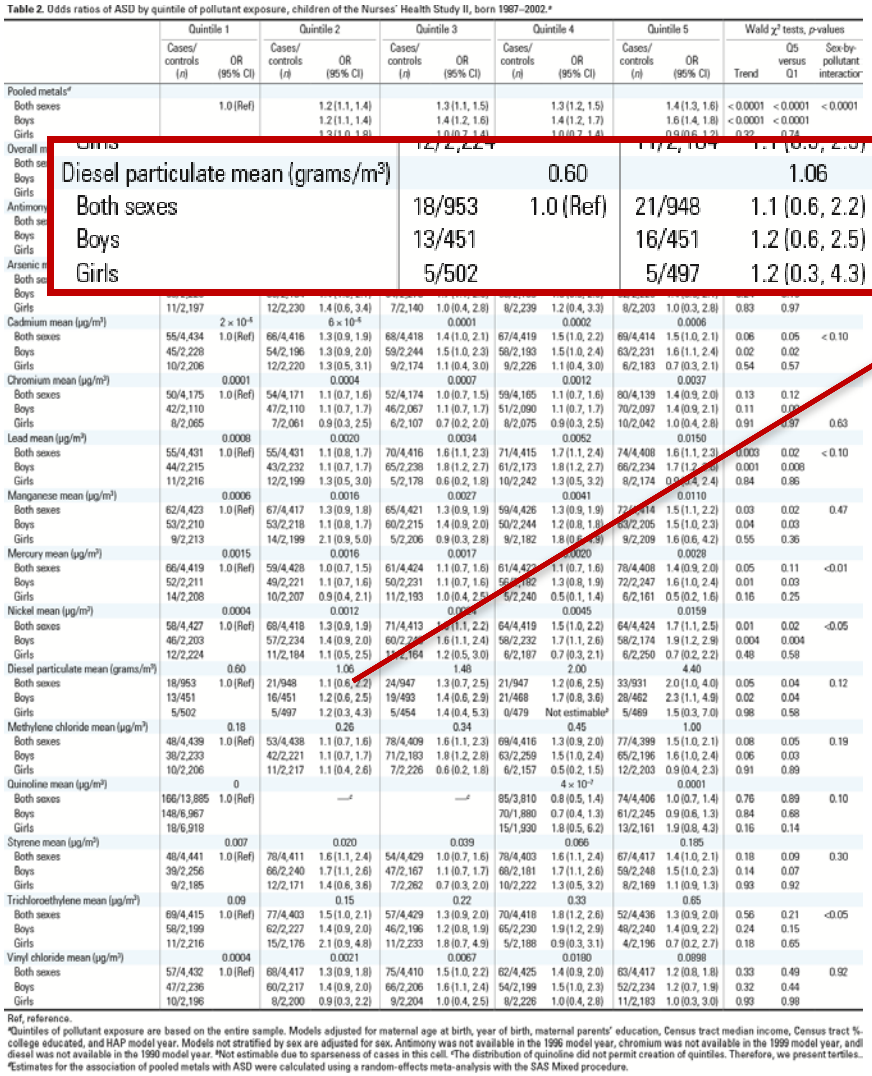


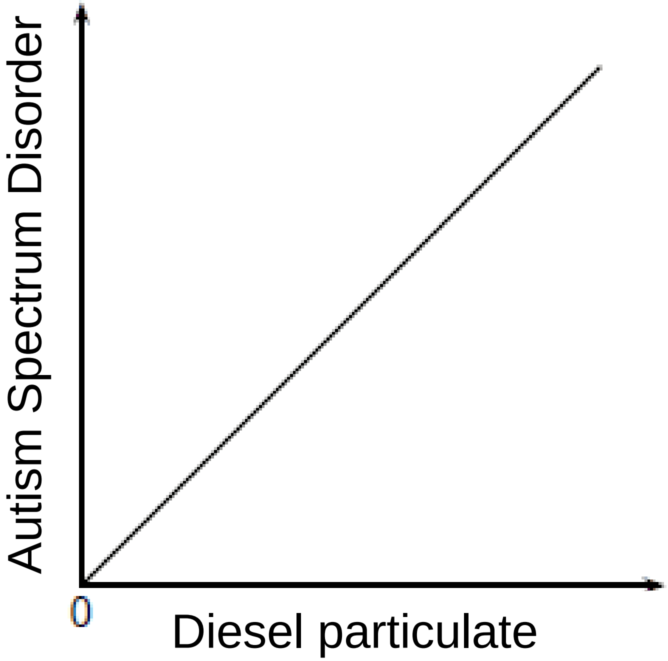
Table 2. Odds ratios of ASD by quintile of pollutant exposure, children of the Nurses' Health Study II, born 1987–2002.[a]

