



Million Hearts 2022:

Understanding the Links between Environmental Pollutant Exposure and Cardiovascular and Cerebrovascular Events

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- ***No conflicts of interest***
- ***The presentation represents the opinions of the speaker and does not necessarily represent the policies of the US EPA***



Air Pollution: A Leading Cause of the Global Burden of Disease

In 2015 ambient PM_{2.5} ranked fifth as a risk factor for global mortality -

Exposure to PM_{2.5} caused:

- 4.2 million deaths
- 103.1 million disability-adjusted life-years (DALYs)

Between 1990-2015 deaths increased in association with PM_{2.5} from:

- 3.5 million to 4.2 million

Ozone exposure contributed to morbidity and mortality -

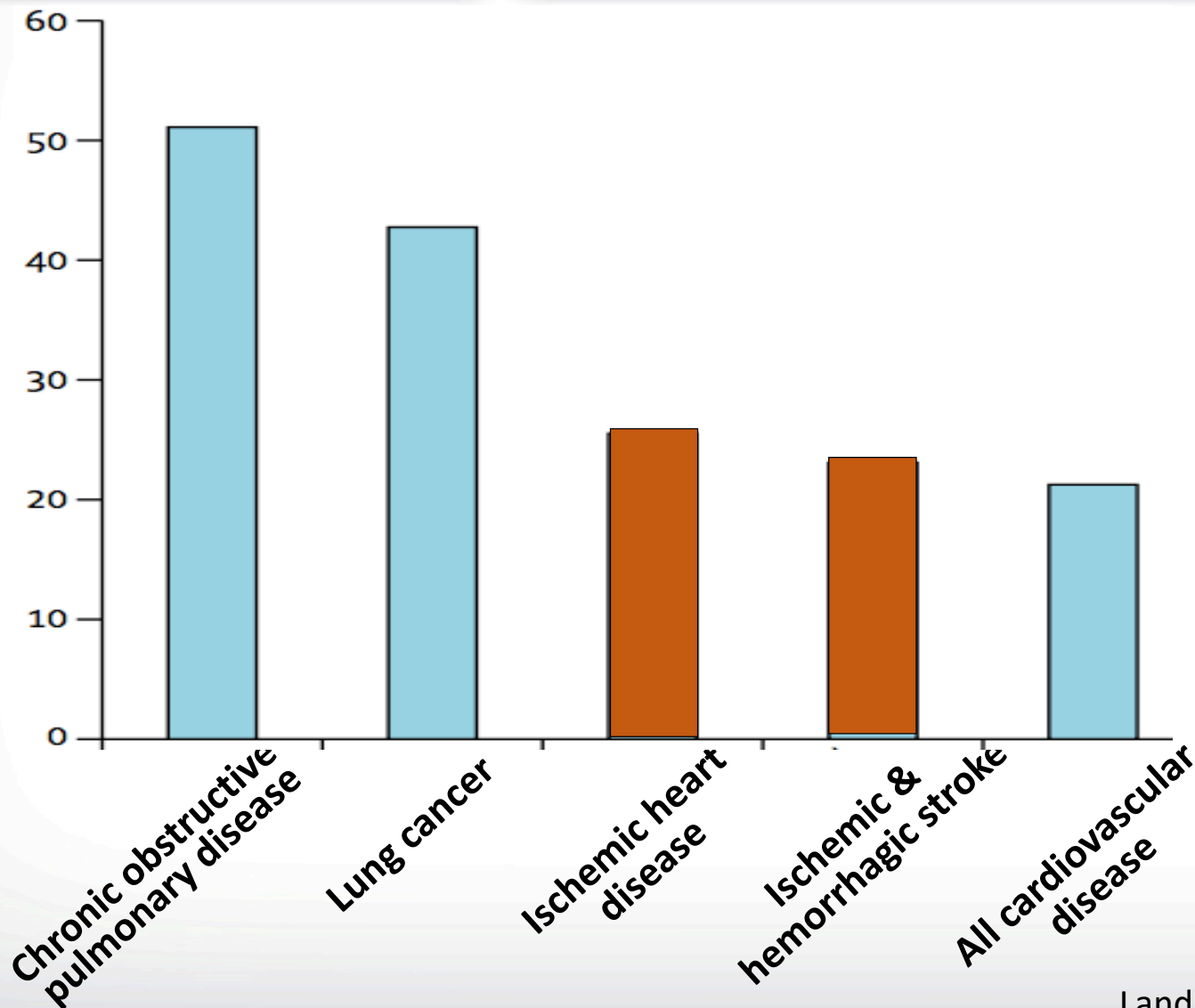
In 2015 ozone exposure is estimated to have accounted for:

- 254,000 deaths
- 4.1 million DALYs from chronic obstructive pulmonary disease



Estimated Contribution of All Pollution to Deaths Caused by Non-Communicable Diseases, 2015

Estimated contribution of all pollution risk factors to deaths caused by non-communicable disease (%)



All pollution contributes to:

- over 20% of ischemic heart disease
- over 20% of ischemic and hemorrhagic stroke
- 20% of all cardiovascular disease

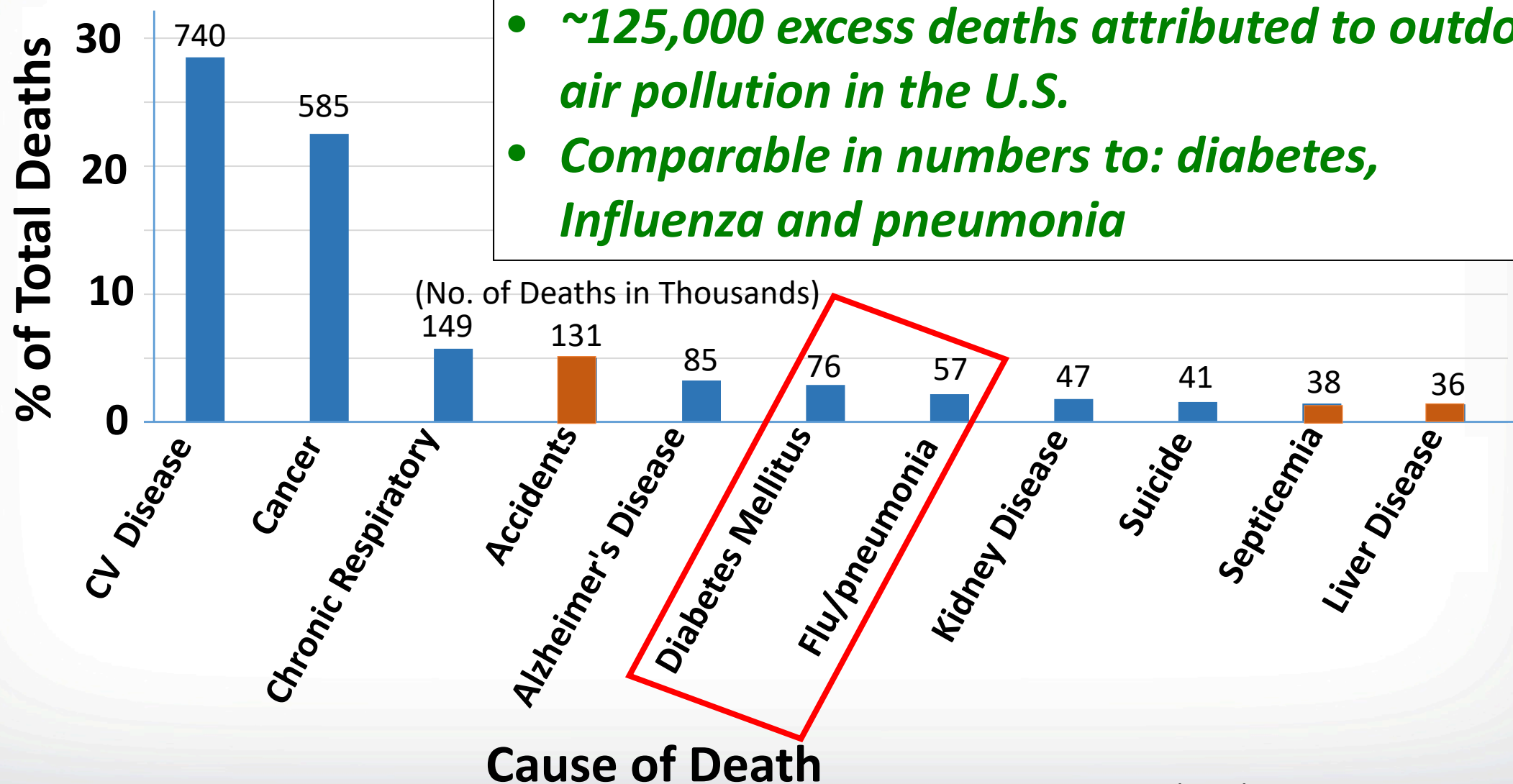


Despite Progress in the U.S. Air Pollution Continues to Impact Population Health

Air Pollution Remains a Significant U.S. Public Health Concern

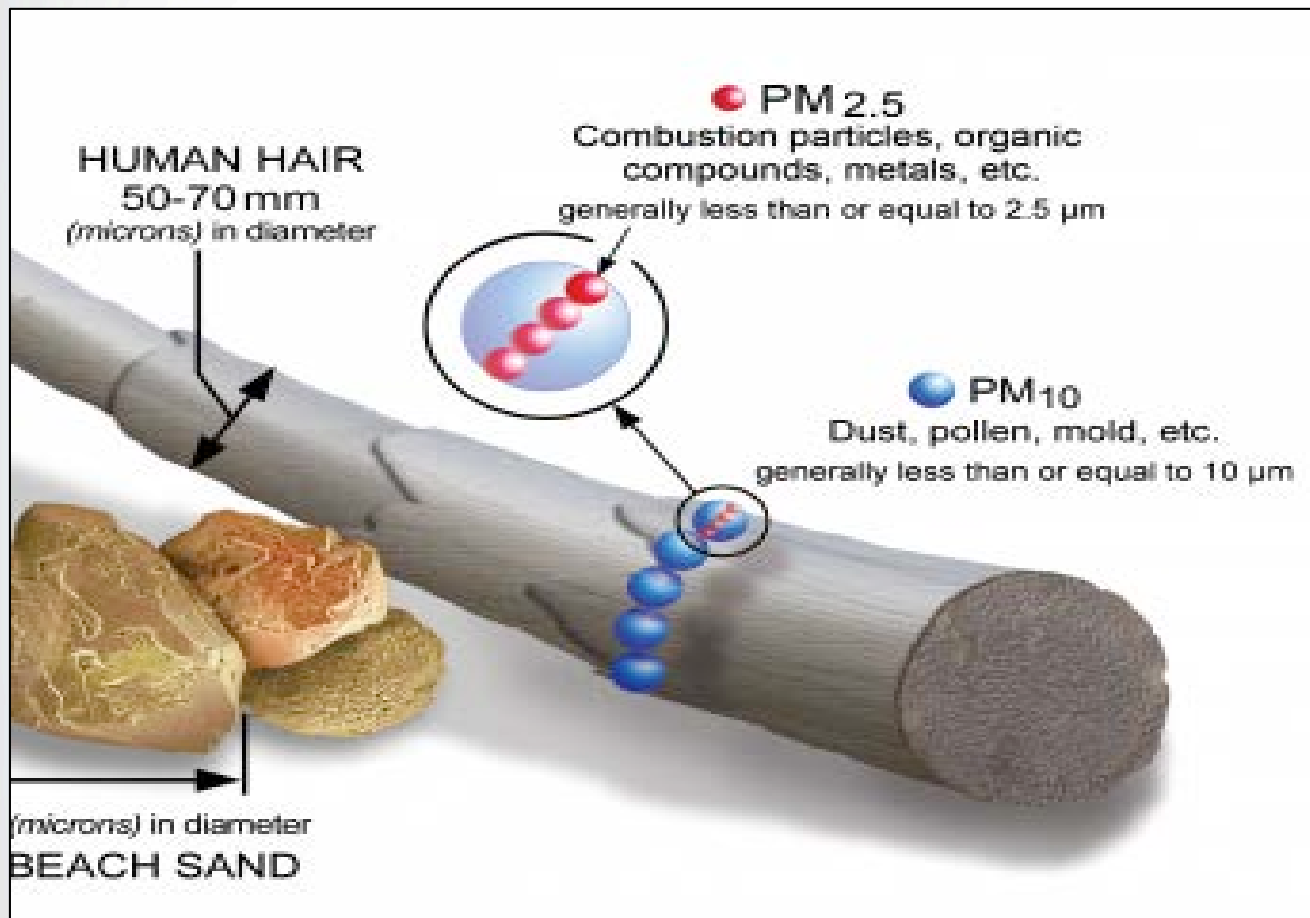
- Estimated excess mortality **125,000 deaths/year**
- Over **20 million school days and work days lost**
- Over **1 million life-years lost**
- **122.5 million people living in counties with one or more pollutants exceeding the NAAQS in 2016**





- *~125,000 excess deaths attributed to outdoor air pollution in the U.S.*
- *Comparable in numbers to: diabetes, Influenza and pneumonia*

What is Airborne Particulate Matter?

