RUTGERS
School of Public Health

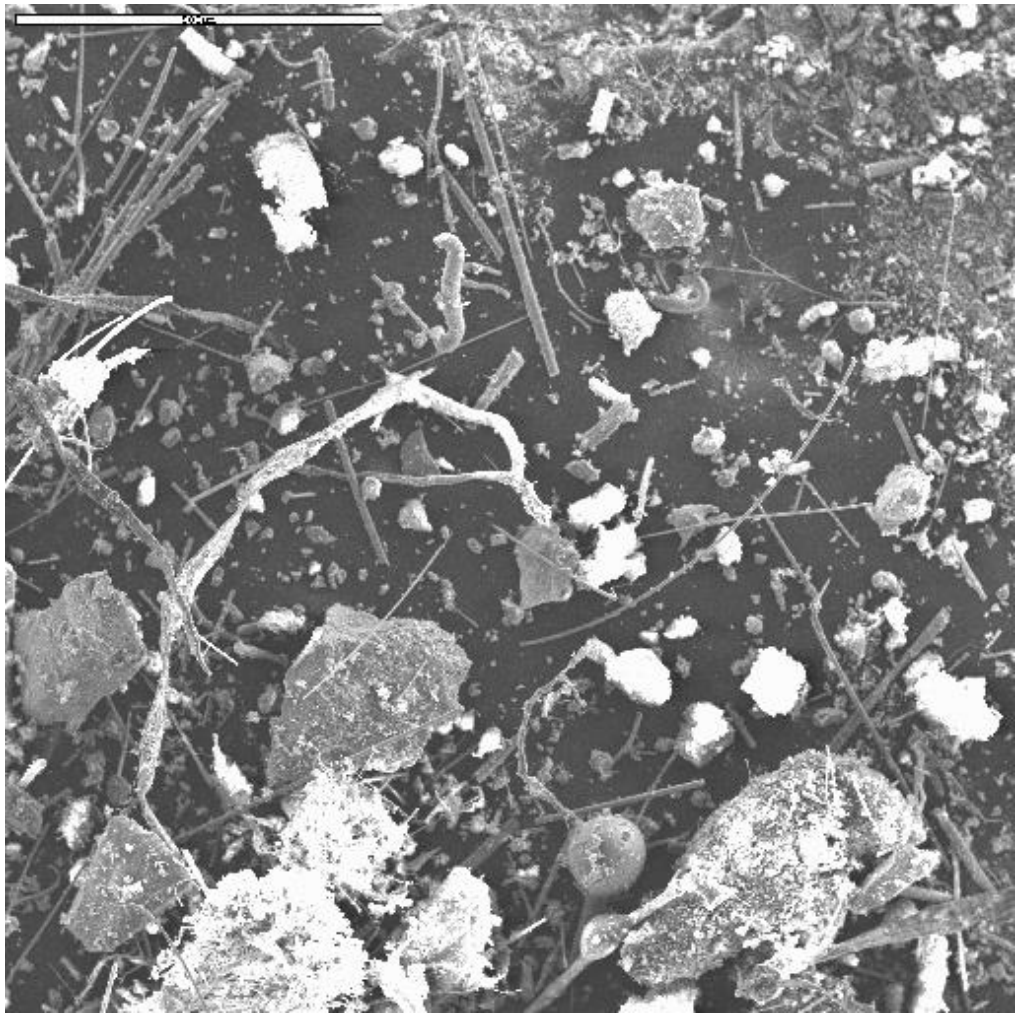
Health Effects of Fugitive Dusts

With Emphasis on Urban Road Dust

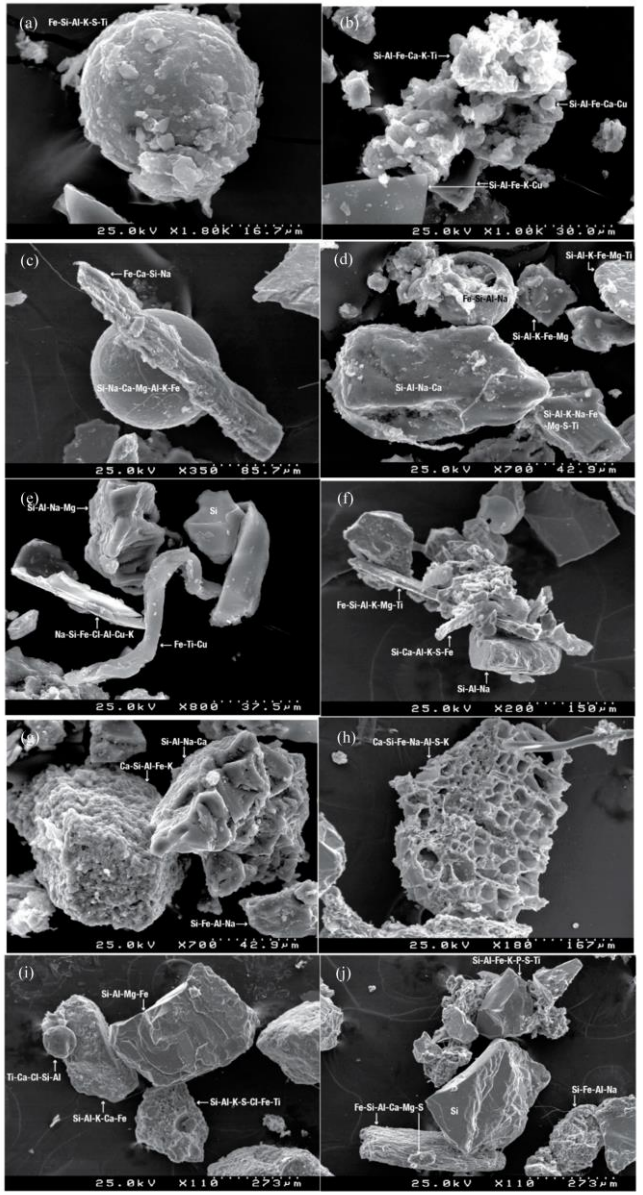
Robert Laumbach MD, MPH, CIH
Rutgers School of Public Health
April 21, 2021

Overview

- The wide range of potential health effects from the wide range of fugitive dusts
- Some general principles that may be useful
- Focus on two examples of greater prominence in New Jersey
  - Construction/demolition dust (silica)
  - Urban road dust



