Respiratory Protection in Children

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Why are Children More Vulnerable?

Increased Exposure

- Often spend more time outdoors
- Often spend more time exercising (higher respiratory rates)

Physiologic Differences

- Higher minute ventilation per kg of body weight

Windows of Development

- Changes early in childhood can have life-long effects

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Key Considerations

Filtration

What proportion of particles pass through the material? How much of a decrease in the particles is there after moving through this material?

Leakage

How many particles can pass around the mask or respirator?

Cloth Masks

- Decrease transmission of infectious droplets
- For some fabric types, $PM_{2.5}$ concentration could be *higher* inside the mask[2]
- Decrease in exposure from bandanas and some commercially available cloth masks is as low as 10%[3, 4]

Medical Masks

- Mean decreases in exposure in NIOSH testing were 15-40%[4]
  - Other groups have found decreases of 33-60%[5,6]
  - In a small sample of children, a surgical mask decreased the exposure 66% or more[7]

[1]Harber et al 2009, [2]Shakya et al 2017, [3]Bowen 2010, [4]Oberg and Brosseau 2008, [5]Bowen 2010, [6]Grinshpun et al 2009, [7]Van der Sande et al 2008

Respirators In the General Public

- In a 2007 NIOSH paper, *without* fit testing:[1]
  - 95th percentile for the class of filtering facepiece respirators was 70%
  - 95th% le for specific products ranged from 9-92%

- When wearing N95 masks during pollution exposure:
  - Healthy adults had less airways inflammation[2]
  - Health adults had lower systolic blood pressure[3]
  - Adults with cardiovascular disease had fewer symptoms and improved short term indicators of cardiovascular health[4]

[1]Duling et al 2007, [2]Guan et al 2018, [3]Langrish et al 2009, [4]Langrish et al 2012

Respirators In Children

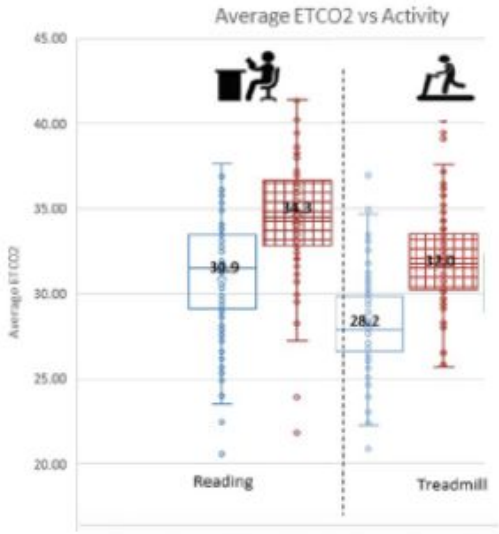
- Two published papers:
  - 11 Dutch children (ages 5-11) had 92-97% decreases in exposure wearing an N95[1]
  - 106 Singaporean children (ages 7-14) achieved a quantitative mask fit with a respirator designed for children[2]

- 3M has shared that they have some proprietary data on N95 testing in children:
  - Many children fall on the NIOSH adult grid for face size
  - Using an adult small respirator, most children's exposure is reduced >80%
  - Potential further reductions with a respirator designed for children

[1]Van der Sande et al 2008, [2]Goh et al 2019

Concerns about Mask/Respirator use

- False Sense of Security/misunderstandings
  - Argues for clear communication
- Safety
  - Most work in healthy adults
    - 10 young men- slight increase in facial temperature, slight increase in respiratory rate[1]
    - Adults - no physiologic changes for 1 hour on treadmill wearing respirators with different pressure drops[2]
    - 10 HCW- no physiologic changes for 1 hour on treadmill wearing respirator v not[3]
    - 10 nurses - no change in bp or SpO_2, but PCO_2 increased slightly after N95 for 12h x2[4]
  - One study in a general population cohort (including those with mild respiratory disease)
    - Mild discomfort reported, objective HR, RR, spirometry within normal adult ranges[5,6]
  - One study in children- on treadmill for 3 minutes[7]
  - Data on the effect of respirators in pregnant people are mixed, but no effect on fetal heart rate[8]



Adapted from Fig. 3 from Goh et al 2019

[1]Jones 1991, [2]Roberge et al 2013, [3]Roberge et al 2010, [4]Rebman et al 2013, [5]Harber et al 2009, [6]Bansal et al 2009, [7]Goh et al 2019, [8]Roberge et al 2014

Children should NOT use face coverings:

- Under age 2
- If they are not able to remove the face covering on their own
- if the only face covering available is a possible choking or strangulation hazard
- if the child has difficulty breathing with the face covering

Thanks!

