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AMBIENT AIR POLLUTION
KILLS ABOUT 4 MILLION PER YEAR GLOBALLY
At least 1.2 million lung cancer cases
In the USA, 234,000 lung cancers annually
At least 10% due to air pollution and
14% due to air+ smoking interactions.

Air Pollution and Other Cancers

- Epidemiologic evidence is growing that air pollution can cause cancers at multiple sites
- Mechanism: absorption, metabolism, and distribution of inhaled carcinogens
- Epidemiologic associations with:
  - Bladder and kidney
  - Breast (incidence and shortened survival time)
  - Brain
  - Blood (e.g., Leukemias and lymphomas)
  - Childhood cancer studies limited by size, but suggestive evidence for leukemia, as well as for other sites (CNS, GI, skin)

Occupation and Cancer

- Occupation plays a historical role in our understanding of environmental cause of cancer:
  - Dr. Percival Pott and London chimney sweeps with soot-related scrotal cancer
  - Most of what we know about environmental exposures that cause cancer comes from occupational exposures – which are usually much higher
  - Examples: asbestos, diesel, benzene, gasoline exhaust, polycyclic aromatic hydrocarbons (PAH), dusts (metals, silica), asphalt fumes, welding, mining industry, trucking industry

Ambient Air Pollution: "A Mixture of Mixtures"

A complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air

Outdoor air pollution - as a *whole* - as **carcinogenic to humans** (Group 1 by IARC)

Globally, air pollution (broadly defined) is estimated to cause about **29% of lung cancer deaths** (WHO)

Major Air Pollutants

Pollutant	Example	Physical state	Major sources
PM ($PM_{2.5}$, PM_{10}, TSP)	Sulfate; metal oxides; carbonaceous materials, OC and EC	Particulate	Dust storms, fossil fuel combustion, biomass fuel combustion, biogenic emissions, fertilizer use
Ozone (O_3)	O_3	Gas	Generated from NOx, VOCs, and CO
Sulfur dioxide (SO_2)	SO_2	Gas	Fossil fuel combustion, natural emissions
Carbon monoxide (CO)	CO	Gas	Fossil fuel combustion, oxidation of biogenic VOC emissions
Nitrogen dioxide (NOx)	NO_2	Gas	Combustion processes
HAPs	benzene, 1,3-butadiene, formaldehyde, acids	Gas	Incomplete combustion, chemical processing, solvent use
Organic carbon (OC)	Hopanes, steranes, PAHs	Particulate	Fossil and biomass fuel combustion
Mercury (Hg)	Hg, methyl mercury	Gas and particulate	Coal combustion, ore refining, natural
Lead (Pb)	Pb	Particulate	Leaded fuel combustion, lead processing

Many Outdoor Air Agents are Established or Probable IARC Carcinogens

	Agent	IARC Classification
Metals and Fibers	Arsenic and inorganic As compounds	1
	Asbestos	1
	Beryllium	1
	Cadmium	1
	Chromium (VI)	1
	Lead, inorganic/organic	2A/3
	Nickel	2B/1
	Silica dust	1
Organic Chemicals	1,3,-Butadiene	1
	Benzene	1
	Ethylene oxide	1
	Formaldehyde	1