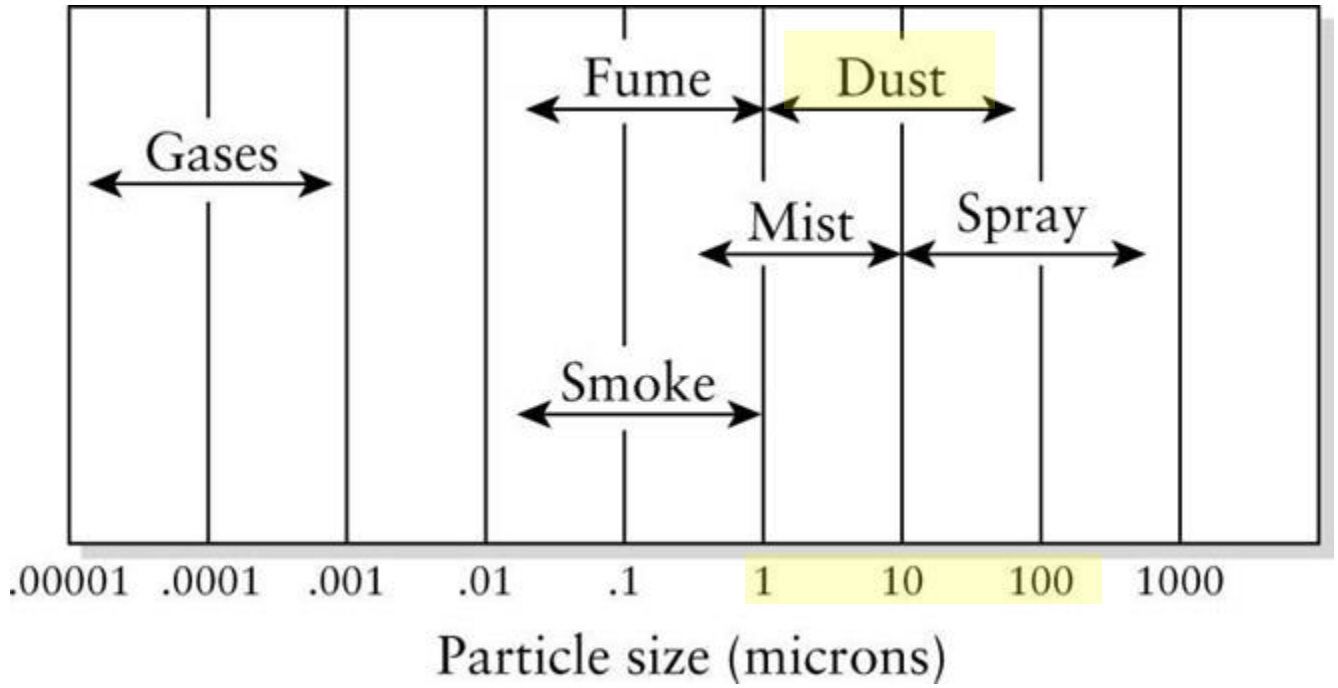
9/11 dust from Battery Park (USGS)