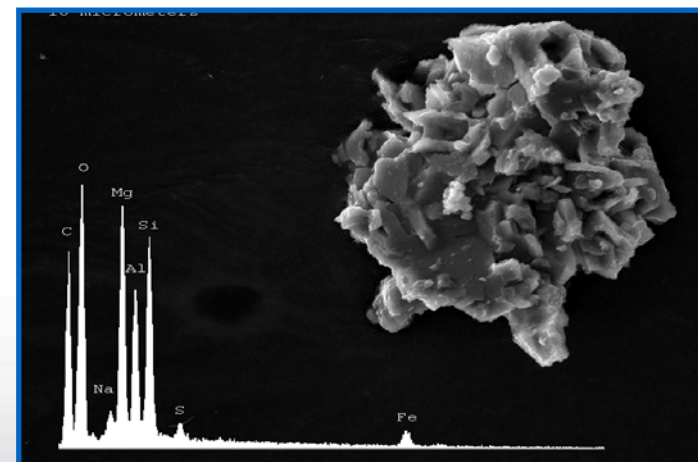


Particulate matter (PM) – “soot”

- from combustion sources
- mixture of solid particles and liquid droplets found in the air

National Ambient Air Quality Standards (NAAQS)

- 35 $\mu\text{g}/\text{m}^3$ - 24 hours
- 12 $\mu\text{g}/\text{m}^3$ - annual average



Scanning
Electron
Micrograph
of
air particle



Foundation of PM's Health Effect Exposure Linked to Morbidity and Mortality

AHA Scientific Statement

Air Pollution and Cardiovascular Disease

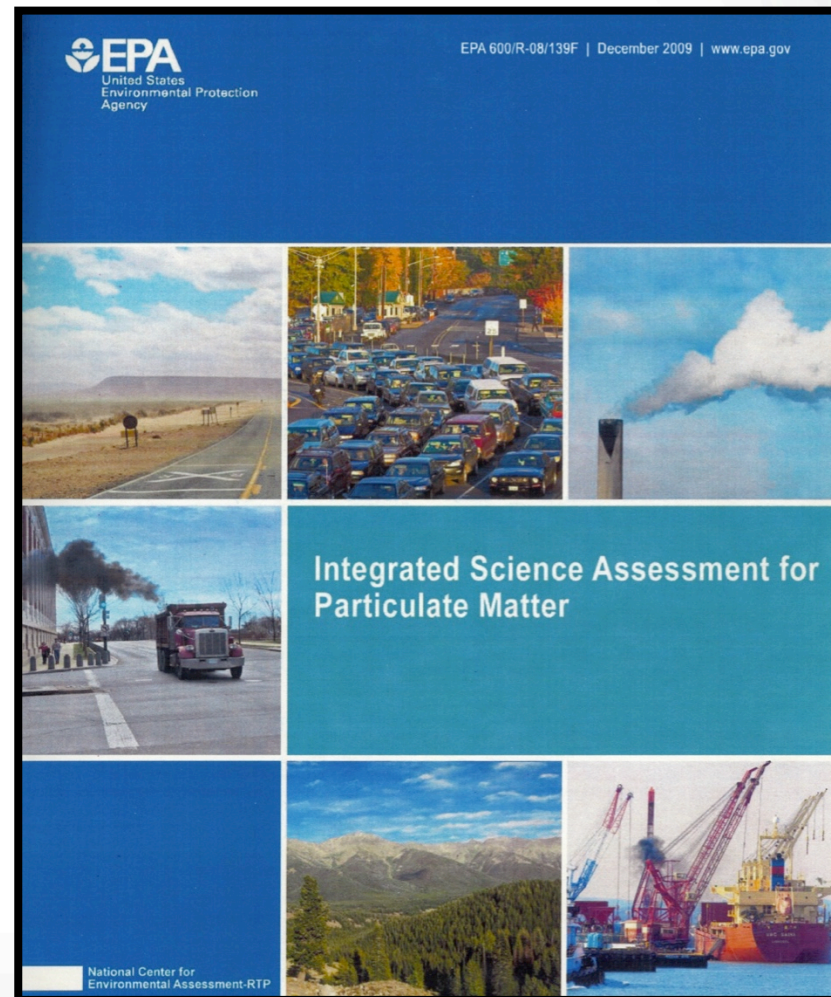
A Statement for Healthcare Professionals From the Expert Panel on Population and Prevention Science of the American Heart Association

Robert D. Brook, MD; Barry Franklin, PhD, Chair; Wayne Cascio, MD; Yuling Hong, MD, PhD; George Howard, PhD; Michael Lipsett, MD; Russell Luepker, MD; Murray Mittleman, MD, ScD; Jonathan Samet, MD; Sidney C. Smith, Jr, MD; Ira Tager, MD

Abstract—Air pollution is a heterogeneous, complex mixture of gases, liquids, and particulate matter. Epidemiological studies have demonstrated a consistent increased risk for cardiovascular events in relation to both short- and long-term exposure to present-day concentrations of ambient particulate matter. Several plausible mechanistic pathways have been described, including enhanced coagulation/thrombosis, a propensity for arrhythmias, acute arterial vasoconstriction, systemic inflammatory responses, and the chronic promotion of atherosclerosis. The purpose of this statement is to provide healthcare professionals and regulatory agencies with a comprehensive review of the literature on air pollution and cardiovascular disease. In addition, the implications of these findings in relation to public health and regulatory policies are addressed. Practical recommendations for healthcare providers and their patients are outlined. In the final section, suggestions for future research are made to address a number of remaining scientific questions. (*Circulation*. 2004;109:2655-2671.)

Brook RD et al. Circulation 2004

Short-term and long-term exposure to ambient air particulate matter is causally associated with cardiovascular morbidity and mortality (EPA ISA 2009)





Short-term Air Pollutant Exposure

Contribution to Cardiovascular Events

AHA Scientific Statement

Particulate Matter Air Pollution and Cardiovascular Disease

An Update to the Scientific Statement From the American Heart Association

Robert D. Brook, MD, Chair; Sanjay Rajagopalan, MD; C. Arden Pope III, PhD; Jeffrey R. Brook, PhD; Aruni Bhatnagar, PhD, FAHA; Ana V. Diez-Roux, MD, PhD, MPH; Fernando Holguin, MD; Yuling Hong, MD, PhD, FAHA; Russell V. Lueker, MD, MS, FAHA.

Fine particulate matter (PM) or particle pollution can:

- *Trigger heart attacks*
- *Trigger stroke*
- *Trigger arrhythmia*
- *Worsen heart failure*

Heart disease patients should reduce their exposure to air pollution when levels are high

- “Air pollution should be viewed as one of several major modifiable risk factors in the prevention and management of cardiovascular disease.”



European Heart Journal (2015) **36**, 83–93
doi:10.1093/eurheartj/ehu458

CURRENT OPINION

Expert position paper on air pollution and cardiovascular disease

David E. Newby¹, Pier M. Mannucci², Grethe S. Tell³, Andrea A. Baccarelli⁴, Robert D. Brook⁵, Ken Donaldson⁶, Francesco Forastiere⁷, Massimo Franchini⁸, Oscar H. Franco⁹, Ian Graham¹⁰, Gerard Hoek¹¹, Barbara Hoffmann¹²,

- “Health professionals, including cardiologists, have an important role to play in supporting educational and policy initiatives as well as counseling their patients.”



Long-term Air Pollutant Exposure Contributes to Cardiovascular Morbidity & Mortality

December 2012
EPA/600/R-12/056F



Provisional Assessment of Recent Studies on Health Effects of Particulate Matter Exposure

National Center for Environmental Assessment RTP Division
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Ambient air particle pollution is associated with:

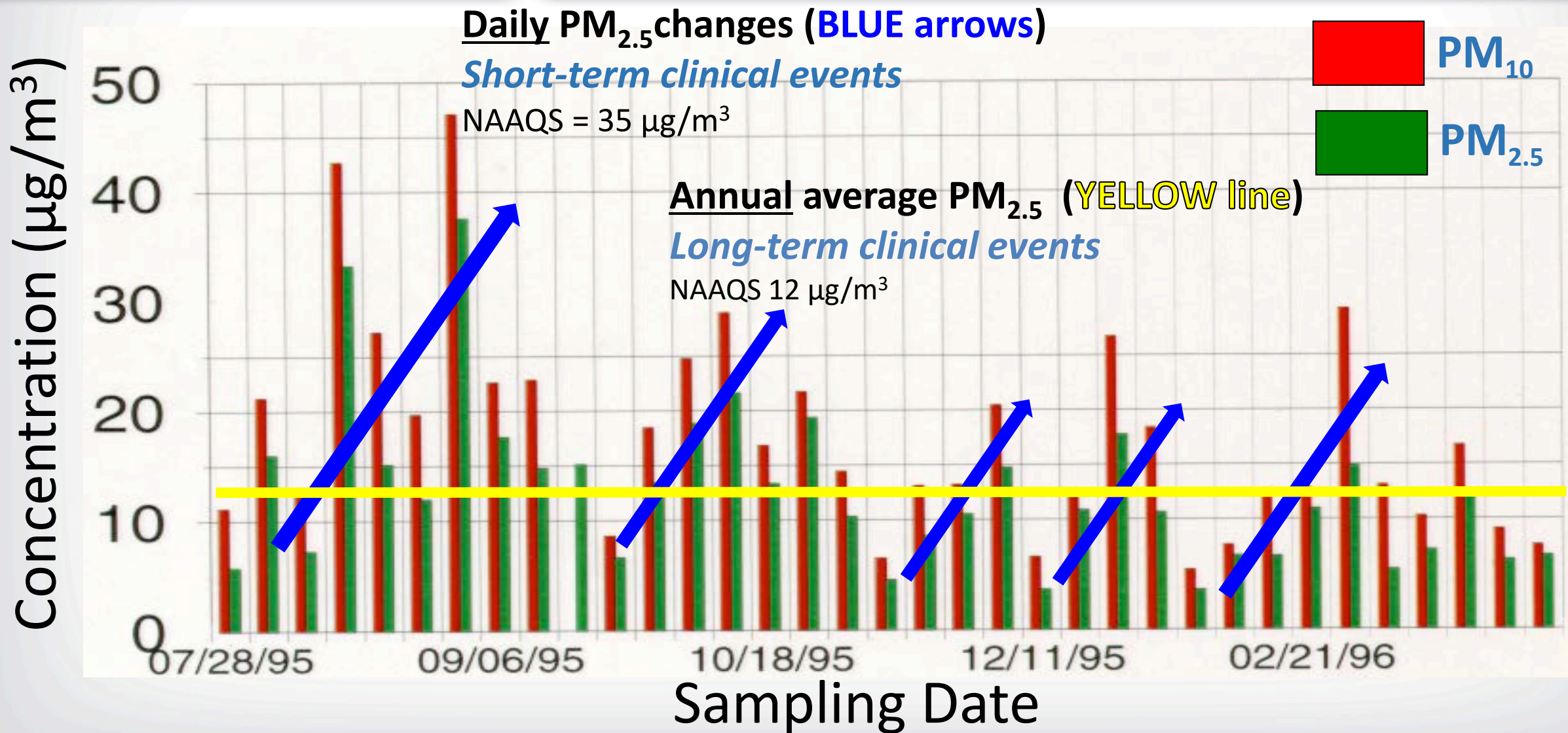
- *Hypertension*
- *Ischemic heart disease*
- *Stroke*
- *Cardiovascular Mortality*

