Ambient Air Quality and Cardiovascular Health: Translation of Environmental Research for Public Health and Clinical Care

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Office of Research & Development, US EPA
Research Triangle Park, NC
Common Air Pollutants
Sources and Distribution

- **Primary air pollutants**
  - CO
  - CO$_2$
  - SO$_2$
  - Suspended particles

- **Secondary air pollutants**
  - O$_3$
  - SO$_3$
  - HNO$_3$
  - H$_2$SO$_4$
  - NO
  - NO$_2$
  - Hydrocarbons
  - H$_2$O$_2$
  - SO$_4$ salts
  - PAHs
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 ug/m³ - 24 hours
- 12 ug/m³ - annual average

Scale of the Public Health and Clinical Impact of Ambient Air Pollution
International Air Quality Measures
September 30, 2018

https://waqi.info/

World's Air Pollution : Real-time Air Quality Index
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 (95% uncertainty interval, 3.7 million to 4.8 million)
  - 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 (95% uncertainty interval 97,000 to 422,000)
  - 4.1 million DALYs from chronic obstructive pulmonary disease
Air quality in the U.S. has improved continuously over the past five decades.

Do we still need to be concerned about air quality and cardiovascular health?
Implementation of Local, State, and Federal Air Quality Policies improved Air Quality

PM2.5 Air Quality, 2000 - 2017
(Seasonally-Weighted Annual Average)
National Trend based on 429 Sites

2000 to 2017: 41% decrease in National Average

Ozone Air Quality, 2000 - 2017
(Annual 4th Maximum of Daily Max 8-Hour Average)
National Trend based on 809 Sites

2000 to 2017: 17% decrease in National Average
Fall in Air Pollution Related Deaths Over Time

Fraction of Total All-Cause Deaths Attributed to PM$_{2.5}$

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

1980

11.21 – 13.70%
10.22 – 11.20%
9.47 – 10.21%
8.78 – 9.46%
8.07 – 8.77%
7.22 – 8.06%
6.20 – 7.21%
5.03 – 6.19%
3.75 – 5.02%
1.83 – 3.74%

2010

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

Fann N, et al. Environmental Health Perspectives 2017
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

Observed PM$_{2.5}$ trends for 1988–2016 in the U.S.

- Values in $\mu$g/m$^3$/year shown by the color ramp
- Arrows show the boundary where the PM$_{2.5}$ trends are increasing or decreasing

Increase in PM$_{2.5}$ annual concentration attributed to and increase in wildfire emissions

McClure CD and Jaffe DA. PNAS 115 (31): 7901-7906, 2018
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
What do we know about the cardiovascular health effects of exposure to air particle pollution?
**Daily Variability of PM$_{10}$ & PM$_{2.5}$**

Chapel Hill, NC 1995-96

**Daily PM$_{2.5}$ changes (BLUE arrows)**

Short-term clinical events

NAAQS = 35 µg/m$^3$

**Annual average PM$_{2.5}$ (YELLOW line)**

Long-term clinical events

NAAQS 12 µg/m$^3$
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 Yang, MD, PhD, FAHA; Russell V. Joffe, MD, MS, FAHA;

Fine particulate matter (PM) or particle pollution can:

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

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

Brook RD, et al. Circulation 2010
Long-term Air Pollutant Exposure Contributes to Cardiovascular Morbidity & Mortality

Communities should be able to improve the cardiovascular health by complying with ambient air quality standards.

Ambient air particle pollution is associated with:

- Hypertension
- Ischemic heart disease
- Stroke
- Cardiovascular Mortality

Short - and Long-term Air Pollutant Exposure Contributes Directly to Cardiovascular Effects & Mortality

Ambient air particle pollution is causally associated with:

• Cardiovascular effects • Mortality

Communities should be able to improve the cardiovascular health by complying with ambient air quality standards
The dose-response curve is now better defined especially for lower concentrations
Estimates of Short-term PM$_{2.5}$ Mortality Risk
U.S. Medicare Population Jan 2000 to Dec 2012

**Exposure-Response Curve for PM$_{2.5}$**

<table>
<thead>
<tr>
<th>Air Pollutant Analysis</th>
<th>Relative Risk Increase, % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main analysis</td>
<td>1.05 (0.95-1.15)</td>
</tr>
<tr>
<td>Low-exposure analysis</td>
<td>1.61 (1.48-1.74)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air Pollutant Analysis</th>
<th>Absolute Risk Difference in Daily Mortality Rates, No per 1 million Persons at Risk/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main analysis</td>
<td>1.42 (1.29-1.56)</td>
</tr>
<tr>
<td>Low-exposure analysis</td>
<td>2.17 (2.00-2.34)</td>
</tr>
</tbody>
</table>