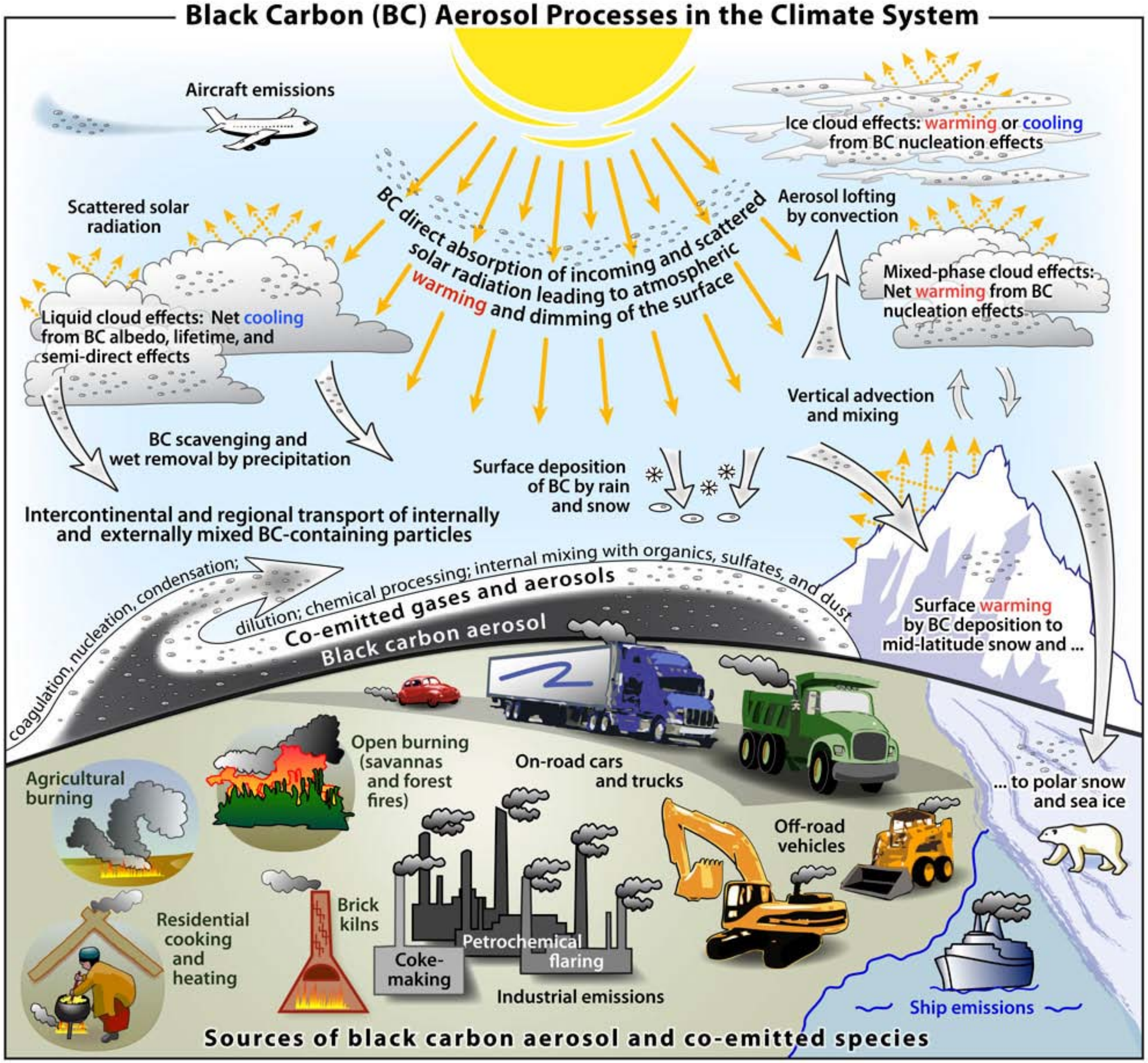
	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5		Wald χ^2 tests, p-values		
	Cases/ controls (n)	OR (95% CI)	Cases/ controls (n)	OR (95% CI)	Cases/ controls (n)	OR (95% CI)	Cases/ controls (n)	OR (95% CI)	Cases/ controls (n)	OR (95% CI)	Trend	Q5 versus Q1	Sex-by-pollutant interaction
Pooled metals[d]													
Both sexes		1.0 (Ref)		1.2 (1.1, 1.4)		1.3 (1.1, 1.5)		1.3 (1.2, 1.5)		1.4 (1.3, 1.6)	< 0.0001	< 0.0001	< 0.0001
Boys				1.2 (1.1, 1.4)		1.4 (1.2, 1.6)		1.4 (1.2, 1.7)		1.6 (1.4, 1.8)	< 0.0001	< 0.0001	
Girls				1.3 (1.0, 1.8)		1.0 (0.7, 1.4)		1.0 (0.7, 1.4)		0.9 (0.6, 1.2)	0.32	0.74	
Overall m													
Both se													
Boys													
Girls													
Antimony													
Both se													
Boys													
Girls													
Arsenic m													
Both se													
Boys													
Girls	11/2,197		12/2,230	1.4 (0.6, 3.4)	7/2,140	1.0 (0.4, 2.8)	8/2,239	1.2 (0.4, 3.3)	8/2,203	1.0 (0.3, 2.8)	0.83	0.97	
Cadmium mean (µg/m³)		2×10^{-5}		6×10^{-5}		0.0001		0.0002		0.0006			
Both sexes	55/4,434	1.0 (Ref)	66/4,416	1.3 (0.9, 1.9)	68/4,418	1.4 (1.0, 2.1)	67/4,419	1.5 (1.0, 2.2)	69/4,414	1.5 (1.0, 2.1)	0.06	0.05	< 0.10
Boys	45/2,228		54/2,196	1.3 (0.9, 2.0)	59/2,244	1.5 (1.0, 2.3)	58/2,193	1.5 (1.0, 2.4)	63/2,231	1.6 (1.1, 2.4)	0.02	0.02	
Girls	10/2,206		12/2,220	1.3 (0.5, 3.1)	9/2,174	1.1 (0.4, 3.0)	9/2,226	1.1 (0.4, 3.0)	6/2,183	0.7 (0.3, 2.1)	0.54	0.57	
Chromium mean (µg/m³)		0.0001		0.0004		0.0007		0.0012		0.0037			
