

HEALTH EFFECTS OF DIESEL EXHAUST

– RECENT FINDINGS

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ACCREDITATION & DISCLOSURES

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WHAT IS A PEDIATRIC ENVIRONMENTAL HEALTH SPECIALTY UNIT (PEHSU)?

- ▶ Grant funded
- ▶ Provide an independent source of information and education to professionals and community members
- ▶ Regarding effects of environmental exposures of all kinds on children and women of child-bearing age
- ▶ Housed for the Southeast US (Federal Region 4) at Emory since the program's inception in 2000

OUTLINE

- ▶ 1. Basic physiology concepts
 - ▶ 2. Why children are more vulnerable
 - ▶ 3. Review of diesel emissions
 - ▶ 4. New findings in health effects of diesel emissions
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Toxicity of Chemicals



**“The dose makes
the poison” –
Paracelsus, c. 1538**



**Exposure is
required to cause
toxicity**

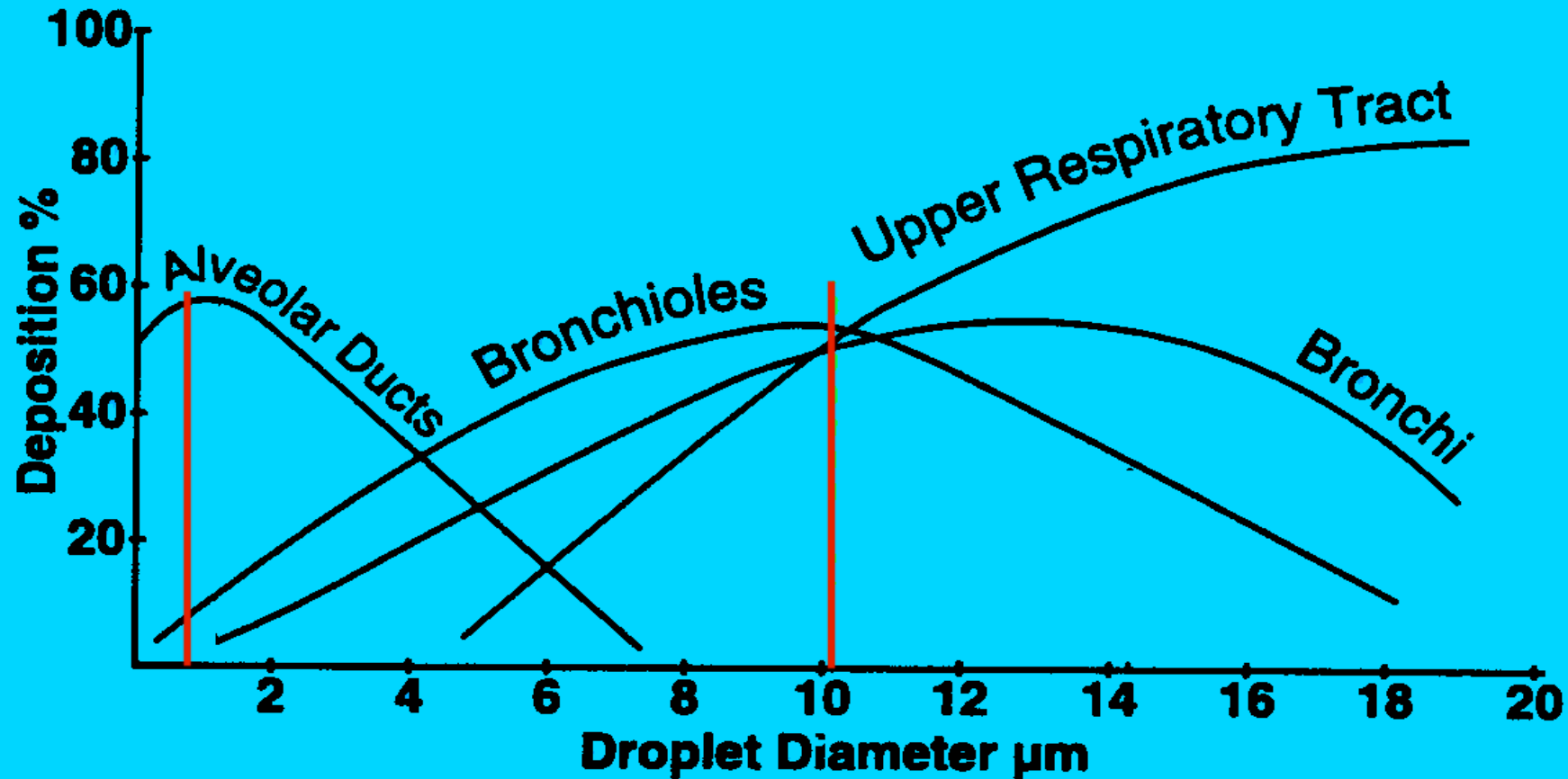


Exposure routes:
Inhalation
Skin Contact
Ingestion
Injection

BASIC PHYSIOLOGY


- ▶ Health effects require exposure
 - ▶ Exposure requires contact with the target tissues
 - ▶ By inhalation, particle size matters
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PARTICLE SIZE INFLUENCES BIOAVAILABILITY




Droplet Size and Penetration of Respiratory Passages


WHY CHILDREN ARE MORE VULNERABLE

- ▶ Still developing and maturing physically
 - ▶ Larger minute ventilation
 - ▶ Higher respiratory rate supports faster growth & metabolism
 - ▶ Inability to recognize hazards
 - ▶ Larger body surface area to weight ratio
 - ▶ Infant 4 kg, 0.7 m² (5.7:1)
 - ▶ Adult 70 kg, 1.73 m² (40.5:1)
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DIESEL EMISSIONS


- ▶ Larger particles (> 2.5 microns)
 - ▶ Small particles (PM_{2.5})
 - ▶ Fine particles (1-2.5 microns)
 - ▶ Ultrafine particles (<0.1 micron)
 - ▶ NO_x
 - ▶ CO₂
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DIESEL EMISSIONS