Road dust, Viana do Castelo, Portugal

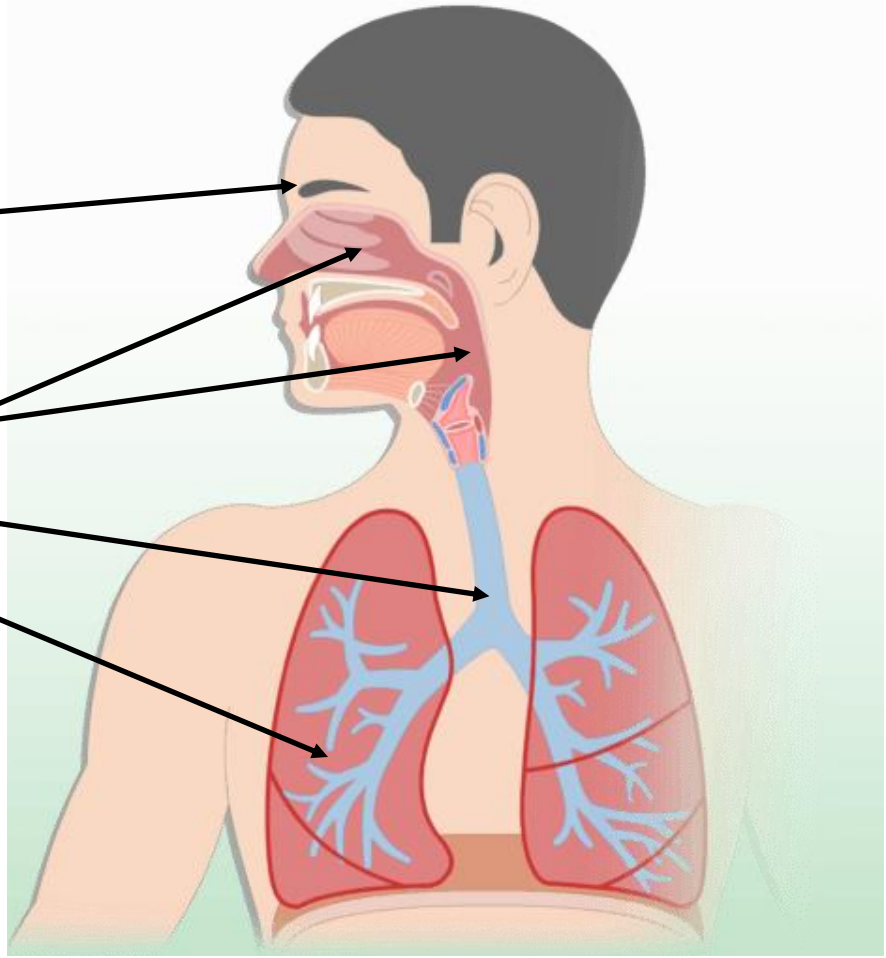
Dust particle size range

- Largely determines health effects of a particular dust
- Airborne dust size ranges from about 1 µm to over 100 µm.
- Covers full range of sizes that can deposit on skin and eyes, and in the respiratory tract from the nose to alveoli



Particle Category	Size (aerodynamic equiv. diameter)
Total	All sizes of particles in air
Inhalable	≤ 100 μm
Thoracic	≤ 10 μm
Respirable	≤ 4 μm
PM_{10}	≤ 10 μm
$PM_{2.5}$	≤ 2.5 μm

Local effects:



Other Factors in Determining Toxicity

- Chemical composition – e.g. metals, organics
- Solubility in airway lining fluid
- Isotopic composition (radioactivity)
- Crystalline structure
- Shape of particle
- Dosing
  - Concentration x Time = K?
  - But high concentrations over short times may overwhelm defense mechanisms

Exposure pathways

- **Inhalation**
  - Inhalable, suspendable particles that fall to the ground within seconds over meters
  - Respirable particles that remain suspended for long periods of time and distance

- **Skin contact**
  - A range of particle sizes can deposit on and adhere to skin

- **Ingestion**
  - Road dust that becomes yard dust and/or house dust
  - Children and hand-to-mouth exposure

The general, potential toxic effects of fugitive dusts

- **Sensory irritation or allergic sensitization** in eyes and upper airway
  - Burning sensation, coughing, bronchoconstriction
  - Exacerbation of asthma or COPD

- **Oxidative stress and inflammation**
  - Recruitment of immune cells that release inflammatory mediators
  - Swelling of epithelium, mucus production, bronchoconstriction
  - Exacerbation of asthma, acute and chronic bronchitis

Potential toxic effects

- **Fibrosis**
  - Chronic “scarring” during injury repair by fibroblasts
  - Loss of lung tissue elasticity and oxygen/CO_2 exchange
  - High-level, long-term exposure to certain dusts

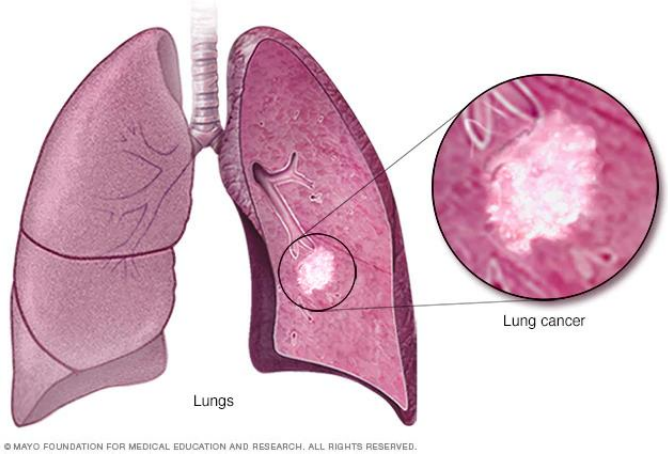
Potential toxic effects

- **Allergic sensitization**
  - Pollen, mold spores
  - Allergic rhinitis / asthma
  - Hypersensitivity pneumonitis (e.g. farmer's lung)

- **Infection**
  - Rare
  - Pathogens such as coccidiomycosis ("valley fever" in western US)
  - Increased susceptibility to infections, such as COVID-19 (?)