Both sexes	50/4,175	1.0 (Ref)	54/4,171	1.1 (0.7, 1.6)	52/4,174	1.0 (0.7, 1.5)	59/4,165	1.1 (0.7, 1.6)	80/4,139	1.4 (0.9, 2.0)	0.13	0.12	
Boys	42/2,110		47/2,110	1.1 (0.7, 1.7)	46/2,067	1.1 (0.7, 1.7)	51/2,090	1.1 (0.7, 1.7)	70/2,097	1.4 (0.9, 2.1)	0.11	[illegible]	
Girls	8/2,065		7/2,061	0.9 (0.3, 2.5)	6/2,107	0.7 (0.2, 2.0)	8/2,075	0.9 (0.3, 2.5)	10/2,042	1.0 (0.4, 2.8)	0.91	0.97	0.63
Lead mean (µg/m³)		0.0008		0.0020		0.0034		0.0052		0.0150			
Both sexes	55/4,431	1.0 (Ref)	55/4,431	1.1 (0.8, 1.7)	70/4,416	1.6 (1.1, 2.3)	71/4,415	1.7 (1.1, 2.4)	74/4,408	1.6 (1.1, 2.3)	0.003	0.02	< 0.10
Boys	44/2,215		43/2,232	1.1 (0.7, 1.7)	65/2,238	1.8 (1.2, 2.7)	61/2,173	1.8 (1.2, 2.7)	66/2,234	[illegible]	0.001	0.008	
Girls	11/2,216		12/2,199	1.3 (0.5, 3.0)	5/2,178	0.6 (0.2, 1.8)	10/2,242	1.3 (0.5, 3.2)	8/2,174	[illegible]	0.84	0.86	
Manganese mean (µg/m³)		0.0006		0.0016		0.0027		0.0041		0.0110			
Both sexes	62/4,423	1.0 (Ref)	67/4,417	1.3 (0.9, 1.8)	65/4,421	1.3 (0.9, 1.9)	59/4,426	1.3 (0.9, 1.9)	[illegible]	1.5 (1.1, 2.2)	0.03	0.02	0.47
Boys	53/2,210		53/2,218	1.1 (0.8, 1.7)	60/2,215	1.4 (0.9, 2.0)	50/2,244	1.2 (0.8, 1.8)	63/2,205	1.5 (1.0, 2.3)	0.04	0.03	
Girls	9/2,213		14/2,199	2.1 (0.9, 5.0)	5/2,206	0.9 (0.3, 2.8)	9/2,182	[illegible]	9/2,209	1.6 (0.6, 4.2)	0.55	0.36	
Mercury mean (µg/m³)		0.0015		0.0016		0.0017		[illegible]		0.0028			
Both sexes	66/4,419	1.0 (Ref)	59/4,428	1.0 (0.7, 1.5)	61/4,424	1.1 (0.7, 1.6)	[illegible]	1.1 (0.7, 1.6)	78/4,408	1.4 (0.9, 2.0)	0.05	0.11	<0.01
Boys	52/2,211		49/2,221	1.1 (0.7, 1.6)	50/2,231	1.1 (0.7, 1.6)	[illegible]	1.3 (0.8, 1.9)	72/2,247	1.6 (1.0, 2.4)	0.01	0.03	
