*The signature physiologic consequence of air pollution is the same as cigarette smoke: a low grade arterial inflammation, arteriolar narrowing, and vascular prothrombotic changes. Chemical markers of these changes are found even in young healthy adults. As with cigarette smoke the effect can be almost immediate and chronic exposure to even low concentrations of pollution are associated with an acceleration of atherosclerosis, damage to the endothelium of blood vessels, and significant arteriolar
narrowing and stiffness. Breathing more ozone in childhood increases arterial wall thickness in young adults.

*Simultaneously high concentrations of multiple pollutants have a synergistic effect on hospitalizations for cardiac disease.

*Air pollution causes average blood pressure to increase within minutes. All organs are affected. Blood pressure rises are found in even in children and from prenatal exposure.

*Air pollution can alter electrical signaling within the heart, starting as early as infancy. Rates of arrhythmias, heart attacks and strokes increase with air pollution and are the primary cause for increased community mortality rates. Those rates correspond to hourly pollution concentrations and stay elevated for as long as 30 days after the exposure has ended.

*In patients who suffer from heart failure, air pollution reduces cardiac function. Even in patients without known heart disease, air pollution increases the size of heart chambers, indicative of impaired function, a precursor of heart failure.

*Particulate pollution concentrations typical of the Wasatch Front increase mortality rates about 10% according to the formula recommended by the American Heart Association published in May, 2010. Ozone causes further increase in mortality, although less than particle matter. That means between 1,000 and 2,000 Utahns die prematurely every year due to our air pollution. Approximately 210,000 premature deaths occur annually in the US from combustion emissions.
The average pollution related premature death represents about ten years of lost life.

*Particulate pollution from coal and diesel combustion are likely much more potent in triggering heart and vascular disease than most other sources.

*Mortality plotted against air pollution concentrations shows no safe threshold, even at low levels, well below EPA national ambient air quality standards (NAAQS). Furthermore this curve is not linear. The steepest part of the curve is at low doses, i.e. small air pollution reductions have even greater public health benefit when the concentrations are already low. Even at what are considered ‘background’ levels of particulate pollution there are increased risks for cardiopulmonary mortality compared to clean, filtered air. Nearly all the mortality caused by air pollution occurs in cities and towns that meet the EPA’s national air quality standards.

*Air pollution impairs exercise capability, even in the very fittest of individuals. Even in young, healthy adults air pollution increases biomarkers of inflammation and thrombosis and increases blood pressure and heart rate. Air pollution offsets the cardiorespiratory benefits of exercise.

*Air pollution shortens life expectancy and accelerates the aging process. The residents of the average American city lose 1-3 years of life expectancy, in Northern China residents lose 5.5 years.

*The increase in mortality risk persists for decades after exposure.
*There are very likely genetic differences in human susceptibility to the arterial inflammation provoked by air pollution. Furthermore, the progression of inflammation and cardiovascular changes are more pronounced in those who are already at higher risk.

*Inhaled nanoparticles preferentially lodge in the lining of blood vessels where inflammation and atherosclerosis already exist, and they can remain there for months, and perhaps much longer. Particle pollution also lodges in heart tissue, in astonishing amounts--billions of particles per gram of heart tissue.

*Air pollution alters the blood lipid profile, decreasing HDL levels.

*Black Americans suffer greater cardiovascular impacts from air pollution than caucasians.

*Radioactive isotopes attached to particulate pollution carry additional cardiovascular risks.

*Preconception air pollution exposure impairs the normal development of the heart in animals.


4. Dockery DW, Stone PH. Cardiovascular Risks from Fine Particulate Air Pollution. NEJM 2007; 356:511-513


atherosclerotic plaques induced by inhalation of diesel exhaust. Atherosclerosis. 2011 Mar 2. [Epub ahead of print]


50. Szyszkowicz M, Rowe BH, Brook RD. Even Low Levels of Ambient Air Pollutants Are Associated With Increased Emergency Department Visits for Hypertension. Can J Cardiol. 2011 Sep 23. [Epub ahead of print]


73. Lepeule J, Laden F, Dockery D, Schwartz J. Chronic Exposure to Fine Particles and Mortality: An Extended Follow-Up


effects study (CAPES). Environ Res. 2012 Jul 23. [Epub ahead of print]


97. Bedada GB, Smith CJ, Tyrrell PJ, Hirst AA, Agius R. Short-term effects of ambient particulates and gaseous pollutants on the incidence of transient ischaemic attack and


102. Atkinson R, Carey I, Kent A, van Staa T, Anderson HR, Cook D Long-Term Exposure to Outdoor Air Pollution and Incidence of Cardiovascular Diseases. Epidemiology, 5 December 2012. doi: 10.1097/EDE 0b013e318276ccb8


122. Son JY, Lee JT, Park YH, Bell ML. Short-Term Effects of Air Pollution on Hospital Admissions in Korea. Epidemiology. 2013 May 14. [Epub ahead of print]


140. Neophytou AM, Hart JE, Cavallari JM, Smith TJ, Dockery DW, Coull BA, Garshick E, Laden F. Traffic-related exposures and


145. Zanobetti A, et al. Brachial Artery Responses to Ambient Pollution, Temperature, and Humidity in People with Type 2
Diabetes: A Repeated-Measures Study. Environ Health Perspect; DOI:10.1289/ehp.1206136