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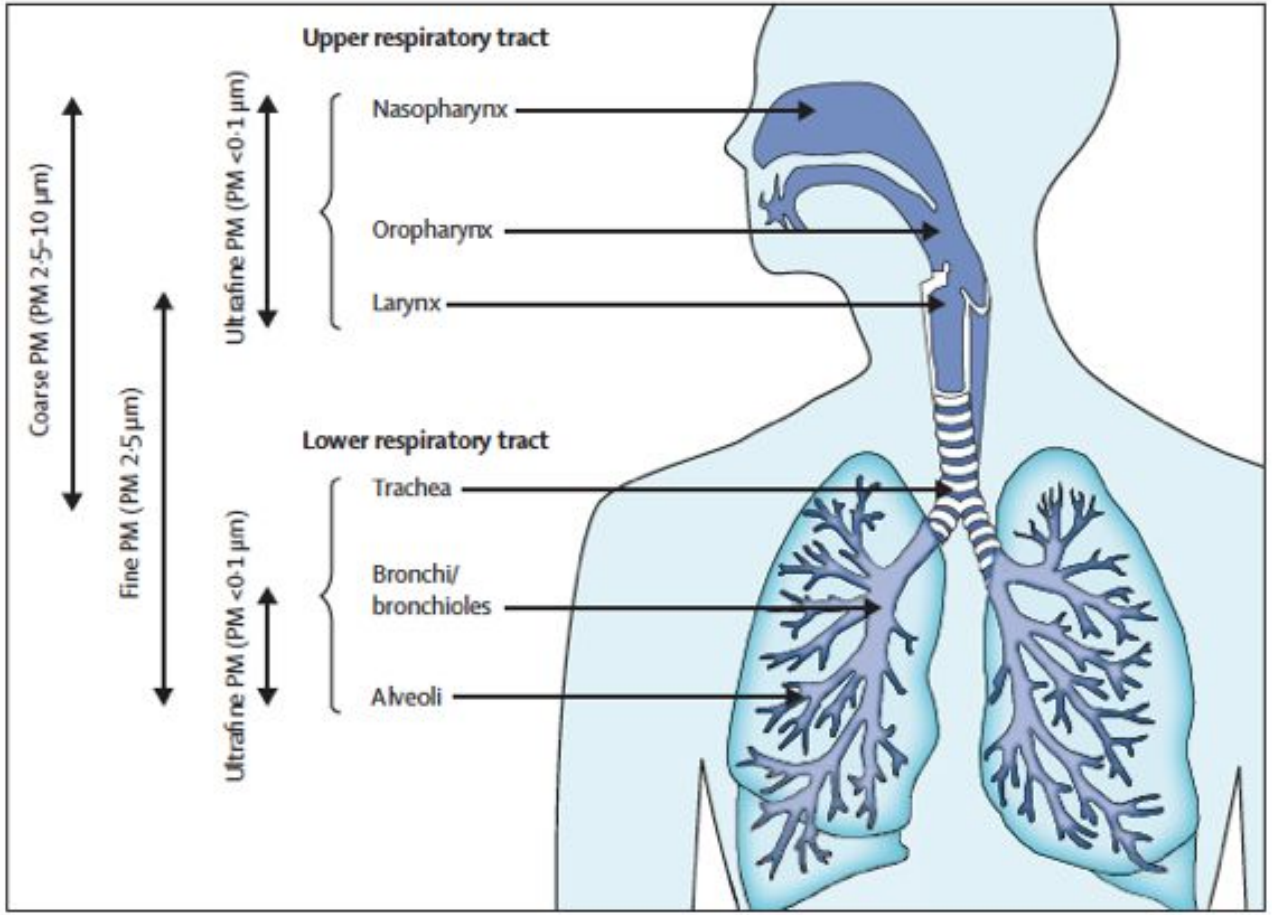