Girls	14/2,208		10/2,207	0.9 (0.4, 2.1)	11/2,193	[illegible]	5/2,240	0.5 (0.1, 1.4)	6/2,161	0.5 (0.2, 1.6)	0.16	0.25	
Nickel mean (µg/m³)		0.0004		0.0012		[illegible]		0.0045		0.0159			
Both sexes	58/4,427	1.0 (Ref)	68/4,418	1.3 (0.9, 1.9)	71/4,413	[illegible]	64/4,419	1.5 (1.0, 2.2)	64/4,424	1.7 (1.1, 2.5)	0.01	0.02	<0.05
Boys	46/2,203		57/2,234	1.4 (0.9, 2.0)	[illegible]	1.6 (1.1, 2.4)	58/2,232	1.7 (1.1, 2.6)	58/2,174	1.9 (1.2, 2.9)	0.004	0.004	
Girls	12/2,224		11/2,184	1.1 (0.5, 2.5)	[illegible]	1.2 (0.5, 3.0)	6/2,187	0.7 (0.3, 2.1)	6/2,250	0.7 (0.2, 2.2)	0.48	0.58	
Diesel particulate mean (grams/m³)		0.60		1.06		1.48		2.00		4.40			
Both sexes	18/953	1.0 (Ref)	21/948	1.1 (0.6, 2.2)	24/947	1.3 (0.7, 2.5)	21/947	1.2 (0.6, 2.5)	33/931	2.0 (1.0, 4.0)	0.05	0.04	0.12
Boys	13/451		16/451	1.2 (0.6, 2.5)	19/493	1.4 (0.6, 2.9)	21/468	1.7 (0.8, 3.6)	28/462	2.3 (1.1, 4.9)	0.02	0.04	
Girls	5/502		5/497	1.2 (0.3, 4.3)	5/454	1.4 (0.4, 5.3)	0/479	Not estimable[b]	5/469	1.5 (0.3, 7.0)	0.98	0.58	
Methylene chloride mean (µg/m³)		0.18		0.26		0.34		0.45		1.00			
Both sexes	48/4,439	1.0 (Ref)	53/4,438	1.1 (0.7, 1.6)	78/4,409	1.6 (1.1, 2.3)	69/4,416	1.3 (0.9, 2.0)	77/4,399	1.5 (1.0, 2.1)	0.08	0.05	0.19
Boys	38/2,233		42/2,221	1.1 (0.7, 1.7)	71/2,183	1.8 (1.2, 2.8)	63/2,259	1.5 (1.0, 2.4)	65/2,196	1.6 (1.0, 2.4)	0.06	0.03	
Girls	10/2,206		11/2,217	1.1 (0.4, 2.6)	7/2,226	0.6 (0.2, 1.8)	6/2,157	0.5 (0.2, 1.5)	12/2,203	0.9 (0.4, 2.3)	0.91	0.89	
Quinoline mean (µg/m³)		0						4×10^{-7}		0.0001			
