Clean Air Catalyst

A Global Partnership for Accelerating Clean Air Solutions

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WORLD RESOURCES INSTITUTE

Vital Strategies

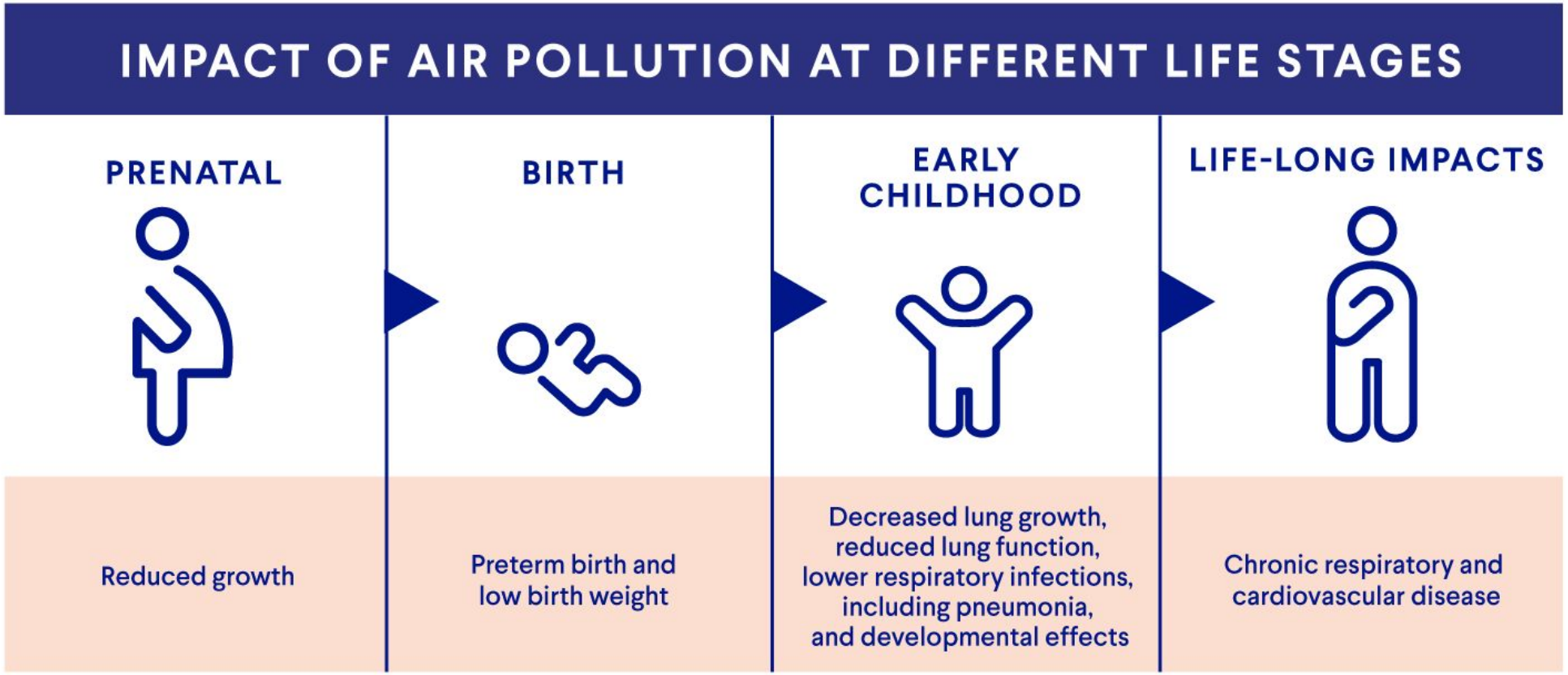
Jakarta
a city of collaboration

Dampak Kesehatan dari Polusi Udara

Ginanjar Syuhada