Potential toxic effects

- **Cancer**
  - Lung, oral cavity, nasal cavity, pharynx, larynx
- **Systemic toxicity**
  - Dissolution and absorption in the respiratory or GI tracts
  - Translocation of insoluble particles to the systemic circulation
  - Inflammation in the respiratory tract that “spills over” into the blood stream
- **“Extra-pulmonary” health effects of PM**
  - Cardiovascular disease
  - Adverse reproductive effects
  - Neurodevelopmental and degenerative

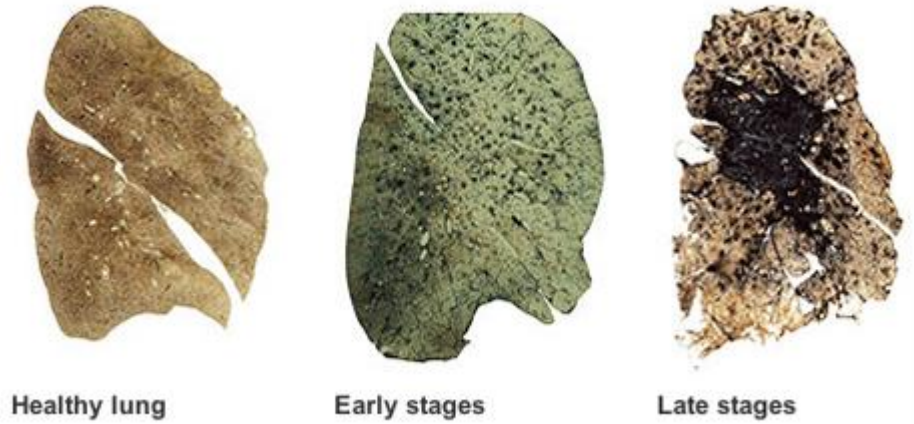


Potential toxic effects

- **Of course, “the dose makes the poison”**
  - We know very little about dose-response relationships and risk from common fugitive dust exposures
  - Especially for chronic exposure