**Communities should be able to improve their cardiovascular health by complying
with ambient air quality standards**



Daily Variability of PM_{10} & $PM_{2.5}$

Chapel Hill, NC 1995-96



Populations At-Risk from PM_{2.5}

Susceptible populations include –

- those with pre-existing cardiovascular disease
- those with pre-existing respiratory disease
- older adults
- those with lower socio-economic status
- children & the developing fetus

Populations suspected to be at greater risk –

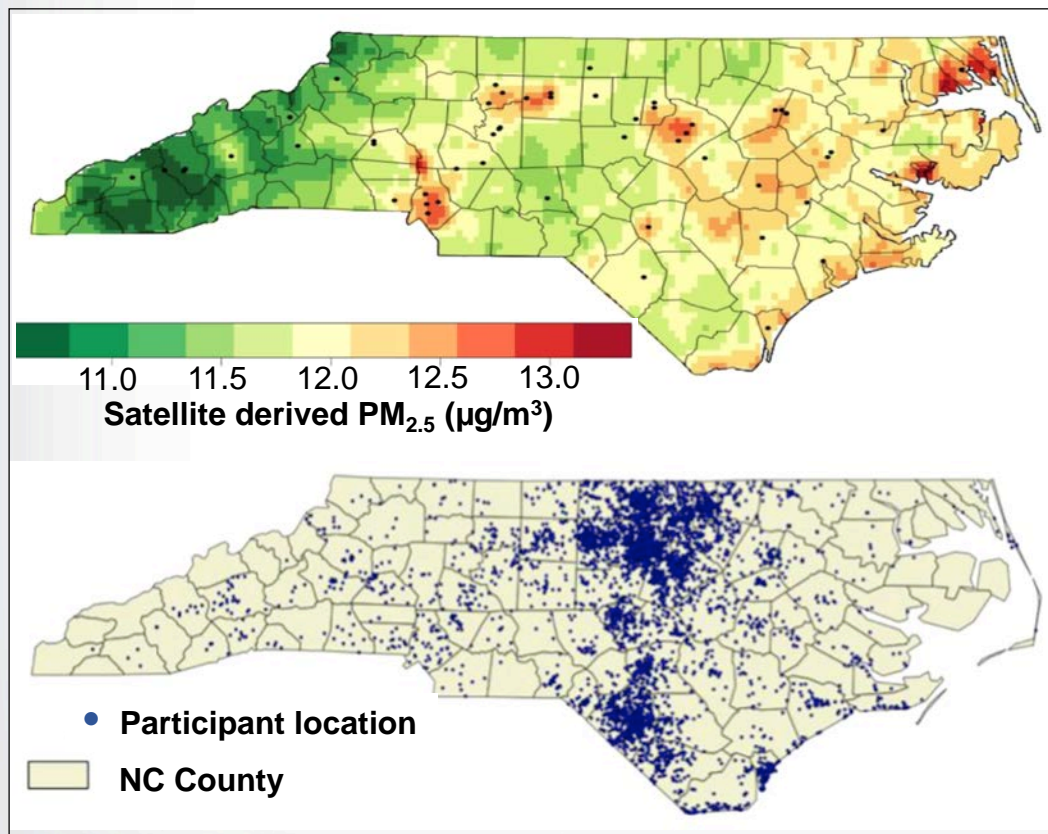
- those with chronic inflammatory diseases (e.g., diabetes, obesity)
- those with specific genetic polymorphisms (e.g., GSTM1)



Health & Long-term Air Pollution Exposure

Association between PM and Coronary Artery Disease

5,679 patients who underwent coronary angiography at Duke University between 2002–2009 and resided in North Carolina*



1 µg/m³ increase in annual average PM_{2.5} was associated with an:

- 11.1% relative increase in odds of significant CAD**
- 14.2% increase in the odds of having had a heart attack during the previous year**

6,575 Ohio residents undergoing elective diagnostic coronary angiography found the same relationship**

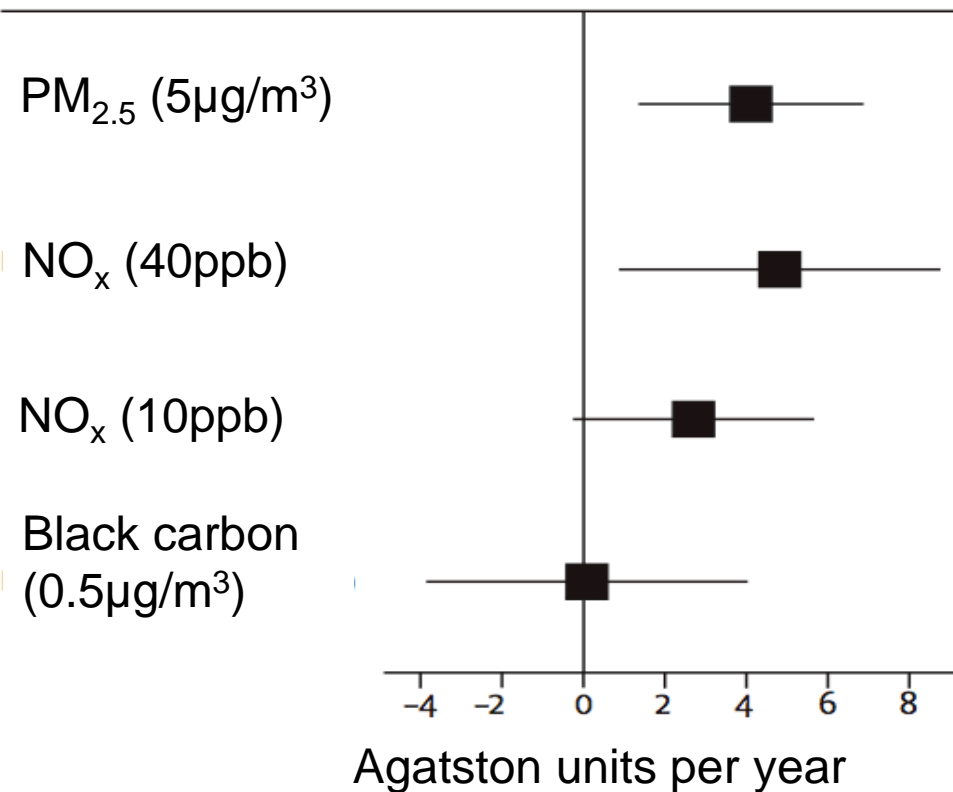
*McGuinn LA, et al. *Environ Res* 2016

**Hartiala J, et al. *J Am Heart Assoc* 2016

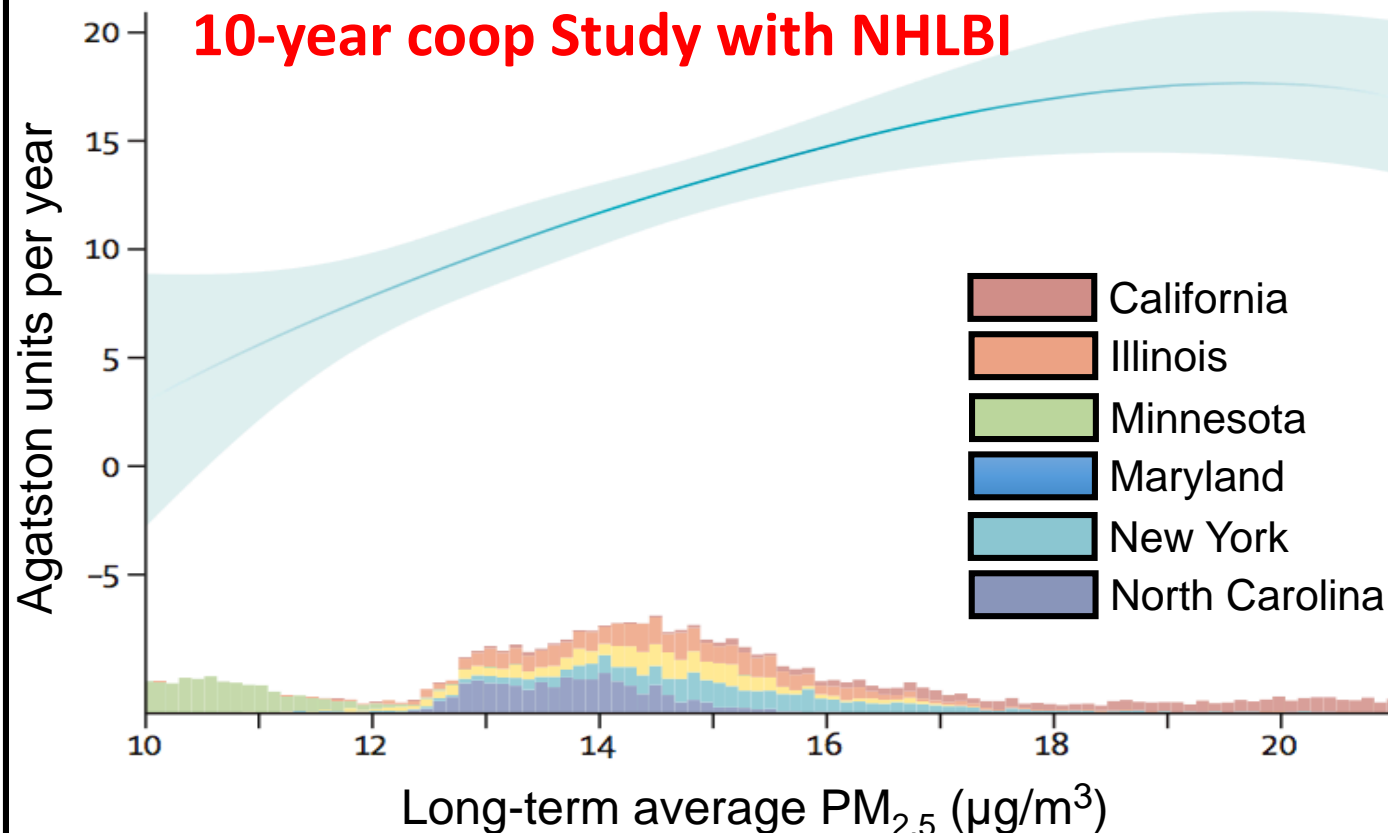


Long-Term $PM_{2.5}$ & NO_2 Exposure Increases Coronary Artery Calcium

Air Pollutants



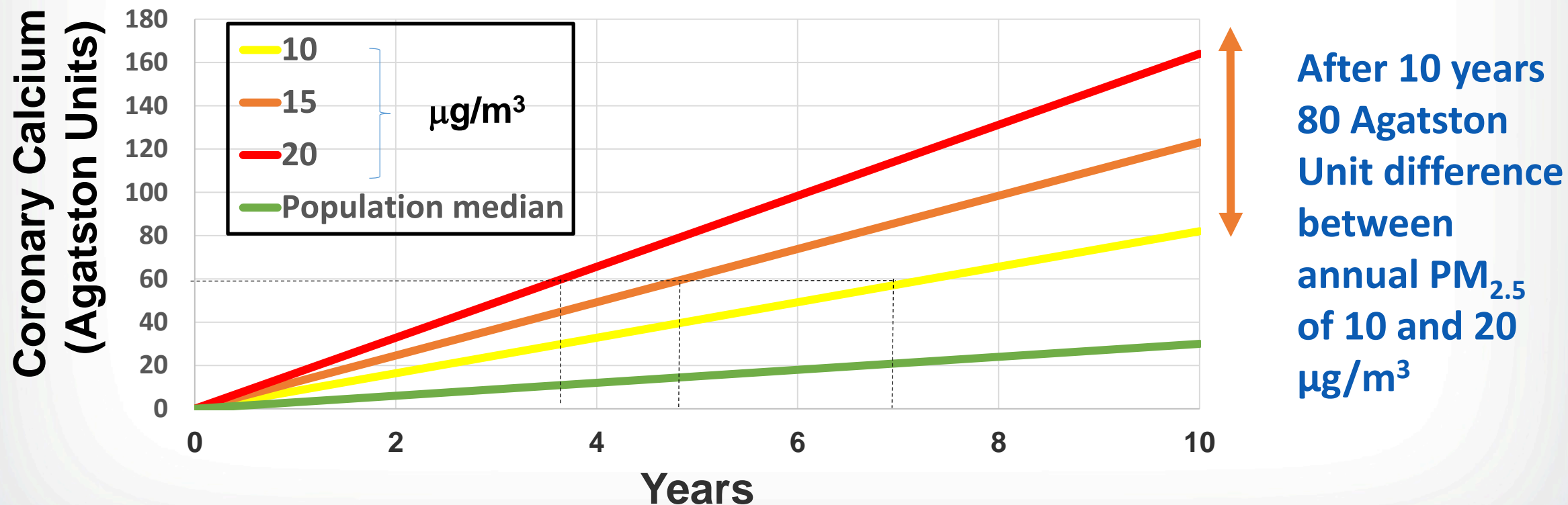
Multi Ethnic Study of Atherosclerosis - Air: 10-year coop Study with NHLBI



