ERS EUROPEAN RESPIRATORY SOCIETY
every breath counts

Respiratory health risks in the era of increased climate change and natural disasters: preparing EU citizens for current and future challenges of extreme weather events

17 March, 2025 | 09:30 to 17:30 CET | The Hotel, Brussels

Suspended dust and Volcanic ash: Assessing the Health Impacts of Earthquakes and Volcanoes in Air Quality

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FERS, ATSFellow

COI (now)

International

- ERS: Ethics and Integrity Committee (Member)
- EAACI: - ExCom
  - Public, Patients & Outreach Hub Editor-in-Chief
- WAO: Working Group on Environment
- DARWIN EU: Advisory Board

National

- IRD: Ethics Committee (Member)
- MEDD: Comité prévention et protection (CPP) (Member)
- SFA: Scientific Committee (Member)
- RNSA: Scientific Committee (Member)
- Météo France: Commission Santé (Member)
- Société de Pneumologie de Langue Française: GT PAPPEI
- APPA: Scientific Council & Board of Directors

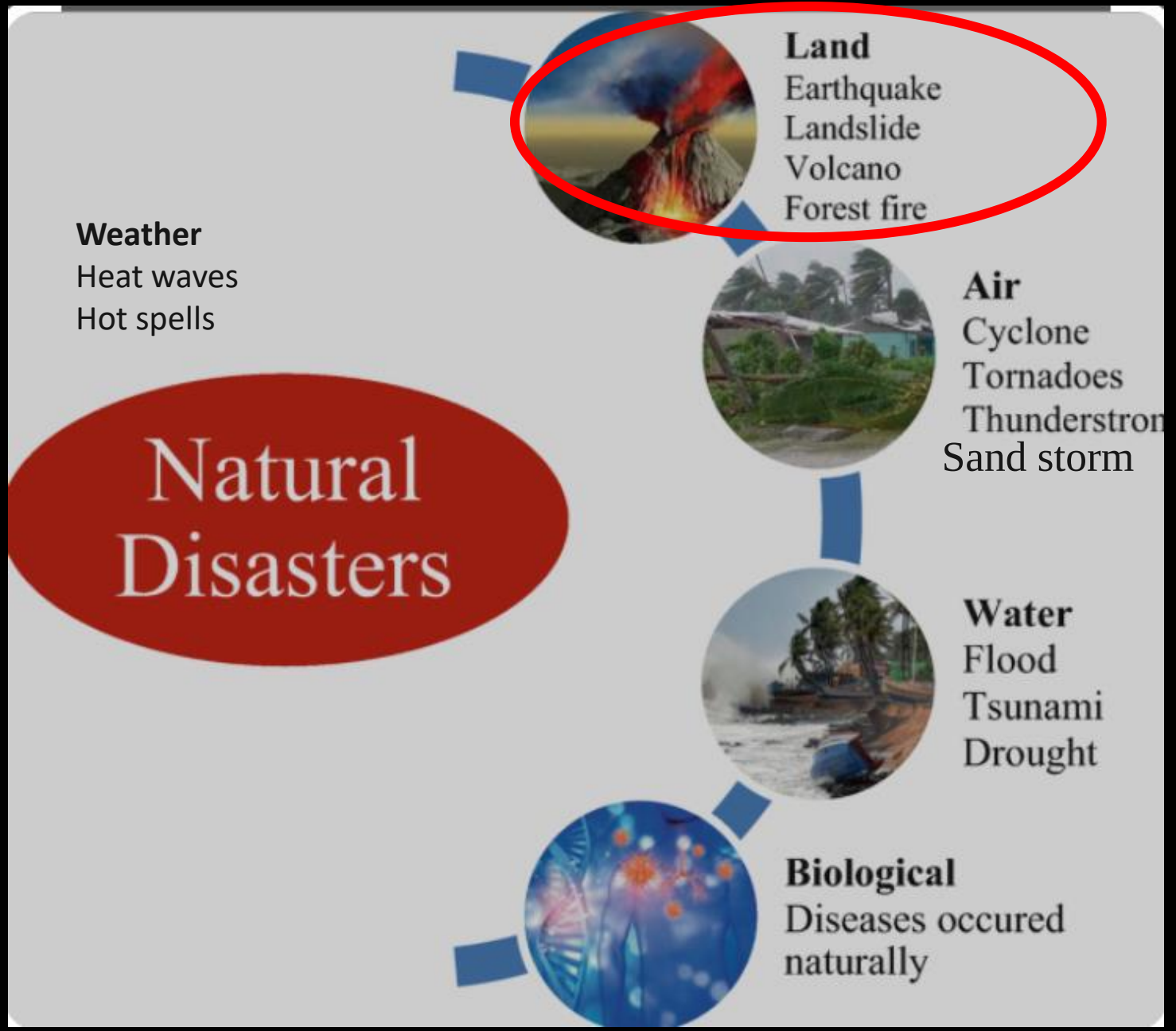
Section Editor for Environmental Health of ERJ and IJTLD

Natural disasters and respiratory health

Isabella Annesi-Maesano[1,2], Hasan Bayram[3,4], Lorenzo Cecchi[5], Daniel Croft[6], Gennaro D'Amato, Arundhati Garud[8,9], Ozgecan Kayalar[3,4], Mehdi Misraedi[10], Subhabrata Moitra[9], Vanitha Sampath[11], Neeta Thakur[6], Kari Nadeau[11], John Balmes[12,13]

Ἐμπεδοκλῆς (494 – c. 434 BC)

The four elements of which all material things are composed: water, earth (land), fire (combustion) and air (ether).


Land
Earthquake
Landslide
Volcano
Forest fire
Weather
Heat waves
Hot spells
Natural Disasters
Air
Cyclone
Tornadoes
Thunderstron
Sand storm
Water
Flood
Tsunami
Drought
Biological
Diseases occured naturally

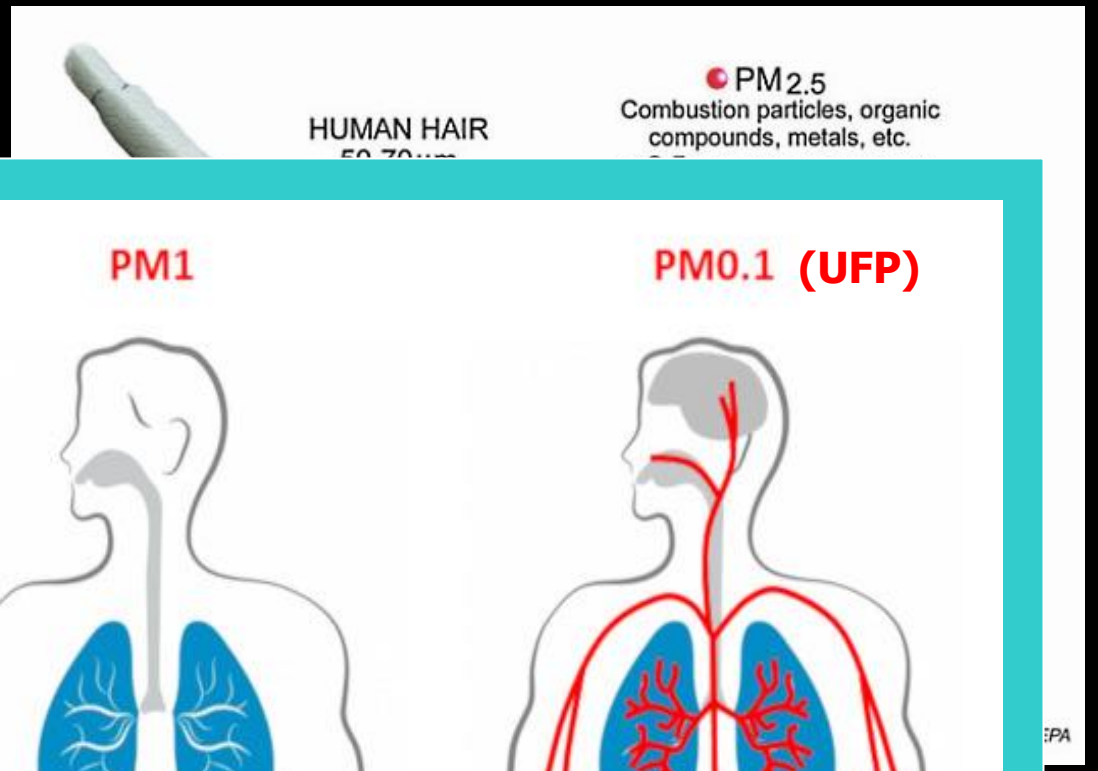
Key air pollutants involved in natural disasters

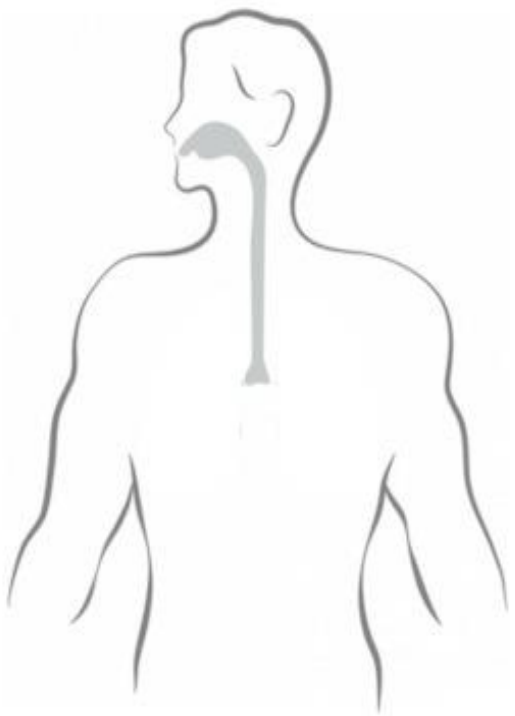
- **A complex mix of several pollutants!**
- **Very elevated concentrations**

You have no choice: you've (the exposed populations) got to breathe!