Di et al. JAMA 2017
Estimates of Short-term $O_3$ Mortality Risk
U.S. Medicare Population Jan 2000 to Dec 2012

Exposure-Response Curve for Ozone

Relative Risk Increase and Absolute Risk Difference of Daily Mortality Associated with each 10 ppb increase in $O_3$

<table>
<thead>
<tr>
<th>Air Pollutant Analysis</th>
<th>Relative Risk Increase, % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main analysis</td>
<td>0.51 (0.41-0.61)</td>
</tr>
<tr>
<td>Low-exposure analysis</td>
<td>0.58 (0.46-0.70)</td>
</tr>
</tbody>
</table>

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<th>Absolute Risk Difference in Daily Mortality Rates, No per 1 million Persons at Risk/Day</th>
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</thead>
<tbody>
<tr>
<td>Main analysis</td>
<td>0.66 (0.53-0.78)</td>
</tr>
<tr>
<td>Low-exposure analysis</td>
<td>0.74 (0.59-0.90)</td>
</tr>
</tbody>
</table>

Di et al. JAMA 2017
**Health & Long-term Air Pollution Exposure**

**Association between PM and Coronary Artery Disease**

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**

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

- 17% relative increase in odds of 1-2 vessel, and 24% increase in ≥ 3 vessel CAD
- 14% increase in odds of having a heart attack within 3 years

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Estimates of Long-term PM$_{2.5}$ Mortality Risk
Meta-Regression Analysis Based on 53 Studies

Meta-Regression analysis of long-term PM$_{2.5}$ exposure and percent change in mortality

Meta-Regression association between long-term PM$_{2.5}$ exposure on overall and specific mortality risk

<table>
<thead>
<tr>
<th>Mortality</th>
<th>Percent Increase at PM$_{2.5}$ = 10 (%)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality</td>
<td>1.29 (1.09-1.50)</td>
<td>0.033</td>
</tr>
<tr>
<td>Cause specific mortality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular mortality</td>
<td>1.46 (1.25-1.67)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lung cancer mortality</td>
<td>1.22 (0.87-1.39)</td>
<td>0.008</td>
</tr>
<tr>
<td>Respiratory mortality</td>
<td>1.13 (0.85-1.41)</td>
<td>0.139</td>
</tr>
<tr>
<td>Cardiopulmonary mortality</td>
<td>1.92 (1.59-2.25)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Elderly studies only</td>
<td>1.61 (1.35-1.85)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Female studies only</td>
<td>1.31 (1.01-1.62)</td>
<td>0.892</td>
</tr>
</tbody>
</table>

Vodonos A et al. Environ Res 2018
Who’s at risk from exposure to air particle pollution?
Susceptible populations include –

- those with pre-existing cardiovascular disease
- those with pre-existing respiratory disease
- older adults
- those having 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)
Air Pollution and Mortality
Effect of PM on Survival and Subsequent Clinical Events

Zanobetti A & Schwartz J.
*Environ Health Perspect* 2007

Koton *et al.*
*Prev Med* 2013

Tonne *et al.*
*Eur Heart J* 2013

Tonne *et al.*
*Int J Hyg Envir Health* 2016

Chen *et al.* *EHP* 2016
*Environ Health Perspect* 2016

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**Hazard Ratio (per 10µg/m³)**

- **PM$_{10}$, 21 U.S. cities, 1985-1999**
- **PM$_{2.5}$, Israel, 1992-2005**
- **PM$_{2.5}$, Israel, 1992-2011**
- **PM$_{2.5}$, London, 2004-2010**
- **PM$_{10}$, London, 2003-2010**
- **PM$_{2.5}$, Ontario, 1999-2011**

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**Data Sources**

- Mortality
- CHF hospitalization
- MI hospitalizations
- MI, CHF, Stroke
- Mortality
- Mortality
- MI Mortality
Are the cardiovascular health effects present in epidemiology studies biologically plausible?
Air-Related Environmental Factors Acting on the Cardiovascular System

Argacha JF et al. Trends in Cardiovascular Medicine 2018


Gaseous
- NO₂
- O₃
- CO

Particles (PM₁₀, PM₂.₅, UFP)
- Transition metal
- PAH
- Quinones

Nicotine
- Lung arc reflex
- Perip. chemoreflex
- Tegmino-cardiac arc reflex

Cold Air
- Airway
- Facial

Factors
- Agent

Transduction
- ALVEOLOCAPILLARY OXYDATIVE STRESS REACTIONS
- SYSTEMIC OXYDATIVE STRESS and INFLAMMATORY REACTIONS
- DECREASE NO BIOAVAILABILITY
- OXIDIZED-LDL, DYSFUNCTIONAL-HDL
- MONOCYTE / PLATELET ACTIVATION