Long-term $PM_{2.5}$ and NO_2 increased coronary calcium, an indicator of atherosclerosis

MESA Air Study – Led by University of Washington


$PM_{2.5}$ and Coronary Calcium





Air Pollution Worsens Vascular Risk Factors

Risk Factors for Atherosclerosis and Air Quality

 **ASCVD Risk Estimator Plus**

Estimate Risk ☐ Therapy Impact **Advice**

Current 10-Year ASCVD Risk ~% **Previous 10-Year ASCVD Risk ~%**

Patient Demographics

Current Age Sex ☐ Male ☐ Female Race ☐ White ☐ African American ☐ Other

Age must be between 40-79

Current Labs/Exam

Total Cholesterol (mg/dL) **HDL Cholesterol (mg/dL)** **LDL Cholesterol (mg/dL)** **Systolic Blood Pressure (mm of Hg)**

Value must be between 130 - 320 Value must be between 20 - 100 Value must be between 30-300 Value must be between 90-200

Personal History

History of Diabetes? ☐ Yes ☐ No **On Hypertension Treatment?** ☐ Yes ☐ No **Smoker:** ☒ Yes ☐ Former ☐ No

On a Statin? ☐ Yes ☐ No **On Aspirin Therapy?** ☐ Yes ☐ No

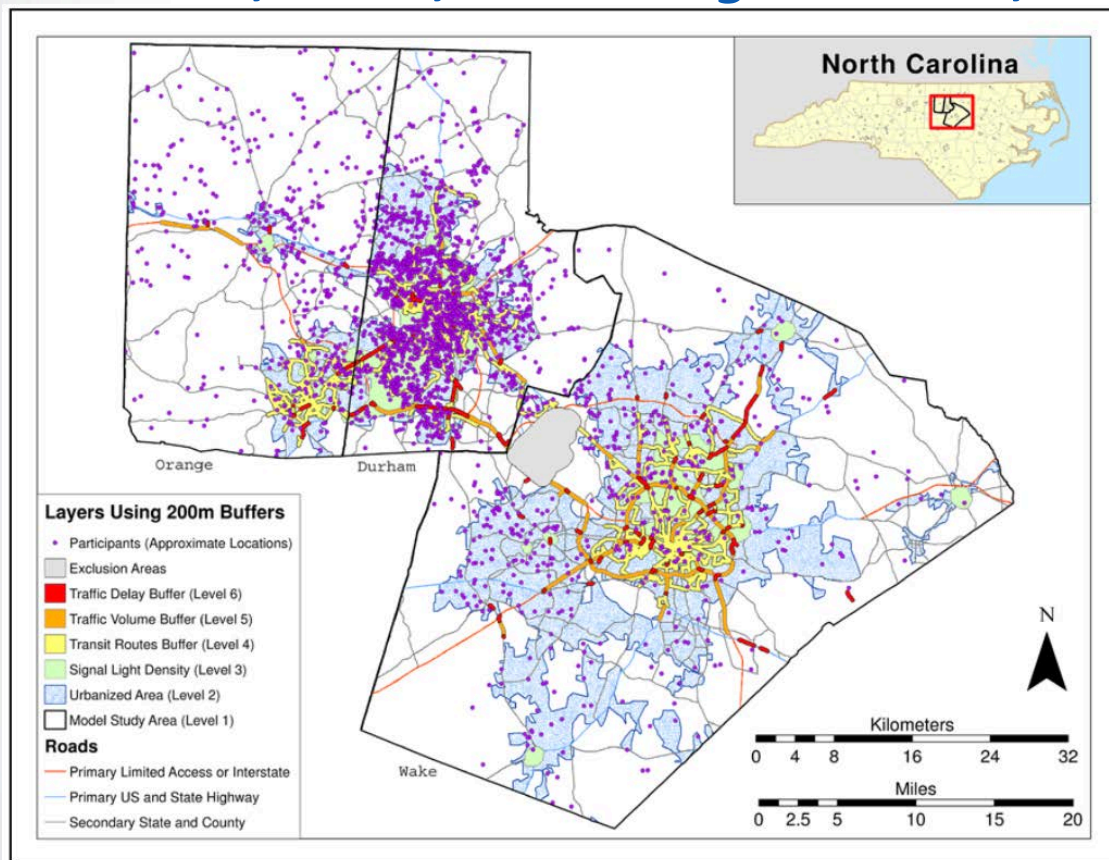
Poor Air Quality:

- **Age** – might accelerate aging
- **Total Cholesterol** – increases cholesterol
- **HDL** – decreases HDL particle number
- **LDL** – oxidizes LDL and ox-LDL receptor
- **Systolic BP** – increases blood pressure
- **Diabetes** – associated with type II diabetes
- **Statin Therapy** – might be protective



Roadway Proximity and Fasting Plasma Glucose

Distribution of CATHGEN participants within the study area of Durham, Wake, and Orange counties, NC