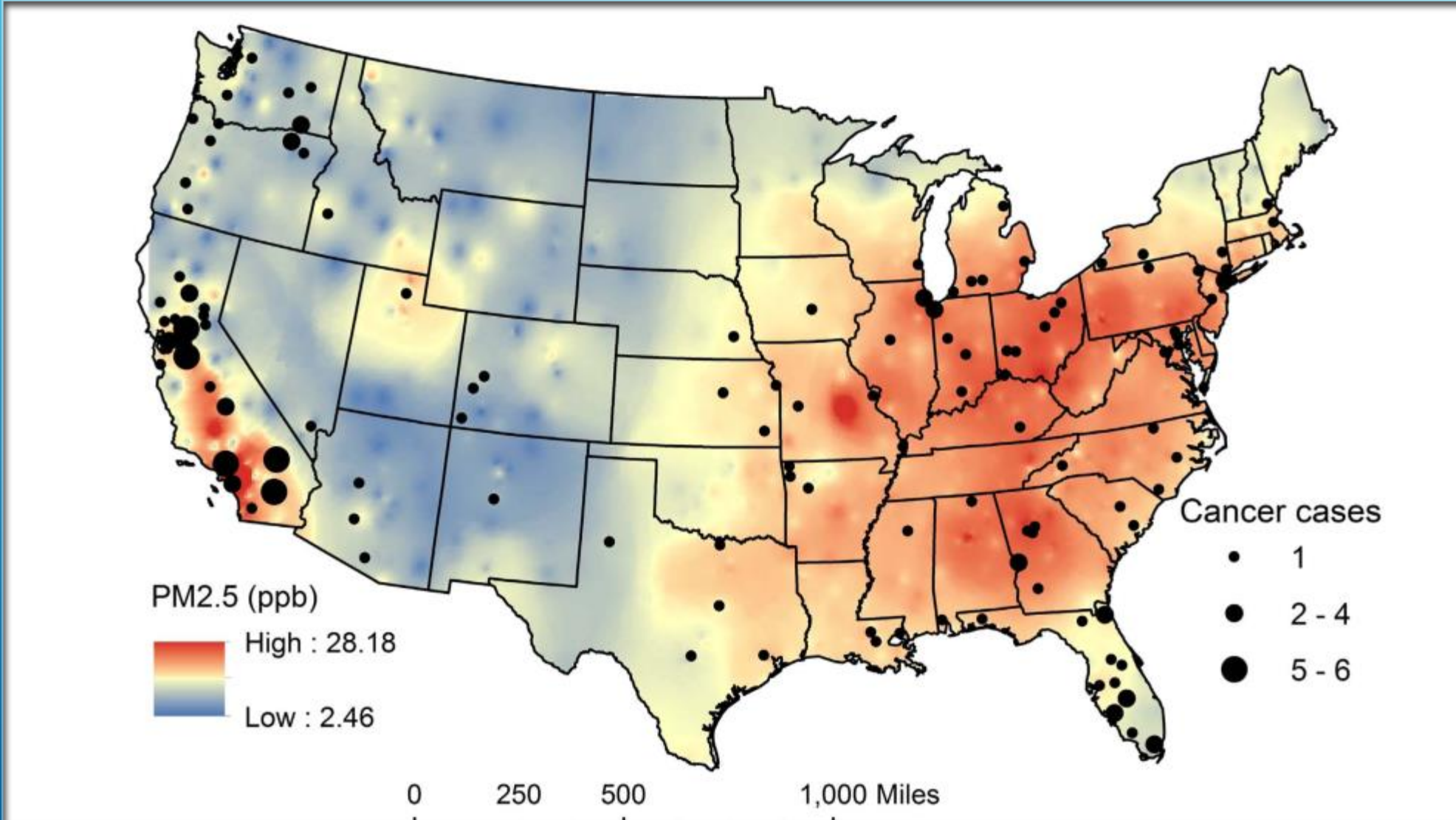
- ▶ Vary somewhat with type of fuel
 - ▶ Biodiesel vs. petroleum diesel
 - ▶ Uncertainty about different health effects
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HEALTH EFFECTS GENERALLY RECOGNIZED

- ▶ According to World Health Organization, >7 million premature deaths worldwide are linked to air pollution
 - ▶ This makes air pollution the largest environmental health risk worldwide

 - ▶ Oxidative stress and related tissue damage
 - ▶ Cardiac inflammation/ ischemia
 - ▶ Neuro inflammation
 - ▶ Increased risk of some cancers
 - ▶ Hematologic, visual, renal diseases
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Adenocarcinoma of the lung attributable to ambient PM2.5



Reis H et al. Diesel exhaust exposure, its multi-system effects, and the effect of new technology diesel exhaust. *Environment International* 2018; 114:257

RISK PERCEPTION

Risk Perception Factors

Acceptable

Risks perceived as:

- ✓ Voluntary
- ✓ Under an individual's control
- ✓ Have clear benefits
- ✓ Distributed fairly
- ✓ Natural
- ✓ Statistical
- ✓ Generated by a trusted source
- ✓ Familiar
- ✓ Affect adults


Unacceptable

Risks perceived as:

- ✓ Being imposed
- ✓ Controlled by others
- ✓ Having little benefit
- ✓ Unfairly distributed
- ✓ Manmade
- ✓ Catastrophic
- ✓ Generated by an untrusted source
- ✓ Exotic
- ✓ Affect children

Accendo Reliability. "Mathematical Models, Algorithms, and Risk Management Methodologies"

NEW HEALTH ISSUES

- ▶ 1. Increased risk of childhood asthma with increased exposure
 - ▶ 2. Increased risk of autism spectrum disorder with increased exposure
 - ▶ 3. Transgenerational effects
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DOES TRAP CAUSE CHILDHOOD ASTHMA?