Clean Air
Catalyst

Polusi Udara Memengaruhi Kesehatan Sepanjang Hidup Manusia



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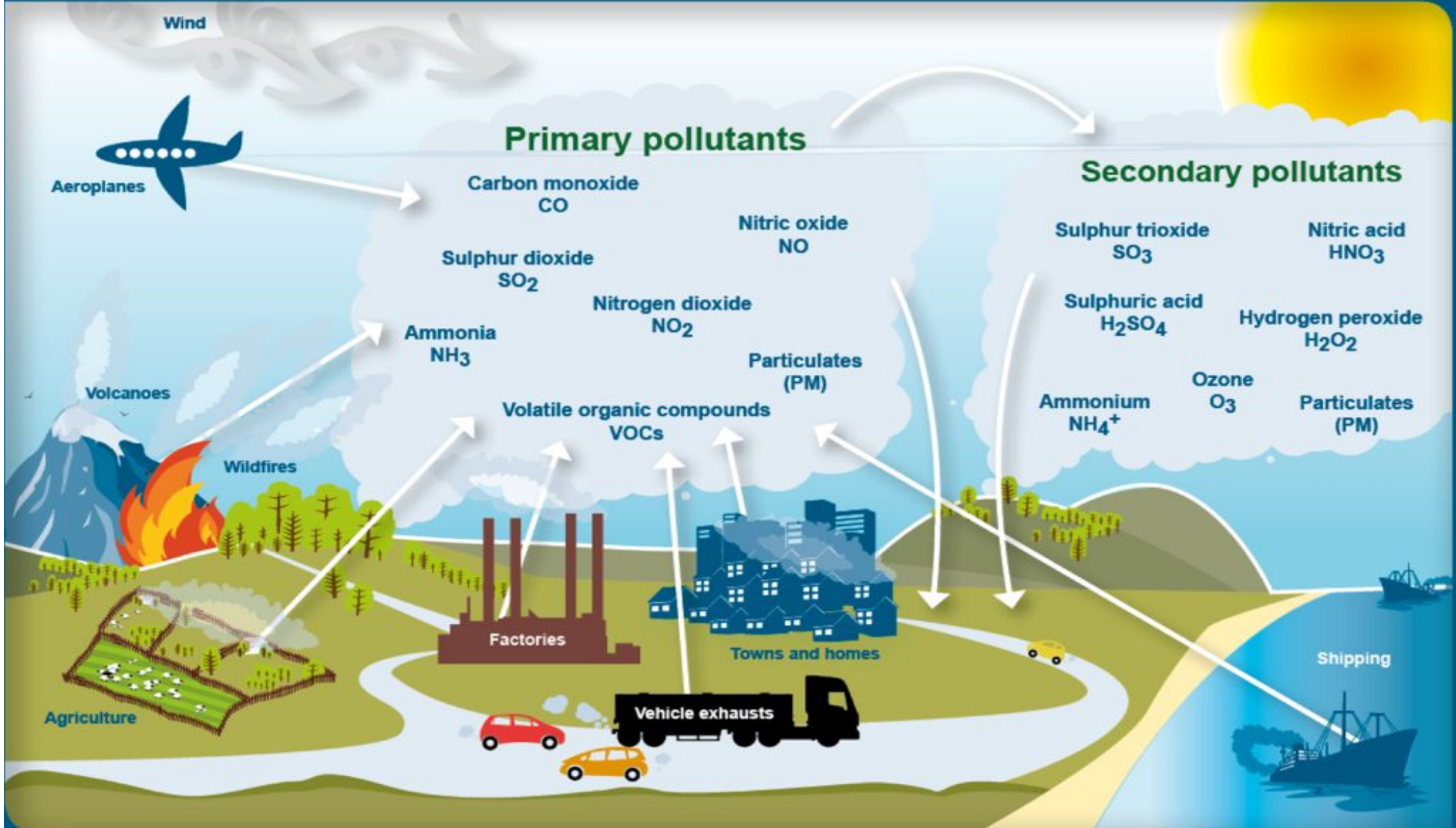
POLUSI UDARA: SILENT KILLER (WHO, 2021)

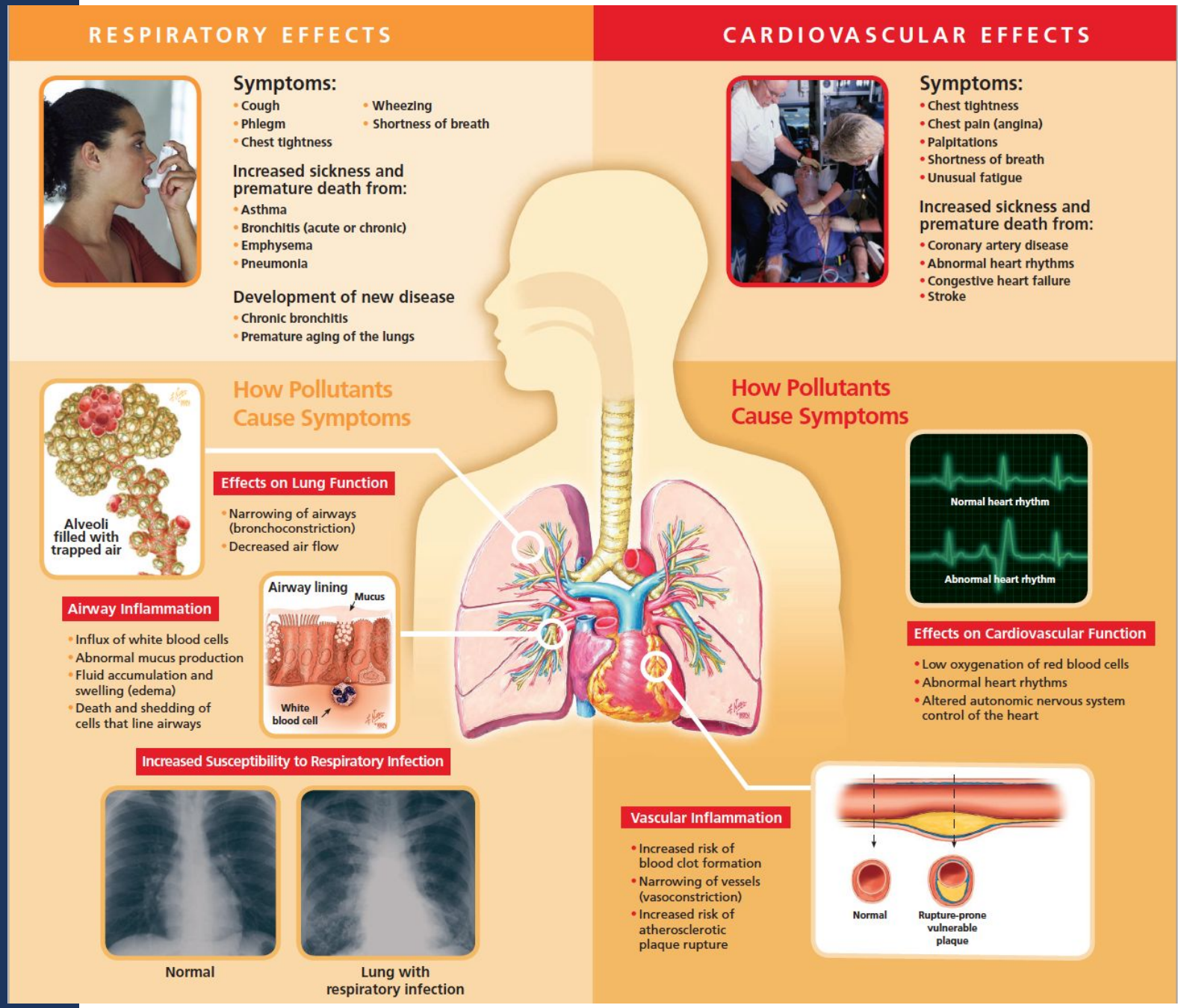
Sumber: Infografis WHO, 2021.