149. Gall S, et al. Exposure to parental smoking in childhood or adolescence is associated with increased carotid intima-media thickness in young adults: evidence from the Cardiovascular Risk in Young Finns study and the Childhood Determinants of Adult Health Study Eur Heart J first published online March 4, 2014 doi:10.1093/eurheartj/ehu049


151. Huang YL, Chen HW, Han BC, Liu CW, Chuang HC, Lin LY, Chuang KJ. Personal Exposure to Household Particulate Matter, Household Activities and Heart Rate Variability among


188. Weichenthal S, Hatzopoulou M, Goldberg MS. Exposure to traffic-related air pollution during physical activity and acute changes in blood pressure, autonomic and micro-vascular function in women: a cross-over study. Part Fibre Toxicol. 2014 Dec 9;11(1):70. [Epub ahead of print]


190. Chung Y, Dominici F, Wang Y, Coull BA, Bell ML. Associations between Long- Term Exposure to Chemical Constituents of Fine Particulate Matter (PM2.5) and Mortality in Medicare Enrollees in the Eastern United States. Environ Health Perspect. 2015 Jan 6. [Epub ahead of print]


193. Li R, Kou X, Geng H, Xie J, Tian J, Cai Z, Dong C. Mitochondrial damage: An important mechanism of ambient


199. Chan S, et al. Long-Term Air Pollution Exposure and Blood Pressure in the Sister Study. Environ Health Perspect; DOI:10.1289/ehp.1408125

200. Pieters N, et al. Blood Pressure and Same-Day Exposure to Air Pollution at School: Associations with Nano-Sized to Coarse PM in Children. Environ Health Perspect; DOI:10.1289/ehp.1408121


203. Ostro B, et al. Associations of Mortality with Long-Term Exposures to Fine and Ultrafine Particles, Species and Sources: Results from the California Teachers Study Cohort. Environmental Health Perspectives, http://dx.doi.org/10.1289/ehp.1408565. Advance Publication: 23 January 201

204. Fischer PH, Marra M, Ameling CB, Hoek G, Beelen R, de Hoogh K, Breugelmans O, Kruize H, Janssen NA, Houthuijs D. Air Pollution and Mortality in Seven Million Adults: The Dutch
Environmental Longitudinal Study (DUELS). Environ Health Perspect. 2015 Mar 11. [Epub ahead of print]

205. van Rossem L, et al. Prenatal Air Pollution Exposure and Newborn Blood Pressure. Environ Health Perspect; DOI:10.1289/ehp.1307419


213. ResBart Ostro R, et al. Associations of Mortality with Long-Term Exposures to Fine and Ultrafine Particles, Species and Sources: Environ Health Perspect; DOI: 10.1289/ehp.1408565


218. Fischer P, et al. Air Pollution and Mortality in Seven Million Adults: The Dutch Environmental Longitudinal Study (DUELS) Environ Health Perspect; DOI: 10.1289/ehp.1408254


224. Crouse D, et al. Ambient PM2.5, O3, and NO2 Exposures and Associations with Mortality over 16 Years of Follow-Up in the Canadian Census Health and Environment Cohort (CanCHEC). Environ Health Perspect; DOI:10.1289/ehp.1409276


Source-Related Components of U.S. Fine Particle Air Pollution. Environ Health Perspect. 2015 Dec 2. [Epub ahead of print]


238. Sen T, Astarcikli MA, Asarcikli LD, Kilit C, Kafes H, Parspur A, Yaymaci M, Pinar M, Tüfekcioglu O, Amasyali. The effects of air pollution and weather conditions on the incidence of


244. Thompson LC, et al. Acrolein Inhalation Alters Myocardial Synchrony and Performance at and Below Exposure
Concentrations that Cause Ventilatory Responses. Cardiovasc Toxicol. 2016 Feb 19. [Epub ahead of print]


257. Zhang Z, et al. Long-Term Exposure to Particulate Matter and Self-Reported Hypertension: A Prospective Analysis in the Nurses’ Health Study. Environ Health Perspect; DOI:10.1289/EHP163


294. Sinharay R, et al. Respiratory and cardiovascular responses to walking down a traffic-polluted road compared with walking in a traffic-free area in participants aged 60 years and older with chronic lung or heart disease and age-matched healthy controls: a randomised, crosso. The Lancet, 2017; DOI:


308. Salameh P, et al. Hypertension prevalence and living conditions related to air pollution: results of a national


327. Geng J, et al. PM2.5 promotes plaque vulnerability at different stages of atherosclerosis and the formation of foam cells


333. Stieb D, et al. Associations between air pollution and cardio-respiratory physiological measures in older adults


337. Ljungman P, et al. Long-Term Exposure to Particulate Air Pollution, Black Carbon, and Their Source Components in Relation to Ischemic Heart Disease and Stroke. Environmental Health Perspectives, 2019; 127 (10): 107012 DOI: 10.1289/EHP4757


352. Chen H, et al. Understanding the joint impacts of fine particulate matter concentration and composition on the incidence and mortality of cardiovascular disease: a


363. WU Jun Hui, WU Yao, WANG Zi Jing, TIAN Yao Hua, WU Yi Qun, WU Tao, WANG Meng Ying, WANG Xiao Wen, WANG Jia Ting, HU Yong Hua. Ambient Particulate Matter Pollution and Hospital Visits for Cardiac Arrhythmia in Beijing, China[J]. Biomedical and Environmental Sciences, 2021, 34(7): 562-566. doi: 10.3967/bes2021.077
364. Lim Y_H, et al. Long-Term Exposure to Air Pollution, Road Traffic Noise, and Heart Failure Incidence: The Danish Nurse Cohort. Journal of the American Heart Association, 2021; DOI: 10.1161/JAHA.121.021436


Pollution and the Brain

* The systemic inflammation caused by air pollution also affects the brain

* Air pollution components, including toxic, metallic nanoparticles, reach the brain and can penetrate deeply into the parenchyma beginning in infancy.