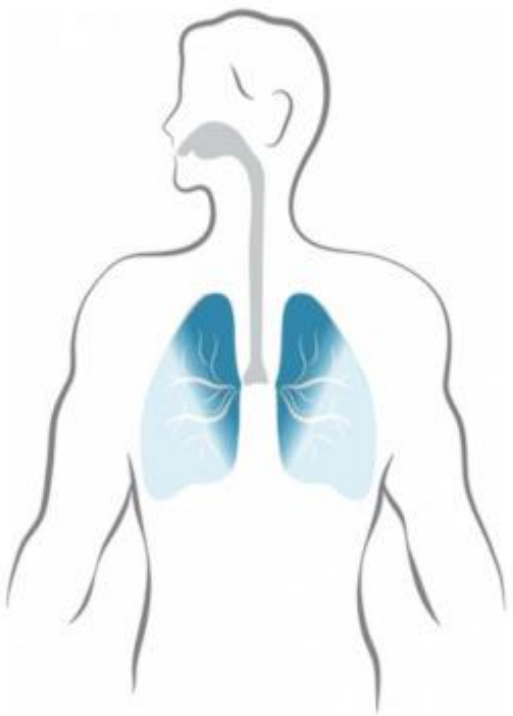
- Gases: **nitrogen dioxide (NO_2), ozone (O_3), sulphur dioxide (SO_2), VOCS , and many others**
- **Particulate matter** (PM), a mix of solid and liquid droplets arising from combustion **(size and composition)**.

PM penetration

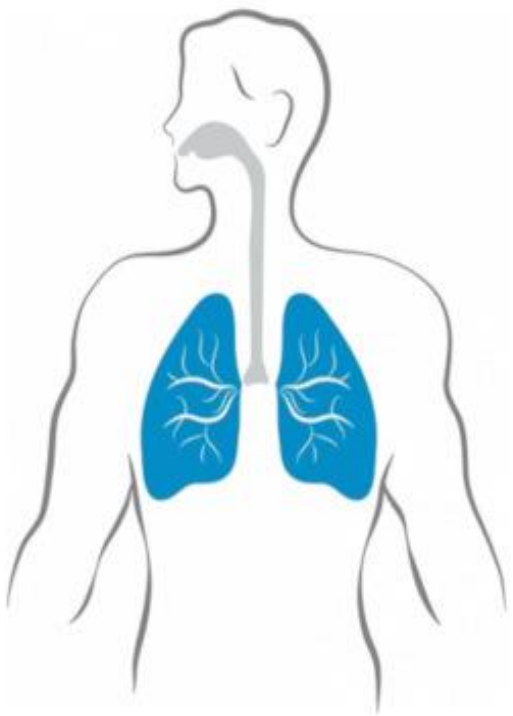




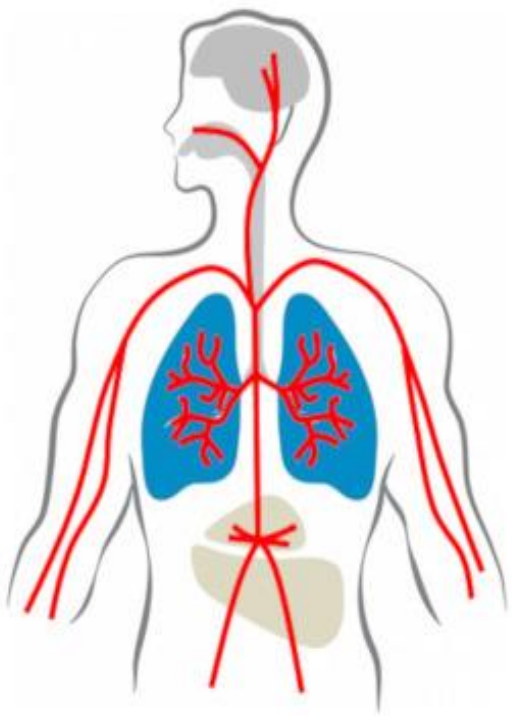
Coarse particules
Upper respiratory tract



Fine particules
Lower respiratory tract

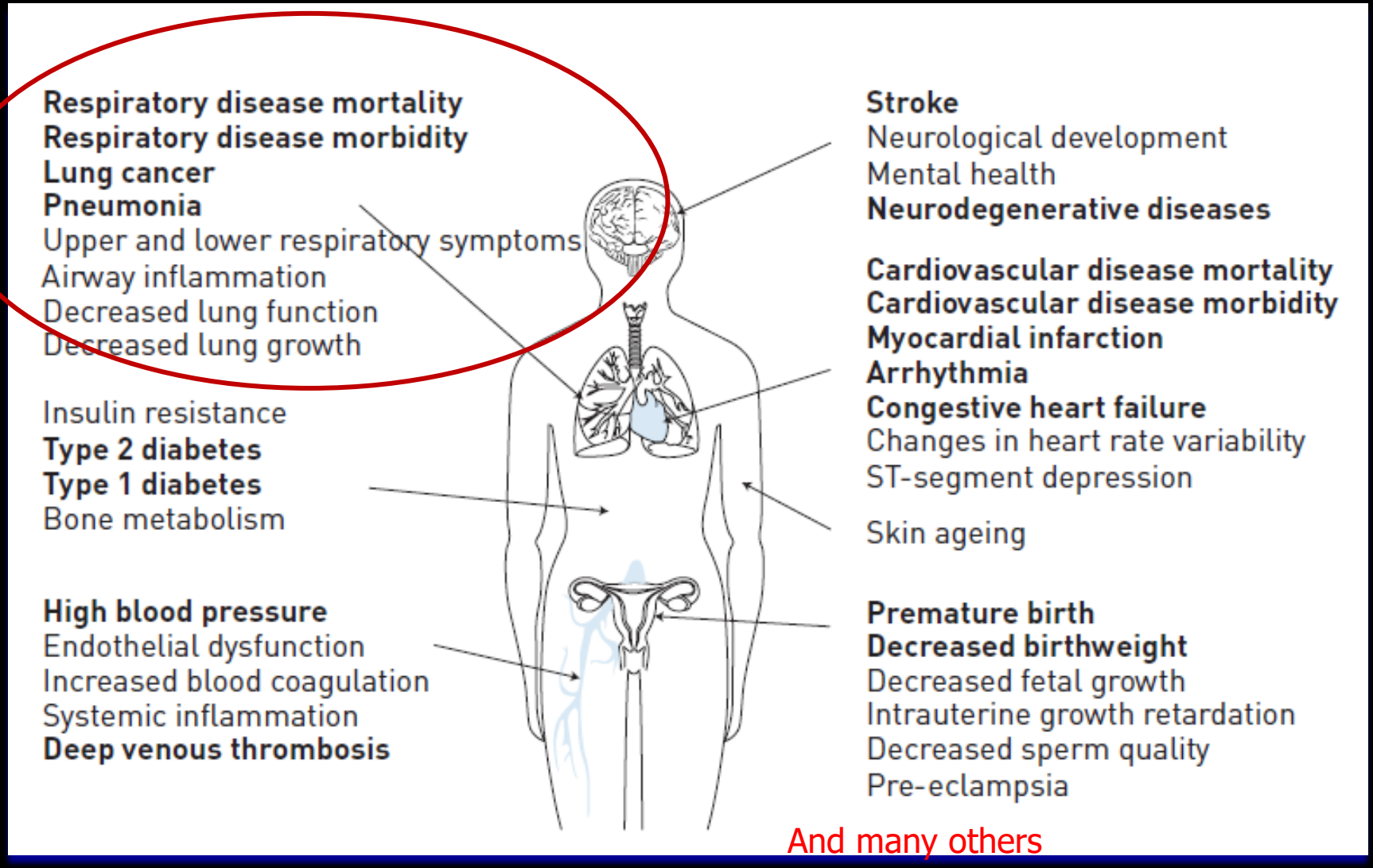


Very fine particules
Alveolus



Ultrafine particules
Blood/Whole body

New evidence: Ambient air pollution can affect almost every organ system of the body



Two types of health effects:

- **Short-term or immediate effects (ST)**
- **Long-term effects**

Thurston GD et al. ERJ 2017

EARTHQUAKES (AND BUILDING COLLAPSES 🏚)

How many earthquakes?