Fasting Plasma Glucose

FPG ≥ 126

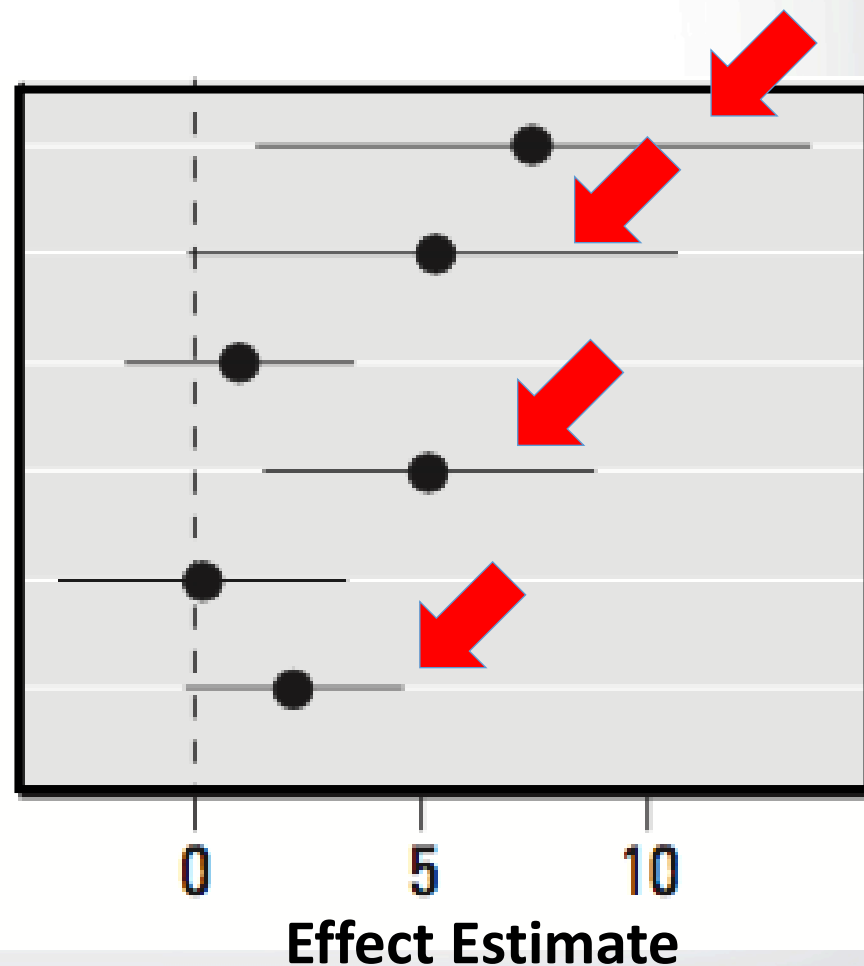
AA

EA

Women

Men

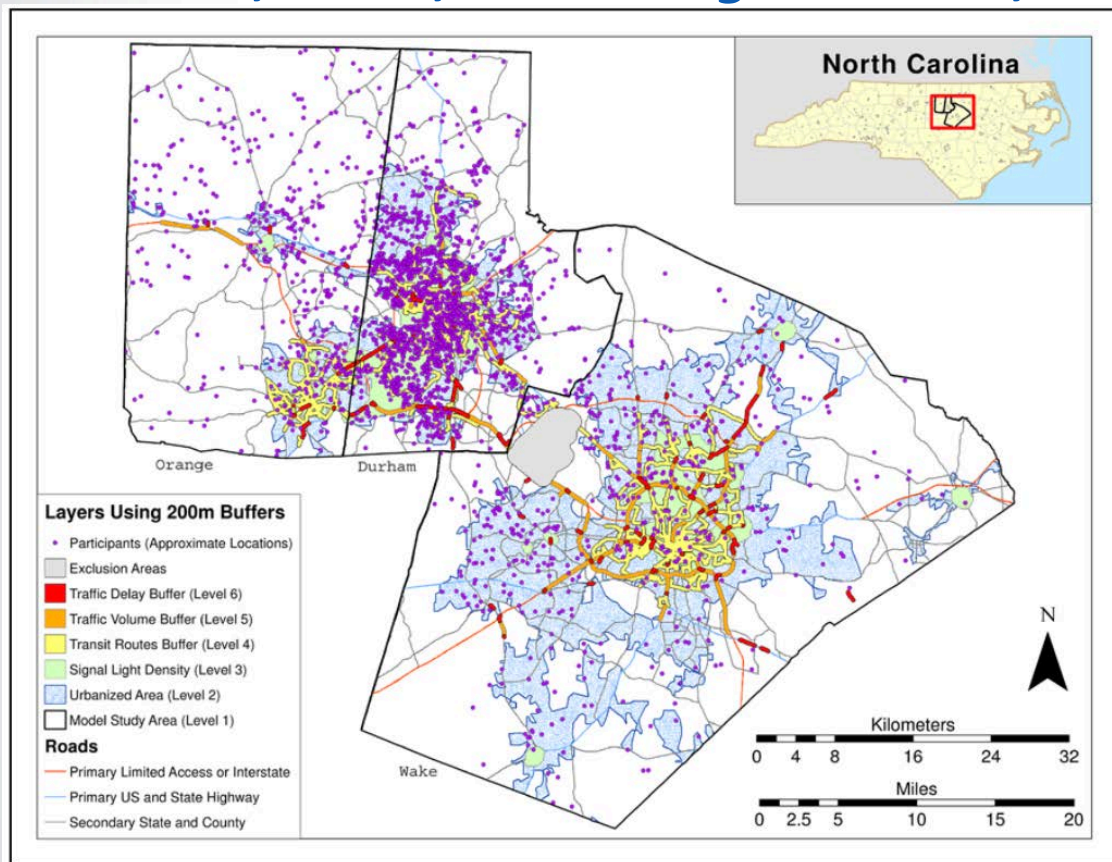
Overall



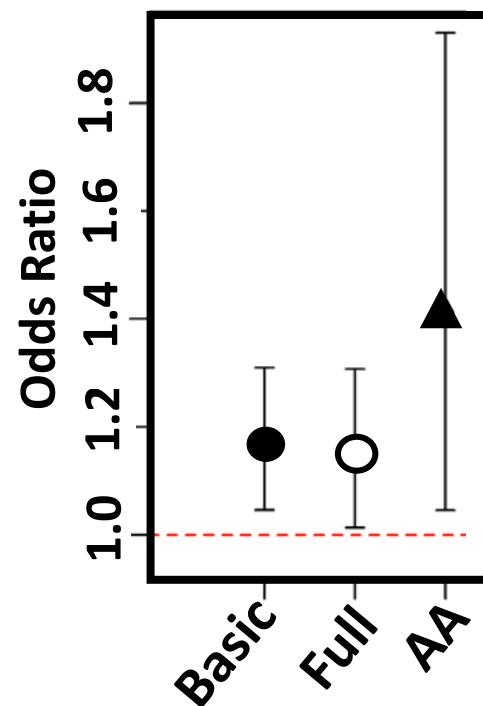


Residential Proximity to Traffic Hypertension, Vascular Disease and

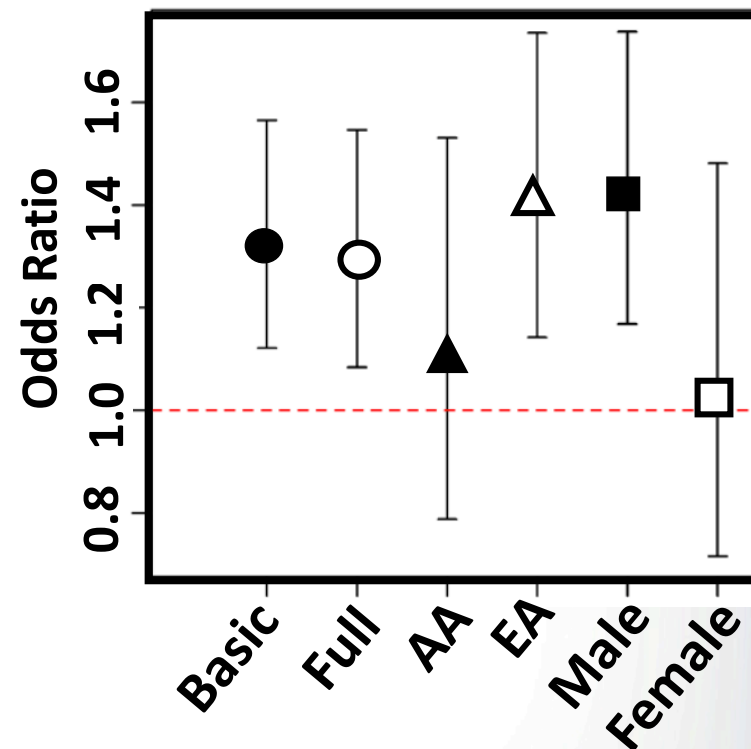
*Distribution of CATHGEN participants
within the study area of
Durham, Wake, and Orange counties, NC*



Hypertension



Peripheral Arterial Disease



Basic
Full

AA
EA

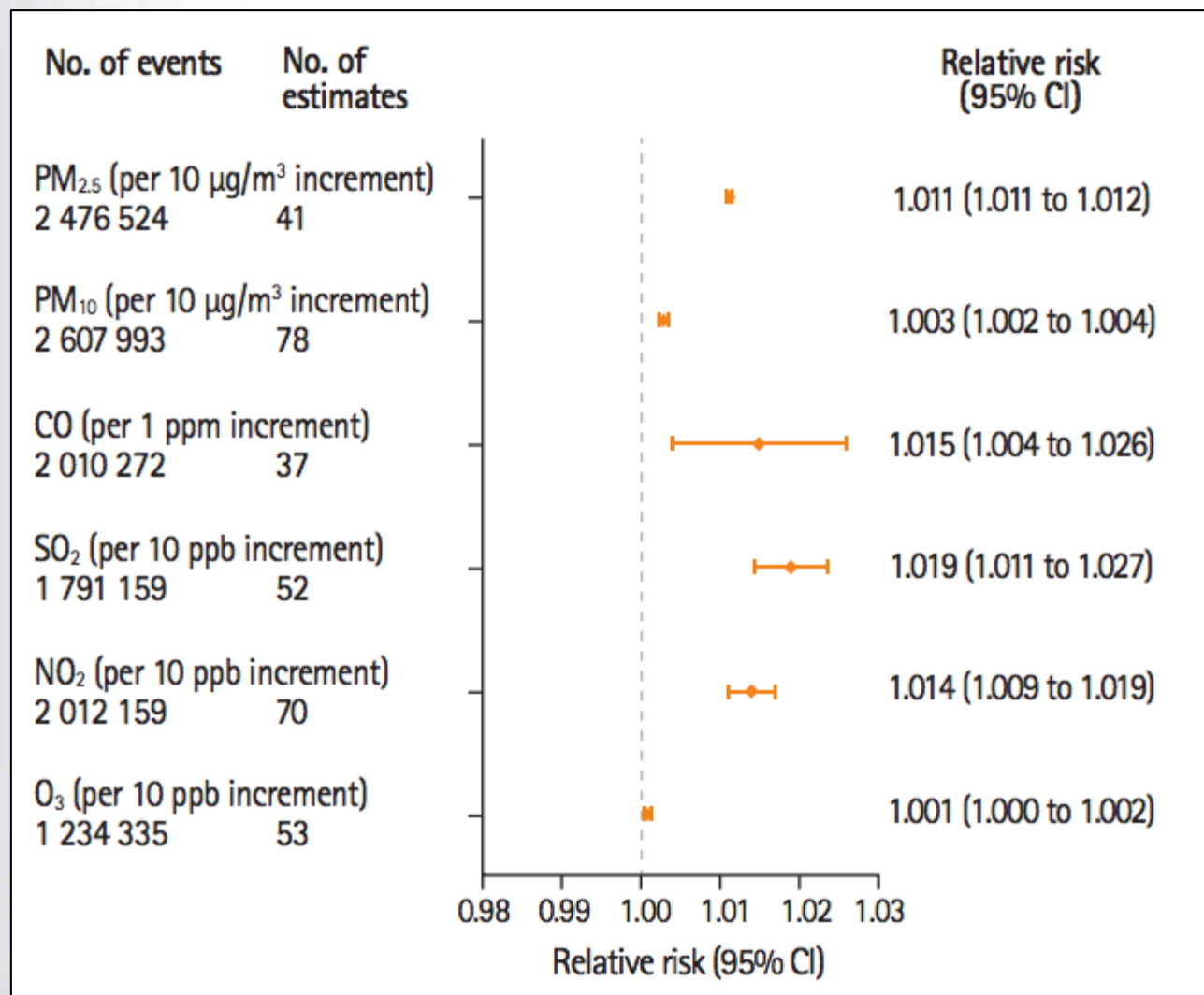


Males
Female





Association Between Air Pollutants and Hospitalization or Mortality from Stroke



Systematic review and meta-analysis reported stroke to be associated with PM and air pollutants gases:

- **PM_{2.5} and PM₁₀ associated with admission to hospital for stroke and mortality**
- **NO₂ associated with hospital admission or mortality**
- **SO₂ and CO associated with admission or mortality**



Air Pollution and Mortality

Effect of PM on Survival and Subsequent Clinical Events

Zanobetti A & Schwartz J.

Environ Health Perspect 2007

Mortality
CHF hospitalization
MI hospitalizations

Koton et al.

Prev Med 2013

MI, CHF, Stroke
Mortality

Tonne et al.

Eur Heart J 2013

Mortality

Tonne et al.

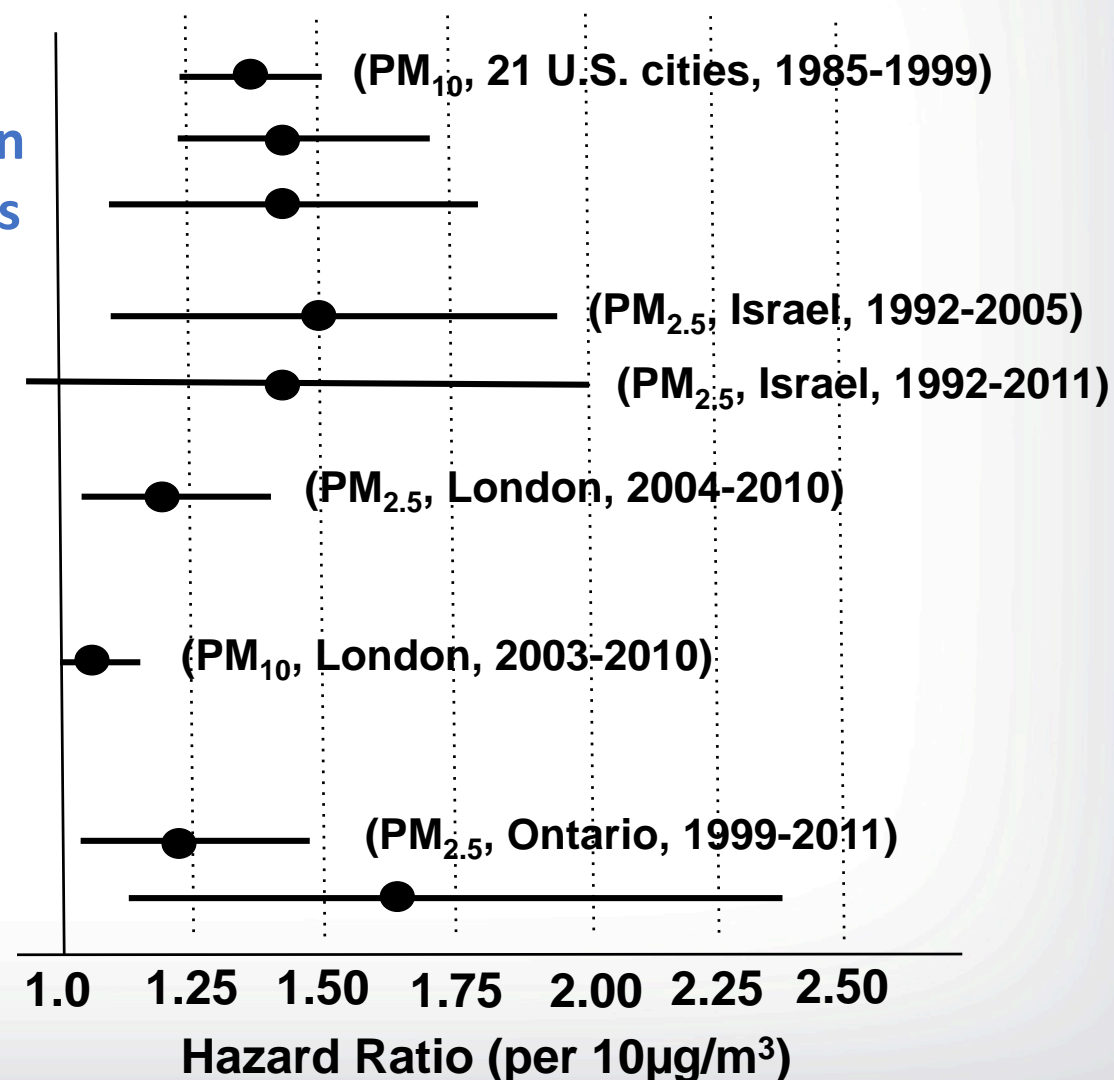
Int J Hyg Envir Health 2016

Mortality

Chen et al. EHP 2016

Environ Health Perspect 2016

Mortality
MI Mortality





Personal Health Care Spending in U.S. for Chronic Disease is High

COPD	\$ 53.8 billion
Asthma	\$ 32.5 billion
Pneumonia	\$ 37.1 billion
Lung cancer	\$ 13.1 billion
Ischemic heart disease	\$ 88.1 billion
High blood pressure	\$ 83.9 billion
Stroke	\$ 43.8 billion
Heart failure	\$ 28.5 billion
Atrial fibrillation	\$ 27.7 billion
Peripheral vascular disease	\$ 2.7 billion
Diabetes	\$101.4 billion
Preterm birth	\$ 4.9 billion

***½ Trillion
Dollars
in
2013***

Dieleman JL et al.
JAMA 2016

Air Pollutant Exposure is a Risk Factor

- *Air pollution adversely affects:*
 - Health, Longevity, Healthcare Resource Utilization and Public Welfare (e.g. effects on visibility, vegetation, and ecosystems)
- *Most healthcare professionals & patients at-risk know of air pollution's adverse health effects*

*Despite Knowledge of the Risks
the Healthcare System is Not Engaged*

- *Few healthcare professionals discuss the risks with their patients*
- *At-risk patients don't take action to reduce exposure*



EPA's Healthy Heart Program Increasing Environmental Health Literacy



EPA's Healthy Heart program aims to prevent heart attacks and strokes by:

- Raising public awareness about the role outdoor air pollution plays in cardiovascular health, and
- Steps individuals can take to reduce their pollution exposure



Examples of Products Engaging the Public

AirNow Local Air Quality Conditions
Zip Code: Go State: Go My Current Location

Forecast Current AQI AQI Loop More Maps

Today's AQI Forecast
Saturday, June 17, 2017

Fires: Current Conditions
Click to see map

U.S. Embassies and Consulates
Data from air quality monitors at select U.S. embassies and consulates around the world

Announcements
6/15/17: National Air Quality Conference, September 11 - 13, 2017. Registration Now Open and Call for Presentations
6/7/17: 2017 Air Quality Flag Program Spring Challenge Winners. [More](#)
[more announcements](#)

Air Quality Basics
Air Quality Index | Ozone | Particle Pollution | Smoke from fires | What You Can Do

Health

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Healthy Heart Toolkit and Research: Steps You Can Take

Steps You Can Take to Reduce Health Effects from Air Pollution

Studies show that air pollution can trigger health effects, especially in people who are at risk for these conditions. If you have a pre-existing condition, you may be at a higher risk for health effects from exposure to high levels of air pollution.

