



Impact of Wildfires on the Pediatric Upper Airway

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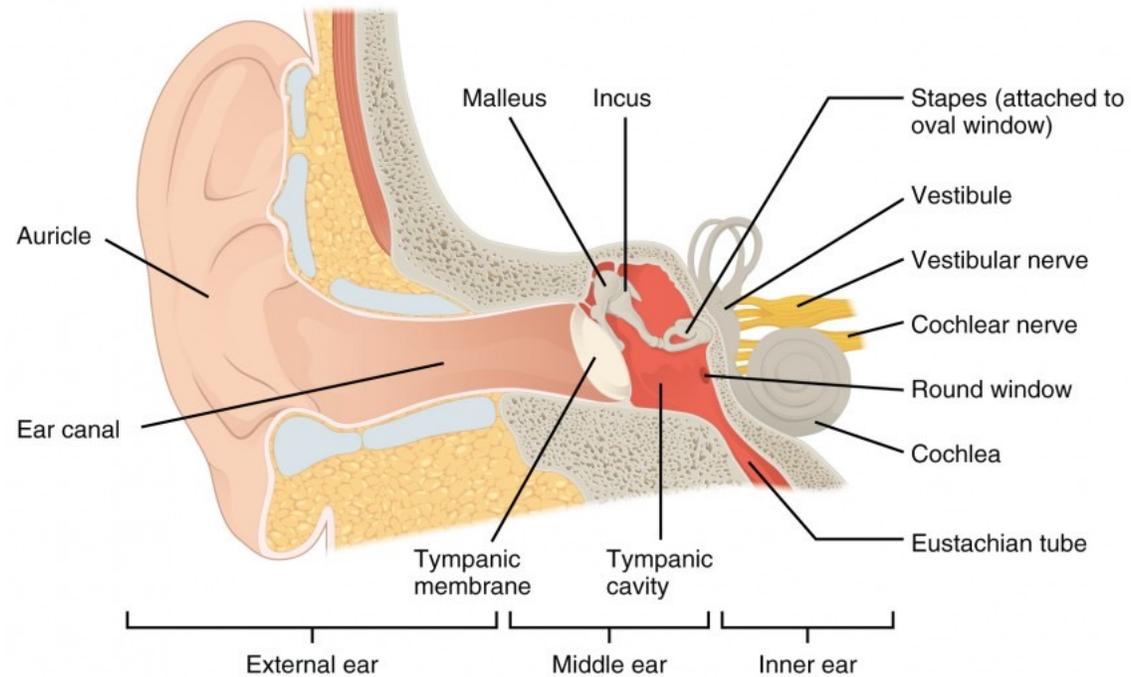
PROFESSOR EMERITA, UCLA, DGSOM

PEDIATRIC OTOLARYNGOLOGY, WESTSIDE HEAD AND NECK

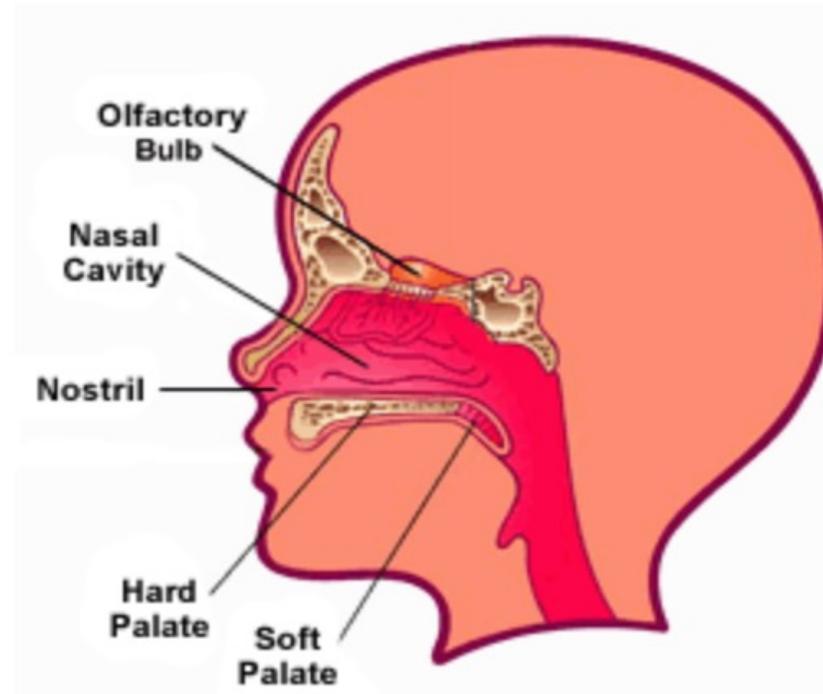
Pediatric Upper Airway

- ▶ Ears/Eustachian Tubes
- ▶ Nose
- ▶ Sinuses
- ▶ Oral cavity
- ▶ Hypopharynx/Larynx
- ▶ Trachea