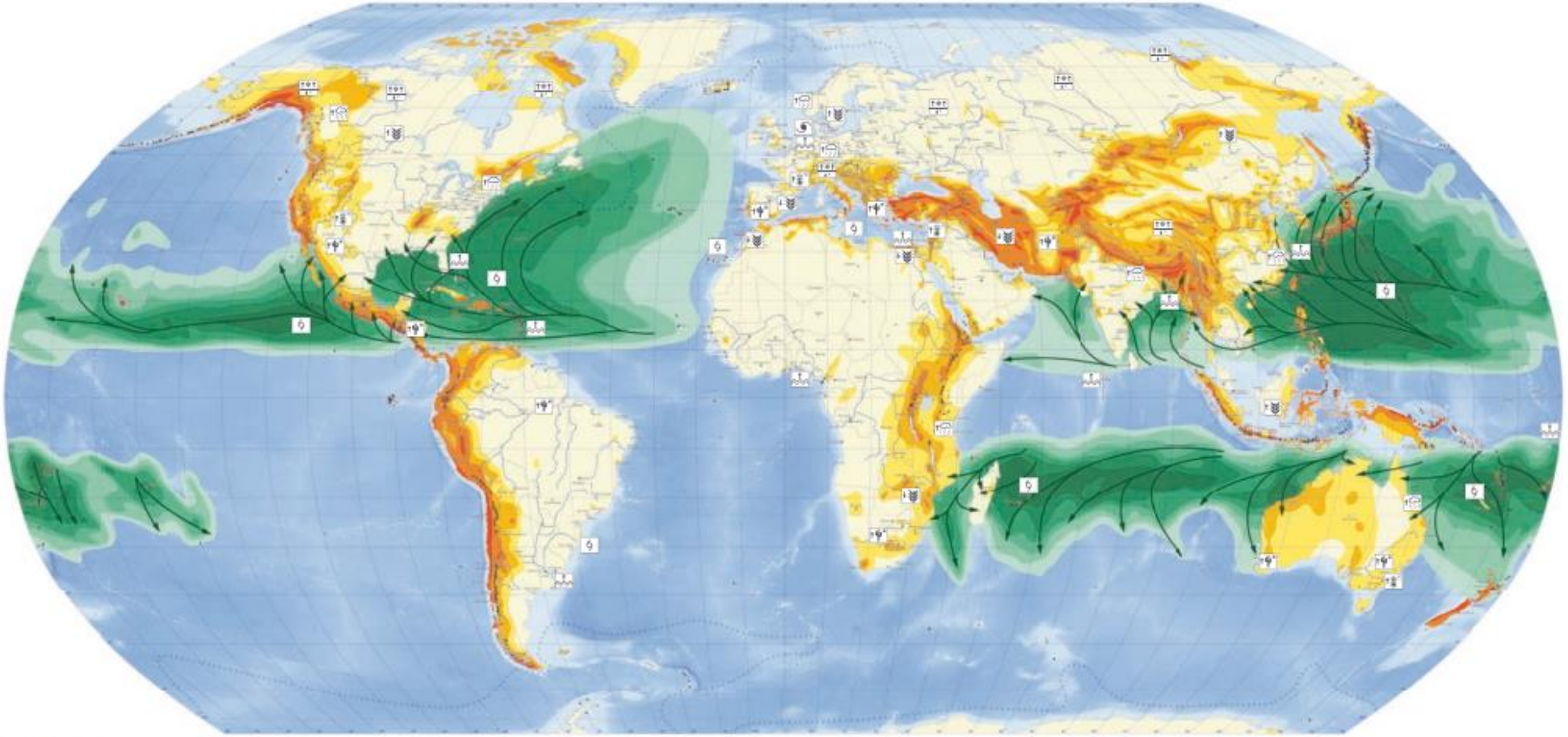
Since Seismometers introduction (20th Century-Present), the Earth experiences each year on avarage:

- ~16 major earthquakes (Magnitude 7.0–7.9)
- ~1 great earthquake (Magnitude 8.0+)
- Hundreds of thousands of smaller quakes annually (Magnitude 4+)

Estimated Total Since 1750 (industrial revolution): **around 150,000–200,000 Magnitude 6+ earthquakes**

WHERE?

NATHAN WORLD MAP OF NATURAL HAZARDS



EARTHQUAKES

- Zone 0: MM V and below
- Zone 1: MM VI
- Zone 2: MM VII
- Zone 3: MM VIII
- Zone 4: MM IX and above

Probable maximum intensity (MM: Modified Mercalli scale) with an exceedance probability of 10% in 50 years (equivalent to a "return period" of 475 years) for medium subsoil conditions.

Large city with "Mexico City effect"

TROPICAL CYCLONES

Peak wind speeds (in km/h)*

- Zone 0: 76–141
- Zone 1: 142–184
- Zone 2: 185–212
- Zone 3: 213–251
- Zone 4: 252–299
- Zone 5: ≥300

* Probable maximum intensity with an exceedance probability of 10% in 10 years (equivalent to a "return period" of 100 years).

Typical track directions

VOLCANOES

- Last eruption before 1800 AD
- Last eruption after 1800 AD
- Particularly hazardous volcanoes

TSUNAMIS AND STORM SURGES

- Tsunami hazard (seismic sea wave)
- Storm surge hazard
- Tsunami and storm surge hazard

ICEBERG DRIFTS

Extent of observed iceberg drifts

CLIMATE IMPACTS

Main impacts of climate change already observed and/or expected to increase in the future

- Change in tropical cyclone activity
- Intensification of extratropical storms
- Increase in heavy rain
- Increase in heatwaves
- Increase in droughts
- Threat of sea level rise
- Permafrost thaw
- Improved agricultural conditions
- Unfavourable agricutural conditions

POLITICAL BORDERS

- State border
- State border controversial (political borders not binding)

CITIES

- Denver >1 million inhabitants
- San Juan 100,000 to 1 million inhabitants
- Maun <100,000 inhabitants
- Berlin Capital city

Data resources

Bathymetry: Amante, C. and B. W. Eakins, ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis, National Geophysical Data Center, NESDIS, NOAA, U.S. Department of Commerce, Boulder, CO, August 2008. **Extratropical storms:** KNMI (Royal Netherlands Meteorological Institute). **Temperature/Precipitation 1978-2007:** Climatic Research Unit, University of East Anglia, Norwich.

Earthquakes (and Building Collapses ) pollution

Earthquakes themselves don't directly "emit" air pollutants, but at the origin of:

- **dust (PM_{10}, $PM_{2.5}$)** release and spread from landslides, rockfalls, and building collapses
- **radon gas** from cracks in the Earth's crust
- significant sources of:
  - pollutants, **CO, VOCs, SO_2, NOx** from secondary events, like fires and chemical spills
  - **asbestos & heavy metals** (Lead, Mercury, etc.) from damage or destructionn of old buildings

Main respiratory effects of earthquakes

- Respiratory problems due to inhalation of dust, smoke, particulates, radioactive, and toxic gases
- Respiratory infections (bacterial, viral, fungal infections, and tuberculosis)
- Chest traumas (pneumothorax, rib fracture, hemothorax, diaphragmatic tear, etc.)
- Exacerbation of respiratory diseases (chronic obstructive pulmonary disease and asthma)
- Asbestos-related lung diseases
- Venous thromboembolism

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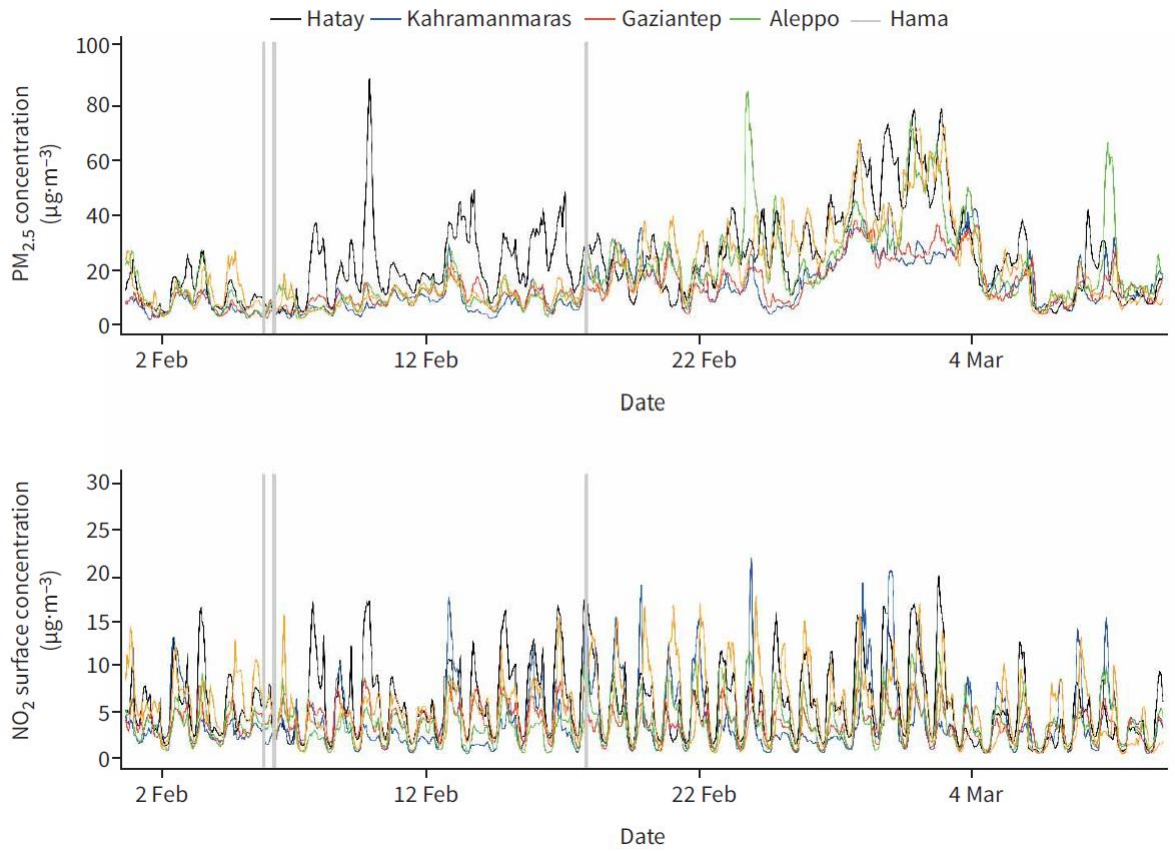
231 papers

ST: Acute psycological trauma from being trapped or witnessing deaths, LT: PSTD, chronic anxiety and sleep disorders related to respiratory health

EUROPEAN RESPIRATORY JOURNAL
EDITORIAL
Y. MOHAMMAD ET AL.

Earthquake disaster and respiratory health: lessons from Turkey and Syria in 2023

Yousser Mohammad[1,2], Hasan Bayram[3], Ozgecan Kayalar[3], Fabio Madonna[4] and Isabella Annesi-Maesano[5]



IAM-ERS-BXL-2025

2023 Turkey-Syria Hearthquake respiratory burden

Youssser ERJ 2024

23 January-6 February and 6–20 February 2023

Antakya (Hatay, Turkey

→ Number of respiratory visits to the emergency room (ER) rose significantly from 44 to 146 (0.19% and 2.19% of total ER admissions respectively). Leading causes were respiratory infections, followed by COPD and asthma.