Both sexes	166/13,885	1.0 (Ref)		—[c]		—[c]	85/3,810	0.8 (0.5, 1.4)	74/4,406	1.0 (0.7, 1.4)	0.76	0.89	0.10
Boys	148/6,967						70/1,880	0.7 (0.4, 1.3)	61/2,245	0.9 (0.6, 1.3)	0.84	0.68	
Girls	18/6,918						15/1,930	1.8 (0.5, 6.2)	13/2,161	1.9 (0.8, 4.3)	0.16	0.14	
Styrene mean (µg/m³)		0.007		0.020		0.039		0.066		0.185			
Both sexes	48/4,441	1.0 (Ref)	78/4,411	1.6 (1.1, 2.4)	54/4,429	1.0 (0.7, 1.6)	78/4,403	1.6 (1.1, 2.4)	67/4,417	1.4 (1.0, 2.1)	0.18	0.09	0.30
Boys	39/2,256		66/2,240	1.7 (1.1, 2.6)	47/2,167	1.1 (0.7, 1.7)	68/2,181	1.7 (1.1, 2.6)	59/2,248	1.5 (1.0, 2.3)	0.14	0.07	
Girls	9/2,185		12/2,171	1.4 (0.6, 3.6)	7/2,262	0.7 (0.3, 2.0)	10/2,222	1.3 (0.5, 3.2)	8/2,169	1.1 (0.9, 1.3)	0.93	0.92	
Trichloroethylene mean (µg/m³)		0.09		0.15		0.22		0.33		0.65			
Both sexes	69/4,415	1.0 (Ref)	77/4,403	1.5 (1.0, 2.1)	57/4,429	1.3 (0.9, 2.0)	70/4,418	1.8 (1.2, 2.6)	52/4,436	1.3 (0.9, 2.0)	0.56	0.21	<0.05
Boys	58/2,199		62/2,227	1.4 (0.9, 2.0)	46/2,196	1.2 (0.8, 1.9)	65/2,230	1.9 (1.2, 2.9)	48/2,240	1.4 (0.9, 2.2)	0.24	0.15	
Girls	11/2,216		15/2,176	2.1 (0.9, 4.8)	11/2,233	1.8 (0.7, 4.9)	5/2,188	0.9 (0.3, 3.1)	4/2,196	0.7 (0.2, 2.7)	0.18	0.65	
Vinyl chloride mean (µg/m³)		0.0004		0.0021		0.0067		0.0180		0.0898			
Both sexes	57/4,432	1.0 (Ref)	68/4,417	1.3 (0.9, 1.8)	75/4,410	1.5 (1.0, 2.2)	62/4,425	1.4 (0.9, 2.0)	63/4,417	1.2 (0.8, 1.8)	0.33	0.49	0.92
Boys	47/2,236		60/2,217	1.4 (0.9, 2.0)	66/2,206	1.6 (1.1, 2.4)	54/2,199	1.5 (1.0, 2.3)	52/2,234	1.2 (0.7, 1.9)	0.32	0.44	
Girls	10/2,196		8/2,200	0.9 (0.3, 2.2)	9/2,204	1.0 (0.4, 2.5)	8/2,226	1.0 (0.4, 2.8)	11/2,183	1.0 (0.3, 3.0)	0.93	0.98	