* Many of the compounds adsorbed to particulate matter are neurotoxic.

* Air pollution causes CNS oxidative stress, neuroinflammation, neuronal damage, neuronal loss, loss of brain mass in key areas that control memory, cortical stress measured by EEG, enhancement of Alzheimer type-abnormal filamentous proteins (beta amyloid and phosphorylated tau), BBB and microglial (immune system) changes, and
cerebrovascular damage. Many of these changes can be found in infants, children and young adults.

* Air pollution exposure is associated with almost the full range of clinical neurologic disorders throughout the age spectrum, including lower intelligence, diminished motor function, attention deficit and behavioral problems, decreased cognition and accelerated dementia in adults, delinquent behavior in adolescents, higher rates of violent crime, higher rates of strokes, ALS, relapses in multiple sclerosis, autism, impaired olfactory sense, Parkinson's, and other neurodegenerative diseases, depression, anxiety, substance abuse, schizophrenia and suicide. Air pollution is even associated with impaired cognition and decision making among numerous professions—indoor office workers, stock traders, chess players, and baseball umpires, for example. Air pollution reduces productivity of factory workers and call center employees.

* Acute air pollution exposure on the way to school affects students’ attention span during the ensuing school day. Air pollution in the room where students take tests reduces test scores on the same day, and air purifiers improve scores, even in areas where the pollution is below the EPA’s standards.

* Air pollution impairs olfactory function (i.e. sense of smell).

* Carbon monoxide in air pollution increases the risk of seizures in epileptic patients.

* Prenatal exposure to air pollution is particularly harmful to fetal brain development, even causing loss of white matter involving the left hemisphere, corpus callous and
hippocampus, which results in impaired memory, cognition and behavioral disorders in childhood.


Age 5 in a Prospective Cohort Study in Poland. Environ Health Perspect . doi:10.1289/ehp.0901070


17. Lopez I, Beltran-Parrazal1 L, Abhimanyu Amarnani A. Evidence for oxidative stress in the developing cerebellum of the rat after chronic mild carbon monoxide exposure (0.0025% in air) BMC Neuroscience 2009, 10:53doi: 10.1186/1471-2202-10-53


22. Kettunen, J. et al. (2007) Associations of fine and ultrafine particulate air pollution with stroke mortality in an area of low air pollution levels. Stroke 38, 918–922


25. Mateen F, Brook R. Air Pollution as an Emerging Global Risk Factor for Stroke JAMA

26. Lopez IA, Acuna D, Beltran-Parrazal L, Lopez IE, Amarnani A, Cortes M, Edmond J. Evidence for oxidative stress in the developing cerebellum of the rat after chronic mild carbon monoxide exposure (0.0025% in air) BMC Neuroscience 2009, 10:53 (27 May 2009)

Nanoscale Particulate Urban Air Pollutants In Vivo and In Vitro. Environ Health Perspect:--. doi:10.1289/ehp.1002973


55. Ljubimova JY, Kleinman MT, Karabalin NM, Inoue S, Konda B, Gangalum P, Markman JL, Ljubimov AV, Black KL. Gene expression changes in rat brain after short and long exposures to particulate matter in Los Angeles basin air: Comparison with


66. Calderon-Garciduenas L, Cross JV, Franco-Lira M. “Brain immune interactions and air pollution: macrophage inhibitory factor (MIF), prion cellular protein (PrPC), interleukin-6 (IL-6), interleukin 1 receptor antagonist (IL-1Ra), and interleukin-2 (IL-2) in cerebrospinal fluid and MIF in serum differentiate urban children exposed to severe vs. low air pollution,” Frontiers in Neuroscience, vol. 7, article 183, 2013

68. Boucher O, et al. Domain-Specific Effects of Prenatal Exposure to PCBs, Mercury, and Lead on Infant Cognition: Results from the Environmental Contaminants and Child Development Study in Nunavik. Environ Health Perspect; DOI:10.1289/ehp.1206323


Air Pollution before, during, and after Pregnancy: A Nested Case-Control Analysis within the Nurses' Health Study II Cohort. Environ Health Perspect. 2014 Dec 18. [Epub ahead of print]


88. Differential effects between one week and four weeks exposure to same mass of SO2 on synaptic plasticity in rat hippocampus. Environ Toxicol. 2014 Dec 23. doi: 10.1002/tox.22093. [Epub ahead of print]


95. Jacobson J, et al. Relation of Prenatal Methylmercury Exposure from Environmental Sources to Childhood IQ. Environ Health Perspect; DOI:10.1289/ehp.1408554