Effects
- Endothelial Dysfunction
- Endothelial Activation
- Endothelial Injury
- BF autoregulation
- Atherogenesis
- Plaque Rupture
- Ischemia
- Athero-thrombosis

Outcome
- ACS-NSTEMI
- ACS-STEMI
- Stroke
- Arrhythmia
- Heart Failure

Short-term and long-term cardiovascular mortality

2018 EHSP Fall Forum
Air Pollution Worsens Vascular Risk Factors
Risk Factors for Atherosclerosis and Air Quality

Poor Air Quality:

Age – might accelerate aging
  Ward-Cavinness et al. Octotarget 2016
  McCracken et al. Environ Health Perspect 2010

Total Cholesterol – increases cholesterol
  Shanley et al. Epidemiology 2016

HDL – decreases HDL particle number
  Bell et al. Arterioscler Thromb Vasc Biol 2017

LDL – oxidizes LDL and ox-LDL receptor
  Gong et al. Genome Biol. 2007
  Wu et al. Chemosphere 2015

Systolic BP – increases blood pressure

Diabetes – associated with type II diabetes
  Renzi et al. Environ Int 2017

Statin Therapy – might protective
  O’Neill et al. Occup Environ Med 2007
  Alexeiff et al. Environ Health Perspect 2011

http://tools.acc.org/ASCVD-Risk-Estimator-Plus/#!/calculate/estimate/
Long-Term PM$_{2.5}$ & NO$_2$ Exposure Increases Coronary Artery Calcium

### Air Pollutants

- PM$_{2.5}$ (5µg/m$^3$)
- NO$_x$ (40ppb)
- NO$_x$ (10ppb)
- Black carbon (0.5µg/m$^3$)

**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


EPA

2018 EHSP Fall Forum
Long-term PM$_{2.5}$ & Nox Exposure Associated Atherosclerosis Progression

MESA Air Study – Led by University of Washington

PM$_{2.5}$ and Coronary Calcium

After 10 years 80 Agatston Unit difference between annual PM$_{2.5}$ of 10 and 20 µg/m$^3$

Emerging Areas of Health Effects Research
Neurological and Neurodegenerative

Air Pollution & Neurotoxicity in Adults

- **Effects on Neurodegenerative Disorders**
  - *Parkinson’s*  
  - *Multiple sclerosis*

- **Non-Specific Neurological Symptoms**
  - *Cognitive Function*  
    (Tallon et al. Environ Internat 2017)
  - *Fatigue*
  - *Anxiety and Depression*  
    (Szyszkowicz M et al. Environ Health insights 2016; Pun EHP 2016; Vert Intern J Hygiene Envir Health 2017)

Air Pollution & Neurotoxicity in Children

- **Effects on Child Neurodevelopment**
  - *Prenatal exposure to air pollution*
  - *Childhood exposure to air pollution*

- **Neurodevelopmental Disorders**
  - *Autism Spectrum Disorder*
  - *Attention-Deficit Hyperactivity Disorder*

Accelerated Biological Aging

- **Effects on telomeres**
  - *Shortened telomeres measured at birth and in adults an indicator of biological aging*  
    (Martens DS et al. JAMA Pediatrics 2017; Ward-Caviness et al. Octotarget 2016)
Emerging Areas of Health Effects Research
Reproductive and Developmental

Infertility
• **Gametogenesis** (Carré J et al. Environmental Health 2017)

Fetal Growth
• exposure to PM_{10}, PM_{2.5} and NO_{2} was associated with reductions in measurements at birth and biparietal diameter from late second trimester onwards. (Clemens T et al. Environ Internat 2017)

Stillbirth
• ambient air pollution suspected of increasing stillbirth (Siddika et al. Occup Environ Med. 2016)

Preterm Delivery
• PM_{2.5} constituents and preterm delivery were observed for Blacks and Asians, older mothers, and those with some college education compared to their reference groups (Basu R et al. Ped Perinatal Epi 2017)

Low Birth Weight
• exposure to PM_{2.5} is associated with low birth weight. (Rosa MJ et al. Environ Internat 2017)

Accelerated Biological Aging
• exposure to PM_{2.5} shortened telomeres measured at birth, an indicator of biological aging (Martens DS et al. JAMA Pediatrics 2017)
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
What can the health care community do to reduce the adverse impact of air pollution?
“Air pollution should be viewed as one of several major modifiable risk factors in the prevention and management of cardiovascular disease.”