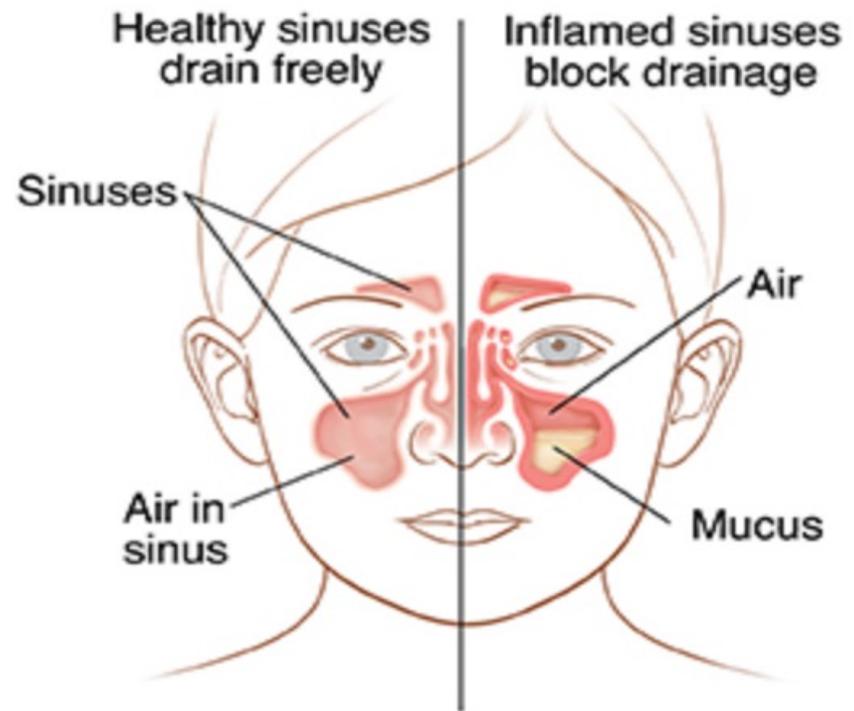
Pediatric Ear/Eustachian Tube



Pediatric Nose



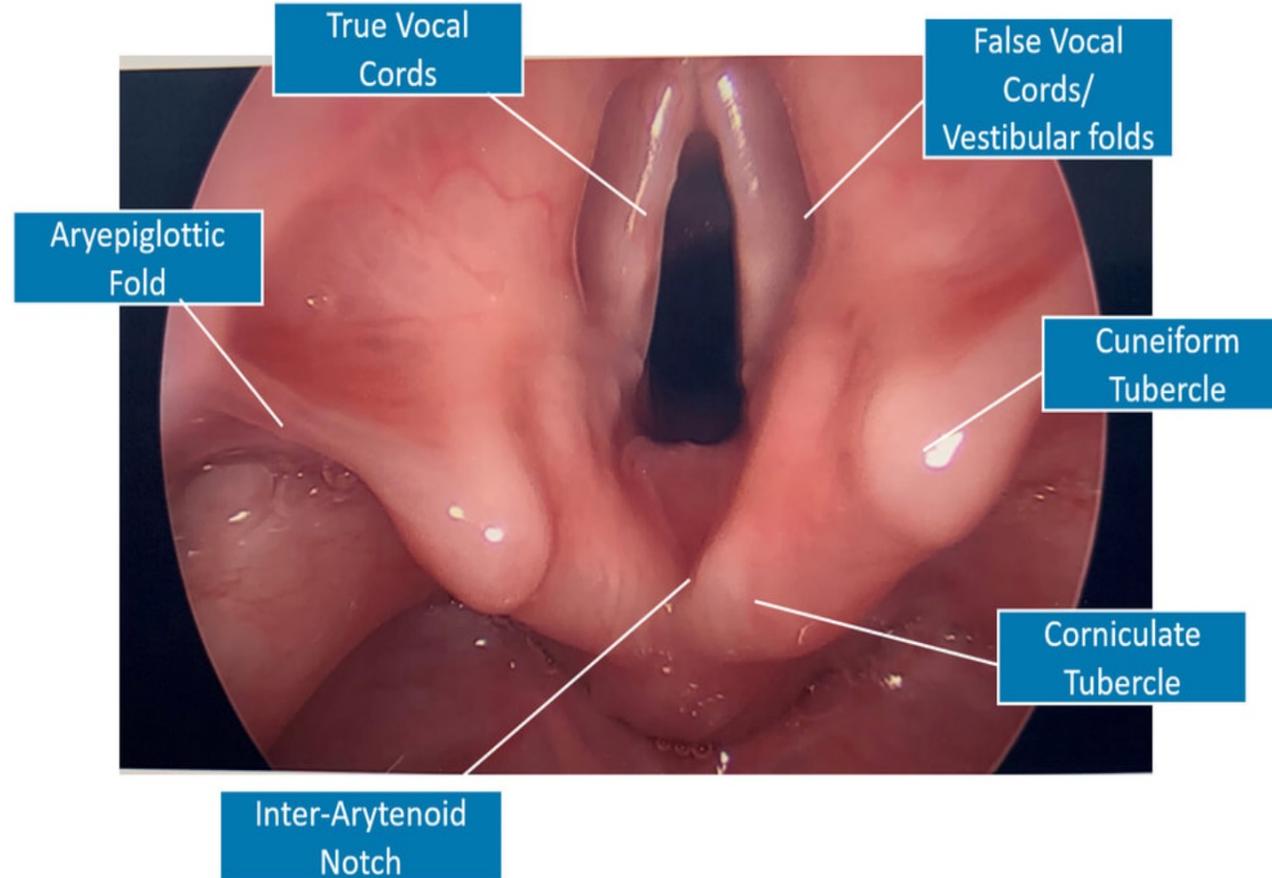
Pediatric Sinuses



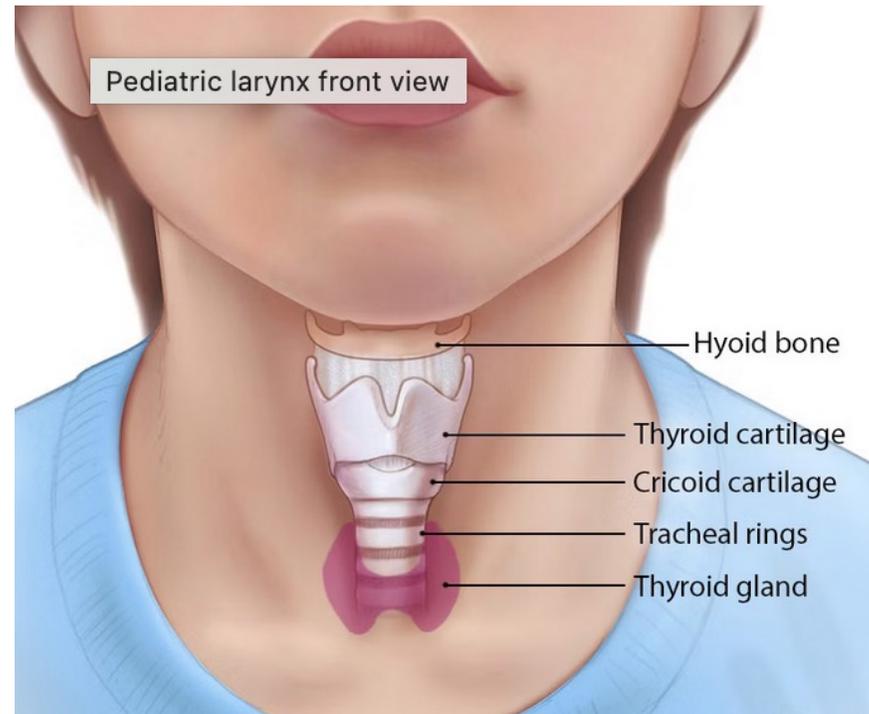
Pediatric Oral Cavity



Pediatric Larynx



Pediatric Trachea



Wildfire Smoke

- ▶ Noxious gases (CO, VOC's, Nitrogen oxides, CO₂, SO₂)
- ▶ Heavy Metals, Hydrocarbons, Microplastics
- ▶ **PARTICULATE MATTER (PM_{2.5})**
 - ▶ **Most critical for upper airway injury**
 - ▶ Particles <2.5 microns
 - ▶ Enter upper airway to cause local inflammatory response

Ear Infections after wildfires

- ▶ Yes, the ears are part of the respiratory system
- ▶ Nasal congestion/respiratory infection extend to the middle ear
- ▶ Eustachian tubes are not fully developed in younger children
- ▶ More predisposed to ear pathology with upper respiratory congestion