99. Seamen N, et al. In Utero Fine Particle Air Pollution and Placental Expression of Genes in the Brain-Derived Neurotrophic Factor Signaling Pathway: An ENVIRONAGE Birth Cohort StudyEnviron Health Perspect; DOI:10.1289/ehp.1408549


106. Kioumourtzoglou MA, Schwartz JD, Weisskopf MG, Melly SJ, Wang Y, Dominici F, Zanobetti A. Long-term PM2.5 Exposure and Neurological Hospital Admissions in the Northeastern United


111. Jacobson JL, et al. Relation of Prenatal Methylmercury Exposure from Environmental Sources to Childhood IQ. Environ Health Perspect; DOI:10.1289/ehp.1408554

112. Saenen N, et al. In Utero Fine Particle Air Pollution and Placental Expression of Genes in the Brain-Derived Neurotrophic Factor Signaling Pathway: An ENVIRONAGE Birth Cohort Study Environ Health Perspect; DOI:10.1289/ehp.1408549


128. Marquesa R, et al. Neurodevelopment of Amazonian children exposed to methylmercury (from Thimerosal in vaccines) and methylmercury (from fish). Environmental Research Available online 7 January 2016

129. Chen JC, et al. Ambient Air Pollution and Neurotoxicity on Brain Structure: Evidence From Women’s Health Initiative Memory Study. ANN NEUROL 2015;78:466–476


147. Basagaña X, et al. Neurodevelopmental Deceleration by Urban Fine Particles from Different Emission Sources: A Longitudinal Observational Study. Environ Health Perspect; DOI:10.1289/EHP209


154. Pun VC, et al. Association of Ambient Air Pollution with Depressive and Anxiety Symptoms in Older Adults: Results from the NSHAP Study. Environ Health Perspect; DOI:10.1289/EHP494


181. Calderón-Garcidueñas L, et al. Hallmarks of Alzheimer disease are evolving relentlessly in Metropolitan Mexico City infants, children and young adults. APOE4 carriers have higher suicide risk and higher odds of reaching NFT stage V at ≤ 40 years of age. Environmental Research, 2018; 164: 475 DOI: 10.1016/j.envres.2018.03.023


197. Peng C, et al. Residential Proximity to Major Roadways at Birth, DNA Methylation at Birth and Midchildhood, and Childhood Cognitive Test Scores: Project Viva(Massachusetts, USA)


229. Wang R, et al. Residential greenness, air pollution and psychological well-being among urban residents in Guangzhou,


244. Calderón-Garciduenas L, et al. Quadruple abnormal protein aggregates in brainstem pathology and exogenous metal-rich magnetic nanoparticles (and engineered Ti-rich nanorods). The substantia nigrae is a very early target in young urbanites and the gastrointestinal tract a key brainstem portal. Environmental Research 191 (2020) 110139


246. Patten K, et al. The Effects of Chronic Exposure to Ambient Traffic-Related Air Pollution on Alzheimer’s Disease Phenotypes in Wildtype and Genetically Predisposed Male and Female Rats. Environmental Health Perspectives, 2021; 129 (5) DOI: 10.1289/EHP8905


253. Jose Guillermo Cedeño Laurent, Piers MacNaughton, Emily Jones, Anna S Young, Maya Bliss, Skye Flanigan, Jose Vallarino, Ling Jyh Chen, Xiaodong Cao, Joseph G Allen. Associations between acute exposures to PM2.5 and carbon dioxide indoors and cognitive function in office workers: a multicountry longitudinal prospective observational study. Environmental Research Letters, 2021; 16 (9): 094047 DOI: 10.1088/1748-9326/ac1bd8


257. Wang X, et al. Association of improved air quality with lower dementia risk in older women Proceedings of the National Academy of Sciences Jan 2022, 119 (2) e2107833119; DOI: 10.1073/pnas.2107833119


266. Letellier N, et al. Air quality improvement and incident dementia: Effects of observed and hypothetical reductions in air


Pollution and Chromosomal Function/Fetal Development/Fertility

*Babies are essentially born pre-polluted by the air breathed by the mother during pregnancy. Particulate matter and the chemicals attached to them can cross the placenta and interfere with fetal development

* Pregnant women exposed to more air pollution give birth to babies with significantly more chromosomal aberrations including shorter telomeres and epigenetic changes which can be passed on to multiple subsequent generations.
* Exposure even to brief episodes of pollution at critical stages in the development of the human embryo can increase the risk of birth defects like neural tube defects, and cause the baby as an adult to experience an increased likelihood of multiple chronic diseases including those of the heart, lungs, immune system and brain and even obesity, diabetes, cancer and shortened life expectancy.

* Air pollution breathed by a pregnant mother causes epigenetic changes in the womb, which is associated with higher rates of lung and heart disease in animals and humans in childhood as an adult.

* Pollution impairs virtually every component of human reproduction—causing sperm DNA damage, increase in the rates of male infertility, decreases fertilization, menstruation, and increases miscarriages and other adverse reproductive outcomes. Preconception/prenatal Air pollution exposure of the father is associated is associated with lower birth weight of newborns.

* Children living near petrochemical industries are exposed to high PAH levels, contributing to DNA damage. Industrial pollution is even more genotoxic than traffic pollution.

*Regarding birth weights and poor neurologic outcomes, males are generally more affected by prenatal air pollution than females.

