# The Near-Roadway Health Impacts of Particulate Matter

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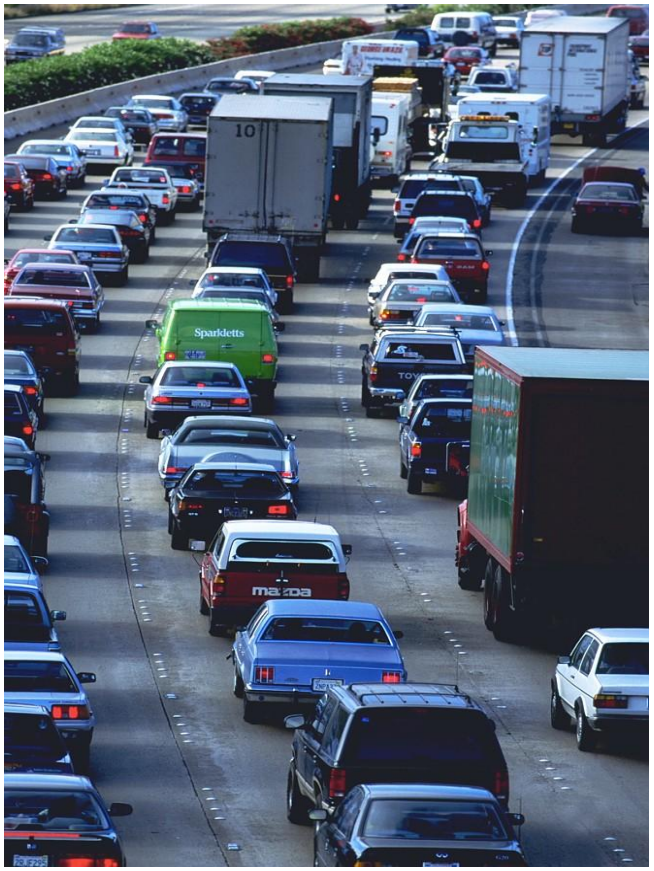
California Air Resources Board
California Environmental Protection Agency

# Overview

- Who is at risk?
- What health effects have been seen?
- Which components of traffic are important?
- How have regulations had an impact on health and exposure?
- What research is ARB conducting on mitigations?



# Background

- PM2.5 is a known health hazard
  - Mortality[1]
  - Cardiovascular effects[2]
  - Respiratory effects[1]
- Traffic pollution is an active area of investigation
  - Linked to health effects
  - Some research on the toxicity of components
  - Diesel is a known health concern

1. U.S., E. P. A. (2009). "Integrated Science Assessment for Particulate Matter (Final Report)." U.S. Environmental Protection Agency **600**(R-08): 139F
2. Brook et al 2010 Particulate matter air pollution and cardiovascular disease and update to the scientific statement from the American Heart Association Circulation 121:2331-2378

# Who is at Risk?

- 40% of Californians live near high volume roads[1]
- Infants and Children
  - Schools
    - About 10% of California schools are located near a major roadway[2]
  - Daycare
- Elderly
- Workers near/on roadways
- Commuters
  - Commute can result in the highest contribution to your total exposure[3]
- Lower Socioeconomic Groups
  - High traffic areas have a larger percentage of low income and minority groups[1]


1. Rowangould A census of the US near-roadway population: Public health and environmental justice considerations Trans Res Part D 2013 25:59-67
2. Green, R.S., et al. Proximity of California public schools to busy roads. Environ Health Perspect 2004; 112: 1.
3. Fruin et al Black carbon concentrations in California vehicles and estimation of in-vehicle diesel exhaust particulate matter exposures

# Birth Outcomes

- Spontaneous abortions associated with living 50m from heavy trafficked roads in African American women[1]
- Low birth weight was associated with
  - Traffic pollution in the San Joaquin Valley[2]
- Increased risk for autism was seen in children born to mothers that lived near a freeway at the time of delivery[3]


1. Green et al 2009 Residential exposure to traffic and spontaneous abortion Envir Health Perspect 117(12): 1939-1944
2. Padula et al 2012 Exposure to traffic-related air pollution during pregnancy and term low birth weight: Estimation of causal associations in a semiparametric model Am J Epidiol 176(9):815-824
3. Volk et al 2011 Residential proximity to freeways and autism in the CHARGE study Environ Health Perspect 119(6):873-877

# Children

- Asthma exacerbation[1]
- Increased symptoms in asthmatics
  - East Bay Children's Respiratory Health Study[2]
  - Southern California Children's Health Study[3,4]
- Reduced lung function[5]
  - Both regional particulate matter pollution and local near roadway exposures have independent impacts[6]
- Increased body mass index[7]