Setiap tahunnya, terdapat sekitar 7 juta kematian akibat paparan polusi udara, yang mana lebih dari 2 juta di antaranya berasal dari Asia Tenggara.

9 dari 10 orang tinggal di area dengan tingkat polusi udara yang melebihi standar baku WHO.


Wind
Aeroplanes
Primary pollutants
Carbon monoxide
CO
Nitric oxide
NO
Sulphur dioxide
SO_2
Nitrogen dioxide
NO_2
Ammonia
NH_3
Particulates
(PM)
Volatile organic compounds
VOCs
Secondary pollutants
Sulphur trioxide
SO_3
Nitric acid
HNO_3
Sulphuric acid
H_2SO_4
Hydrogen peroxide
H_2O_2
Ozone
O_3
Ammonium
NH_4^+
Particulates
(PM)
Volcanoes
Wildfires
Factories
Towns and homes
Agriculture
Vehicle exhausts
Shipping

Review: Air pollution has adverse respiratory and cardiovascular effects



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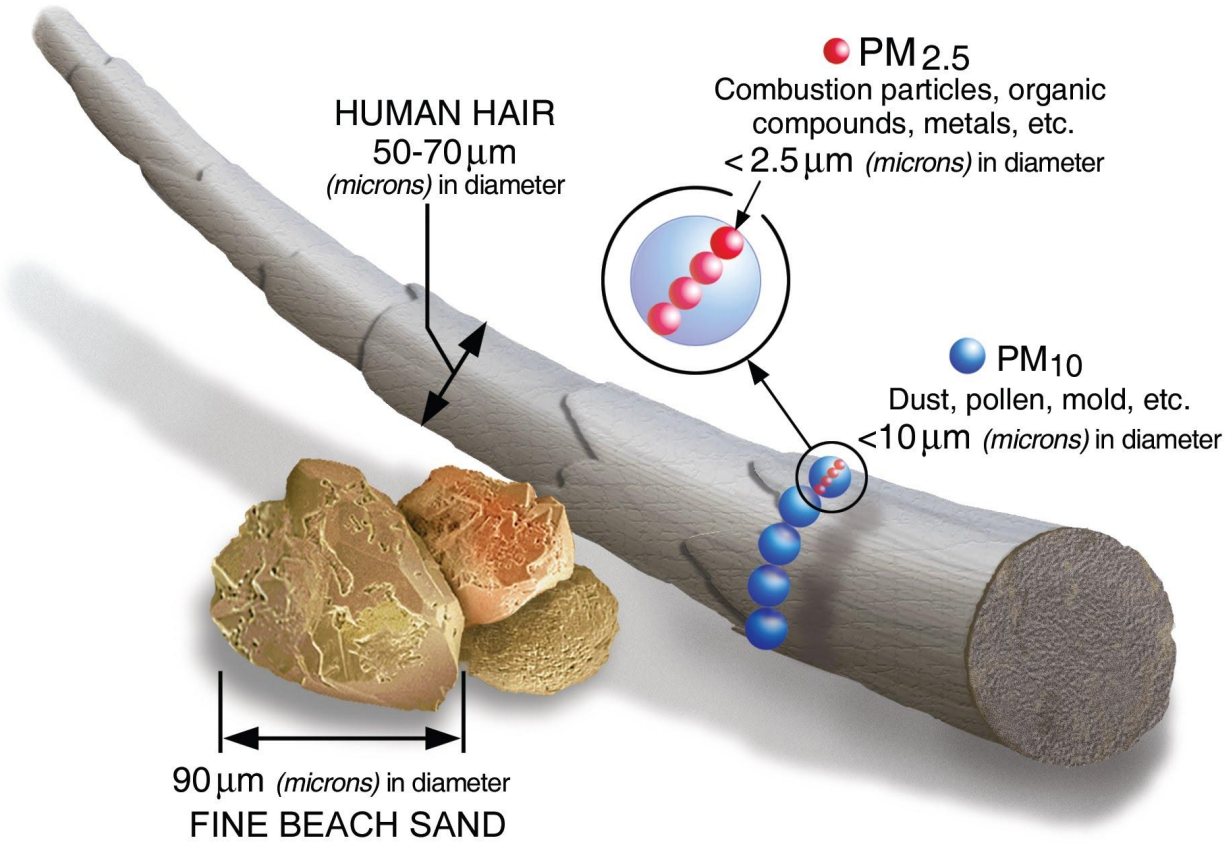
Particulate Matter (PM) / Partikulat