*Even preconception pollution exposure of the mother increases the risk of congenital malformations
1. Bruner-Tran, KL and KG Osteen. 2010. Developmental exposure to TCDD reduces fertility and negatively affects pregnancy outcomes across multiple generations. Reproductive Toxicology http://dx.doi.org/10.1016/j.reprotox.2010.10.003


(Industrial PM2.5 is more genotoxic and causative of oxidative stress than traffic PM2.5)


Particulate Air Pollution During in Utero Life. Environ Health Perspect: . http://dx.doi.org/10.1289/ehp.1104458


42. Tillett T Potential Mechanism for PM10 Effects on Birth Outcomes: In Utero Exposure Linked to Mitochondrial DNA


54. Demarini DM. Genotoxicity biomarkers associated with exposure to traffic and near-road atmospheres: a review.


62. XU DQ, ZHANG W. Monitoring of Pollution of Air Fine Particles (PM2.5) and Study on Their Genetic Toxicity. BIOMEDICAL AND ENVIRONMENTAL SCIENCES 17, 452-458(2004)


79. Seamen N, et al. In Utero Fine Particle Air Pollution and Placental Expression of Genes in the Brain-Derived Neurotrophic Factor Signaling Pathway: An ENVIRONAGE Birth Cohort Study. Environ Health Perspect; DOI:10.1289/ehp.1408549


83. Grevendonk L, et al. Mitochondrial oxidative DNA damage and exposure to particulate air pollution in mother-newborn pairs. Environmental Health 2016, 15:10

84. Hou L, et al. Particulate Air Pollution Exposure and Expression of Viral and Human MicroRNAs in Blood: The Beijing


94. Mao G, et al. Individual and Joint Effects of Early-Life Ambient PM2.5 Exposure and Maternal Prepregnancy Obesity on Childhood Overweight or Obesity. Environ Health Perspect; DOI:10.1289/EHP261


98. Goodson J, et al. In utero exposure to diesel exhaust particulates is associated with an altered cardiac transcriptional


105. Nemmar A, et al. Thrombosis, systemic and cardiac oxidative stress and DNA damage induced by pulmonary


111. Domingues ÉP, et al. Genotoxic effects following exposure to air pollution in street vendors from a high-traffic urban area.


131. Sun X, et al. Prenatal exposure to residential PM$_{2.5}$ and anogenital distance in infants at birth: A


Pollution and Birth Outcomes

Air pollution causes systemic inflammation in the pregnant mother, morphologic changes in the placenta, narrowing blood vessels, and inhibiting blood transfer to the fetus. Pollution nanoparticles can be found embedded in the placenta itself.

Pregnant women exposed to more air pollution have multiple clinical adverse pregnancy outcomes including: higher blood pressure, higher rates of pre-eclampsia, intrauterine growth retardation, decreased gestational age at delivery, miscarriages, still births, higher rates of gestational diabetes, premature birth, premature rupture of membranes (PROM), low birth weight syndrome, neonates with smaller head circumference, and heart and spinal cord birth defects.

Intrauterine inflammation, a significant risk factor for premature birth, is increased with air pollution exposure during pregnancy and even prior to conception.

Hourly increases in air pollution at the beginning of labor is associated with higher rates of premature birth.
Both acute and chronic ozone exposure is related to increased rates of still births, even exposure just in the several days prior to delivery.

Babies born within 3 km of an oil and gas drilling site had a lower birth weight than babies in the same area born before the drilling took place.

Folate supplements can offset the negative impact of air pollution on the success of assisted reproduction.

# References #


7. Suzuki, T., Oshio, S., Iwata, M., et al. In utero exposure to a low concentration of diesel exhaust affects spontaneous locomotor activity and monoaminergic system in m


13. Dadvand P, Rankin J, Rushton S, Pless-Mulloli T. Ambient air pollution and congenital heart disease


16. Lee PC, Talbott EO, Roberts JM, Catov JM, Sharma RK, Ritz B. Particulate Air Pollution Exp

17. Darrow LA, Klein M, Strickland MJ, Mulholland JA, Tolbert PE 2011. Ambient Air Pollution and Birth Weight in Full-Term Infants


case-control study in Los Angeles County, California.


http://dx.doi.org/10.1289/ehp.1003316


http://dx.doi.org/10.1289/ ehp.1204918


2013 Jan 30. Air pollution metric analysis while determining susceptible periods of pregnancy for low birth weight.


72. Stingone J. Maternal Exposure to Criteria Air Pollutants and Congenital Heart Defects in Offspring: Results from the National Birth Defects Prevention Study. Environ Health Perspect; DOI:10.1289/ehp.1307289


77. Stingone J. et al. Maternal Exposure to Criteria Air Pollutants and Congenital Heart Defects in Offspring: Results from the National Birth Defects Prevention Study. Environ Health Perspect; DOI:10.1289/ehp.1307289


80. Holstius DM, Reid CE, Jesdale BM, Morello-Frosch R. Birth weight following pregnancy during the 2003 Southern California


82. Kahn L. et al. Blood Lead Concentration and Thyroid Function during Pregnancy: Results from the Yugoslavia Prospective Study of Environmental Lead Exposure. Environ Health Perspect; DOI:10.1289/ehp.1307669