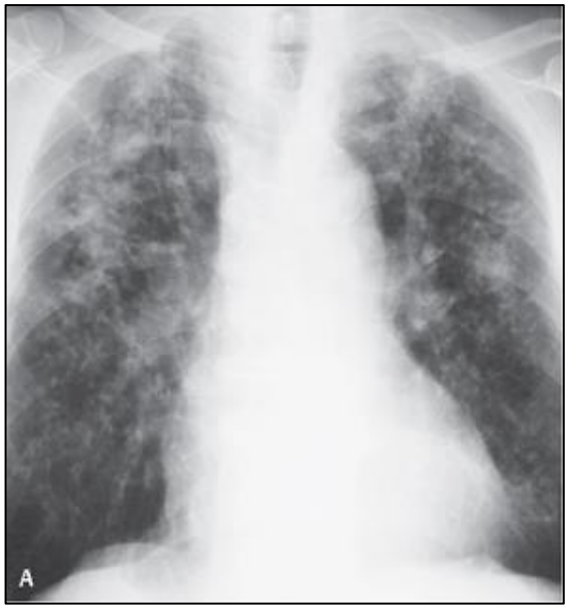
Pneumoconioses

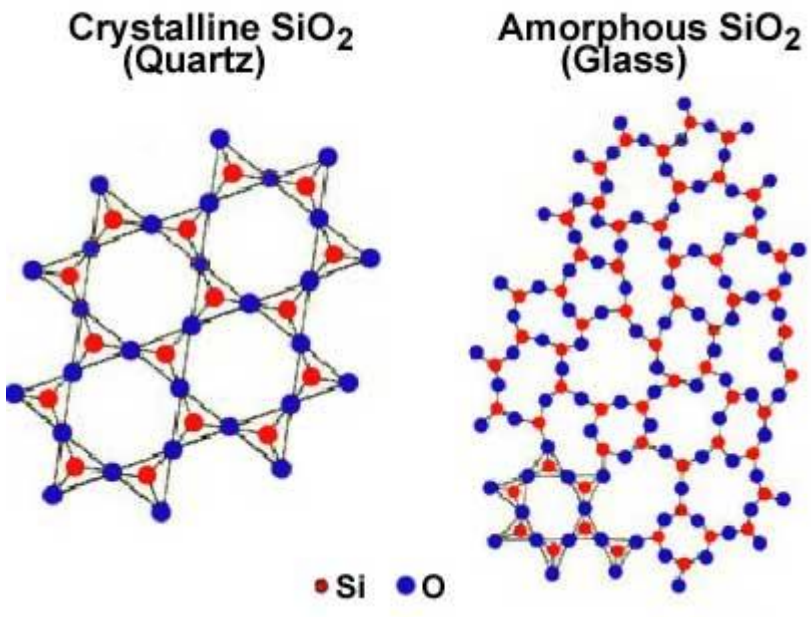
- “Accumulation of dust in the lungs and the tissue reaction to its presence.” – International Labor Organization (ILO)
- Asymptomatic to fatal
- Asbestosis, silicosis, black lung (coal), stannosis (tin), siderosis (iron)
- Usually caused by prolonged, high-level exposure
- Chronic development of fibrosis (scarring), typically over many years or decades



Example: Silicates (SiO_2- containing minerals)

- Vary in toxicity from relatively inert (silicon, amorphous silica) to highly toxic (asbestos, quartz)
- Respirable size crystalline silica causes silicosis and lung cancer





Fugitive silica dust from construction

- Controls that reduce worker exposure also limit broader public exposure