- ▶ Meta-analysis of 41 studies
- ▶ $PM_{2.5}$, PM_{10} , NO_2 , black carbon all statistically significantly associated with risk of development of childhood asthma
- ▶ Khreis H et al. *Exposure to traffic related air pollution and risk of development of childhood asthma: A systematic review and meta-analysis.* *Environment International* 2017; 100:1-31

TRAP AND CHILDHOOD ASTHMA

- ▶ Childhood asthma due to traffic related air pollution (TRAP) estimated at 18-36% of new cases
- ▶ $PM_{2.5}$ accounted for 26 – 33% of new cases in 2010
- ▶ If $PM_{2.5}$ were reduced from 9 to 0.55 $\mu\text{g}/\text{m}^3$, likely to reduce new cases of childhood asthma by 22%
- ▶ *Alotaibi R et al, Traffic related air pollution and the burden of childhood asthma in the contiguous United States in 2000 and 2010. Environment International 2019; 127:858-867*

AUTISM SPECTRUM DISORDER AND AIR POLLUTION

- ▶ Maternal exposure to air pollution studied in cohort of 116,430 US female nurses
- ▶ PM_{2.5} exposure during pregnancy associated with ASD
- ▶ Exposure during the third trimester was most strongly associated with ASD
 - ▶ OR 1.42 per interquartile range for third trimester