Syria

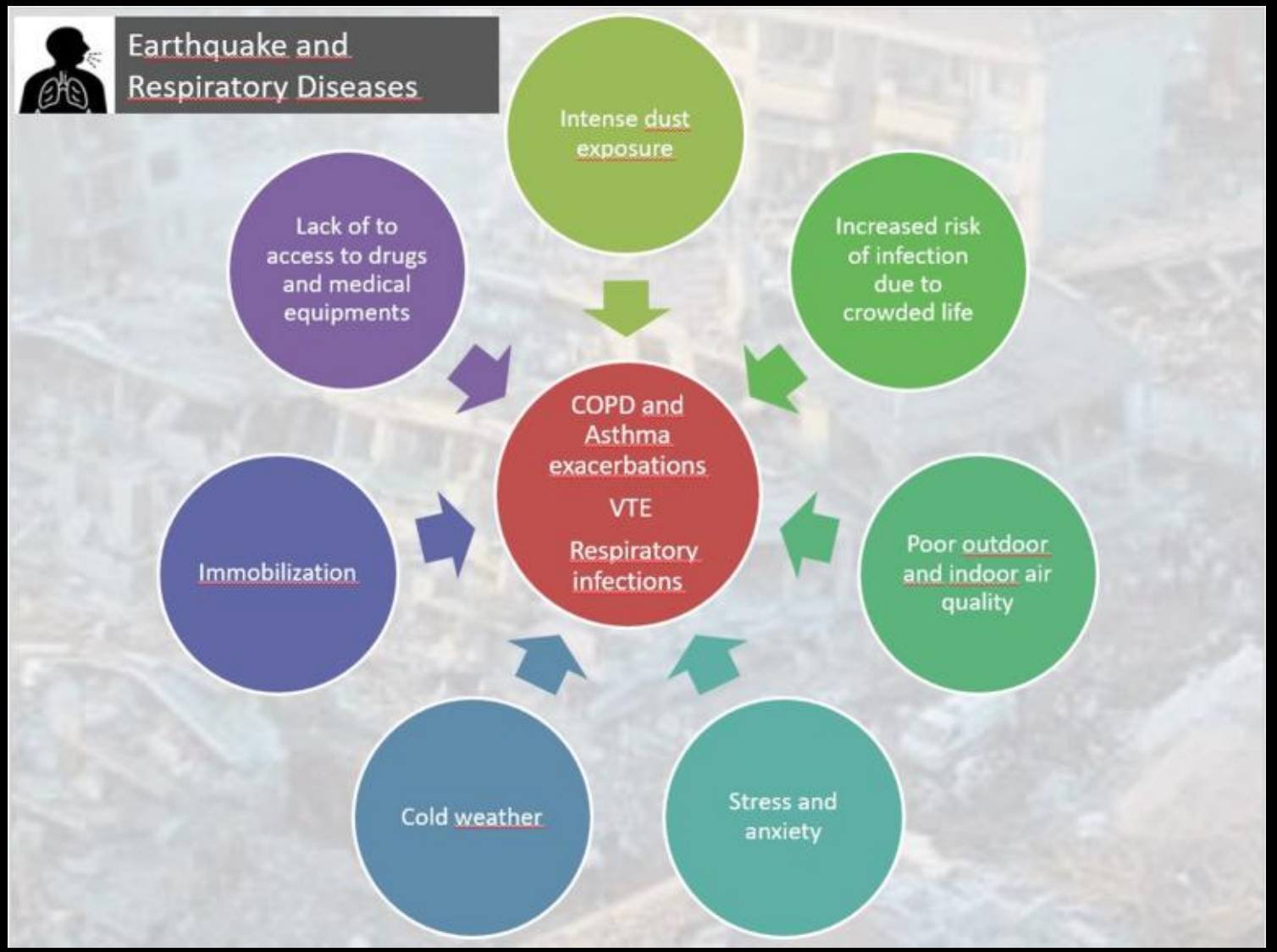
→ at least 5000 people HOSPITALIZED

- 17% of injuries related to the pulmonary system: haemothorax, pneumothorax, contusion, ARDS, crush syndrome)

- respiratory inpatients (20% of all inpatients): 24% asthma, 30% non-tuberculosis infection, 15% tuberculosis, 10% COPD

- respiratory outpatients: 30% asthma, 40% non-tuberculosis infection, 10% tuberculosis, 6% COPD).

A conundrum



Balbay et al. Thorac Res Pract 2024

VOLCANIC ERUPTIONS

How many volcanoes eruption?

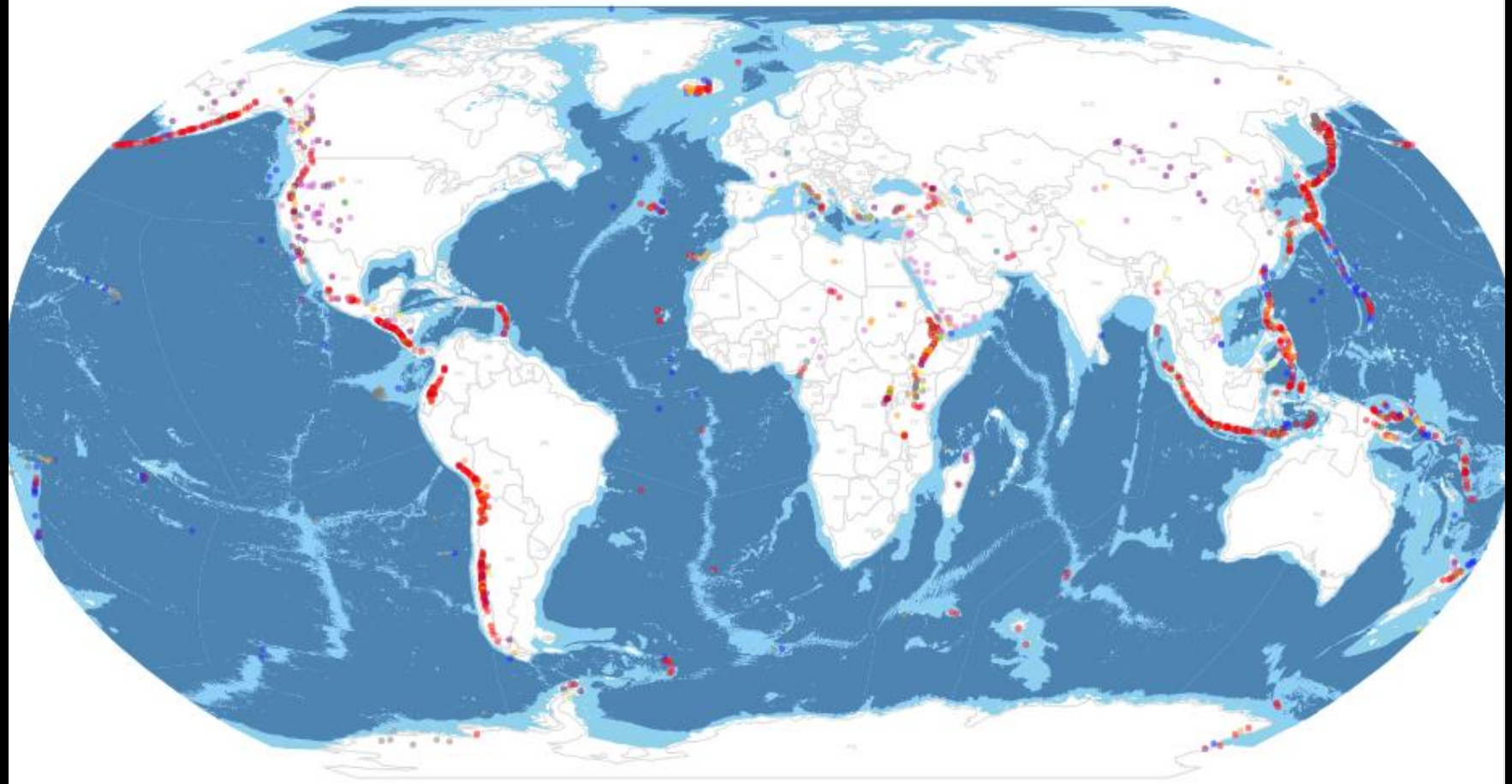
Since 1750 (industrial revolution):143 documented major volcanic eruptions (VEI ≥ 4).

Significant eruptions include:

- **Mount Tambora, Indonesia (1815)**: VEI 7, leading to the "Year Without a Summer" in 1816.
- **Krakatoa, Indonesia (1883)**: VEI 6, causing global climatic effects.
- **Novarupta, Alaska (1912)**: VEI 6, one of the largest eruptions of the 20th century.
- **Mount Pinatubo, Philippines (1991)**: VEI 6, resulting in global temperature decreases