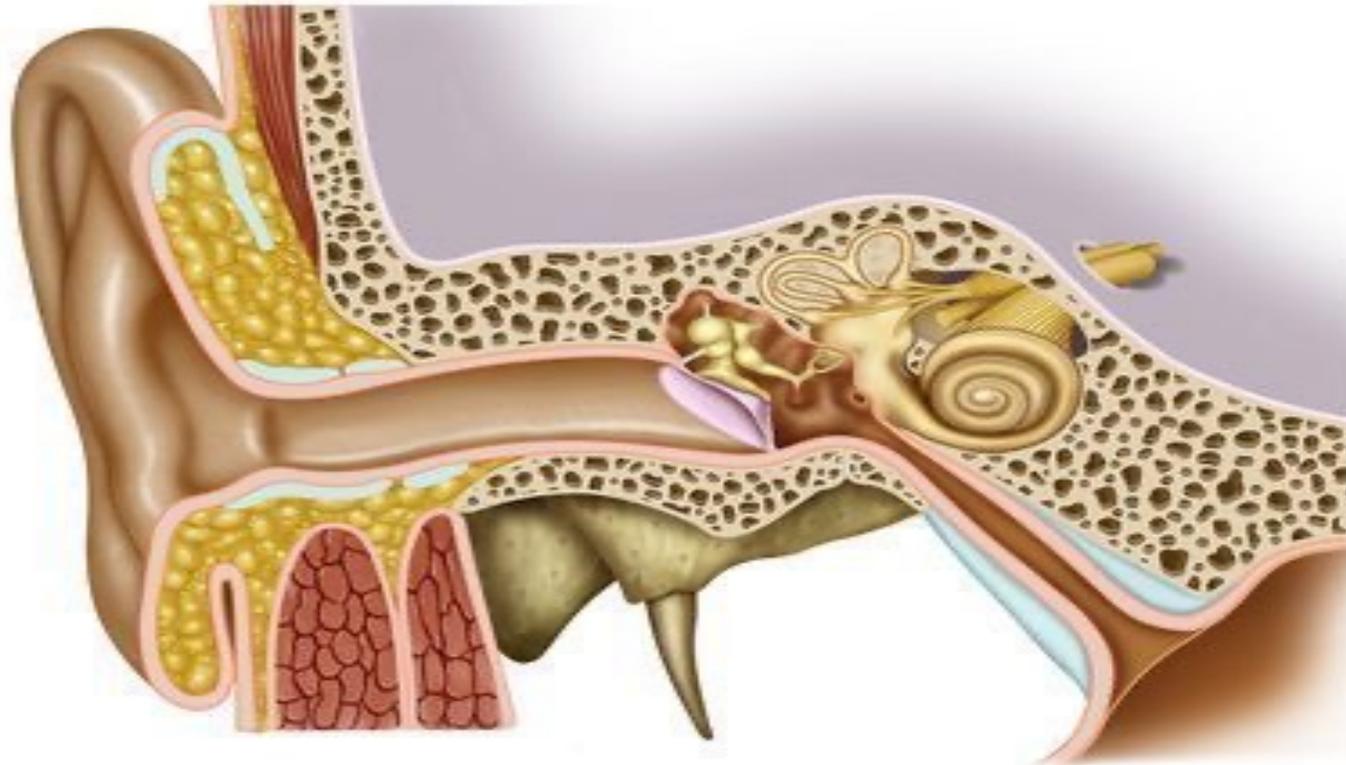
Prenatal exposure risks to ears

- ▶ British Columbia 2017-2018 wildfire season
 - ▶ (79,000 pregnant subjects)
- ▶ Compared with low-level wildfire seasons
- ▶ Prenatal wildfire exposure throughout gestation