1. Traffic-related air pollution: a critical review of the literature on emissions, exposure, and heal effects HEI Special Report 17 2010
2. Kim et al 2008 Residential traffic and children's respiratory health, Envir Health Perspect 116(9):1274-1279
3. Gauderman WJ, et al. Childhood asthma and exposure to traffic and nitrogen dioxide 2005 Epidemiology, 16:737-743
4. McConnell R, et al. Traffic, susceptibility, and childhood asthma 2006 Environ Health Perspect. 114(5):766-72 (2006)
5. Gauderman et al. 2007 Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study 369:571-577
6. Urman et al. 2014 Associations of children's lung function with ambient air pollution: joint effects of regional and near-roadway pollutants Thorax 69(6):540-547
7. Jerrett et al 2010 Automobile traffic around the home and attained body mass index: A longitudinal cohort study of children aged 10-18 Pev Med 50(0):S50-S58

# Adults

- Cardiovascular mortality and morbidity[1]
  - Ischemic heart disease causes, especially in women[2]
- Exacerbation of asthma in adults[1]
- Progression of atherosclerosis[3]
- Lung cancer mortality[4]


1. Traffic-related air pollution: a critical review of the literature on emissions, exposure, and health effects HEI Special Report 17 2010
2. Hart et al 2013 Changes in traffic exposure and the risk of incident myocardial infarction and all-cause mortality
3. Kunzli et al 2010 Ambient air pollution and the progression of atherosclerosis in adults Plos One 5(2)1-10
4. Jerrett et al 2009 Spatial analysis of air pollution and mortality in Los Angeles Epidemiology 16(8):727-736

# Pollutants as Markers and Noise Effects

- CO
  - Traffic pollution exposures associated with preterm birth in Los Angeles[1]
- $NO_2$ /NOx
  - Reduced fetal growth[2]
  - Increased risk of autism[3]
  - Increase in some childhood cancers with prenatal exposures[4]
  - Increased development of asthma[5]
  - Increased risk for cardiovascular mortality[6]
  - Increase the risk of type 2 diabetes in African American women[7]
- Noise may also have an effect
  - Noise and other neighborhood problems are associated with reduced physical abilities in older adults[8]
  - Effects of noise from traffic are difficult to separate from effects of traffic pollution


1. Ritz et al 2007 Ambient air pollution and preterm birth in the environment and pregnancy outcomes study at the University of California, Los Angeles Am J Epidemiol 166:1045-1052
2. Ritz et al 2014 Prenatal air pollution exposures and ultrasound measures of fetal growth in Los Angeles, California Envir Res 130:7-13
3. Volk et al 2013 Traffic related air pollution, particulate matter , and autism JAMA Psychiatry 70(1):71-77
4. Ghosh et al. 2013 Prenatal exposure to traffic-related air pollution and risk of early childhood cancers am J Epi 178(8):1233-1239
5. McConnell et al. 2010 Childhood incident asthma and traffic-related air pollution at home and school 118(7):1021-1026
6. Jerrett et al2013 Spatial analysis of air pollution and mortality in California Am J Resp Crit Care Med 188(5):593-599
7. Coogan et al 2012 Air pollution and incidence of hypertension and diabetes in African American women living in Los Angeles Circul 125(6):767-772
8. Balfour et al 2002 Neighborhood environment and loss of physical function in older adults: Evidence from the Alameda County Study Am J Epidemiol 155(6): 507-515

# Which Components of Traffic are Important?

- Few studies on components of traffic
- Diesel Particulate Matter
  - Diesel engine exhaust recently classified as carcinogenic[1]
- Toxics
  - Low birth weight with benzene, toluene, ethyl benzene and xylene[2]
- Organic carbon
  - Increased blood pressure in the elderly[3]
- Tire and brake wear
  - Metals in dust may induce oxidative stress[4,5]
- Ultrafine PM
  - May play a major role in toxicity: results are not confirmed[6,7]
  - Mortality for ischemic heart disease in post menopausal women using a model of ultrafine components[8]


1. 2012 Carcinogenicity of diesel-engine and gasoline-engine exhausts and some nitroarenes the lancet oncologyhttp://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf
2. Ghosh et al 2012 Assessing the influence of traffic-related air pollution on risk of term low birth weight on the basis of land-use –regression models and measures of air toxics
3. Delfino et al 2010 Traffic-related air pollution and blood pressure in elderly subjects with coronary artery disease Epidemiol 21(3):
4. Cassee et al 2013 Particulate matter beyond mass: recent health evidence on the role of fractions, chemical constituents and sources on emission Inhal Toxicol 25(14):802-812
5. Grogoratos and Martini 2015 Brake wear particle emissions: a review Environ Sci Pollut Res 22:2491-2504
6. Delfino et al 2005 Potential role of ultrafine particles in association between airborne particle mass and cardiovascular health Environ Health Perspect 113(8): 934-946
7. Sioutas et al 2005 Exposure assessment for atmospheric ultrafine particles (UFPs) and implications in epidemiologic research Environ Health Perspect 113(8): 947-955
8. Ostro et al. 2015 Associations of mortality with long-term exposures to fine and ultrafine particles, species and sources: Results from the California Teachers Study Cohort Envir Health Perspect advanced publication