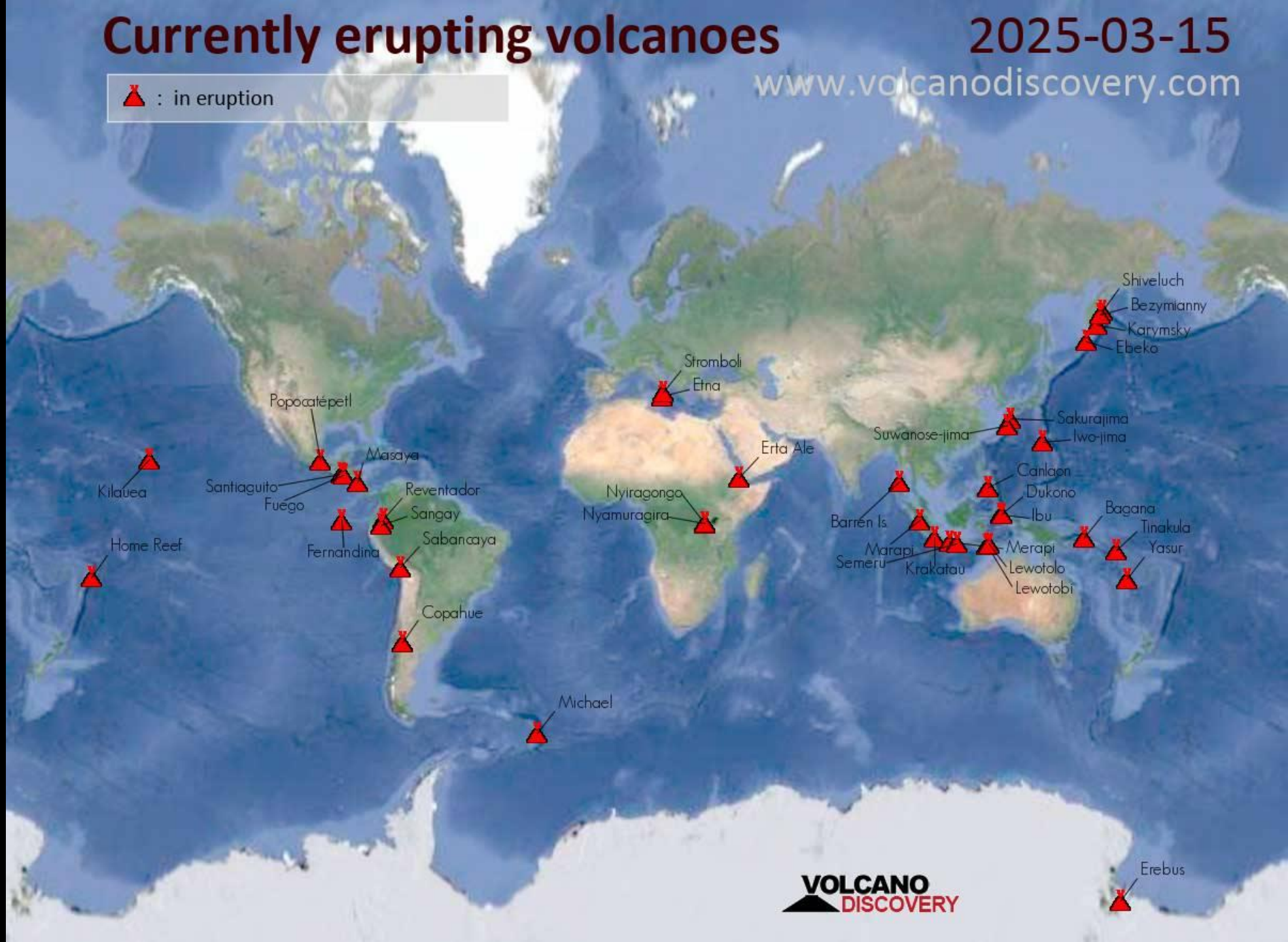
VEI: Volcanic Explosivity Index measures the explosiveness of volcanic eruptions

WHERE? (Total)



Volcano Types in this Map			
Shield Volcano	Strato Volcano	Caldera	Cinder Cone
Pyroclast	Explosion	Complex volcano	Lava
Maars	Fumarole	Submarine	Volcanic
Other			

WHERE? Active)



Volcanic eruptions pollution

- **A complex mixture of gases and particulates**
  - **Pa**
  - **Su**
  - **CO**
  - **CO**
  - **Hy**
  - **Oth**
  - **Me**
  - **Ra**

<u>Volcanic Smog (VOG) formation</u>:

- **Sulfur dioxide (SO_2) + atmospheric oxygen + water vapor → sulfuric acid (H_2SO_4) aerosols**
- **SO_2 and sulfate aerosols mix with other volcanic gases (e.g., hydrogen sulfide, carbon dioxide) and fine ash**, forming a <u>thick, hazy smog</u>.
- **Winds transport vog over long distances**, affecting communities **hundreds to thousands of kilometers away.**

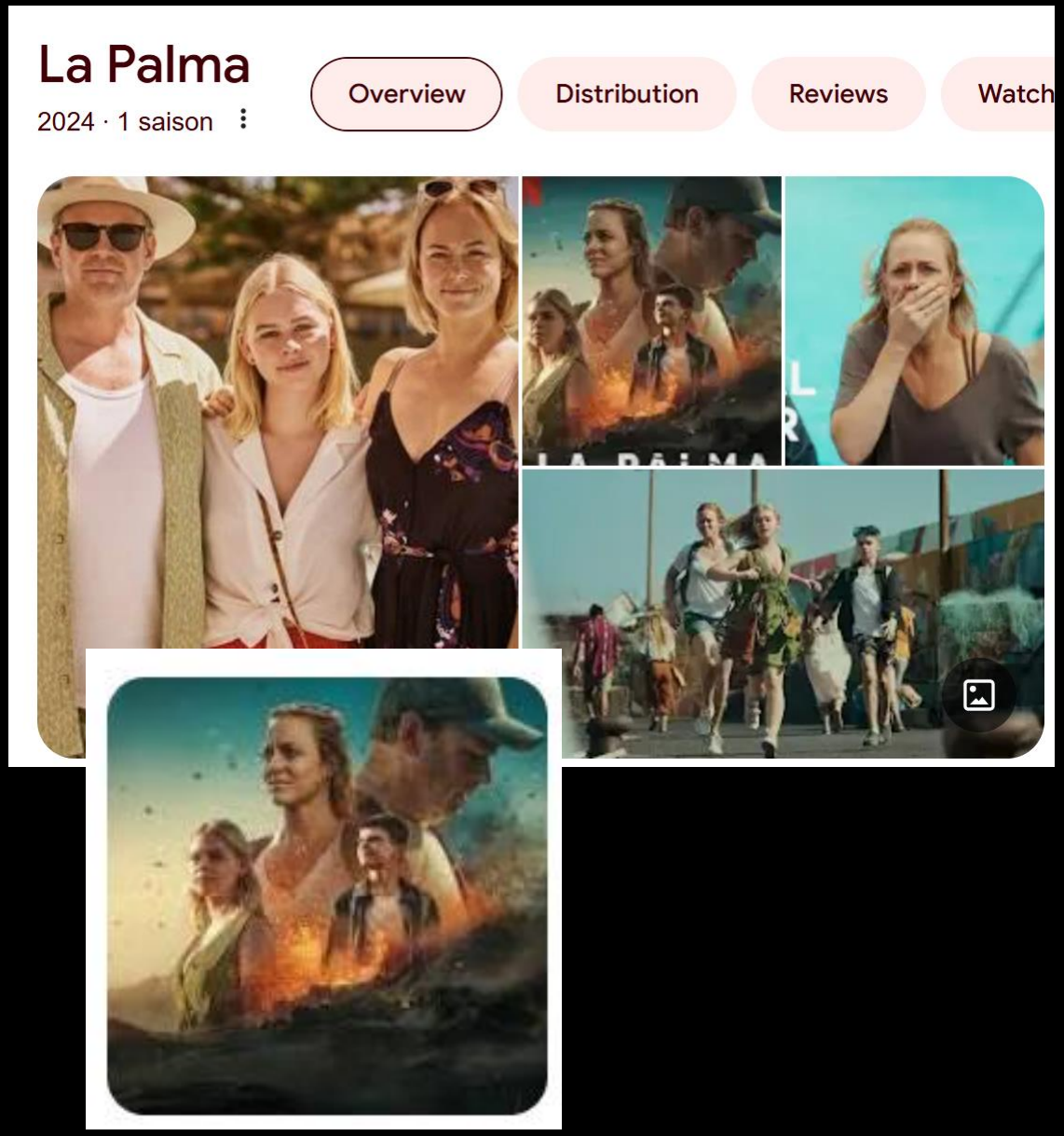
Main respiratory health effects of volcaneos eruptions