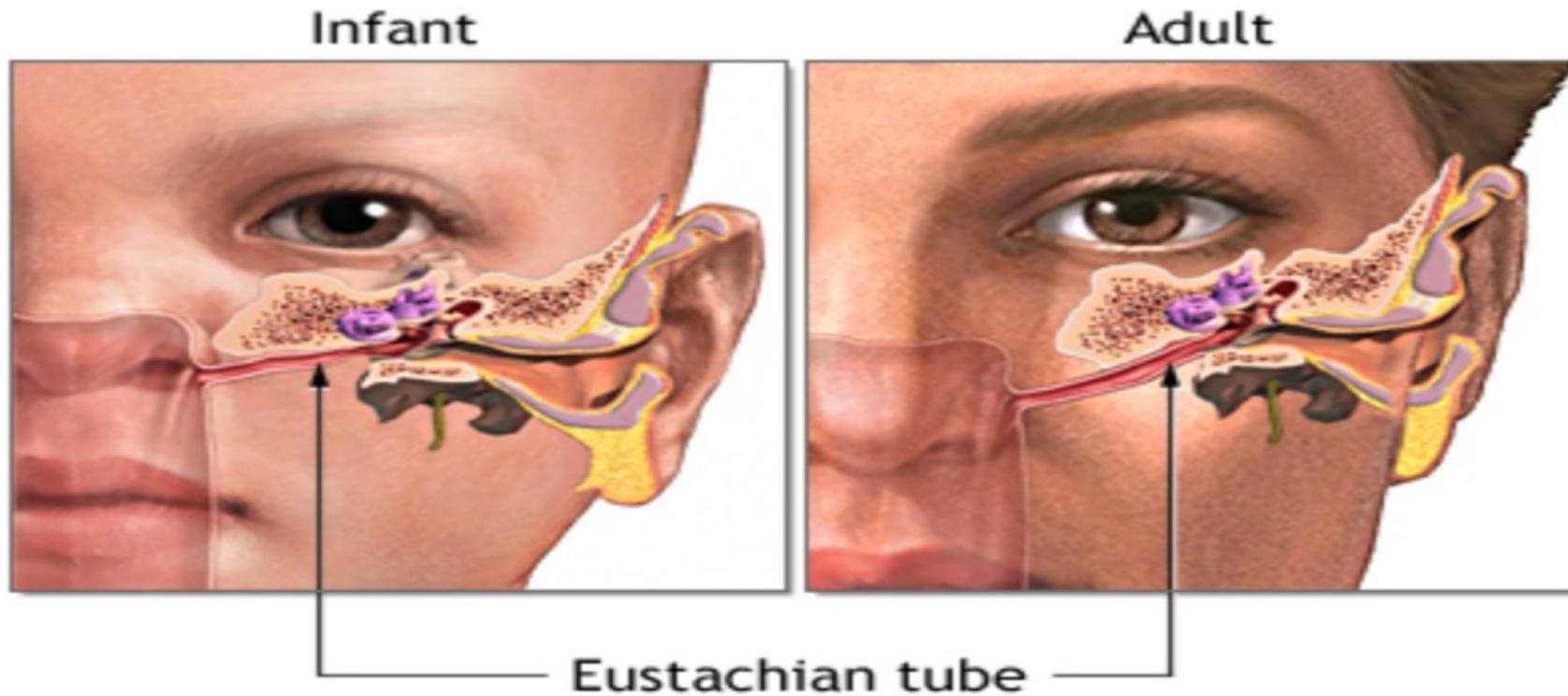
Prenatal exposure risks to ears

- ▶ Increased risks of infant respiratory infections in first year of life
- ▶ Eustachian tube developmental stages throughout pregnancy
- ▶ 9,000 cases of otitis media
- ▶ Exposure during second trimester (19-28 weeks) with highest risk of otitis media in first year

Eustachian tube/middle ear



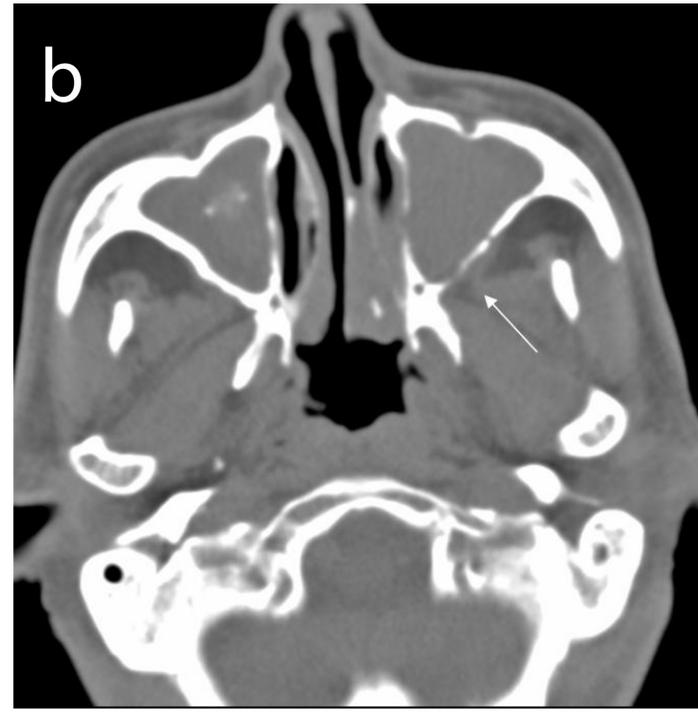
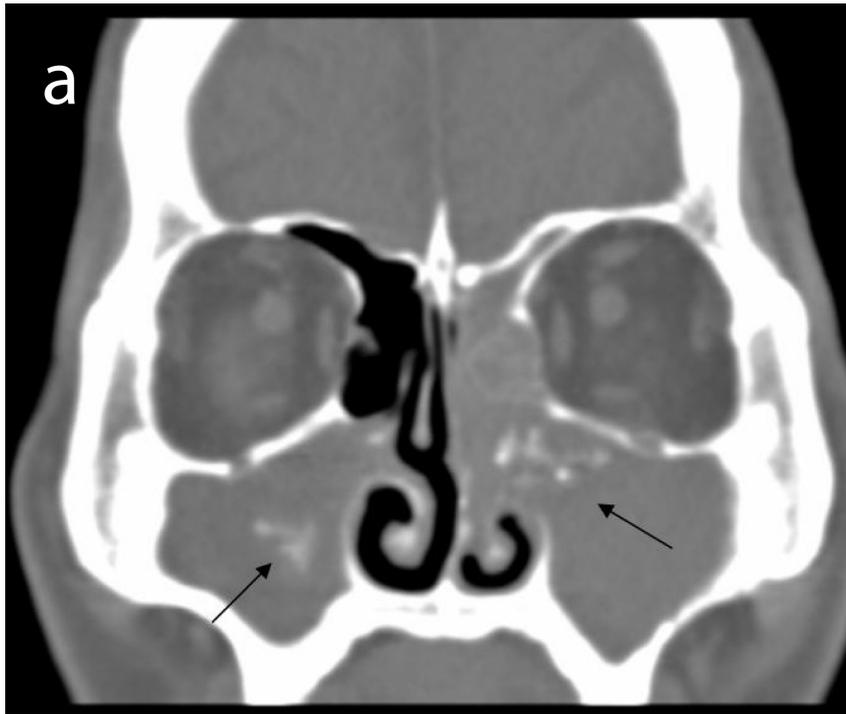
Eustachian Tube Development



Nasal congestion/Sinusitis

- ▶ Particulate Matter leads to local inflammatory response
- ▶ Nasal congestion leads to sinus infections
- ▶ Pediatric noses have relatively lower volume to clear and remove particles