Circular saw cutting concrete with no controls

Wet cutting methods

Non-exhaust particle emissions from road traffic

- Wearing down of brakes, clutches, tires, and road surface
- Resuspended road dust particles

Non-exhaust particle emissions from road traffic

- Health impacts are disproportionately large compared to other PM sources with highest emission levels in densely populated areas.
- Contain metals and organics such as PAHs linked to health effects
- Significant burden on public health
- New report: OECD 2020. *Non-exhaust Particulate Emissions from Road Transport : An Ignored Environmental Policy Challenge*

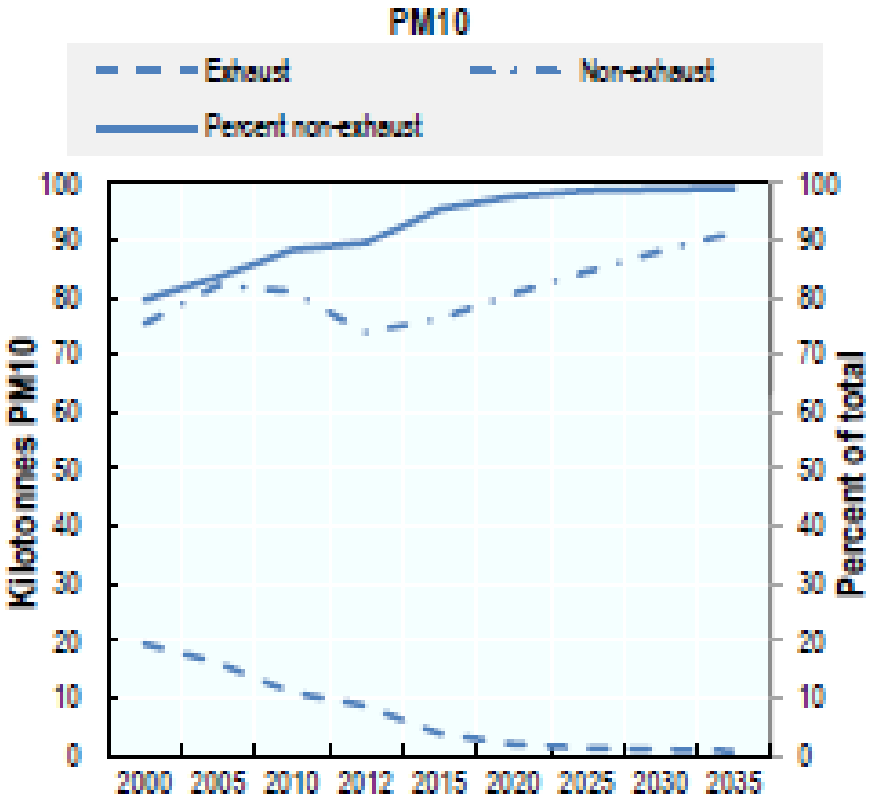
US estimates for road dust vs. on-road mobile PM emissions