When are air pollution levels likely to be high?

- Any time of year
- When weather is calm
- Near busy roads
- In urban areas
- In industrial areas
- When there is smoke



Particle Pollution and Your Patients' Health

Helps health care providers advise their patients about particle pollution exposure.

This course is designed for family medicine physicians, internists, pediatricians, occupational and rehabilitation physicians, nurse practitioners, nurses, asthma educators, pulmonary specialists, cardiologists, and other medical professionals.

[Start the Course](#)



EPA United States Environmental Protection Agency

AMERICAN COLLEGE of CARDIOLOGY

American Heart Association | **American Stroke Association**

Heart Disease, Stroke, and Outdoor Air Pollution

1 Did you know that air pollution can trigger heart attacks, stroke, and other health effects?

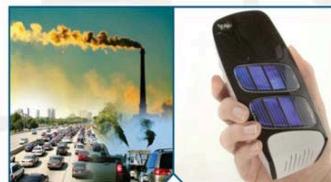
Medical studies show that air pollution can trigger heart attacks, stroke, and irregular heart rhythms—especially in people who are already at risk for these conditions. Also, for people with a medical condition called heart failure, air pollution can further reduce the ability of the heart to pump blood the way that it should. Very small particles are the pollutants of greatest concern for triggering these effects. Particle pollution is found in haze, smoke, and dust—and sometimes in air that looks clean. This fact sheet tells you how you can:

- Get up-to-date information about your



3 How can you protect your health?

Air Sensor Guidebook



AIRNow Current Location **AIRNOW**

Zip Code **27707** Go OR

The Air Quality Index (AQI) for Raleigh-Durham-Chapel Hill

Current	Current
2/6/2013	2/6/2013
8:00 PM EST	8:00 PM EST
Pollutant: PM2.5	Pollutant: OZONE
40	23
Good	Good

Efectos de los Contaminantes Comunes del Aire

EFFECTOS RESPIRATORIOS **EFFECTOS CARDIOVASCULARES**

Síntomas

Respiratorios: Tos, Irritación en el pecho, Dificultad en el pecho, Aumento de enfermedades y muerte prematura causados por el deterioro de las vías respiratorias.

Cardiovasculares: Dificultad en el pecho, Tos, Irritación en el pecho, Aumento de enfermedades y muerte prematura causados por el deterioro de las vías respiratorias.

Cómo los contaminantes causan síntomas

Efectos en la función pulmonar: Irritación en las vías respiratorias, Aumento de enfermedades y muerte prematura causados por el deterioro de las vías respiratorias.

Efectos en la función cardiovascular: Irritación en las vías respiratorias, Aumento de enfermedades y muerte prematura causados por el deterioro de las vías respiratorias.

Reduzca su riesgo, usando el Índice de Calidad del Aire (AQI) por sus siglas en inglés) al planear actividades al aire libre - www.airnow.gov		
Nivel de calidad del aire y su impacto en la salud	Valor del índice	¿Qué medidas deben tomar las personas?
Bueno	0-50	Disfrutar sus actividades al aire libre.
Moderado	51-100	Personas con problemas sensibles a la contaminación del aire deben reducir sus actividades al aire libre cuando reporten la calidad del aire.
Deficiente para la salud de los grupos sensibles	101-150	Grupos sensibles deben reducir sus actividades al aire libre. Las personas con problemas de salud deben reducir sus actividades al aire libre. Evitar actividades que generen polvo o que produzcan aerosoles. Evitar actividades que generen mucho sudor. Evitar actividades que generen mucho esfuerzo físico.
Deficiente para la salud	151-200	Evitar actividades que generen mucho sudor o que produzcan aerosoles. Evitar actividades que generen mucho esfuerzo físico. Evitar actividades que generen mucho sudor o que produzcan aerosoles.
Muy deficiente para la salud	201-300	Evitar actividades que generen mucho sudor o que produzcan aerosoles. Evitar actividades que generen mucho esfuerzo físico. Evitar actividades que generen mucho sudor o que produzcan aerosoles.



- ***Color scale detailing how clean or polluted the air is***
- ***Local air quality conditions also often part of local weather reports***
- ***Where can it be found?***
 - Local TV, radio or newspapers
 - AirNow app
 - Email alerts at www.enviroflash.info

Public Education

Air Quality Index Available at AirNow.gov

Descriptors	Cautionary Statement
Good 0 – 50	No message
Moderate 51 – 100	Unusually sensitive individuals
Unhealthy for Sensitive Groups 101 - 150	Identifiable groups at risk - different groups for different pollutants
Unhealthy 151 - 200	General public at risk; sensitive groups at greater risk
Very Unhealthy 201 - 300	General public at greater risk; sensitive groups at greatest risk



Informing the Public

www.airnow.gov via the Internet



AirNow National AQIs & forecast August 29, 2017

Fresno, CA AQI & forecast August 29, 2017

Current Conditions	
Air Quality Index (AQI) observed at 3:00 PDT	
33 Good	
Health Message: None	
Note: Values above 500 are considered Beyond the AQI. Follow recommendations for the Hazardous category. Additional information on reducing exposure to extremely high levels of particle pollution is available here .	
AQI - Pollutant Details	
Ozone	33 Good

Air Quality Forecast	
Today	Tomorrow
Air Quality Index (AQI)	
177 Unhealthy	Unhealthy for Sensitive Groups
Health Message: Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.	Health Message: People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
AQI - Pollutant Details	
Ozone	177 Unhealthy
Particles (PM2.5)	Unhealthy for Sensitive Groups





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Healthy Heart Toolkit and Research: Steps You Can Take

Steps You Can Take to Reduce Health Effects from Air Pollution

Studies show that air pollution can trigger heart attacks, strokes and worsen heart failure in people who are at risk for these conditions. If you have a heart condition, you could benefit by reducing your exposure to high levels of air pollution.

When are air pollution levels high?

- Any time of year
- When weather is calm
- Near busy roads
- In urban areas
- In industrial areas
- When there is smoke



Daily Air Quality

- [Check Pollution Forecasts](#)
- [Get Free Email Alerts](#)

EXIT

Resources

- [Be Smart, Protect Your Heart video](#) EXIT
- [Heart Disease, Stroke and Outdoor Air Pollution](#)
- [Million Hearts Initiative:](#)

- *When are air pollution levels high?*
- *Are you at risk?*
- *Steps to Protect Your Heart*
- *How to Reduce your Risk?*
- *Warning Signs of a Heart Attack*
- *Warning Signs of a Stroke*



CME for Health Care Professionals

Particle Pollution and Your Patients' Health



www.epa.gov/particle-pollution-and-your-patients-health

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Particle Pollution and Your Patients' Health

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An evidence-based training for healthcare professionals that:

- Describes the biological mechanisms responsible for the cardiovascular and respiratory health effects associated with particle pollution exposure.
- Provides educational tools to help patients understand how particle pollution exposure can affect their health and how they can use the Air Quality Index to protect their health.



This course is designed for family medicine physicians, internists, pediatricians, occupational and rehabilitation physicians, nurse practitioners, nurses, asthma educators, pulmonary specialists, cardiologists, and other medical professionals.

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[Particle Pollution Exposure](#)

[Cardiovascular Effects](#)

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Partnering with HHS' Million Hearts[®] Recommendations Supported by EPA Science



EPA contributes the *Healthy Heart* program to lower air pollutant exposures in at-risk populations in an effort to:



- *decrease heart attacks and strokes*
- *improve vascular disease outcomes*
- *decrease disability and healthcare expenditures*
- *decrease the societal burden of vascular diseases*



Million Hearts[®]

Provides Educational Tools on Particle Pollution



Connect with us:   

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Tools & Protocols ▾

Data & Reports ▾

Partners & Progress ▾

Learn & Prevent ▾

Undiagnosed Hypertension
Self-Measured Blood Pressure

Medication Adherence

Treatment Protocols

Action Guides

Tools

Health IT

Particle Pollution

Physical Activity

Tobacco

Tools & Protocols

Find treatment protocols, action guides, and other tools to help educate, motivate, and monitor your patients.

Data & Reports

Access the latest data and published research on heart disease and stroke.



e-update

Tools You Can Use

- **New Million Hearts[®] website on physical activity promotes community programs and resources.** Physical activity is one of the most effective ways to prevent and manage heart disease, but just half of U.S. adults get enough. Take advantage of resources and information about community-based programs to boost physical activity in your community.
- **Vermont Department of Health releases Hypertension Management Toolkit.** The toolkit uses Lean quality improvement tools and methods to support evidence-based strategies that improve blood pressure control. A new statewide peer learning collaborative will share best practices to keep the toolkit updated.
- **Million Hearts[®] Tobacco Cessation Protocol now available on the go.** Find the CDC Protocol for Identifying and Treating Patients Who Use Tobacco on Epocrates, a free website and app for clinicians. (Registration may be required.)
- **A visual air quality alert makes air awareness easy.** The EPA's Air Quality Flag Program provides instructions on using physical and digital flags at your business or online to alert people to daily air quality.
- **New EPA toolkit details the link between heart problems and air pollution.** Use the Healthy Heart Toolkit to take steps to protect yourself and your community, sign up for air alerts, and download public education materials.



Air quality as a risk factor for heart attack? It may sound strange, but worsening air quality puts people at risk for heart attacks and other cardiovascular (CV) conditions, especially among people who are already vulnerable. More than 1.5 million people in the United States suffer from heart attacks and strokes each year. Millions more have high blood pressure or heart rhythm disorders, putting this priority population especially at risk from particle pollution's effects.

Million Hearts[®] is dedicated to driving implementation of evidence-based public health and clinical strategies that help prevent CV events. With that in mind, we recently launched a webpage to spread awareness about particle pollution and CV health, with resources to help track local air quality. Use the resources in this newsletter to learn about the connection between heart health and particle pollution to help keep people healthy this summer and beyond.

—Janet Wright, MD, FACC
Executive Director, Million Hearts[®]

Million Hearts[®] in the Community

- **The District of Columbia Department of Health's Million Hearts[®] program builds a framework for success.** Learn how D.C.'s Million Hearts[®] program's strong partnerships, data monitoring, and targeted interventions have reduced CV disease morbidity and mortality in the nation's capital.
- **Find your niche when partnering with Million Hearts[®].** Hospitals, employers, and clinical care teams in communities across the nation have tailored unique approaches to keeping people healthy, optimizing care, and helping priority populations. Learn how they did it—and then craft your own plan.
- **Million Hearts[®] continues engagement to find patients with hypertension "hiding in plain sight."** How many people in your practice have undiagnosed high blood pressure? Learn how to establish criteria for finding people with hypertension, implement evidence-based strategies to treat them, and improve their CV outcomes.
- **Pilot program with National Association of Community Health Centers (NACHC) shows progress in fighting hypertension.** In honor of National Heart Center Week (Aug. 13-19), take the time to learn how Million Hearts[®] partner NACHC is making strides in blood pressure control.