Figure 4: **Compartmental deposition of particulate matter**

Guarnieri and Balmes 2014

Mechanisms of Toxicity

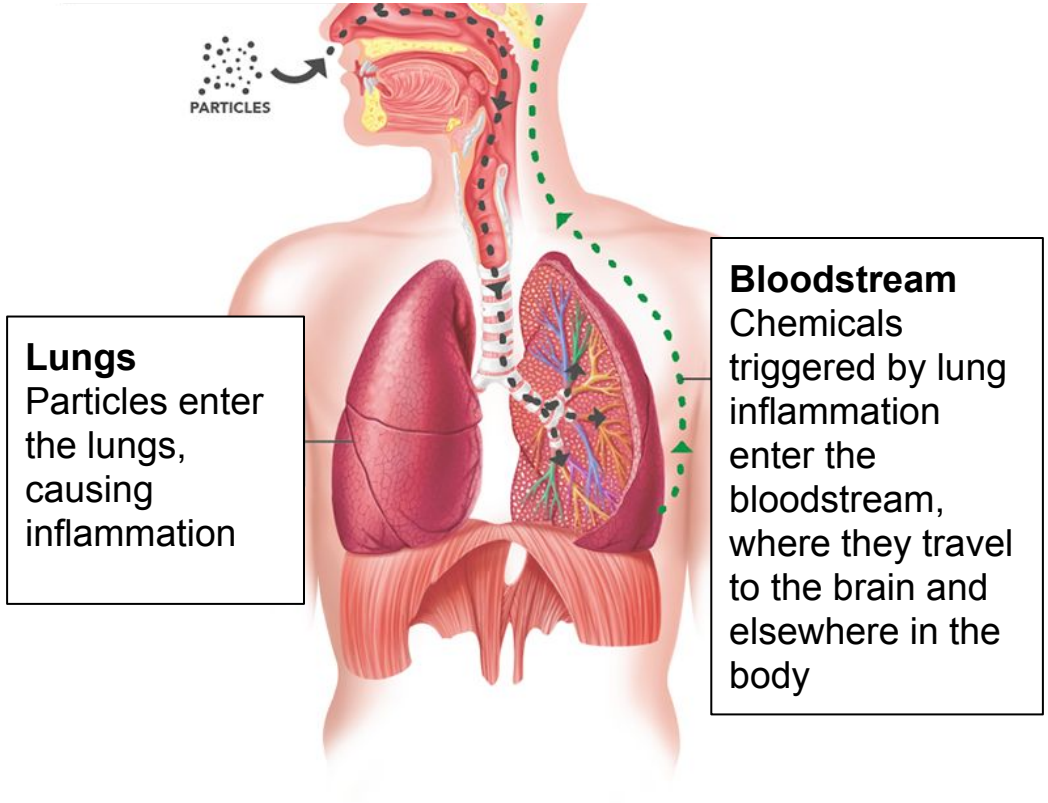
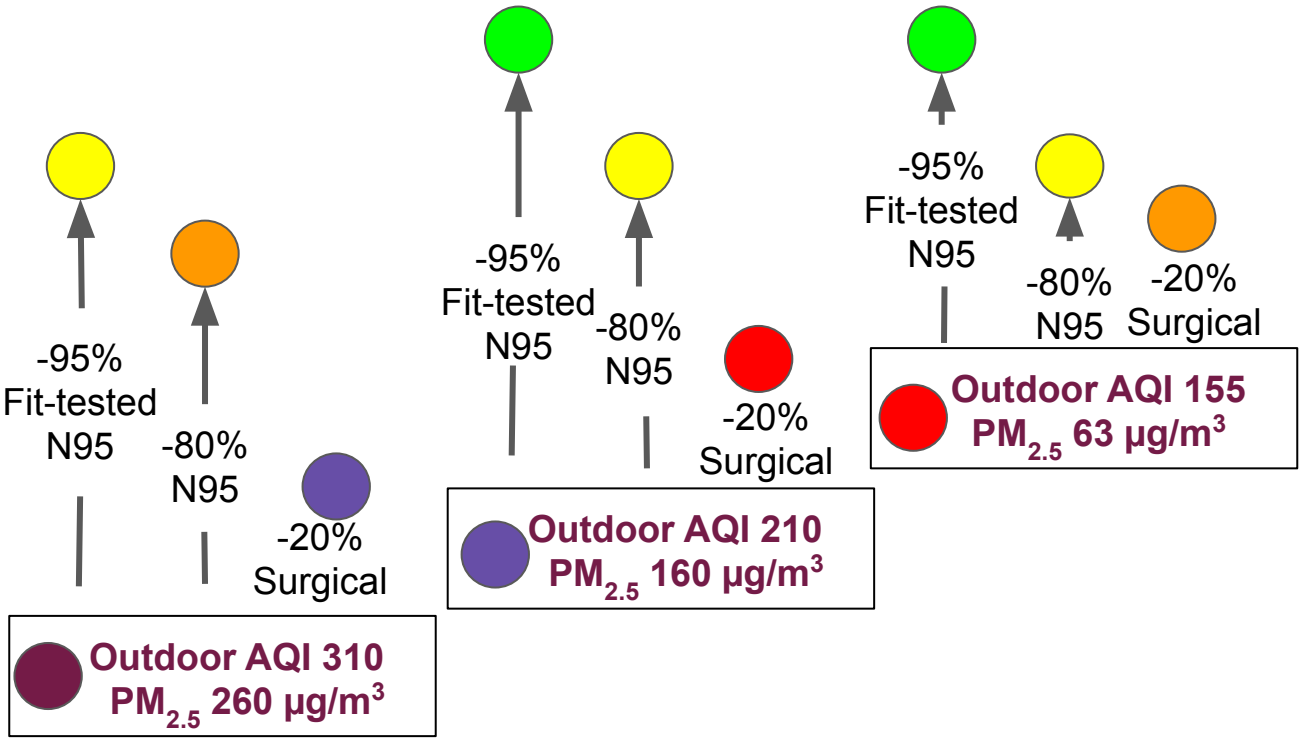