Ref, reference.

[a] Quintiles of pollutant exposure are based on the entire sample. Models adjusted for maternal age at birth, year of birth, maternal parents' education, Census tract median income, Census tract %-college educated, and HAP model year. Models not stratified by sex are adjusted for sex. Antimony was not available in the 1996 model year, chromium was not available in the 1999 model year, andl diesel was not available in the 1990 model year. [b] Not estimable due to sparseness of cases in this cell. [c] The distribution of quinoline did not permit creation of quintiles. Therefore, we present tertiles..
[d] Estimates for the association of pooled metals with ASD were calculated using a random-effects meta-analysis with the SAS Mixed procedure.

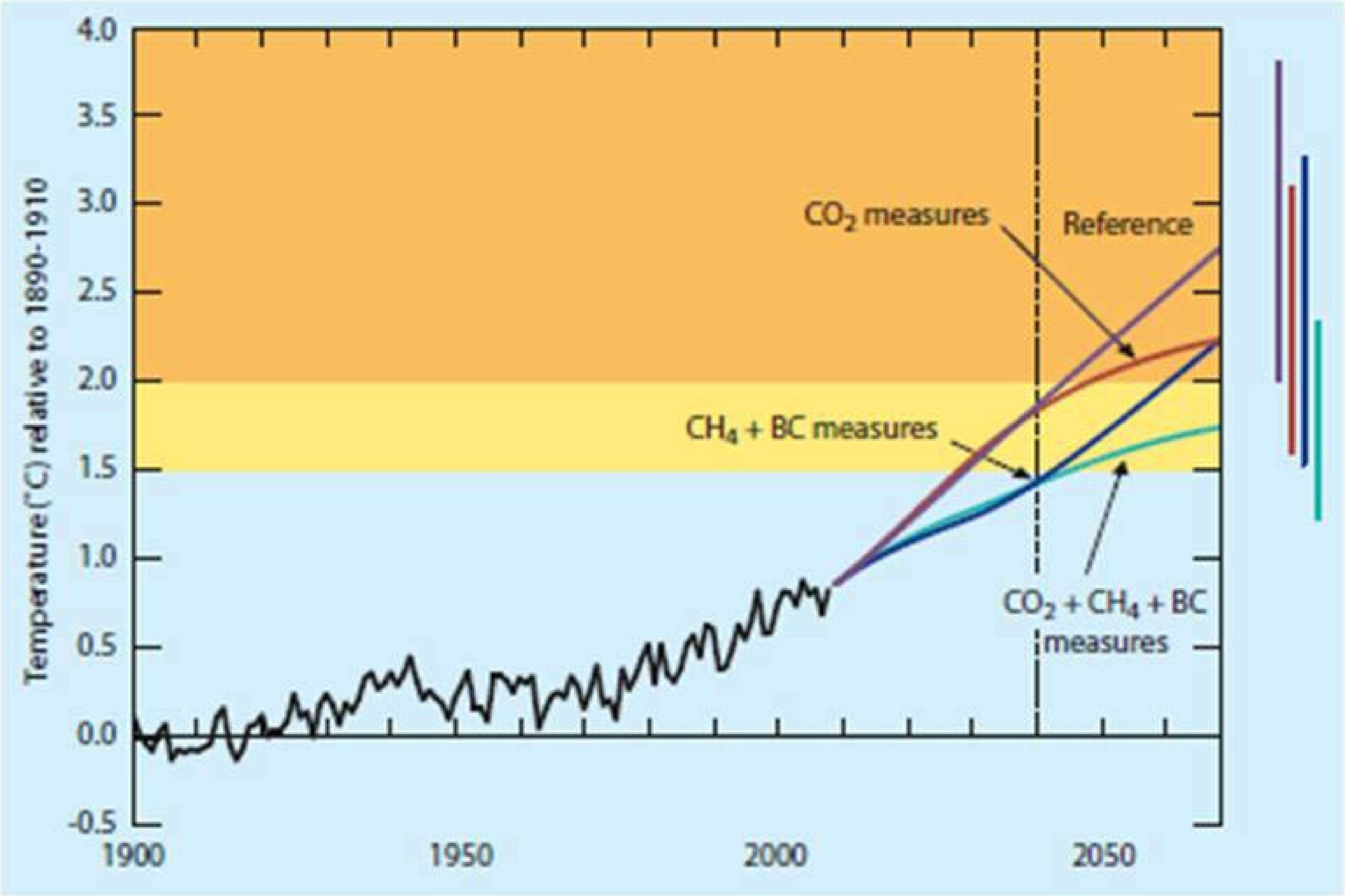
Diesel particulate mean (grams/m³)		0.60		1.06		1.48		2.00		4.40		
Both sexes	18/953	1.0 (Ref)	21/948	1.1 (0.6, 2.2)	24/947	1.3 (0.7, 2.5)	21/947	1.2 (0.6, 2.5)	33/931	2.0 (1.0, 4.0)	0.05	0.04
Boys	13/451		16/451	1.2 (0.6, 2.5)	19/493	1.4 (0.6, 2.9)	21/468	1.7 (0.8, 3.6)	28/462	2.3 (1.1, 4.9)	0.02	0.04
Girls	5/502		5/497	1.2 (0.3, 4.3)	5/454	1.4 (0.4, 5.3)	0/479	Not estimable[b]	5/469	1.5 (0.3, 7.0)	0.98	0.58