98. Rich D, et al. Differences in Birth Weight Associated with the 2008 Beijing Olympic Air Pollution Reduction: Results from a Natural Experiment. Environ Health Perspect; DOI:10.1289/ehp.1408795


101. Hao Y, et al. Geographic Variation in the Association between Ambient Fine Particulate Matter (PM2.5) and Term Low Birth Weight in the United States. Environ Health Perspect; DOI:10.1289/ehp.1408798


Monitor Measurements. Environ Health Perspect; DOI:10.1289/ehp.1409651


115. Stieb D, et al. Associations of Pregnancy Outcomes and PM$_{2.5}$ in a National Canadian Study. Environ Health Perspect; DOI:10.1289/ehp.1408995

116. Yongping H, et al. Geographic Variation in the Association between Ambient Fine Particulate Matter (PM$_{2.5}$) and Term Low Birth Weight in the United States. Environ Health Perspect; DOI:10.1289/ehp.1408798


118. Rich D, et al. Differences in Birth Weight Associated with the 2008 Beijing Olympic Air Pollution Reduction: Results from a Natural Experiment. Environ Health Perspect; DOI:10.1289/ehp.1408795

119. Laurent O, et al. A Statewide Nested Case-Control Study of Preterm Birth and Air Pollution by Source and Composition:


142. Janssen BG, et al. Fetal Thyroid Function, Birth Weight, and in Utero Exposure to Fine Particle Air Pollution: A Birth Cohort Study. Environ Health Perspect; DOI:10.1289/EHP508


185. Liu X, et al. Effects of prenatal exposure to air particulate matter on the risk of preterm birth and roles of maternal and cord blood LINE-1 methylation: A birth cohort study in Guangzhou,


195. Jiajianghui Li, Tianjia Guan, Qian Guo, Guannan Geng, Huiyu Wang, Fuyu Guo, Jiwei Li, Tao Xue. Exposure to landscape fire smoke reduced birthweight in low- and middle-income countries: findings from a siblings-matched case-control study. eLife, 2021; 10 DOI: 10.7554/eLife.69298


Pollution and the Lung

* Air pollution permanently inhibits lung growth in children. In fact prenatal exposure can reduce fetal lung development, impairing lung function in childhood and permanently reducing the number of alveoli (air sacs) in the lungs.

* Brief exposure to ozone and particulate matter reduce lung function even in young healthy adults and the reduction can last for a week after the pollution exposure is over.

* Air pollution causes lung cancer.

* Long term ozone exposure causes an increase in overall mortality in addition to that from particulate matter. Most of the mortality is respiratory.

* Long term exposure to even small increases in ozone cause as much emphysematous destruction of lung tissue and function as 29 years of cigarette smoking a pack a day.

* Air pollution causes, complicates, or exacerbates virtually all pulmonary diseases, from mild reactive airways disease to fatal pulmonary fibrosis.

* Air pollution is associated with increased rates of serious lower respiratory infections, and hospitalization and death from most respiratory diseases from neonates to the elderly.
* The correlation between the above health outcomes and ozone are still found at concentrations between one half and one third the current EPA NAAQS.

*Air pollution causes DNA damage and cell death to lung cells.

*Wildfire smoke maybe ten times more toxic to the lung than other sources of particulate pollution.


10. Chong S Kim1*, Neil E Alexis2, Ana G Rappold1, Howard Kehrl1, Milan J Hazucha2, John C Lay2, Mike T Schmitt1, Martin Case1, Robert B Devlin1, David B Peden2, and David Diaz-Sanchez1 Lung Function and Inflammatory Responses in Healthy Young Adults Exposed to 0.06 ppm Ozone for 6.6 Hours. Published ahead of print on January 7, 2011. Am. J. Respir. Crit. Care Med. 2011, doi:10.1164/rccm. 201011-1813OC


and mortality after lung transplantation. Thorax. 2011 Mar 23. [Epub ahead of print]


35. Turner MC, Krewski D, Pope Iii CA, Chen Y, Gapstur SM, Thun MJ. Long-Term Ambient Fine Particulate Matter Air Pollution


54. Gan WQ, Fitzgerald JM, Carlsten C, Sadatsafavi M, Brauer M. Associations of Ambient Air Pollution with Chronic Obstructive
Pulmonary Disease Hospitalization and Mortality. Am J Respir Crit Care Med. 2013 Feb 7. [Epub ahead of print]


78. Jung KH1, Perzanowski M2, Rundle A3, Moors K4, Yan B5, Chillrud SN6, Whyatt R7, Camann D8, Perera FP9, Miller RL10. Polycyclic aromatic hydrocarbon exposure, obesity and


89. Qiu H, Tian LW, Pun VC, Ho KF, Wong TW, Yu IT. Coarse particulate matter associated with increased risk of emergency hospital admissions for pneumonia in Hong Kong. Thorax. 2014


110. Künzi L, et al., Toxicity of aged gasoline exhaust particles to normal and diseased airway epithelia. Scientific Reports, 2015; 5: 11801 DOI: 10.1038/srep11801


126. Mirabelli MC, et al. Outdoor PM2.5, Ambient Air Temperature, and Asthma Symptoms in the Past 14 Days among
Adults with Active Asthma. Environ Health Perspect. 2016 Jul 6. [Epub ahead of print]