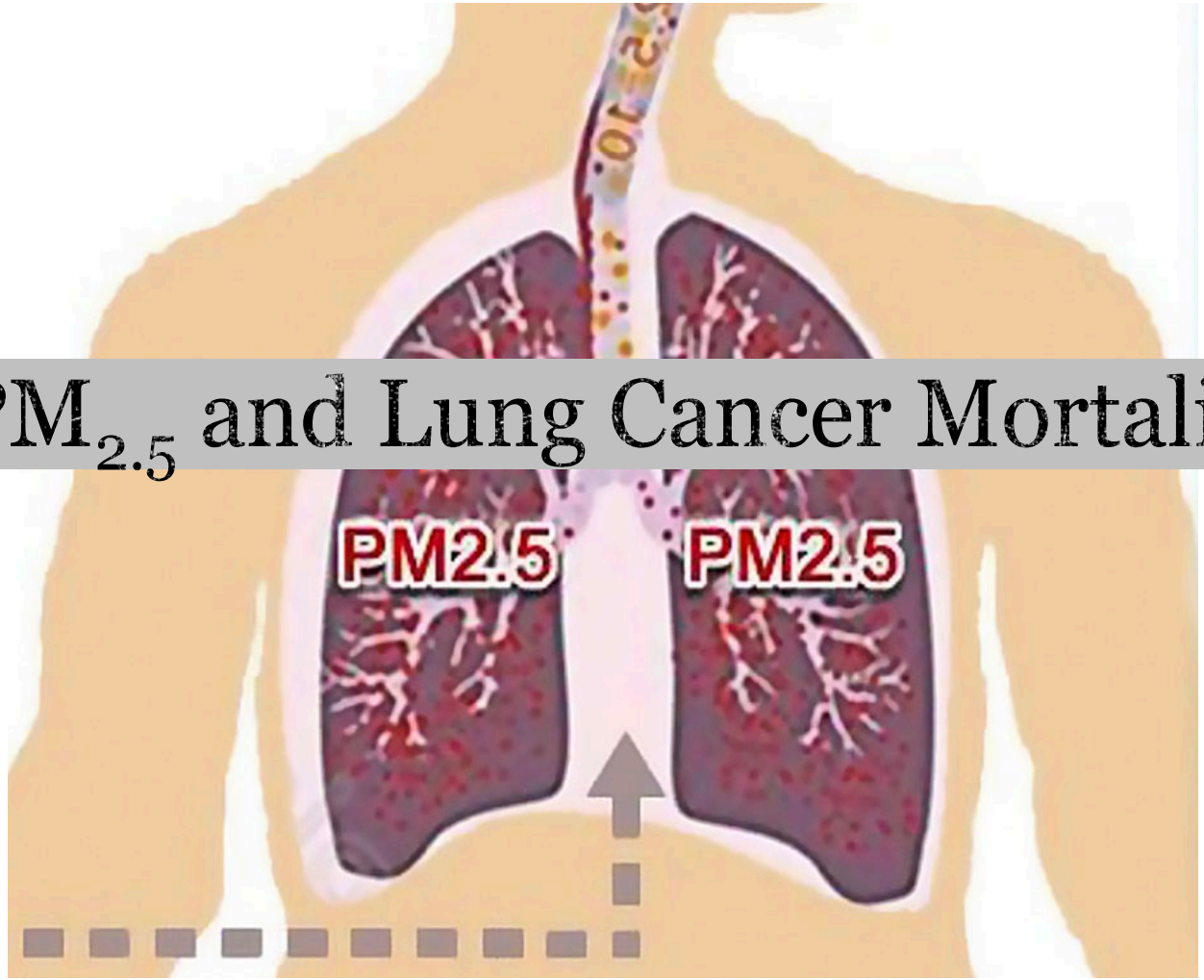
Outdoor Air Agents that are Established or Probable IARC Carcinogens

	Agent	IARC Classification
Halogenated chemicals	Ethylene dibromide	2A
	2,3,7,8-Tetrachlorodibenzo-para-dioxin	1
	Tetrachloroethylene	2A
	Trichloroethylene	1
	Vinyl bromide	2A
	Vinyl chloride	1
	Vinyl fluoride	2A
PAHs	**Benzo[a]pyrene**	**1**
	Cyclopenta[cd]pyrene	2A
	Dibenz[a,h]anthracene	2A
	6-Nitrochrysene	2A
	1-Nitropyrene	2A
	2-Nitrotoluene	2A

Outdoor Air Agents that are Established or Probable IARC Carcinogens

	Agent	IARC Classification
Mixtures	Biomass fuel (primarily wood), indoor emissions from household combustion	2A
	Coal	1
	Coal tar pitch	1
	Coke production	1
	Creosotes	2A
	Diesel engine exhaust	1
	Frying, emissions from high-temperature	2A
	Mineral oils, untreated or mildly treated	1
	Polychlorinated biphenyls (PCBs)	1
	Polybrominated biphenyls	2A
	Tobacco smoke, second-hand smoke	1
	Wood dust	1

$PM_{2.5}$ and Lung Cancer Mortality



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American Cancer Society Study (2002)

- 1.2 million adults enrolled in 1982
- 500,000 adults were linked with air pollution data, 1982-1998
- **10 µg/m³ elevation in $PM_{2.5}$** was associated with:
  - **8%** increase in lung cancer mortality
  - **6%** increase in cardiopulmonary mortality
  - **4%** in crease in all-cause mortality

Pope et al. *JAMA* 2002

$PM_{2.5}$ Global Burden of Disease (GBD) Study

- Lung cancer and COPD mortality
  - 195 countries from 1990 to 2015
  - Spatial and temporal trends in mortality and burden of disease attributable to ambient *PM 2.5 air pollution* from 1990 to 2015

	Lung Cancer	COPD
GBD 2015	16.5%	27.1%
GBD 2017	18.6%	31.3%

PATHWAYS FOR CLINICIANS TO REDUCE AIR POLLUTION RISKS

- **What roles can clinicians play?**
  - Reducing exposure to air pollution is an important opportunity for cancer prevention. Yet the tools most familiar to clinicians--education about risk factors and steps that individuals can take--are insufficient for reducing exposures because pollution is largely beyond the control of the individual.

PATHWAYS TO REDUCE AIR POLLUTION CANCER RISKS

- Inform patients: AQI: air alerts- patient advisories.
- Workplace controls (substitution, engineering, PPE).
- Transportation (walk/bike/public vs driving)
- Reducing fossil fuel use: health-care waste reduction.
- Energy efficient appliances & tools
- Recycle & Reuse
- Advocacy: Speaking, public education, policy pressure
- Example of professional advocacy: American Thoracic Society (ATS), American Lung Association (ALA) and American Cancer Society (ACS) amicus briefs, professional and public education
- Public policy is key: science-based regulations
- Protect the Clean Air Act