Source: Bounding the role of black carbon in the climate system: A Scientific Assessment. Bond et al.

Diesel // Climate Change

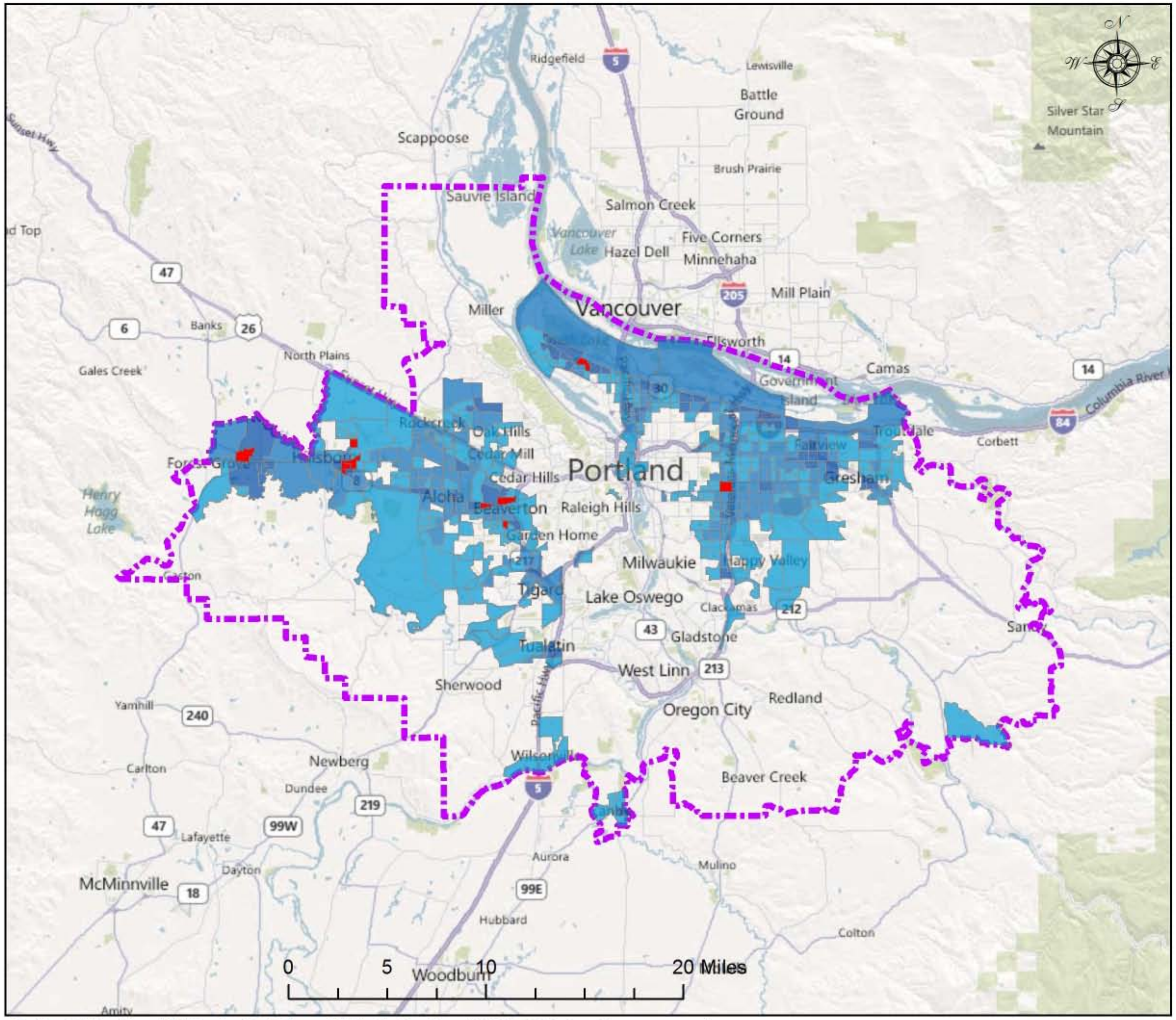


Source: Black carbon: Integrated Assessment of Black Carbon and Tropospheric Ozone, World Meteorological Organization