128. Strickland M, et al. Pediatric Emergency Visits and Short-Term Changes in PM2.5 Concentrations in the U.S. State of Georgia. Environ Health Perspect; DOI:10.1289/ehp.1509856


144. Malley C, et al. Updated Global Estimates of Respiratory Mortality in Adults ≥30 Years of Age Attributable to Long-Term Ozone Exposure. Environ Health Perspect; DOI:10.1289/EHP1390

145. Doiron D, et al. Residential Air Pollution and Associations with Wheeze and Shortness of Breath in Adults: A Combined
146. de Oliveira Alves N, et al. Biomass burning in the Amazon region causes DNA damage and cell death in human lung cells. Scientific Reports, 2017; 7 (1) DOI: 10.1038/s41598-017-11024-3


167. Lopes dB, et al. Pre- and postnatal exposure of mice to concentrated urban PM2.5 decreases the number of alveoli and leads to altered lung function at an early stage of life. Environ Pollut. 2018 Jun 4;241:511-520. doi: 10.1016/j.envpol.2018.05.055. [Epub ahead of print]


####################################################

####################################################
Air Pollution and Cancer

*Air pollution is associated with higher rates of breast, lung, prostate, cervical, brain, nasal, pharyngeal, esophageal, liver, pancreatic and stomach cancer, and adult and childhood leukemia. Pre-natal pollution exposure is associated with increased rates of multiple childhood cancers.

*World health experts now believe that nearly 30% of lung cancer is due to air pollution

*Air pollution is associated with decreased survival in patients with all types of cancer, especially breast cancer, including those treated for cancer. Air pollution decreases the efficacy of chemotherapy.

*The World Health Organization has declared air pollution the most important environmental cause of cancer, more important that second hand cigarette smoke. The WHO placed it in the same category as asbestos and ionizing radiation


The ESCALE Study (SFCE). Environ Health Perspect 119:566-572. doi:10.1289/ehp.1002429


27. Puett RC, Hart JE, Yanosky JD, Spiegelman D, Wang M, Fisher JA, Hong B, Laden F. Particulate Matter Air Pollution Exposure, Distance to Road, and Incident Lung Cancer in the


44. von Ehrenstein O, et al. In Utero and Early-Life Exposure to Ambient Air Toxics and Childhood Brain Tumors: A Population-Based Case–Control Study in California, USA. Environ Health Perspect; DOI:10.1289/ehp.1408582


52. Wong CM, et al. Cancer Mortality Risks from Long-term Exposure to Ambient Fine Particle. Cancer Epidemiol Biomarkers Prev; Published OnlineFirst April 29, 2016; doi 10.1158/1055-9965.EPI-15-0626


55. von Ehrenstein O, et al. In Utero and Early-Life Exposure to Ambient Air Toxics and Childhood Brain Tumors: A Population-Based Case–Control Study in California, USA Environ Health Perspect; DOI:10.1289/ehp.1408582


60. Gharibvand L, et al. The Association between Ambient Fine Particulate Air Pollution and Lung Cancer Incidence: Results from
the AHSMOG-2 Study. Environ Health Perspect; DOI:10.1289/EHP124


digestive system in towns lying in the vicinity of metal production and processing installations. Sci Total Environ 2010;408:3102–12.


73. Delgado J, et al. Lung Cancer Pathogenesis Associated With Wood Smoke Exposure


75. Ljubimova, JY, et al. Coarse particulate matter (PM2.5–10) in Los Angeles Basin air induces expression of inflammation and cancer biomarkers in rat brains. Scientific Reports, 2018; 8 (1) DOI: 10.1038/s41598-018-23885-3


96. Ou JY, Kirchhoff AC, Hanson HA. Air Pollution across the Cancer Continuum: Extending Our Understanding of the Relationship between Environmental Exposures and Cancer.


Air Pollution and Metabolic and Kidney Disorders

* More exposure to air pollution, even short term, decreases insulin sensitivity, glucose tolerance, increases rates of Type I and Type II diabetes, and promotes obesity and metabolic syndrome.

* Prenatal exposure has a particularly strong association with childhood obesity.
Lipid metabolism is impaired, good cholesterol (HDL) is decreased, and bad cholesterol (LDL) is increased with more air pollution.

Air pollution impairs thyroid function in pregnant mothers, thyroid development in the fetus, and thyroid function newborns. Impaired thyroid function is a likely mechanism for air pollution causing low birth weight and can impair fetal brain development.

Diesel exhaust impairs liver function.

Early evidence shows air pollution impairs kidney function.


24. Wang Y, Eliot MN, Kuchel GA, Schwartz J, Coull BA, Mittleman MA, Lipsitz LA, Wellenius GA. Long-Term Exposure to Ambient Air Pollution and Serum Leptin in Older Adults: Results


32. Malmqvist E. Maternal exposure to air pollution and type 1 diabetes - Accounting for genetic factors. Environ Res. 2015 Apr 13;140:268-274. doi: 10.1016/j.envres.2015.03.024. [Epub ahead of print]


37. Wei Y, et al. Chronic exposure to air pollution particles increases the risk of obesity and metabolic syndrome: findings


56. Lucht SA, et al. Air Pollution and Glucose Metabolism: An Analysis in Non-Diabetic Participants of the Heinz Nixdorf Recall


76. Bing Guo, Yuming Guo, Quocuo Nima, Yuemei Feng, Ziyun Wang, Rong Lu, Baimayangji, Yue Ma, Junmin Zhou, Huan Xu, Lin Chen, Gongbo Chen, Shanshan Li, Huan Tong, Xianbin Ding, Xing Zhao. Exposure to air pollution is associated with an increased risk of metabolic dysfunction-associated fatty liver disease. Journal of Hepatology, 2021; DOI: 10.1016/j.jhep.2021.10.016


###############################
###
###
Miscellaneous Health Consequences

* Immune suppression, inflammatory bowel disease, bacterial and viral infections, lupus, juvenile arthritis, sleep apnea, and obesity are elevated in populations exposed to more air pollution.