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

Examples of Products

Particle Pollution and Your Patients’ Health

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

Heart Disease, Stroke, and Outdoor Air Pollution

- 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 other health effects.
  - The pollution can also increase the risk of heart disease and stroke.
  - In some cases, it can even cause death.

Million Hearts®

- Working to prevent a million heart attacks and strokes

Proud Supporter

- Environmental Protection Agency (EPA)
AirNow.gov Redesign Now Active

• Up-dated Look: focus on local conditions
• Mobile-friendly web site
• Same great information
  - Health Care Provider page
  - Fires: Current Conditions page
• Better display of temporal changes in air quality
Public Education
Air Quality Index Available at AirNow.gov

- 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

<table>
<thead>
<tr>
<th>Descriptors</th>
<th>Cautionary Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>No message</td>
</tr>
<tr>
<td>0 – 50</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>Unusually sensitive individuals</td>
</tr>
<tr>
<td>51 – 100</td>
<td></td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups</td>
<td>Identifiable groups at risk - different groups for different pollutants</td>
</tr>
<tr>
<td>101 - 150</td>
<td></td>
</tr>
<tr>
<td>Unhealthy</td>
<td>General public at risk; sensitive groups at greater risk</td>
</tr>
<tr>
<td>151 - 200</td>
<td></td>
</tr>
<tr>
<td>Very Unhealthy</td>
<td>General public at greater risk; sensitive groups at greatest risk</td>
</tr>
<tr>
<td>201 - 300</td>
<td></td>
</tr>
</tbody>
</table>
AirNow
National AQIs & forecast
August 29, 2017

Fresno, CA
AQI & forecast
August 29, 2017
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

http://www.epa.gov/healthyheart/
Healthy Heart Toolkit
www.epa.gov/air-research/healthy-heart-toolkit-and-research

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

Are you at risk?
- Age 65 or older
- Heart disease
- High blood pressure
- High cholesterol
- Diabetes
- Asthma

Steps to Protect Your Heart

How to Reduce your Risk?

Warning Signs of a Heart Attack

Warning Signs of a Stroke
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

http://millionhearts.hhs.gov/aboutmh/partners/epa.html
**Optimizing Care**

### Support includes: Counseling on risks of particulate matter

<table>
<thead>
<tr>
<th>Goals</th>
<th>Effective Health Care Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Improve ABCS</strong></td>
<td><em>High Performers Excel in the Use of...</em></td>
</tr>
<tr>
<td>Targets: 80%</td>
<td>• <strong>Teams</strong>—including pharmacists, nurses, community health workers, and cardiac rehab professionals</td>
</tr>
<tr>
<td></td>
<td>• <strong>Technology</strong>—decision support, patient portals, e- and default referrals, registries, and algorithms to find gaps in care</td>
</tr>
<tr>
<td></td>
<td>• <strong>Processes</strong>—treatment protocols; daily huddles; ABCS scorecards; proactive outreach; finding patients with undiagnosed high BP, high cholesterol, or tobacco use</td>
</tr>
<tr>
<td><strong>Increase Use of Cardiac Rehab</strong></td>
<td>• <strong>Patient and Family Supports</strong>—training in home blood pressure monitoring; problem-solving in medication adherence; counseling on nutrition, physical activity, tobacco use, risks of particulate matter; referral to community-based physical activity programs and cardiac rehab</td>
</tr>
<tr>
<td>Target: 70%</td>
<td></td>
</tr>
<tr>
<td><strong>Engage Patients in Heart-Healthy Behaviors</strong></td>
<td></td>
</tr>
<tr>
<td>Targets: TBD</td>
<td></td>
</tr>
</tbody>
</table>

*Aspirin when appropriate, Blood pressure control, Cholesterol management, Smoking cessation*
## Improving Outcomes for Priority Populations

<table>
<thead>
<tr>
<th>Priority Populations</th>
<th>Major Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blacks/African Americans</td>
<td>Improving hypertension control</td>
</tr>
<tr>
<td>35- to 64-year-olds, because event rates are rising</td>
<td>• Improving hypertension control and statin use</td>
</tr>
<tr>
<td></td>
<td>• Increasing physical activity</td>
</tr>
<tr>
<td>People who have had a heart attack or stroke</td>
<td>• Increasing cardiac rehab referral and participation</td>
</tr>
<tr>
<td></td>
<td>• Avoiding exposure to particulate matter</td>
</tr>
<tr>
<td>People with mental illness or substance use disorders</td>
<td>Reducing tobacco use</td>
</tr>
</tbody>
</table>
Million Hearts®

Provides Educational Tools on Particle Pollution

https://millionhearts.hhs.gov
Particle Pollution and Your Patients' Health

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.