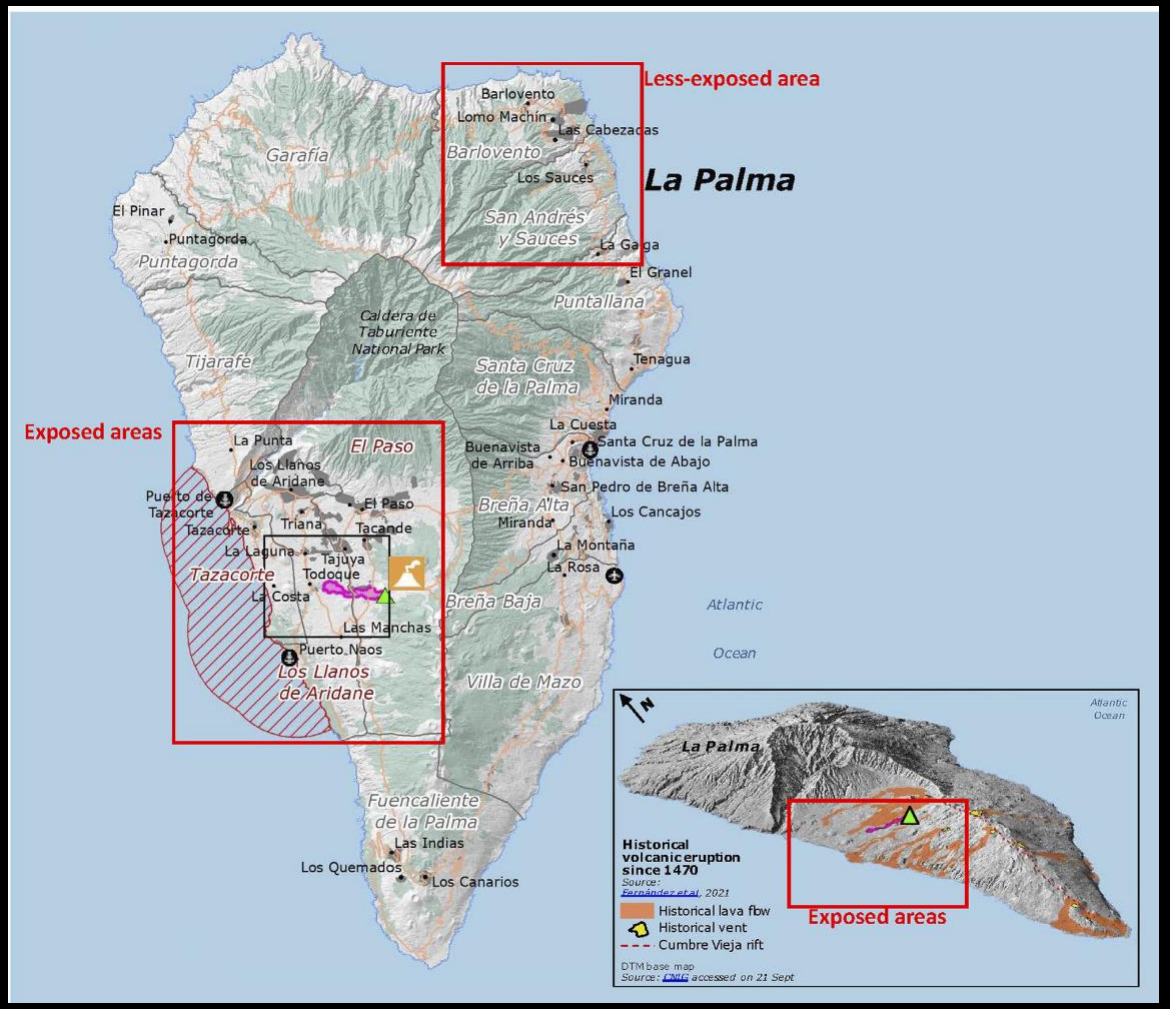
109 publications

- Sulfur dioxide (SO_2), ash, and acidic aerosols
  - → ST exposure: Severe lung irritation, increased asthma/bronchitis/COPD exacerbations, and even acute respiratory failure, especially in sensitive individuals (children, elderly, and those with pre-existing conditions).
  - → LT exposure: Silicosis, **pneumoconiosis and chronic lung diseases from ash**.
  - → Lung function decline

Gudmundsson G. Clin Respir J. 2011.
Annesi-Maesano ERJ 2025

2021 volcanic eruption in La Palma





Archivos de Bronconeumología 60 (2024) 475–482

Sociedad Española de Neumología y Cirugía Torácica SEPAR

ARCHIVOS DE Bronconeumología

www.archbronconeumol.org

Original article

Lung Function and Symptoms of Exposure to the Volcanic Eruption in the Canary Islands: First Follow-Up of the ASHES Study

Cristina Candal-Pedreira[a], David Díaz-Pérez[b], Valle Velasco[c], Ciro Casanova[d], Orlando Acosta[e], [illegible] Castaño[i], [illegible]erich[l,m,n], Cristina Martínez[o], [illegible]z-Íñigo[i], Alberto Ruano-Ravina[a,q,*]

Introduction: Exposure to gases and particulate matter released during volcanic eruptions can prove harmful to population health. This paper reports the preliminary results of the ASHES study, aimed at ascertaining the respiratory health effects of the 2021 volcanic eruption in La Palma Island (Spain) on the adult population without previous respiratory disease.

Methods: Ambispective cohort study on the healthy adult population. Three exposure groups were considered: Group 1, high exposure; Group 2, moderate exposure; and Group 3, minor or no exposure. We carried out a descriptive analysis of symptoms during and after the eruption, as well as measure lung function after the eruption (through forced spirometry and diffusing capacity of carbon monoxide).

Results: The analysis included 474 subjects: 54 in Group 1, 335 in Group 2, and 85 in Group 3. A significant increase in most symptoms was observed for subjects in the groups exposed during the eruption. After the eruption, this increase remained for some symptoms. There seems to be a dose-response relationship, such that the higher the exposure, the higher the odds ratio. A prebronchodilator FEV_1/FVC ratio < 70% was observed in 13.0% of subjects in Group 1, 8.6% of subjects in Group 2, and 7.1% of subjects in Group 3.

Conclusions: This study is the first to report a dose-response relationship between exposure to volcanic eruptions and the presence of symptoms in adults. Furthermore, there is a tendency toward obstructive impairment in individuals with higher exposure.

DOSE-RESPONSE BETWEEN EXPOSURE AND HEALTH

Environmental Research 216 (2023) 114486

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

A longitudinal and multidesign epidemiological study to analyze the effect of the volcanic eruption of Tajogaite volcano (La Palma, Canary Islands). The ASHES study protocol

Alberto Ruano-Ravina [a,b,c], Orlando Acosta [d,*], David Díaz Pérez [e], Ciro Casanova [f,g], Valle Velasco [h], Germán Peces-Barba [g,i], Esther Barreiro [g,j,o], Ana Cañas [k], Argelia Castaño [k], María Jesús Cruz Carmona [g,l], Carmen Diego [m], Judith Garcia-Aymerich [c,n,o], Cristina Martínez [p], María Molina-Molina [q], Xavier Muñoz [g,l], Francisco Javier Sánchez-Íñigo [k], Cristina Candal-Pedreira [a,b]

EXCLUSIVELY OF NATURAL ORIGIN?

Natural disasters are catastrophic events that occur due to natural processes of the Earth, causing significant damage to life, property, and the environment. These events can be sudden or develop over time, leading to severe disruptions in communities and ecosystems and impacting health.

Human activities can contribute to these events in the short and the long term.

Extreme natural catastrophe on the rise

Catastrophe	Antropogenic impact
Heatwaves & hot spells	Elevated ozone levels, emissions from power generation for air conditioning
Cyclones, thunderstorms, flood	Rise of sea water level, water cycle
Dust storms	Draught and extreme wind
Wildfires	Draught and extreme wind
Earthquakes	Long-term indirect climate change effects
Volcanic eruptions	Long-term indirect climate change effects

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ERJ 2025

Interactions between earthquakes and climate

Climate change **does not directly cause earthquakes**, but it can **influence seismic activities (stress on fault lines)** through:

1. Glacial Melt and Isostatic Rebound

- Example: The retreat of glaciers in **Alaska, Greenland, and Antarctica** has been linked to increased seismic activity in these regions.

2. Changes in Water and Ice Mass Distribution

- Example: The **Three Gorges Dam in China** (filled in 2003) led to an increase in small earthquakes due to the added water weight and pressure on faults.

3. Intense Precipitation and Landslides

- Example: The 2017 Chiapas earthquake (Mexico) was preceded by heavy rainfall, which may have played a role in triggering movement along the fault.

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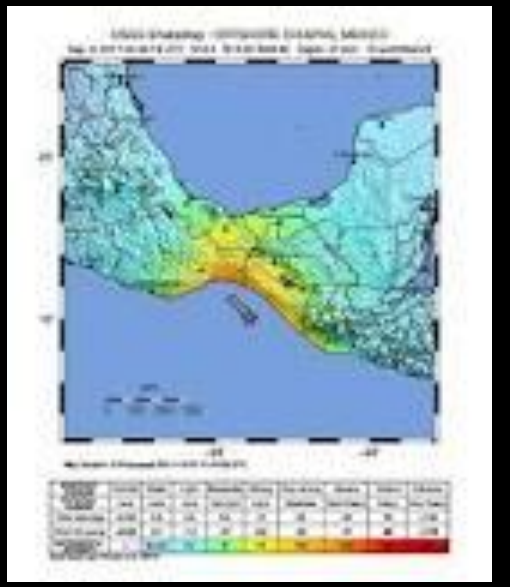
Potential link

The International Programme on Landslides (IPL)

ISDR

The San Juan de Grijalva Catastrophic Landslide, Chiapas, Mexico: Lessons Learnt

Irasema Alcántara-Ayala (Instituto de Geografía, Universidad Nacional Autónoma de México) · Leobardo Domínguez-Morales (Centro Nacional de Prevención de Desastres, México)



Intense rainfall can infiltrate faults, increasing pore pressure and potentially triggering earthquakes

DE GRUYTER Open Geosciences 2022; 14: 453–461

Research Article

Yaxiang Wang, Ziyi Cao, Zhaojun Pang*, Yan Liu, Jiawei Tian, Juan Li, Lirong Yin*, Wenfeng Zheng, and Shan Liu

Influence of Three Gorges Dam on earthquakes based on GRACE gravity field

Interactions between volcanic eruptions and climate system are dynamic and bidirectional

- Volcanic eruptions influences the climate:
  - Volcanic greenhouse gas emissions, like carbon dioxide, contribute to long-term warming.
  - Volcanic ash and dust can absorb solar radiation.
  - Large quantities of aerosols, such as sulphur dioxide, which form sulphate particles in the atmosphere reflect sunlight and influence cloud formation and precipitation patterns.
- Climatic changes affects volcanic activity:
  - Melting glaciers reduce pressure on the Earth's crust, potentially increasing volcanic activity
  - Rising sea levels alter pressure on underwater volcanoes, potentially influencing their eruption patterns.

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WORKERS CONFRONTED WITH NATURAL DISASTERS

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Respiratory effects of natural disasters among first responders (firefighters). Healthy Worker Effects?

Type of Natural Disaster	Exposure	Short-Term Respiratory Effects	Long-Term Respiratory Effects	Key Notes
Wildfires	Smoke inhalation, fine particulate matter ($PM_{2.5}$), carbon monoxide (CO), toxic gases (e.g., formaldehyde, benzene)	- Cough - Wheezing - Shortness of breath - Acute bronchitis	- Decline in lung function (FEV_1) - Chronic bronchitis - Increased risk of asthma - Pulmonary fibrosis (in severe cases)	Extended exposure linked to oxidative stress and airway inflammation. High levels of $PM_{2.5}$ are associated with exacerbations of pre-existing conditions (e.g., asthma).
Earthquakes	Dust from collapsed buildings (silica, asbestos), toxic chemical exposure	- Acute respiratory distress syndrome (ARDS) - Coughing - Shortness of breath	- Silicosis - Risk of COPD (from chronic silica exposure)	Firefighters involved in rescue operations are exposed to high concentrations of respirable crystalline silica. Use of personal protective equipment (PPE) is critical to mitigate risks.
Volcanic Eruptions	Volcanic ash (silica, SO_2, heavy metals), toxic gases	- Upper airway irritation - Cough - Acute bronchospasm	- Airway remodelling - Development of chronic respiratory diseases	Exposure to volcanic ash and gases can cause long-term scarring of lung tissue, especially without proper respiratory protection.
Floods	Mold, waterborne pathogens, and chemicals from polluted water	- Allergic reactions - Asthma exacerbation - Respiratory infections (e.g., pneumonia)	- Chronic asthma - Increased susceptibility to respiratory infections	Mold spores and endotoxins are common respiratory irritants in post-flood environments. Decontamination procedures are essential to reduce health risks.
Hurricanes and Tornadoes	Debris particles, toxic fumes from chemical spills, mould	- Irritation of airways - Acute bronchitis - Hypoxemia (in severe cases)	- Persistent asthma - Potential COPD development	Exposure to airborne debris and chemicals during rescue operations is a major concern. Respiratory symptoms are often compounded by physical exertion in high-stress conditions.