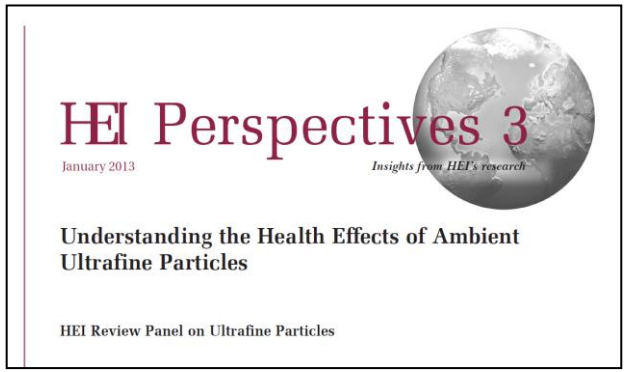
# Ultrafine PM

- Linked to respiratory, cardiovascular effects[1]
- Reasons for our concern
  - Inhalation of ultrafine particles leads to deposition on the lung surface[2]
  - Surface effects of ultrafine particles may be important in deposition[3]
  - Particles can enter the blood stream, can be translocated to the liver[4]
  - Particles can enter nervous system by nasal deposition, translocated to the brain through the olfactory nerve[5]


1. Kumar et al 2013 Ultrafine particles in urban ambient air and their health perspective Rev Environ Health 28(2-3):117-128
2. Peters et al 2006 Translocation and potential neurological effects of fine and ultrafine particles a critical update Particle and Fibre Tox 3:13
3. Geiser et al 2003 Influence of surface chemistry and topography of particles on their immersion into the lung's surface –lining layer J Appl Physiol 94:1793-1801
4. Oberdoster et al 2002 Extrapulmonary translocation of ultrafine carbon particles following whole-body inhalation exposure of rats J Toxicol Envion Health 65:1531-1543
5. Oberdorster et al 2004 Translocation of inhaled ultrafine particles to the brain Inhal Toxicol 16:437-445

# Ultrafine PM

"..the considerable body of research that has been conducted has not provided a definitive answer to this question."




**U.S.EPA Integrated Science Assessment for Particulate Matter (2009)**
Data on health effects and air quality data insufficient for a separate standard for ultrafine particles