The Science of Million Hearts[®]

- **Physicians experienced in health information technology are more likely to achieve 70% blood pressure control.** (*Journal of the American Medical Association*)
- **Lowering prices of fruits and vegetables could reduce the number of deaths from CV disease.** (*PLOS Medicine*)
- **A cost-benefit analysis shows how indoor air filtration may reduce mortality due to particulate matter.** (*International Journal of Indoor Environment and Health*)

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Do This! Share the EPA Air Quality Index with networks and people at risk.

Particle pollution puts people with CV conditions at higher risk for heart problems or stroke. Post this tool on your websites and social media so people can check air quality before they go outside for physical activity. Those at risk should avoid going outside on days ranked "orange" or worse and instead choose indoor versions of their favorite activities.

Quick Fact

One in three American adults has heart or blood vessel disease and is at higher risk from air pollution, which can trigger heart attacks and strokes and contribute to



The Environmental “Buckets” of Prevention Framework

Total Population Community-Wide Prevention

NAAQS
Built-Environment
Health Literacy

- **Attain & maintain NAAQS Stds**
- **Improve built-environment:**
 - Places for physical activity
 - Create healthier near-road environments
- **Improve overall CV health status**

Innovative Clinical Prevention



- **Optimize clinical care of the at-risk priority population**
- **Increase awareness of health effects of PM among physicians, health care professionals, and the at-risk population**
- **Provide guidance to lower exposure & associated risk**

Traditional Clinical Prevention

**“evidence-based”
clinical prevention
management strategies**

- **Long-term indoor air filtration lowered markers of oxidative stress and inflammation**
(Chuang H-C, et al. Environ International 2017)

Public Health

Health Care

High Resolution Air Pollution Mapping

Small Scale Variability due to Local Sources

ENVIRONMENTAL
Science & Technology

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Article

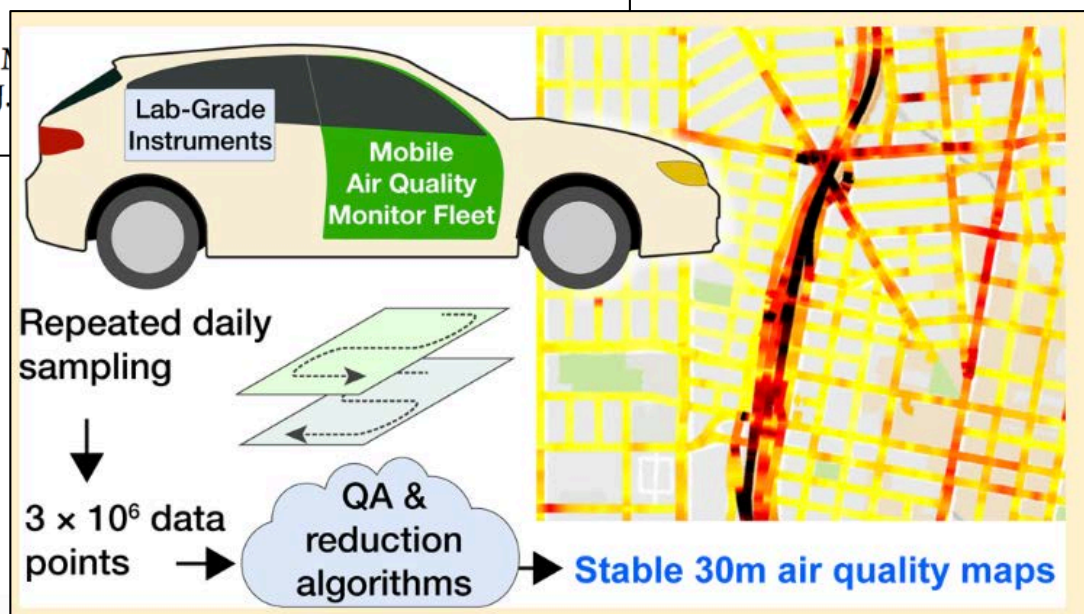
pubs.acs.org/est

High-Resolution Air Pollution Mapping with Google Street View Cars: Exploiting Big Data

Joshua S. Apte,^{*,†,‡} Kyle P. Messier,^{†,‡} Shahzad Gani,[†] Melissa M. Lunden,[‡] Julian D. Marshall,[#] Christopher J. and Steven P. Hamburg[‡]

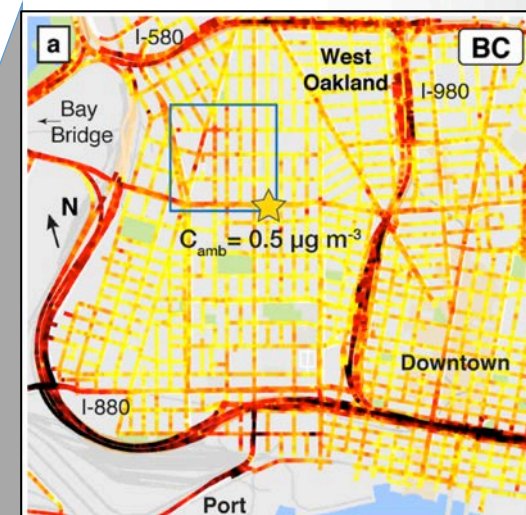
Apte JS et al. Environ Sci Technol 2017

Hankey S et al. Population-Level Exposure to Particulate Air Pollution during Active Travel: Planning for Low-Exposure, Health-Promoting Cities. Environmental Health Perspectives 125:527–534, 2017



Oakland, CA

Spatial distribution of Black Carbon (BC)





Moving to the Future

ENVIRONMENTAL Science & Technology

Policy Analysis

pubs.acs.org/est

Forecast-Based Interventions Can Reduce the Health and Economic Burden of Wildfires

Ana G. Rappold,^{*,†} Neal L. Fann,[‡] James Crooks,[†] Jin Huang,[§] Wayne E. Cascio,[†] Robert B. Devlin,[†] and David Diaz-Sanchez[†]

Forecast-based interventions predicted to reduce the health and economic burden of wildfires

Rappold AG, et al.
Environ Sci Technol 2014

Cost effectiveness is improved by intervening only in the homes of those at highest risk, e.g. older persons

ORIGINAL ARTICLE

WILEY

Effectiveness and cost of reducing particle-related mortality with particle filtration

Indoor Air. 2017;1–12.

W. J. Fisk  | W. R. Chan

Fisk WJ, Chan WR *Indoor Air* 2017

VIEWPOINT

The Global Threat of Outdoor Ambient Air Pollution to Cardiovascular Health Time for Intervention

Robert D. Brook, MD

Anthropogenic ambient fine particulate matter less etal air pollution problem appears to be

“... we believe that the time is ripe to definitively test the efficacy of personal-level interventions...”

Brook RD, et al.
JAMA Cardiol. 2017

- **High attributable health burden**
- Particle pollution increases short- and long-term cardiovascular morbidity & mortality
- **Improvements in air pollution levels reduce health impacts and increase life expectancy**
- Many regions of US fail to meet EPA standards - >100 million exposed
- **EPA is working with the States to help communities meet NAAQS**
- Older-people, those with pre-existing heart & lung disease, & diabetes are at higher risk from air pollution

- **High-risk patients should be educated about risks of air pollution and educated about measures to reduce exposure**
- Decreased short-term exposure in high patients is predicted to mitigate adverse health effects in high-risk individuals
- **Randomized controlled trials are needed to proved effectiveness of interventions to reduce exposure**
- Health risks need to be addressed through integrated efforts of public health and health care at the community and individual level
- **More effective health communication strategies are needed to encourage health protective behaviors**

Thank you

Wayne E. Cascio, MD, FACC
Director, National Health and Environmental Effects Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency

Email: cascio.wayne@epa.gov

- No conflicts of interest
- The presentation represents the opinions of the speaker and does not necessarily represent the policies of the US EPA



Fall in Air Pollution Related Deaths Over Time

Fraction of Total All-Cause Deaths Attributed to PM_{2.5}

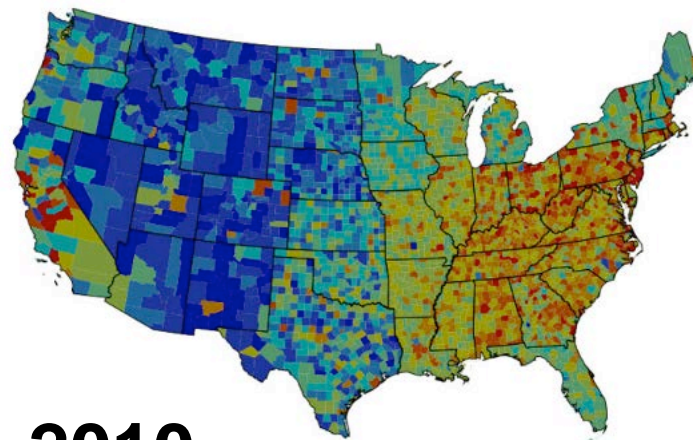
After the implementation of local, state, and federal air quality policies

- PM_{2.5} precursor emissions declined over the course of several decades

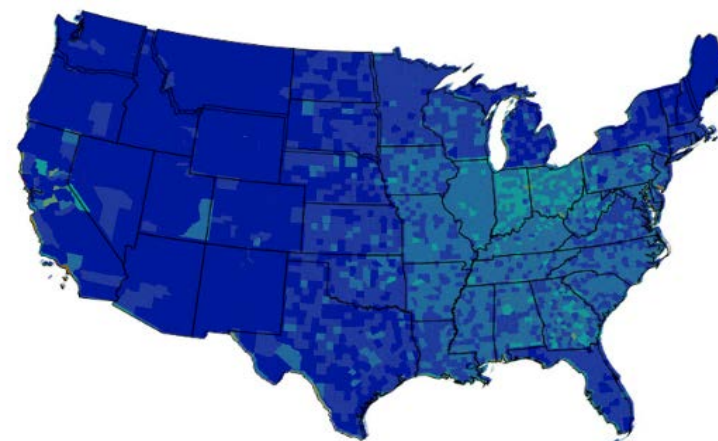
Between 1980 - 2010, PM_{2.5} exposures fell by about half, and estimated excess deaths decreased by about a third

- California, Virginia, New Jersey, and Georgia had some of the largest estimated reductions in PM_{2.5}-attributable deaths

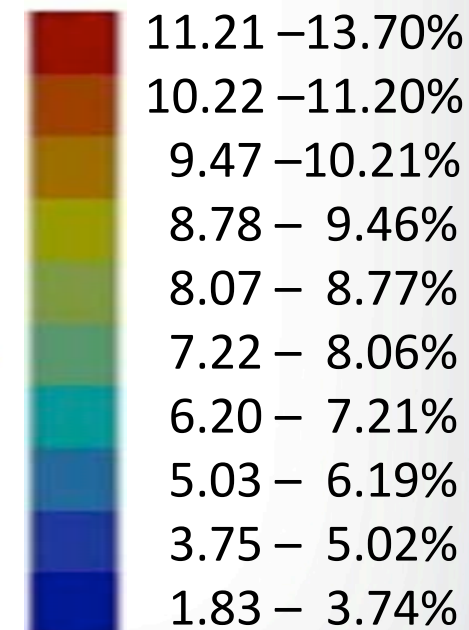
1980



2010



% of Total All-Cause Deaths Due to PM_{2.5} Between 1980 & 2010





Long-term Health Effects of Air Pollution

PM_{2.5} Exposure and Post-MI Survival in Ontario, Canada

Post-Myocardial Infarction Survival *Ontario, Canada 1999-2011*

- 8,873 patients with 4,016 non-accidental deaths
- Mortality follow-up through 2011
- Cumulative time-weighted exposures to PM_{2.5} were derived from satellite observations
- **For each 10-μg/m³ increase in PM_{2.5} non-accidental mortality increased by 22%**

Conclusions:

- Long-term air pollution exposure adversely affects the survival of Heart Attack patients

Post-Stroke Survival *London, England 1995-2006*

- 3,320 patients with 1,856 deaths
- Stroke follow-up to mid-2006
- Outdoor NO₂ and PM₁₀ modeled for 2002
- HRs were adjusted for relevant factors
- **10-μg/m³ increase in NO₂ and PM₁₀ was associated with a 28% and 52% increase in risk of death, respectively**

Conclusions:

- Improvements in outdoor air quality might contribute to better survival after stroke
- A 10 μg/m³ reduction in NO₂ exposure is expected to reduce mortality comparable to that for stroke units



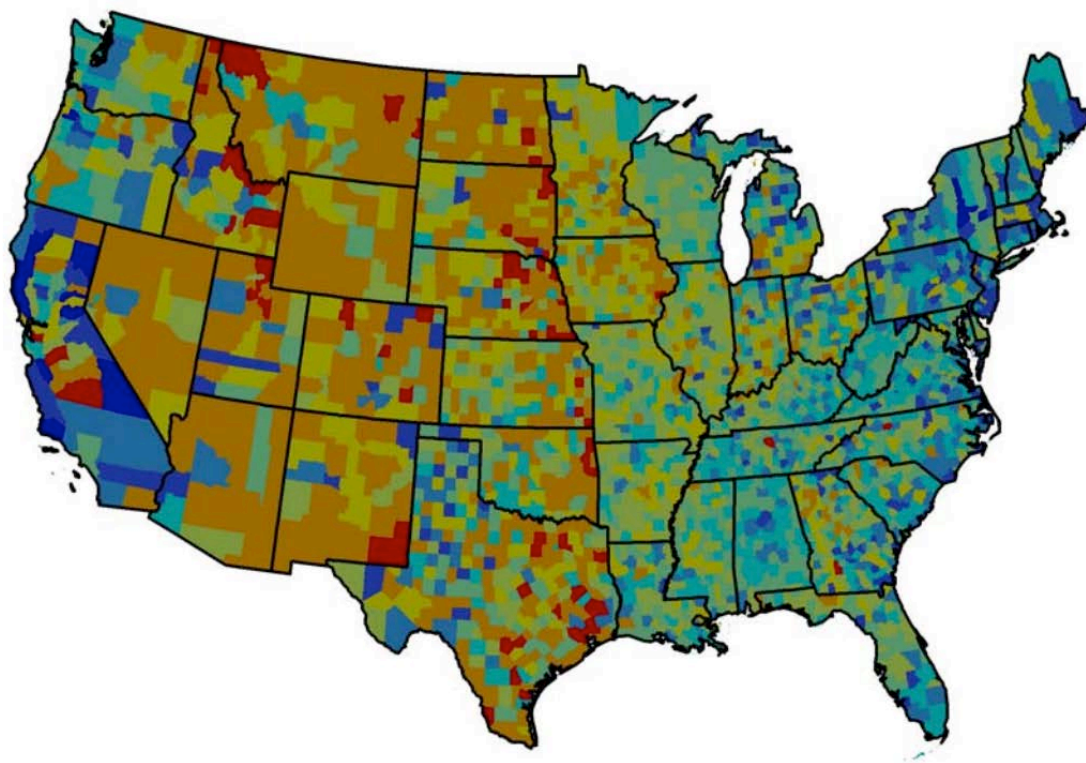
Air Pollution

Public Health Benefits of Decreasing PM_{2.5} 1980-2010

Change in the %
of Death Due to PM_{2.5}
Between 1980 - 2010



-2.85 – -0.04%
-0.03 – -0.01%
0.02 – 2.18%
2.19 – 3.01%
3.02 – 3.71%
3.72 – 4.37%
4.38 – 5.09%
5.10 – 6.07%
6.08 – 8.11%
8.12 – 11.7%



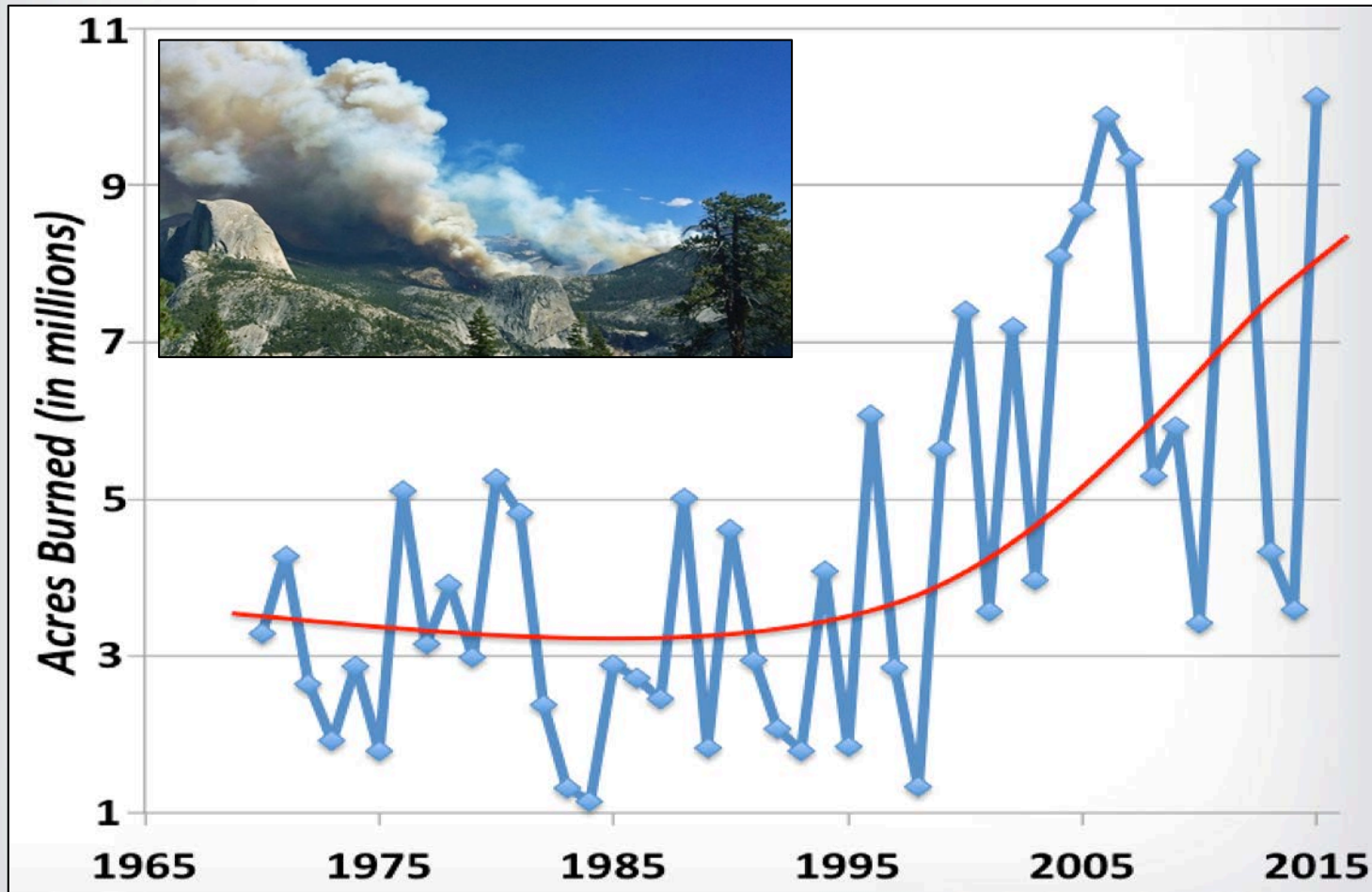
*Relative to a
hypothetical population
with exposures held
constant at 1980 levels*

- people born in 2050 would live about 1 year longer
- there would be a cumulative gain of 4.4 million life years among adults ≥30 years of age



Wildfire: An Issue of Concern for the States

Impacts of Local and National Importance



- **Wildland fires accounted for 38% of $PM_{2.5}$ emissions in 2014**
- **2017 was substantially worse than the average of the last 10 years**
- **Between 2001 - 2010 over 40% of the country's large wildfires occurred in the Southeast**
- **U.S. spends more than \$2 billion each year to fight wildfires**

Adapted from https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html



Wildfire-PM_{2.5} Increases Heart Attack & Stroke

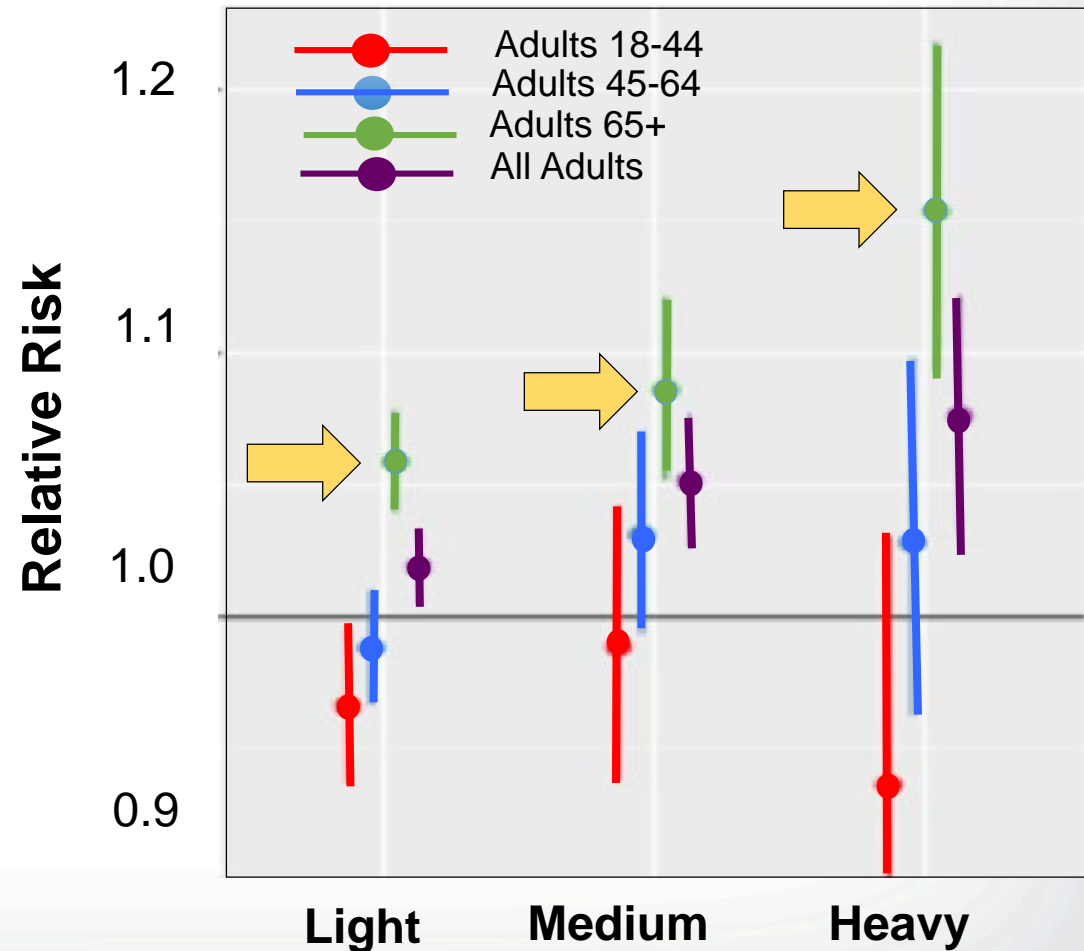
California 2015 Wildfire Study

Results: Wildfire-PM_{2.5} associated with heart attacks and strokes for all adults, particularly for those over 65 years old

- Increase in risk the day after exposure:
 - All cardiovascular, 12%
 - Heart attack, 42%
 - Abnormal heart rhythm, 24% (same day)
 - Heart failure 16%
 - Stroke 22%
 - All respiratory causes 18%

Impact: Highlights the importance of decreasing exposure in at-risk populations

All Cardiovascular Causes



Wettstein Z, Hoshiko S, Cascio WE, Rappold AG et al.
(in review, 2018)