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Protection Measures for Earthquakes and Volcanic Eruptions First Responders

Eartquakes

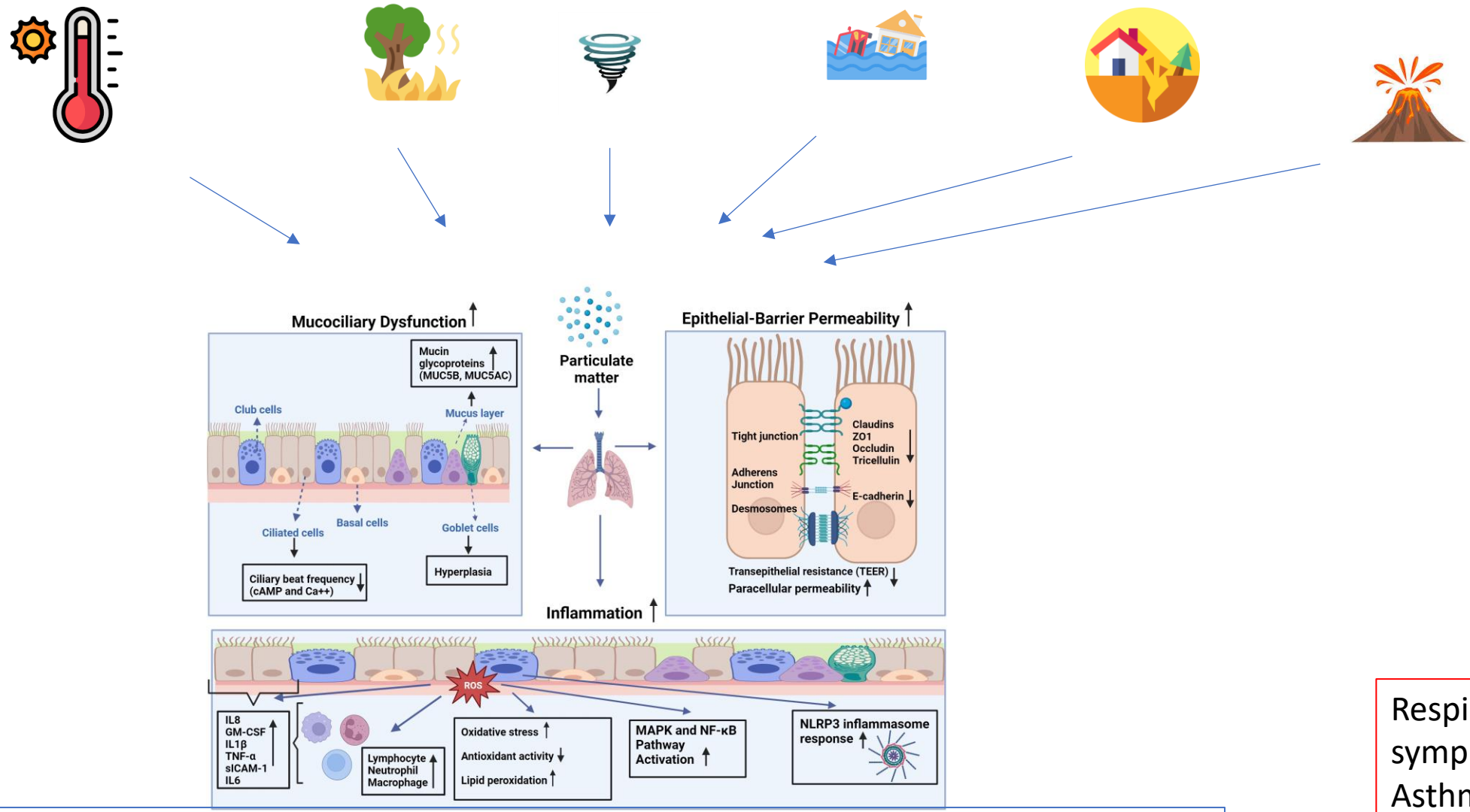
- Protection Measures for Earthquake First Responders
  - **Helmet, eye protection, gloves, protective gloves**
  - **Respiratory Protection** – N95 or P100 masks to prevent inhalation of dust and asbestos.
- Training & safety protocols
- Advanced technology
  - Drones, sensors, robotics

Volcanic eruptions

- Protection Measures for Earthquake First Responders
  - Heat-resistent clothing, booths, google
  - Respiratory Protection – Gas Masks or Self-Contained Breathing Apparatus (SCBA) – Protects against toxic gases (SO_2, CO_2, H_2S, fluorine
- Training & safety protocols
- Advanced technology
  - Thermal cameras&satellite, drone &sensors,
  - Lahar Early Warning Systems – Detects volcanic mudflows to protect responders.

MECHANISMS

Annesi-Maesano ERJ 2025



bronchial hyperreactivity, mucus production, local inflammation, systemic inflammation, microbiome disturbance, epigenetic changes ...

Respiratory symproms
Asthma
COPD
IPF
Etc.

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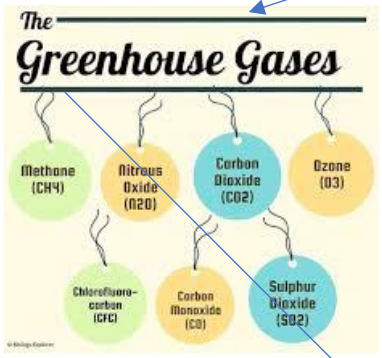
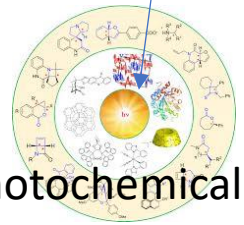
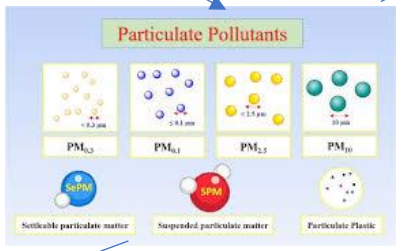
NATURAL DISASTERS

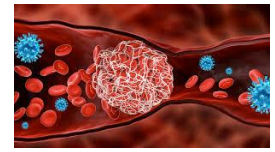




photochemically reactive compounds

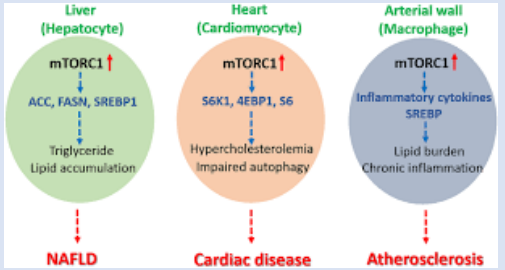


Systemic inflammation

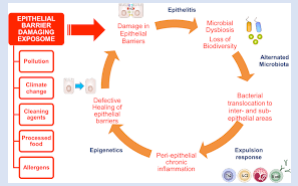


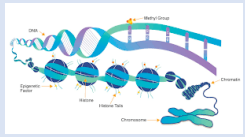
Long-term consequences

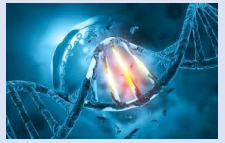
Metabolic impact on blood vessels, liver, heart, brain