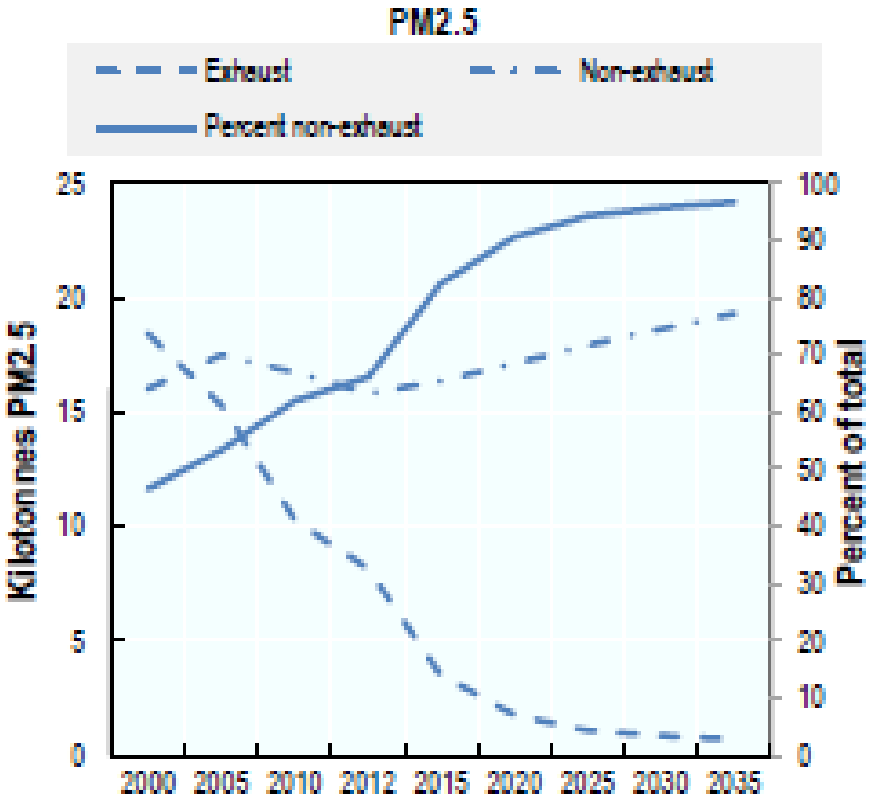
		Kilotonnes		% of road traffic		% of total	
PM10		Road dust	Mobile[1]	Road dust	Mobile[1]	Road dust	Mobile[1]
	2008	1 037.320	331.899	76	24	5	2
	2011	1 047.690	370.825	74	26	5	2
	2014	944.948	304.269	76	24	5	2
PM2.5							
	2008	259.330	252.603	51	49	4	4
	2011	261.922	197.527	57	43	4	3
	2014	229.466	163.092	58	42	4	3

Note: [1] Includes brake and tyre wear emissions.
Data source: (U.S. Environmental Protection Agency, 2019[76]).

OECD 2020

Non-exhaust and exhaust PM10 and PM2.5 emissions and percentage of total from non-exhaust, 2000-2035





OECD 2020

Conclusions

- Fugitive dusts can have very serious adverse health effects
- Affects large populations
  - Affects susceptible populations
  - Contributes the growing majority of traffic-related PM exposure
  - Won’t be solved by zero tailpipe emissions
- Consider policies to incentivize fewer VMTs, light-weighting of vehicles, restrict metal content in brakes