Diesel // Environmental Justice

Portland Air Toxics Solutions

DEQ
State of Oregon
Department of Environmental Quality



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Date: 9/6/2011

🟥 Highest 10 by % minority

Census 2010 % Minority

4 - 15

16 - 24

🟦 25 - 35

🟦 36 - 49

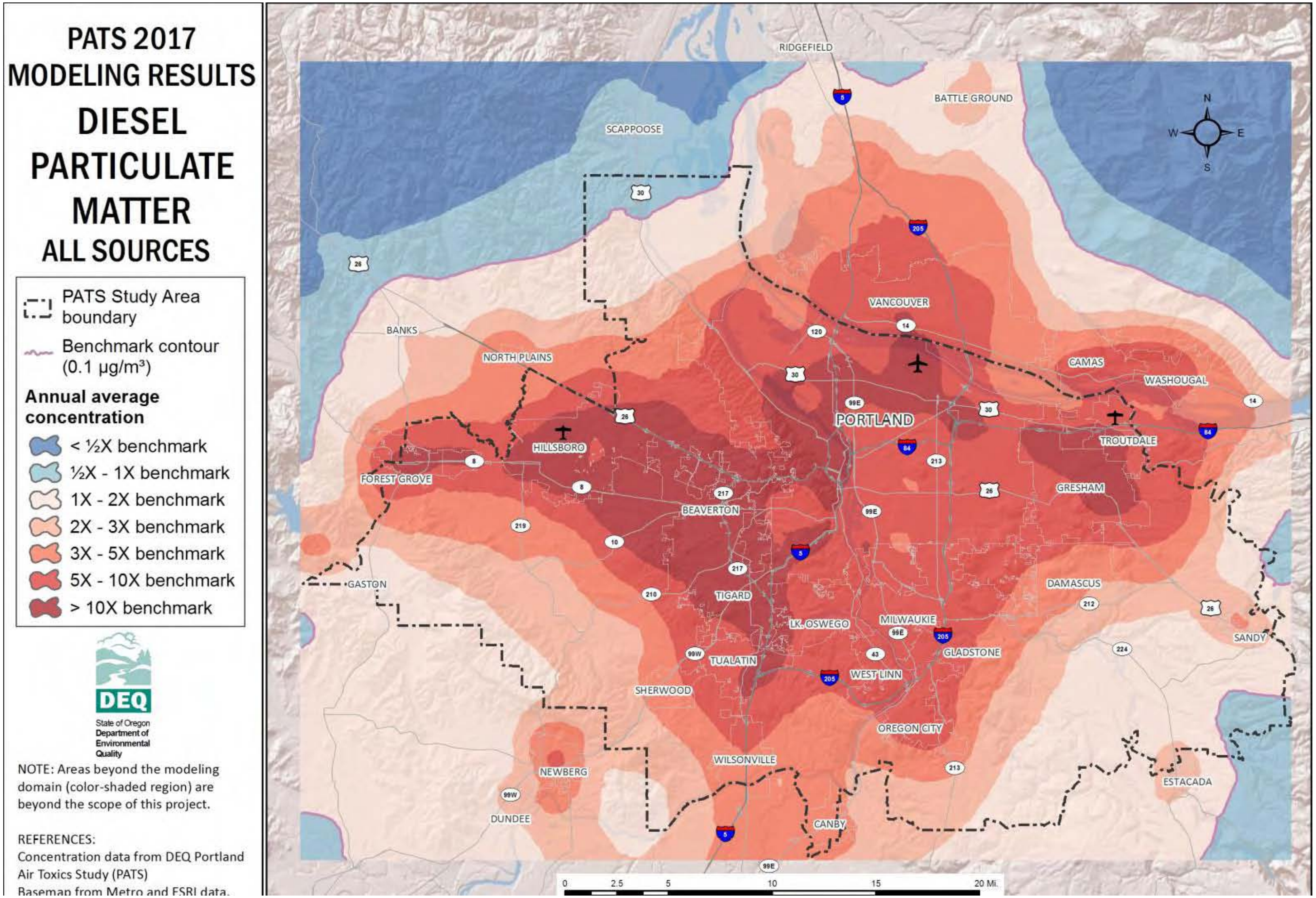
🟦 50 - 87

PATS Study Area

▭ PATS Study Area

Reference:
Census 2010 and
American Community Survey
ESRI base data

Diesel // Environmental Justice



PATS 2017
MODELING RESULTS
DIESEL
PARTICULATE
MATTER
ALL SOURCES

NOTE: Areas beyond the modeling domain (color-shaded region) are beyond the scope of this project.

REFERENCES:
Concentration data from DEQ Portland Air Toxics Study (PATS)
Basemap from Metro and ESRI data.

Diesel // Conclusions

- Diesel engine exhaust is damaging to public health
- The impacts are felt disproportionately by the very young, older adults and communities of color
- What should we do?