Image from https://ww2.arb.ca.gov/resources/fact-sheets/air-pollution-and-brain

Example of Why These Sorts of Interventions Could be Worthwhile in the General Public

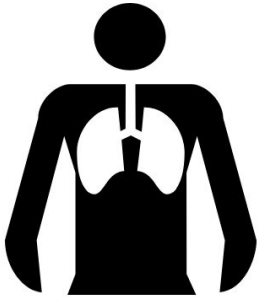
Daily AQI Color	Levels of Concern	Values of Index
Green	Good	0 to 50
Yellow	Moderate	51 to 100
Orange	Unhealthy for Sensitive Groups	101 to 150
Red	Unhealthy	151 to 200
Purple	Very Unhealthy	201 to 300
Maroon	Hazardous	301 and higher

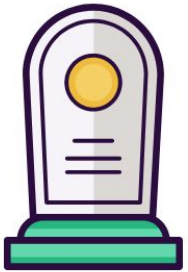


Health Effects

Wildfire Smoke Effects in Adults

Consistent relationships with respiratory illnesses, hospitalizations and clinical visits.





Consistent relationships with non-traumatic mortality, especially respiratory mortality

Findings regarding cardiovascular outcomes are much more inconsistent.

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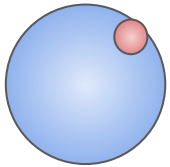
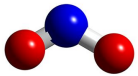
Adetona et al 2016, Black et al 2017, Liu et al 2015, Reid et al 2016

Effects of Specific Pollutants in Children





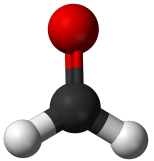
PM_{10}, $PM_{2.5}$, NO_2

- Respiratory Visits/Admissions
- Asthma exacerbations
- Development of asthma
- Respiratory Infections
- Decreased Lung Function