Sinusitis

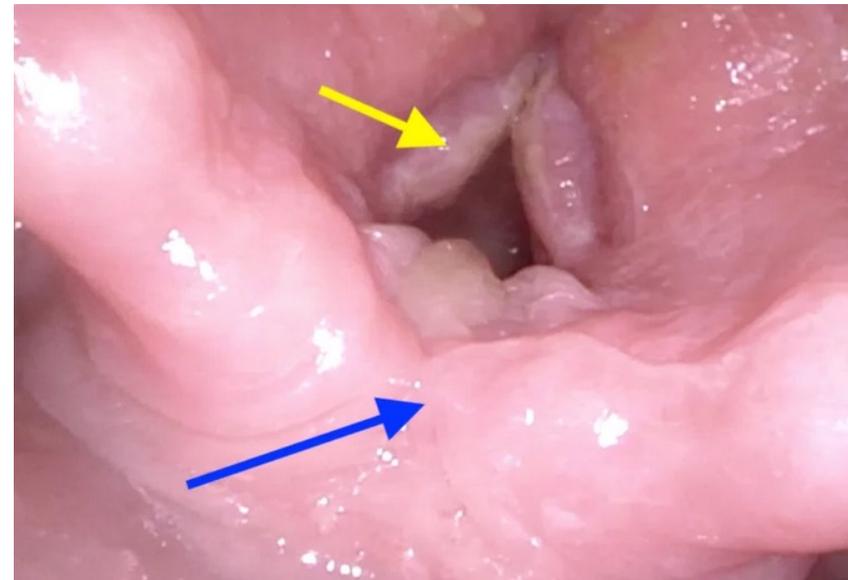
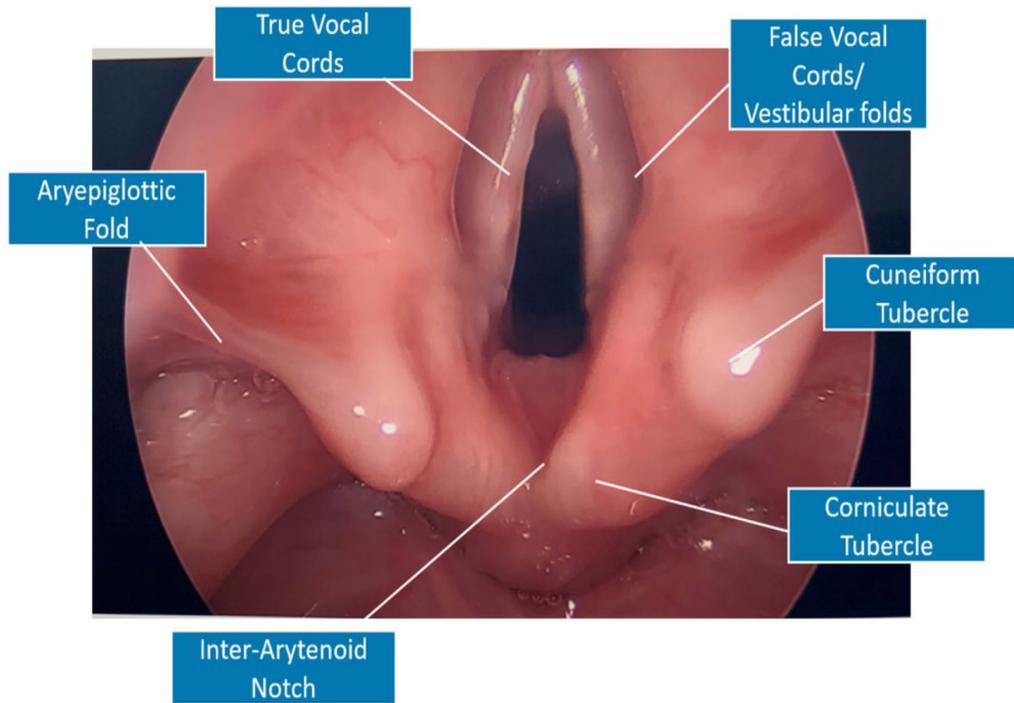


Throat pain

- ▶ Nasal congestion leads to mouth-breathing/throat pain



Laryngitis



Croup

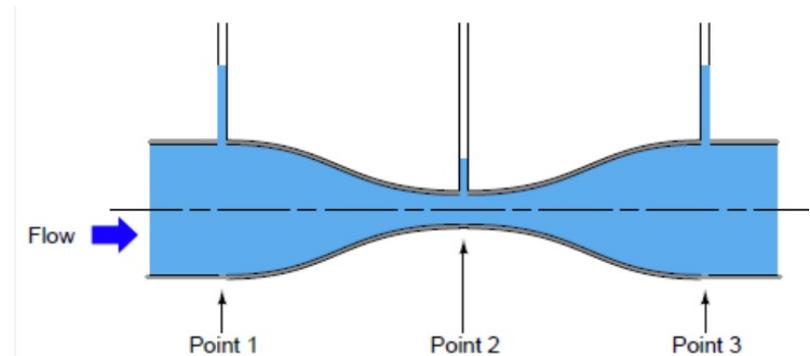
- ▶ Viral illness (parainfluenza; rhinovirus; coronavirus, etc)
- ▶ Cricoid cartilage inflammation
- ▶ Narrowest part of the pediatric airway
- ▶ Cricoid is the ONLY complete cartilaginous ring