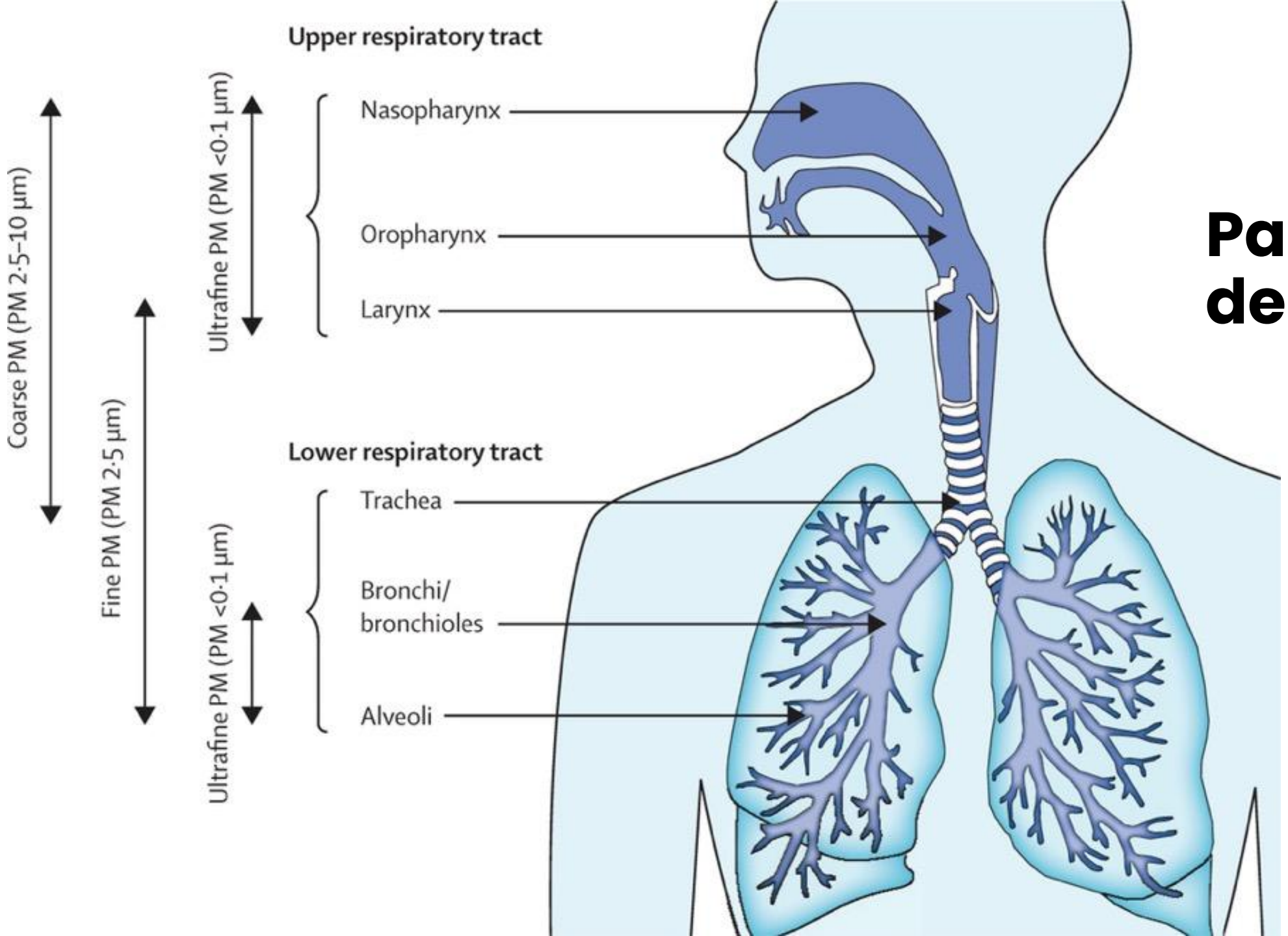


Sumber: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

- PM merupakan campuran berbagai macam partikel yang merusak kesehatan
- Partikel berdiameter kurang dari 2.5 mikrometer dikenal juga sebagai partikel halus atau PM2.5, memiliki risiko kesehatan yang paling besar.
- Sebagian besar dari PM2.5 berasal dari pembakaran yang tidak sempurna, seperti dari industri dan lalu lintas, pembakaran bahan bakar dari pembangkit listrik dan kilang minyak, serta biomassa dan pembakaran sampah di ruang terbuka.