Chronic epithelitis



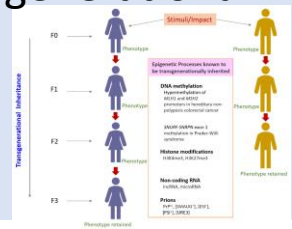




Epigenetic changes

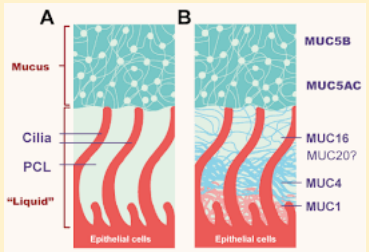
Gene toxicity

Transgenerational impact

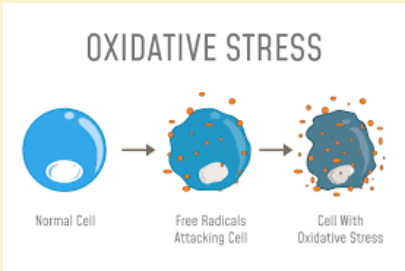


Immediate consequences

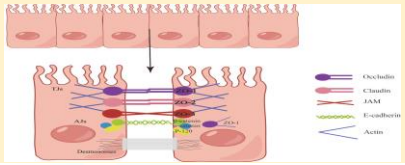
Mucus production



Oxidative stress

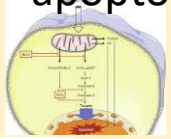


Epithelial barrier dysfunction

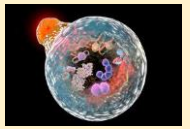


Microbiome perturbance

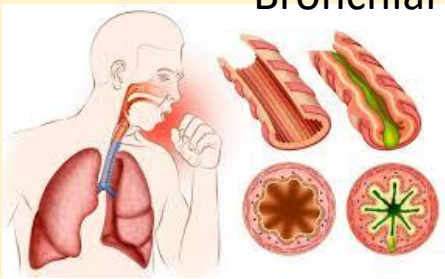
apoptosis

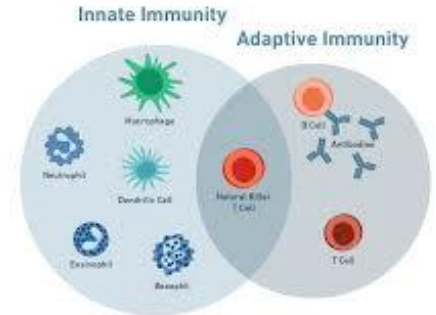


autophagy



Airway hyperreactivity
Bronchial obstruction





Innate and adaptive immune response

Local inflammation

PREVENTION

Mitigation strategy

Annesi-Maesano ERJ 2025

Type of Natural Disaster	Mitigation Strategies	Most Affected Groups/Populations	Health and Environmental Inequalities
Floods	Climate-adaptive infrastructure, early warning systems, clean water supply, rapid post-disaster medical response	Residents in disaster-prone areas, immunocompromised individuals, elderly, children	Lack of infrastructure, challenges in accessing shelter and healthcare after disasters
Cyclones, Hurricanes and Storms	Early warning systems, post-disaster clean water supply, securing shelters	Residents in disaster-prone areas, low-income individuals, immunocompromised populations	Lack of infrastructure in low-income areas, challenges in accessing clean water
Dust Storms	Use of masks, reducing soil erosion (increasing vegetation), monitoring occupational exposure, education for vulnerable groups	Farmers, outdoor workers, elderly, young children, individuals with chronic diseases	Limited access to healthcare in rural areas, economic barriers to mask availability
Wildfires	Indoor air filtration systems, HEPA filters, N95 masks, specific health measures for firefighters and vulnerable populations	Firefighters, outdoor workers, children, elderly, individuals with chronic respiratory conditions	Lack of access to air filtration systems in low-income households, insufficient protective equipment for firefighters
Volcanic Eruptions	Use of masks, evacuation plans, public health advisories, volcanic ash analyses	Residents near volcanic regions, asthma patients, elderly, children	Barriers to evacuation and healthcare access, inadequate infrastructure in rural areas
Earthquakes	Earthquake-safe buildings, dust control measures, distribution of proper protective equipment, post-earthquake emergency health services	Residents in disaster zones, rescue teams, workers, individuals with chronic conditions	Presence of unsafe, older buildings in low-income areas, difficulties accessing healthcare after disasters

PATIENT EDUCATION

In addition to the Air Quality Index, keeping track of wind conditions is important as winds carry vog to different areas further from the volcano. Vog and wind forecasts are available to the public online (https://vog.ivhhn.org/vog-and-wind-forecasts).

People can reduce vog exposure by taking the following measures:

- Seek the local wind and weather pattern.
- Avoid strenuous outdoor activities in areas with increased vog conditions.
- Close windows and doors, and remain indoors or upwind of the vog source.
- Use air conditioning and HEPA filters. In the same way that air conditioning removes water vapor, it will remove sulfate particles. A HEPA ($PM_{2.5}$) filter provides additional protection.
- Shelter in pollution-free areas.
- Be careful to reduce other sources of indoor air pollution such as tobacco smoke, dust, animal dander, and mold.

For vog, sheltering in such places or leaving a high SO_2 or voggy area is more effective than masks or respirators which require special fitting or cannisters to effectively remove gases and respirable particles, and may add to the work of breathing for those with pre-existing lung disease.

If you are exposed to vog and are having symptoms, contact your healthcare providers right away and get away from further vog exposure. Treatment of symptoms often includes staying hydrated and (for those who have been diagnosed with asthma or COPD) using a rescue bronchodilator inhaler as prescribed. A short course of oral steroids, to reduce airway inflammation, could be considered by your healthcare provider.

What about ash?

Ash is defined as fragments that are ≤2 millimeters in size. Kīlauea has low viscosity basaltic magma and does not usually erupt significant amounts of ash. However, in the time since the lava lake at the summit of Kīlauea started to drain, there have been remarkable explosions of gas and ash reaching as high as 30,000 feet above sea level. From that height, smaller ash particles can drift downwind and fall miles away. The ash particles are generally not breathed into the lungs. Nevertheless, ash can deposit in the eyes, nose, mouth, and throat, causing discomfort and irritation.


U.S. Geological Survey

Eye protection and simple masks can reduce deposition of particles the size of pollens or hair. N95 masks can block smaller particles but can also clog if pollution is high, limiting breathing. Neither will remove sulfur dioxide gas.

What is laze?

Laze is formed when molten lava flows into the ocean and boils seawater. This creates large amounts of steam filled with hydrochloric acid and glass shards, making it very noxious to inhale. Irritation of mucosal surfaces including the skin, eyes, and airways can lead to shortness of breath. Two deaths have been reported in individuals with high levels of exposure near a laze cloud in 2000. Laze is confined to very localized areas, off limits to sightseers on foot or on boat.


U.S. Geological Survey

Lava flows reaching the ocean on Hawaii's Big Island on May 20th, 2018 creating a cloud of laze.

Authors: W. Graham Carlos MD, Jane E. Gross MD, PhD, Shazia Jamil MD, Charles S. Dela Cruz MD, PhD, David Damby PhD, Elizabeth Tam MD
Reviewer: Marianna Sockrider MD, DrPH

Rx Action Steps

- ✔ Monitor wind and air quality to know when air pollution will be a health risk in your location (www.airnow.gov)
- ✔ Keep your indoor air free of contaminants. Close windows and doors and do not smoke
- ✔ Avoid strenuous outdoor activity
- ✔ Remain indoors if air quality is a health risk
- ✔ Consider recirculating indoor air using an air conditioner, or air purifier with a HEPA ($PM_{2.5}$) filter
- ✔ Seek medical advice immediately if respiratory symptoms persist despite getting out of the vog, staying hydrated, and (for those with a respiratory diagnosis) taking your prescribed medications

References and Additional Resources:

Frequently Asked Questions on Vog from Kīlauea Volcano
- https://vog.ivhhn.org/FAQ.pdf

American Lung Association: Volcanic Ash
- http://www.lung.org/our-initiatives/healthy-air/outdoor/emergencies-and-natural-disasters/volcanic-ash.html

Centers for Disease Control and Prevention
- https://www.cdc.gov/disasters/volcanoes/pdf/aftereruption.pdf

AirNow: Particle Pollution and Your Health
- https://airnow.gov/index.cfm?action=particle_health.index

Air Purifier Information
- https://vog.ivhhn.org/air-purifier-information

Volcanic Eruptions and Threats to Respiratory Health

In early May 2018, Kīlauea volcano became increasingly active, posing an increase in threat to respiratory health. The emission of gases such as sulfur dioxide from Kīlauea produces large amounts of respirable acid particles as the gases react with water vapor and sunlight, resulting in a visible haze called "vog". Additionally, the lava lake at Kīlauea's summit crater has fallen, leading to explosions of "ash" that have reached as high up as 30,000 feet above sea level. Finally, lava entering the Pacific Ocean boils sea water to dryness, creating thick clouds of "laze" that is filled with hydrochloric acid and tiny shards of glass. Depending on your location and wind direction and speed, vog, ash, and laze can reach hazardous levels of air pollution that are toxic to humans. This fact sheet serves to inform you of potential adverse health effects following exposure to these airborne products of volcanic activity. This outdoor air quality issue is relevant to other locations worldwide at risk for volcanic activity.


U.S. Geological Survey

CLIP AND COPY

What is vog and what are the symptoms following exposure?

Vog is a cloudy air mixture of sulfur dioxide gas (SO_2), water vapor (H_2O), carbon dioxide (CO_2), sulfate particles and volcanic ash. Human exposure may lead to respiratory symptoms, particularly among those with a history of pre-existing conditions such as:

- Obstructive airway diseases (e.g. asthma, bronchitis, bronchiectasis and chronic obstructive pulmonary disease - COPD)
- Cardiovascular diseases
- Extremes of age (infants and elderly)
- Pregnancy

People with known airway reactivity (such as asthma or COPD) may develop bronchospasm (tightening of airway muscles) that causes symptoms such as shortness of breath, wheezing, cough, and inflammation in the airways leading to swelling and mucus production, even with limited vog exposure. At high exposures, anyone (even healthy people with no lung disease) may develop breathing problems. Sustained levels of exposure have been associated with an increased risk of needing emergency room care. People, especially those at higher risk (listed above) should follow the health advisories listed in the Air Quality Index for particle pollution produced by the Environmental Protection Agency (Figure 1). For example, the Air Quality Index for Kona (about 10 miles north of Kailua-Kona) on the west coast of the summit was at "orange" level on May 20th, 2018, and therefore was unhealthy for older individuals or those with pre-existing heart or lung disease.

Figure 1. Air Quality Index for Particle Pollution

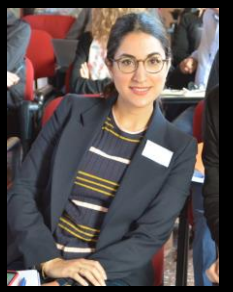
Air Quality Index	Health Advisory
Good (Green) 0–50	None
Moderate (Yellow) 51–100	Unusually sensitive people should consider reducing prolonged or heavy exertion.
Unhealthy for Sensitive Groups (Orange) 101–150	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy (Red) 151–200	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
Very Unhealthy (Purple) 201–300	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

Adapted from the Environmental Protection Agency (EPA) Air Quality Index (AQI)
https://airnow.gov/index.cfm?action=aqibasics.aqi

Take-home message

- Volcanic eruptions and earthquakes, as the other natural disasters, produce high amount of a mix of air pollutants
- Natural disasters have a significant impact on respiratory health in general populations, especially in susceptible and vulnerable individuals, and first responders.
- Earthquakes and volcanic eruptions although natural may be interconnected to climate change
- Need for call for action for effective prevention and intervention strategies for protecting respiratory health, and general physical and mental health in general, during such natural disasters
- Need for protection measures for first responders (overall volonteers)
- Need for patients information and protection
- Need for further studies and research (available data are scarce)

To my collaborators



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