Poiseuille's Law

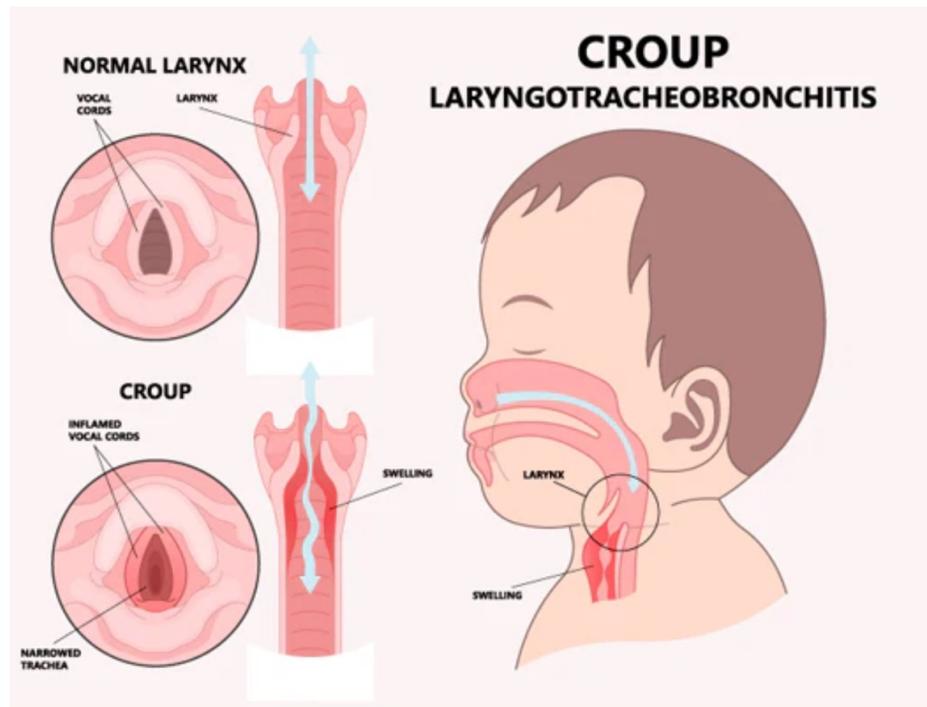
Resistance inversely proportional to r^4

Circumferential narrowing increases airway resistance to the FOURTH power of the radius