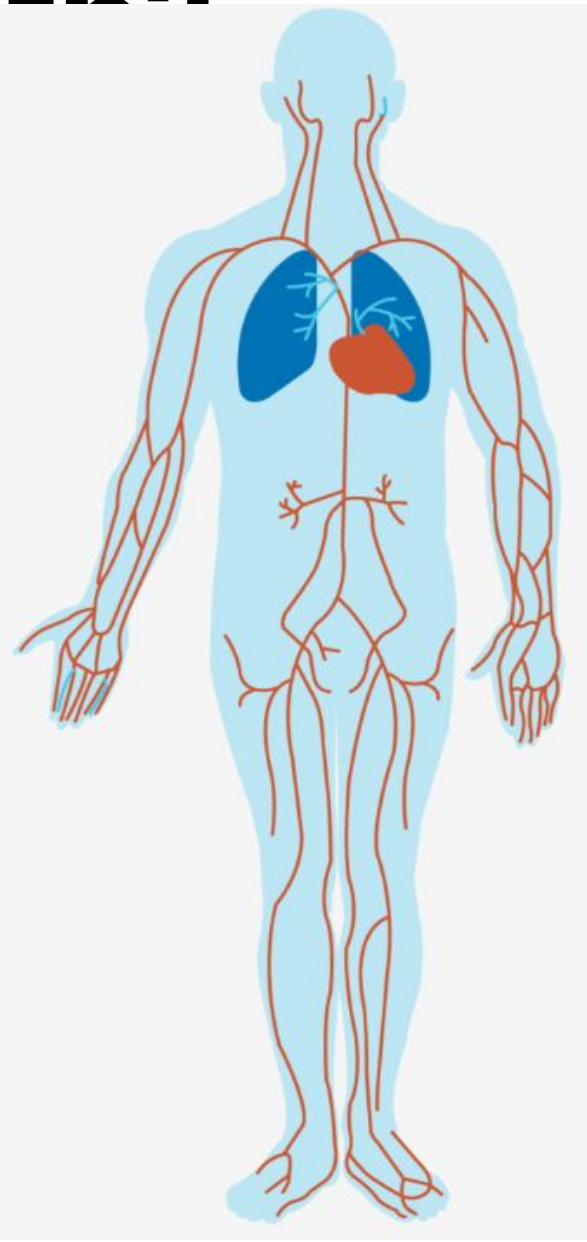
Referensi:
Kim, K.-H., Kabir, E., & Kabir, S. (2015). *A review on the human health impact of airborne particulate matter. Environment International, 74, 136–143.* doi:10.1016/j.envint.2014.10.005

Particle deposition



How does $PM_{2.5}$ affect health?

1. menyebabkan **iritasi paru-paru** yang menyebabkan peningkatan permeabilitas jaringan paru-paru;
2. meningkatkan **kerentanan terhadap virus dan bakteri patogen** yang menyebabkan pneumonia pada orang yang rentan;
3. **memperburuk keparahan penyakit paru-paru kronis** yang menyebabkan hilangnya fungsi saluran napas dengan cepat;
4. menyebabkan **peradangan jaringan paru-paru**, mengakibatkan pelepasan bahan kimia yang mempengaruhi fungsi jantung;
5. menyebabkan **perubahan kimia darah yang menghasilkan gumpalan** yang dapat menyebabkan serangan jantung