- Metabolism/Growth Effects

- Neurocognitive Effects

- Carcinogenic

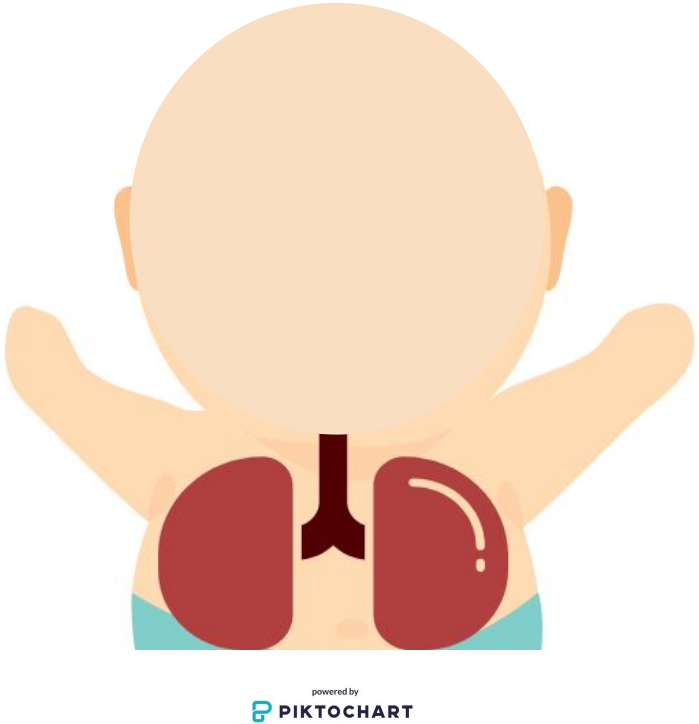


VOCs

- Wheezing
- carcinogenic

Guarnieri and Balmes 2014, Oliveira et al 2019, Khreis et al 2017, Gauderman et al 2015, Montero-Montoya et al 2018, Nung et al 2017

Wildfire Smoke Effects in Children-Lower Respiratory



- Asthma exacerbations (well-established)
  - 2000 ER visits in US annually due to wildfire ozone[1]
  - ↑ BMI associated with ↑ albuterol use[2]
  - ↑ asthma visits with ↓ age[3,4]
- Effects likely due to fine and ultrafine particles, multiple studies have found no relationship with PM_{10}[5-7]
- Lower Respiratory Infections (pneumonia, bronchitis)[4]

Chew et al 1995, [1]Pratt et al 2019, [2]Tse et al 2015, [3]Delfino et al 2009, [4]Hutchinson et al 2018, [5]Henderson et al 2011, [6]Morgan et al 2010, [7]Jalaludin et al 2000

Wildfire Smoke Effects in Children-Upper Respiratory

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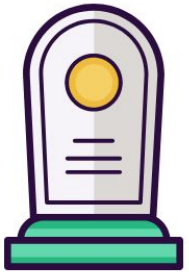
- Itchy eyes, sneezing, sore throat[1]
  - occur more frequently for children who could smell smoke indoors longer[2]
- Increased upper respiratory infections in young children[3]

[1]Vicedo-Cabrera et al 2016, [2]Kunzli et al 2006, [3]Hutchinson et al 2018

Wildfire Smoke Effects in Children- Other

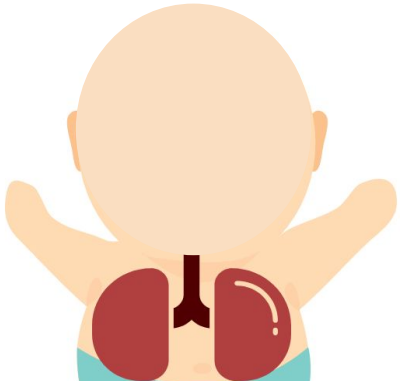
- ↓ Birthweight[1,2]
- ↑ preterm birth[1]



- ↑ respiratory mortality[3]

[1]Abdo et al 2019, [2]Holstius et al 2012, [3]Doubleday et al 2020

Comparing Effects in Children versus Adults



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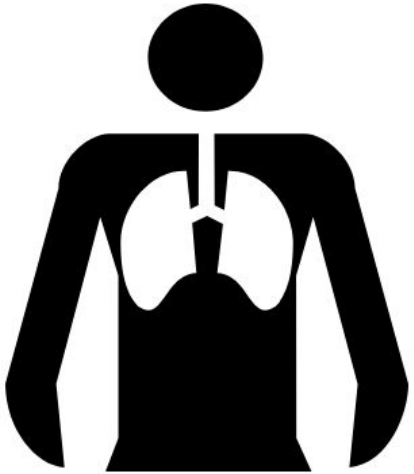
RR 1.08 infants	Asthma Admissions[1]	RR 1.10 elderly
RR 3.43 infants RR 1.39 2-4 yo RR 2.00 5-17 yo	Asthma ER Visits[2]	RR 1.08 18-64 yo
OR 1.08	Asthma ER Visits[3]	OR 1.09
RR 1.15	Asthma Symptoms[4] (prescribed burns)	RR 1.17
OR 1.52 infants	Respiratory Mortality[5]	OR 1.35 middle-aged



[1]Delfino et al 2009, [2]Hutchinson et al 2018, [3]Stowell et al 2018 , [4]Johnston et al 2006, [5]Doubleday et al 2020