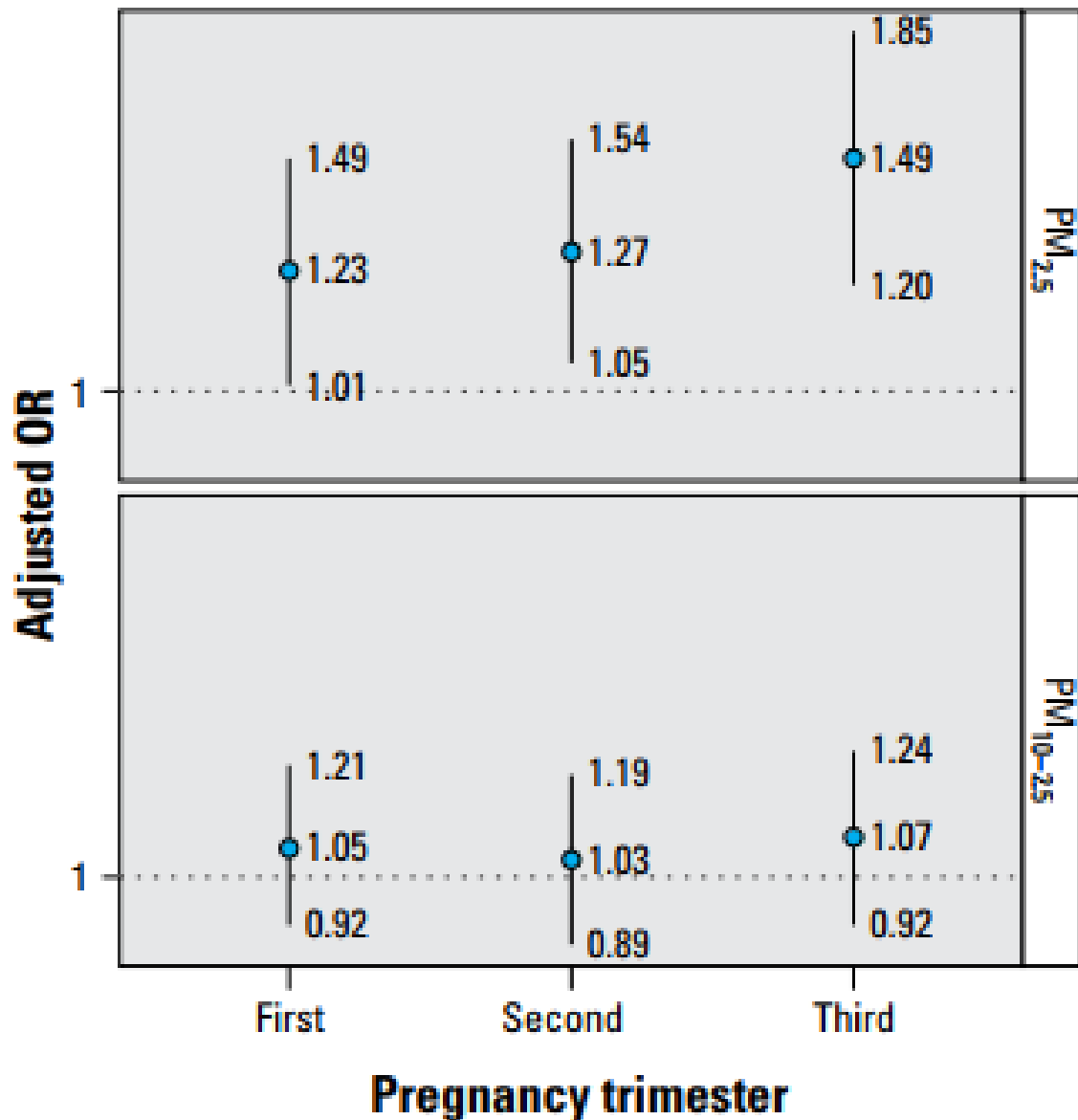


Figure 2. ORs for ASD with exposure to particulate matter during pregnancy trimesters. ORs are adjusted for child sex, year of birth, month of birth, maternal age at birth, paternal age at birth, and census income. The analyses are limited to nonmovers only (i.e., those for whom prepregnancy and postpregnancy addresses were the same). Cases, $n = 160$, controls $n = 986$.

ULTRAFINE PARTICLE AIR POLLUTION AND AUTISM SPECTRUM DISORDER

- ▶ UFP causes inflammation and oxidative stress in the developing brain
- ▶ Confirmed in both animal models and epidemiologically in humans
- ▶ Third trimester a particularly vulnerable period to neurodevelopmental toxicity of UFP
- ▶ *Allen JL et al. Developmental Neurotoxicity of Inhaled Ambient Ultrafine Particle Air Pollution. Neurotoxicology 2017; 59:140-154.*


PRENATAL EXPOSURE TO AIR POLLUTION AND ASD

- ▶ Cohort of almost all births in Vancouver, BC, 2004-2009
- ▶ Of eligible 132,256 births, data available for 129,436; 1276 children diagnosed with ASD
- ▶ Monthly mean exposures to $PM_{2.5}$, NO, and NO_2 at maternal residence during pregnancy compared to risk of ASD in births by multivariate logistic regression
- ▶ Association statistically significant for exposure to NO but not $PM_{2.5}$ or NO_2
- ▶ Pagalan L et al. Association of Prenatal Exposure to Air Pollution with Autism Spectrum Disorder. *JAMA Pediatrics* 2019; 173:86-92.


TRAP AND DEVELOPMENTAL NEUROTOXICITY

- ▶ Associations between TRAP and ASD in multiple studies
- ▶ Children with ASD have higher levels of neuroinflammation and systemic inflammation, hallmarks of TRAP
- ▶ Likely that some children are more susceptible to these effects than others
- ▶ *Costa LG, Chang Y-C, Cole TB, Developmental neurotoxicity of traffic related air pollution: focus on autism. Curr Environ Health Rep 2017; 4:156-165*

CONCLUSIONS

- ▶ Diesel exhaust is a large and important component of TRAP
 - ▶ TRAP seems to be involved in the currently increased burden of childhood asthma
 - ▶ TRAP is implicated by many but not all studies in the currently increasing burden of Autism Spectrum Disorder
 - ▶ Further study is needed
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CONCLUSIONS

- ▶ There is no data suggesting benefits from TRAP increases
 - ▶ There is extensive data suggesting adverse health impacts from TRAP
 - ▶ Therefore, it is prudent and important to make every effort to reduce TRAP
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Questions?

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