Source: Johns Hopkins Bloomberg School of Public Health

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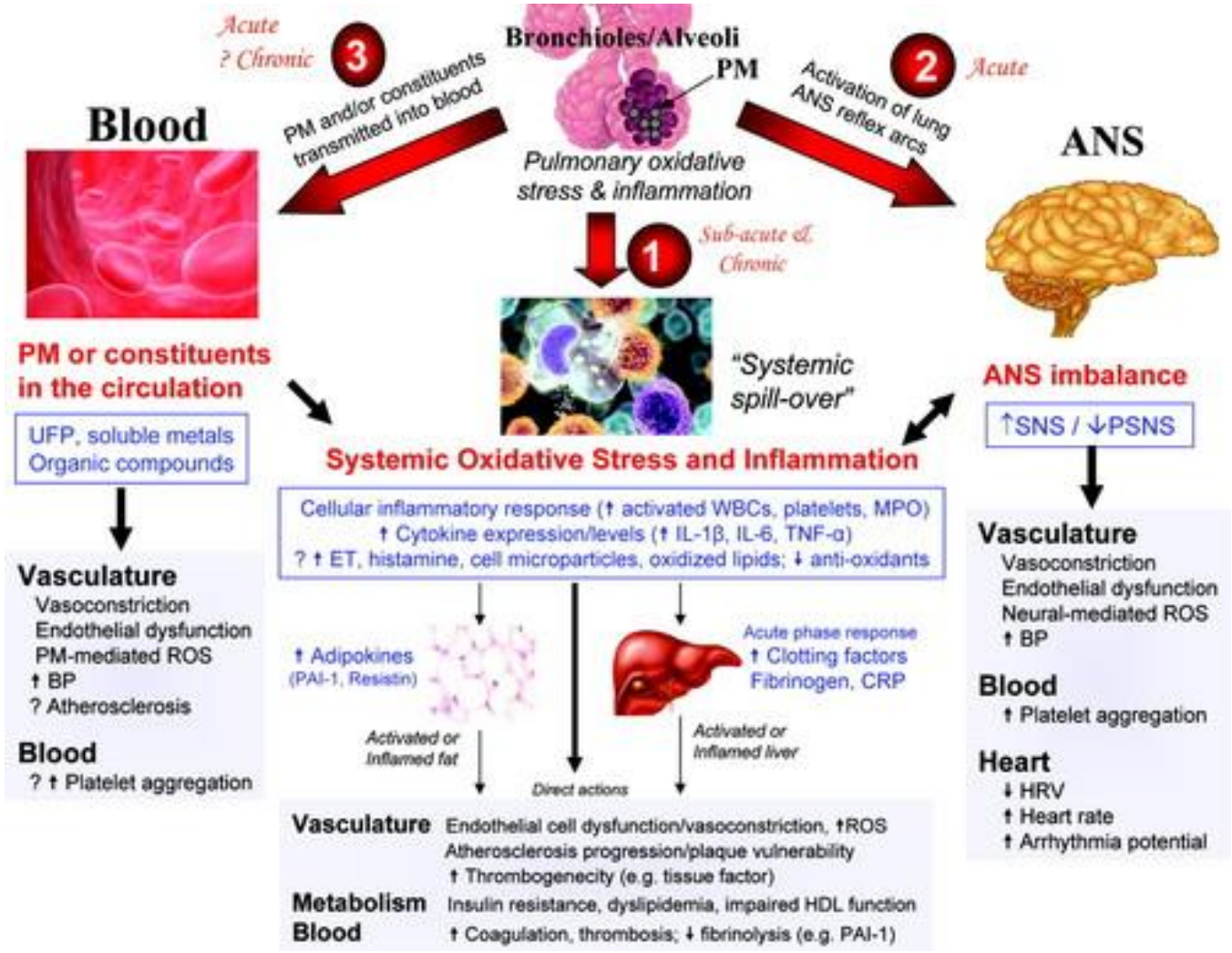
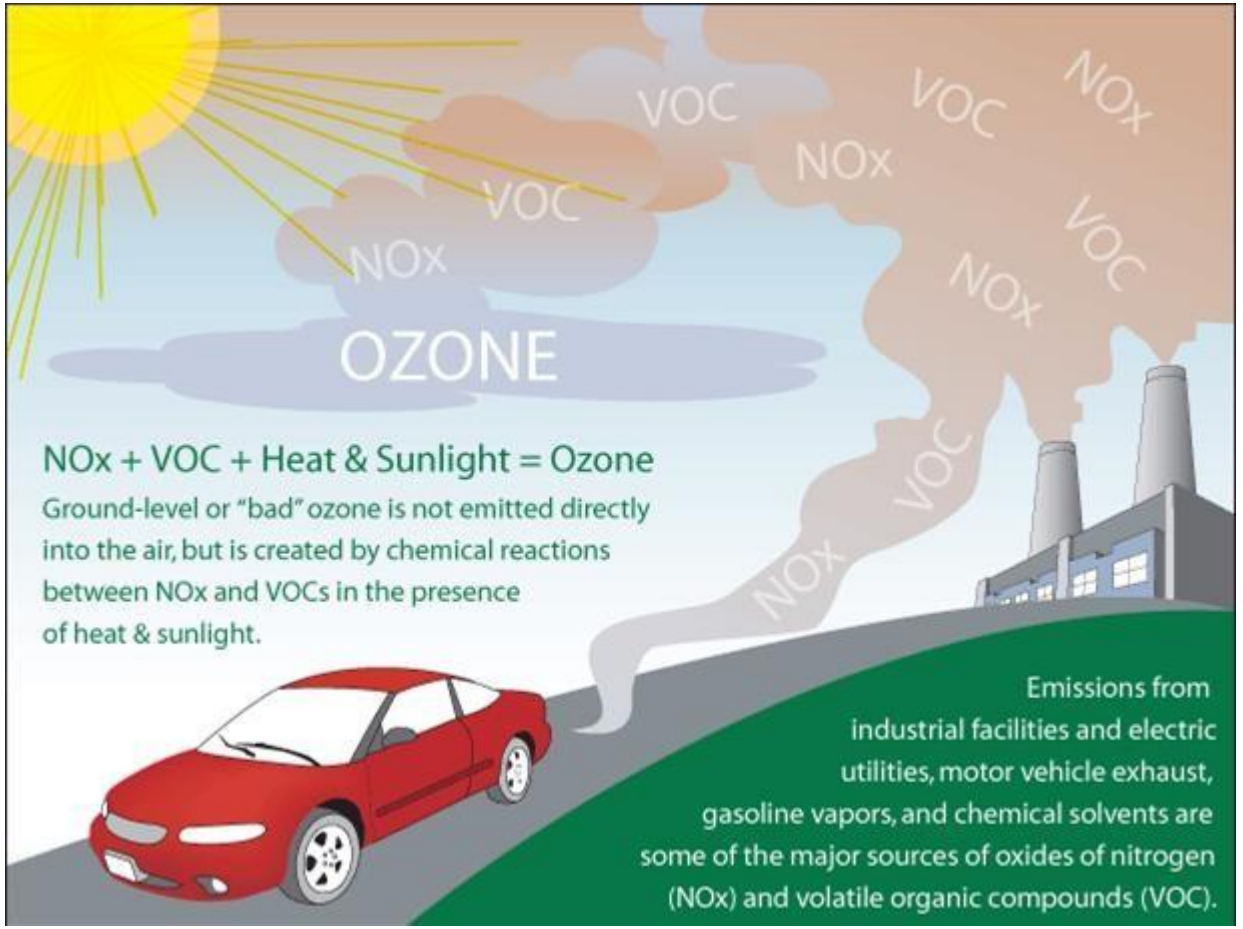