Start the Course

Course developers

www.epa.gov/particle-pollution-and-your-patients-health
Particle Pollution and Your Patients' Health

What is Particle Pollution?

On this page:

- What is particle pollution and what types of particles are it?
- Where does particle pollution come from?
- Where and when is particle pollution a problem?

Particle pollution, also known as particulate matter or PM, is a complex mixture of liquid droplets and solid particles in the air. These particles can be either natural, such as dust and pollen, or from human activities, like burning fossil fuels or industrial processes. They come in various sizes, from very small to larger ones, each with its own health impacts.

Particle Pollution Exposure

On this page:

- Why is particle pollution exposure a health concern?
- What groups are at increased risk from particle pollution?
- Are there symptoms of particle pollution exposure?
- How does an individual’s genetic background influence particle pollution response?
- How are particles deposited in the respiratory system?
- What are the lung’s defense mechanisms against fine particles?

Why is particle pollution exposure a health concern?
Particle Pollution: Cardiovascular Effects

On this page:
- Why is particle pollution a cardiovascular health concern?
- How does particle pollution affect the cardiovascular system?
- What are the cardiovascular effects?
- What are the acute exposure effects?
- What are the chronic exposure effects?

Particle Pollution and Your Patients' Health

Why is particle pollution a cardiovascular health concern?

Cardiovascular disease accounts for the greatest number of deaths per year. An estimated 610,000 Americans die annually from cardiovascular disease, accounting for one in three deaths. Cardiovascular diseases include coronary artery disease (CAD), heart attack, stroke, hypertension, and other conditions that affect the heart or blood vessels. Exposure to particle pollution can contribute to the development and progression of cardiovascular disease, increasing the risk of heart attack, stroke, and other complications.

Clinical Scenarios – Particle Pollution

Clinical Scenario 1

Mr. Richards is a man of 75 years with a history of hypertension, hyperlipidemia, diabetes, and atherosclerotic coronary artery disease. In spite of coronary artery bypass grafting, he still has residual flow-limiting coronary artery disease and stable angina. With therapeutic lifestyle changes and medications, Mr. Richards has achieved his goal for blood pressure, A1C, and serum lipids, and is generally free from angina except when doing very strenuous activity. His daily exercise routine includes walking in his neighborhood in the late afternoon. The initial part of Mr. Richards' route takes him along a sidewalk adjacent to a busy road carrying heavy afternoon automobile, bus, and truck traffic. As he returns to his home, his route takes him up a steep hill. Most of the time, Mr. Richards can complete his walk in 60 minutes without shortness of breath or angina. Occasionally, though, he
High Resolution Air Pollution Mapping
Small Scale Variability due to Local Sources

Oakland, CA
Spatial distribution of Black Carbon (BC)

Apte JS et al. Environ Sci Technol 2017

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


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

Fisk WJ, Chan WR Indoor Air 2017

“… 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

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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
Particulate Matter (PM) is derived from many different sources.
Wildland Fires & Their Emissions
Rural & Urban Community Public Health Issue

Wildfire spreads to Gatlinburg and Pigeon Forge

Photo: Bruce McCamish
Wildfire in the U.S.
Acreage Burned in the U.S. Annually

Present Concerns

• Increasing acreage burned
• Increased vulnerability of populations
• Increasing impact on urban areas
  - 10% of all land with housing are situated in the wildland-urban interface
  - 38.5% of U.S. housing units (Radeloff et al. 2005)

Adapted from https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html
**Problem:**
Cardiovascular health effects of wildfire smoke are uncertain

**Approach:**
- Epidemiology study during the 2015 California wildfire season
- Associate wildfire-PM$_{2.5}$ exposure with emergency department visits for cardiovascular and respiratory diagnoses

*Measuring the Health Effects of Wildfire Smoke*
*California 2015 Wildfire Study*

**Smoky days/county during the study: May through September 2015**

California air basins included in the study are labeled and outlined in black

Wettstein Z, Hoshiko S, Cascio WE, Rappold AG et al. JAHA April 11, 2018
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%
- Heart failure, 16%
- Stroke, 22%
- All respiratory causes, 18%
- Abnormal heart rhythm, 24% (on the same day as exposure)
National map of community-health vulnerability index and air pollution awareness to adverse health effects

Factors of Vulnerability
- Peds & Adult Asthma
- COPD
- Obesity
- Diabetes
- Hypertension
- % population age 65+
- Income, education, poverty, unemployment