**U.S.EPA Ultrafine Particle Workshop (2015)**
Reviewed the latest findings for ultrafine exposure and impacts

**ARB funded research**
Association of long-term UFP exposure and premature death

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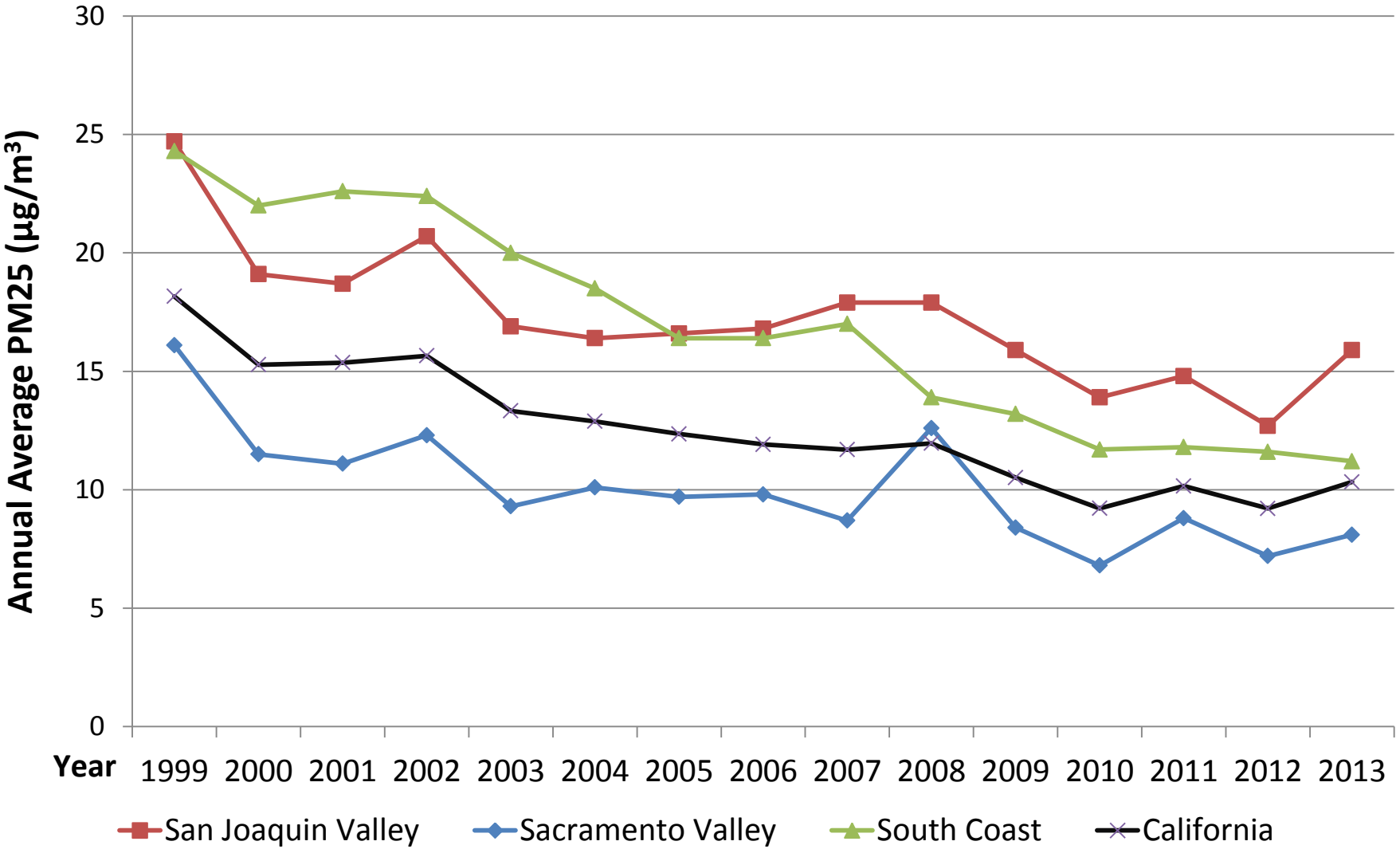
# ARB Regulations to Reduce Emissions

- Many of the ARB's regulations are targeted to reduce traffic pollution, including PM2.5, NOx and UFPM
- ARB Programs to Reduce Sources of Emissions
  - Diesel Risk Reduction Plan
  - Sustainable Freight Transport Initiative
  - Climate Change Regulations

# Annual Ambient PM2.5 Concentration Trends in California



# Health Impacts from Improved Air Quality

- Children showed increased lung function growth when relocated to areas with lower pollution[1]
- Significant improvements in lung function growth of children in the Los Angeles air basin where air quality has improved[2]
- Cardiovascular health improved in the elderly in the San Joaquin Valley air basin and reductions in particulate matter were seen from wood-burning regulations[3]


1. Avol et al 2001 Respiratory effects of relocating to areas of differing air pollution levels Am J Respir Crit Care Med 164:2067-2072
2. Gauderman et al 2015 Association of improved air quality with lung development in children N Eng J Med 372:905-913
3. Yap et al 2015 Effectiveness of residential wood-burning regulations on decreasing particulate matter levels and hospitalizations in the San Joaquin Valley Air Basin Am J Public Health 105(4):772-778

# Potential Mitigation Measures

- Air quality is improving, but some areas may have higher exposures
- ARB's research on possible mitigation measures to reduce traffic exposures
  - Soundwalls and Vegetation
    - Soundwall increased the levels of ultrafines in areas further from the sound wall[1]
    - Benefits of vegetation barriers have been variable and may be due to the density of the barrier[2]
    - Current study will examine the impacts of sound walls and vegetation
  - Studies on Urban Design
    - Light Rail, Complete Streets, Transit Stops
  - In Home Filtration
  - In Cabin Filtration for Motor Vehicles

1. Sioutas 2011 Fine-scale spatial and temporal variability of particle number concentrations within communities and in the vicinity of freeway sound walls ARB final report
2. Hagler et al 2012 Field investigation of roadside vegetative and structural barrier impact on near-road ultrafine particle concentrations under a variety of wind conditions Sci of the Total Envir 419:7-15

# Conclusions

- Health impacts from traffic exposures well established
- Ultrafine PM health impacts unclear
- PM/Ultrafine significantly reduced by ARB regulations
  - public health improvements have been seen
- Current ARB research will provide information help to further reduce exposures

http://www.arb.ca.gov/homepage.htm