Robert D. Brook. Circulation. Particulate Matter Air Pollution and Cardiovascular Disease, 2010, Volume: 121, Issue: 21, Pages: 2331-2378, DOI: (10.1161/CIR.0b013e3181dbece1)

Ozon Permukaan (Nuvolone et al., 2018)



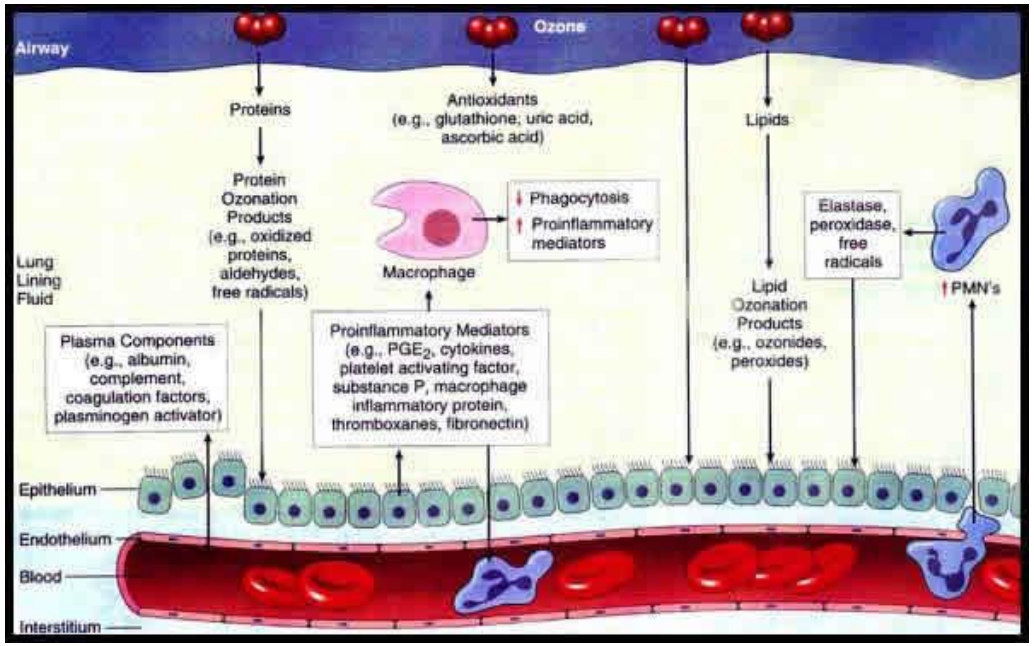
Source: https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics

- Ozon (O3) di permukaan sangat reaktif dalam saluran pernapasan, dan telah banyak diteliti memiliki hubungan dengan penyakit/gejala pernapasan seperti batuk, sesak napas, asma, radang saluran napas, bronkitis, PPOK, dsb.
- Ozon dapat menyebabkan otot saluran pernapasan menyempit sehingga menyebabkan udara terperangkap di dalam alveoli. Hal ini menyebabkan mengi dan sesak napas.

Referensi:
Nuvolone, D., Petri, D. & Voller, F. The effects of ozone on human health. *Environ Sci Pollut Res* **25,** 8074–8088 (2018). https://doi.org/10.1007/s11356-017-9239-3

Health effects attributable to the exposure of high level of Ozone

- Ozon sangat reaktif di saluran pernapasan, dan telah dikaitkan dengan banyak gejala/penyakit pernapasan, seperti batuk, sesak napas, asma, radang saluran pernapasan, bronkitis, COPD, dll.
- Ozon dapat menyebabkan otot-otot di saluran udara menyempit, menjebak udara di alveoli. Hal ini menyebabkan mengi dan sesak napas.



Source: https://www.epa.gov/ozone-pollution-and-your-patients-health/health-effects-ozone-general-population

Vital Strategies

Polusi udara membahayakan kesehatan dan kelangsungan hidup anak-anak

- Secara global, **93% anak-anak dunia di bawah usia 15 tahun terpapar pada tingkat partikel halus (PM2.5) di atas pedoman kualitas udara WHO.**
- Polusi udara mempengaruhi perkembangan saraf, yang mengarah pada hasil tes **kognitif yang lebih rendah**, yang secara negatif mempengaruhi perkembangan mental dan motorik.
- Polusi udara **merusak fungsi paru-paru anak-anak**, bahkan pada tingkat paparan yang lebih rendah
- Di negara-negara berpenghasilan rendah dan menengah di seluruh dunia, **98% dari semua anak di bawah 5 tahun terpapar tingkat PM2,5 di atas pedoman kualitas udara WHO**. Di negara-negara berpenghasilan tinggi, 52% anak di bawah 5 tahun terpapar pada tingkat di atas pedoman kualitas udara WHO.
- Lebih dari 40% populasi dunia – termasuk 1 miliar anak di bawah usia 15 tahun – terpapar polusi udara rumah tangga dengan level tinggi terutama dari memasak dengan bahan bakar yang berpolusi.
- Sekitar **600.000 kematian pada anak-anak di bawah usia 15 tahun dikaitkan dengan efek gabungan dari polusi udara ambien dan rumah tangga** pada tahun 2016.
- Polusi udara rumah tangga dari memasak dan polusi udara ambien (luar) **menyebabkan lebih dari 50% infeksi saluran pernapasan bawah akut** pada anak-anak di bawah usia 5 tahun di negara-negara berpenghasilan rendah dan menengah.
- Polusi udara adalah salah satu ancaman utama bagi kesehatan anak, terhitung hampir **1 dari 10 kematian pada anak di bawah usia lima tahun.**