*The severity, lethality, and transmissibility of COVID is increased by particulate air pollution.

*Air pollution can induce liver toxicity, accelerate liver inflammation and steatosis.

*Air pollution causes systemic oxidative stress, triggers the inflammatory chemical cascade, endothelial cell death, cytotoxicity, macrophage infiltration, and increases lipid deposition. Particulate matter penetrates intracellular structures. Air filtration leads to increased protein synthesis and enhanced mitochondrial efficiency, resulting in significant triggering of ATP synthesis and a reduction in oxidative damage.

*Air pollution accelerates the aging process.

*Air pollution increases infant mortality and SIDS.

* Wood smoke is uniquely toxic, the most toxic type of air pollution that most people are ever exposed to. Wildfire smoke causes dramatic increases community death rates.

*Osteoporosis is associated with air pollution.
*Pollution exposure in utero or in infancy increases the likelihood of osteoarthritis and rheumatoid arthritis decades later in adulthood.

*Lead exposure (common in urban air pollution) is associated with significant increased adult mortality primarily related to cardiovascular disease.

*Air pollution damages the skin and corneas.

############################################################


25. Kloog I, Coull B, Zanobetti A, Koutrakis P, Schwartz J. Acute and Chronic Effects of Particles on Hospital Admissions in

27. Lim YH, Kim H, Kim JH, Bae S, Park HY, Hong YC. Air Pollution and Depressive Symptoms in Elderly Adults. Environ Health Perspect. 2012 Apr 18. [Epub ahead of print]


Ozone Reduction in the United States. Environ Health Perspect http://dx.doi.org/10.1289/ehp.1104851


33. Tong, H, AG Rappold, D Diaz-Sanchez, SE Steck, J Berntsen, WE Cascio, et al. 2012. Omega-3 fatty acid supplementation appears to attenuate particulate air pollution induced cardiac effects and lipid changes in healthy middle-aged adults. Environmental Health Perspective http://dx.doi.org/10.1289/ehp.1104472.


43. Cupr P, Flegrová Z, Franců J, Landlová L, Klánová J. Mineralogical, chemical and toxicological characterization of


47. Lue S, Wellenius G, Wilker E, Mostofsky E, Mittleman M. Residential proximity to major roadways and renal function. J Epidemiol Community Health Published Online First: 13 May 2013 doi:10.1136/jech-2012-202307


55. Ortiz L, Nakamura B, Li X, Blumberg B, Luderer U. In Utero Exposure to Benzo[a]pyrene Increases Adiposity and Causes Hepatic Steatosis in Female Mice, and Glutathione Deficiency Is

57. Eum K, Weisskopf M, Nie L, Hu H, Korrick S. Cumulative Lead Exposure and Age at Menopause in the Nurses’ Health Study Cohort. Environ Health Perspect; DOI: 10.1289/ehp.1206399


84. Lanki T, et al. Air Pollution from Road Traffic and Systemic Inflammation in Adults: A Cross-Sectional Analysis in the European ESCAPE Project. Environ Health Perspect; DOI:10.1289/ehp.1408224


93. Burchiel SW, et al. Changes in HPBMC markers of immune function following controlled short-term inhalation exposures of


100. Dėdelė A, et al. Seasonal variation of indoor and outdoor air quality of nitrogen dioxide in homes with gas and electric


122. Blount, R, et al. Traffic-Related Air Pollution and All-Cause Mortality during Tuberculosis Treatment in California. Environ Health Perspect; DOI:10.1289/EHP1699


133. Li D, et al. Association between short-term exposure to ambient air pollution and daily mortality: a time-series study in


139. Yitshak-Sade M, et al. The association between short and long-term exposure to PM2.5 and temperature and hospital admissions in New England and the synergistic effect of the


159. De Marco A et al. Impacts of air pollution on human and ecosystem health, and implications for the National Emission


195. https://projects.iq.harvard.edu/covid-pm


212. Yazdi MD, et al. Long-Term Association of Air Pollution and Hospital Admissions Among Medicare Participants Using a Doubly Robust Additive Model. Circulation, 2021; DOI: 10.1161/CIRCULATIONAHA.120.050252


225. Moradi M, Hadei M, Yazdani M, Goudarzi M, Baboli Z, Tahmasebi Birgani Y, Neisi A, Goudarzi G. Effect of long-term exposure to PM2.5 on years of life lost in a populated Middle


231. Heo S, Kim H, Kim S, Choe SA, Byun G, Lee JT, Bell ML. Associations between Long-Term Air Pollution Exposure and Risk of Osteoporosis-Related Fracture in a Nationwide Cohort Study