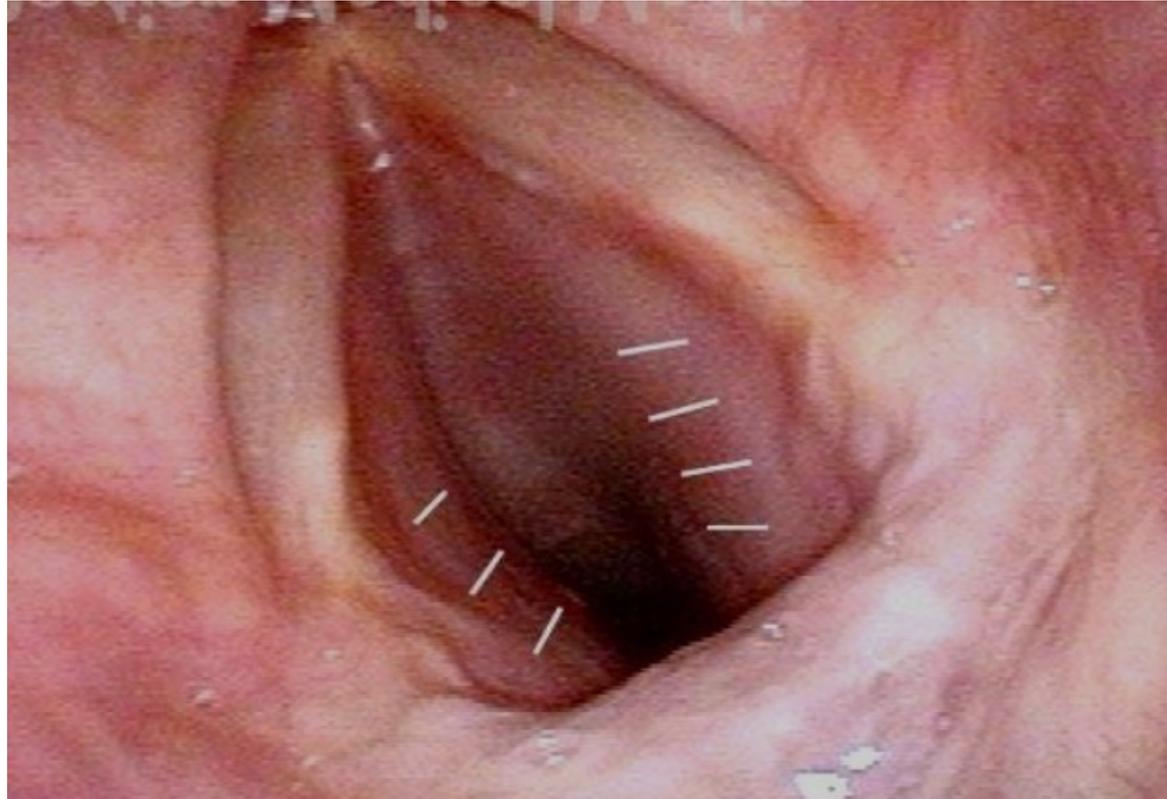
$$R = \frac{8l\eta}{\pi r^4}$$



Croup



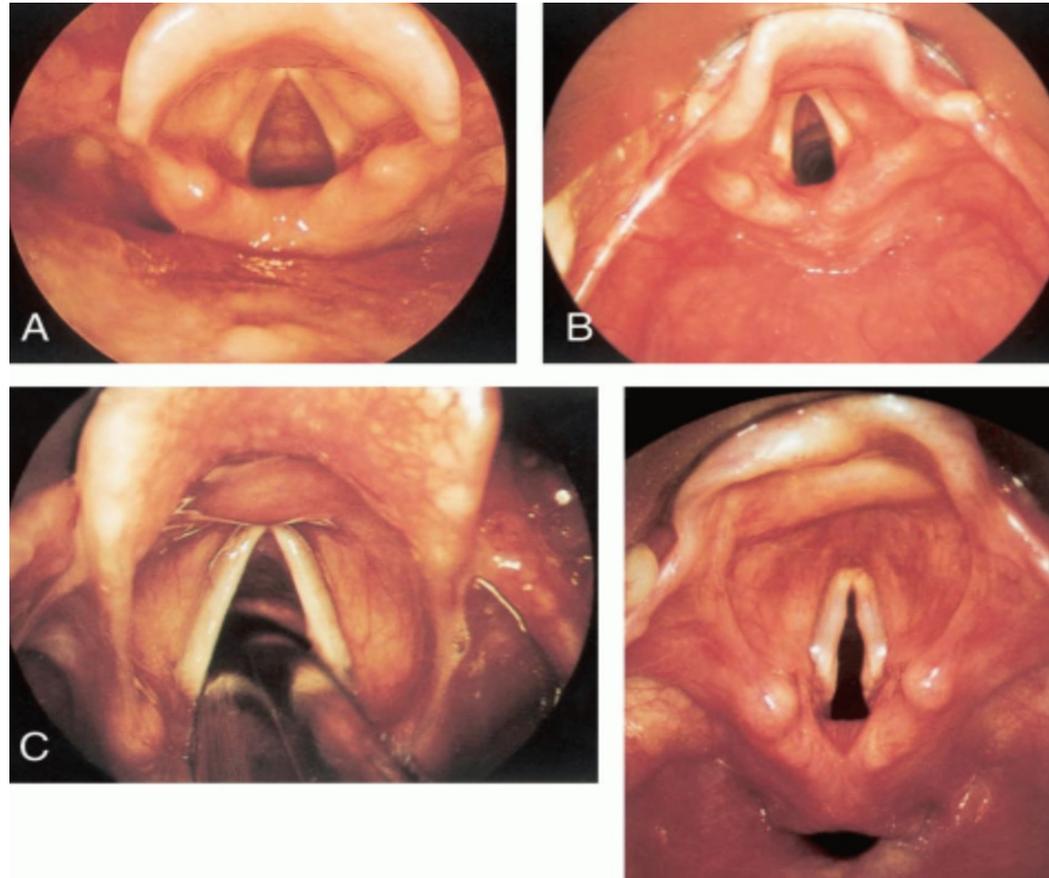
Croup



Croup during wildfires

- ▶ 2014-2023
- ▶ Emergency Room Visits (Stanford)
- ▶ With increased wildfire-generated $PM_{2.5}$
 - ▶ Increased croup visits
 - ▶ Increased new-onset dysphonia (hoarseness) visits

General Anesthesia/Intubation



Adverse anesthesia events

- ▶ 625 Pediatric Patients
- ▶ Elective Surgery (UCSF)
- ▶ Retrospective review of adverse respiratory events based on air quality
- ▶ No difference overall in children without RAD
- ▶ Those with RAD
 - ▶ 36.8% in healthy air quality
 - ▶ 55.1% adverse respiratory events in times of poor air quality ($p=0.04$)

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“They have these masks”



Wildfire Smoke

- ▶ Damages pediatric upper airway, including the middle ear
- ▶ $PM_{2.5}$ is most important factor
- ▶ Monitor children for increase in upper airway symptoms, especially with prior history of these issues
- ▶ Special consideration for elective procedures under general anesthesia

Thank you.