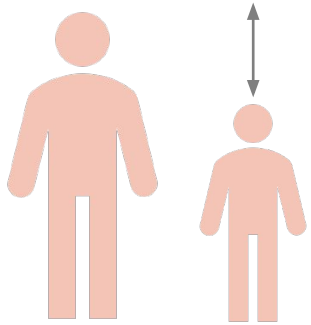
Sumber: WHO, 2018
(https://www.who.int/publications/i/item/air-pollution-and-child-health)

Vital Strategies

Polusi udara juga berkaitan dengan kasus BBLR, stunting, dan kelahiran prematur.

Dalam beberapa pubikasi global, disebutkan bahwa paparan terhadap polusi udara meningkatkan risiko terjadinya:

- Kasus stunting (Pun et al., 2021);
- BBLR dan kelahiran prematur (Liu et al., 2019).



Referensi:
V. C. Pun, R. Dowling, and S. Mehta, “Ambient and household air pollution on early-life determinants of stunting—a systematic review and meta-analysis,” Environmental Science and Pollution Research, vol. 28, no. 21, pp. 26404–26412, 2021, doi: 10.1007/s11356-021-13719-7.

Y. Liu, J. Xu, D. Chen, P. Sun, and X. Ma, “The association between air pollution and preterm birth and low birth weight in Guangdong, China,” BMC Public Health, vol. 19, no. 1, p. 3, 2019, doi: 10.1186/s12889-018-6307-7.

Vital Strategies

Epidemiologi Polusi Udara

Kajian saintifik yang menghubungkan polusi udara dengan dampak kesehatan

Clean Air Catalyst

Global Burden of Disease (GBD) Study 2019

Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019

*GBD 2019 Risk Factors Collaborators**

Summary

Background Rigorous analysis of levels and trends in exposure to leading risk factors and quantification of their effect on human health are important to identify where public health is making progress and in which cases current efforts are inadequate. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 provides a standardised and comprehensive assessment of the magnitude of risk factor exposure, relative risk, and attributable burden of disease.

Methods GBD 2019 estimated attributable mortality, years of life lost (YLLs), years of life lived with disability (YLDs), and disability-adjusted life-years (DALYs) for 87 risk factors and combinations of risk factors, at the global level, regionally, and for 204 countries and territories. GBD uses a hierarchical list of risk factors so that specific risk factors (eg, sodium intake), and related aggregates (eg, diet quality), are both evaluated. This method has six analytical steps. (1) We included 560 risk–outcome pairs that met criteria for convincing or probable evidence on the basis of research studies. 12 risk–outcome pairs included in GBD 2017 no longer met inclusion criteria and 47 risk–outcome pairs for risks already included in GBD 2017 were added based on new evidence. (2) Relative risks were estimated as a function of exposure based on published systematic reviews, 81 systematic reviews done for GBD 2019, and meta-regression. (3) Levels of exposure in each age-sex-location-year included in the study were estimated based on all available data sources using spatiotemporal Gaussian process regression, DisMod-MR 2.1, a Bayesian meta-regression method, or alternative methods. (4) We determined, from published trials or cohort studies, the level of exposure associated with

Lancet 2020; 396: 1223–49

*For the list of Collaborators see Viewpoint *Lancet* 2020; 396: 1135–59

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Terminologi Kunci: Mortality metrics
(i.e., cara menghitung kematian)

Counts

- Deaths

Rates

- Crude death rate
- Age-specific rate

Relative Risk

- By age
- By gender

Proportion

- Share of deaths

Epidemiology of air pollution: methodologies

- **Ecological studies**
  - These studies correlate measures of environmental air pollution (NO_2, SO_3, ozone, black carbon, PM_{10}, $PM_{2.5}$) in a given region with health effects and/or outcomes of people living in that region
  - Allow examination of large populations over long periods of time
- **Exposure studies**
  - Allow for more precise estimates of exposure-outcome correlation
  - Difficult to do over large populations for long periods of time
  - Poorly suited to examination of chronic health effects
- **Time-series studies**
  - Often used to examine short-term outcomes
  - Examine health outcomes over time and correlate with levels of air pollution

Epidemiology of air pollution: methodologies

- **Case-control studies**
  - Examine risk for health outcomes in persons with high or low exposure to pollution
- **Panel studies**
  - Examine risk for outcomes over time in a population
- **Cohort studies**
  - Often used to examine long-term outcomes
  - Longitudinal study of health
- **Intervention studies**
  - These evaluate the health outcomes of interventions designed to lower exposure to pollution
  - Note: Opportunities to conduct randomized control trials for air pollution are rare