# Health Effects of Air Pollution

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G20 2019 Transport Task Group Meeting, Tokyo, October 30, 2019

Tokyo, 2009

### Key pollutants for health impacts

#### Particulate Matter (PM)

Jorge Uzon—AFP/Getty Images





Image courtesy of the U.S. EPA

#### Nitrogen Dioxide (NO<sub>2</sub>)



Ozone  $(O_3)$ 

# Air pollution and health

- Ambient air pollution (individual) risk is small...but large exposed population = large population risk
- Diseases impacted by air pollution have other causes...
- ...Air pollution as a contributing risk factor



### Air pollution and health

• On **days** with worse air quality, more people die\*



#### Larrieu et al. Am J Epidemiol, 2009

\*out-of-hospital, >65 yrs

#### The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812

AUGUST 22, 2019 VOL. 381 NO. 8

#### Ambient Particulate Air Pollution and Daily Mortality in 652 Cities

C. Liu, R. Chen, F. Sera, A.M. Vicedo-Cabrera, Y. Guo, S. Tong, M.S.Z.S. Coelho, P.H.N. Saldiva, E. Lavigne,
P. Matus, N. Valdes Ortega, S. Osorio Garcia, M. Pascal, M. Stafoggia, M. Scortichini, M. Hashizume, Y. Honda,
M. Hurtado-Díaz, J. Cruz, B. Nunes, J.P. Teixeira, H. Kim, A. Tobias, C. Íñiguez, B. Forsberg, C. Åström,
M.S. Ragettli, Y.-L. Guo, B.-Y. Chen, M.L. Bell, C.Y. Wright, N. Scovronick, R.M. Garland, A. Milojevic, J. Kyselý,
A. Urban, H. Orru, E. Indermitte, J.J.K. Jaakkola, N.R.I. Ryti, K. Katsouyanni, A. Analitis, A. Zanobetti, J. Schwartz,
J. Chen, T. Wu, A. Cohen, A. Gasparrini, and H. Kan





### Air pollution and health

- On **days** with worse air quality, more people die\*
- In more polluted cities, people die earlier than in less polluted cities...



#### Larrieu et al. Am J Epidemiol, 2009

\*out-of-hospital, >65 yrs

Long-term fine particulate matter exposure and non-accidental and cause-specific mortality in a large national cohort of Chinese men

Baoging





- 10 km satellite-based estimates + surface measurements
- ~190,000 men > 40 years, 45 locations randomly selected from 145 DSPs
- 15 year follow-up

Yin P, Brauer M, Cohen A, Burnett RT, Liu J, Liu Y, Liang R, Wang W, Qi J, Wang L, Zhou M. Environmental Health Perspectives. 2017



Pappin et al., 2019; Christidis et al., 2019

### Air pollution and health

- On **days** with worse air quality, more people die\*
- In more polluted cities, people die earlier than in less polluted cities...
- ...and, in the most polluted areas of cities, there is an increased risk of dying



Larrieu et al. Am J Epidemiol, 2009

\*out-of-hospital, >65 yrs

### Traffic-related air pollution



Coronary heart disease (CHD) mortality

Henderson SB et al. Environmental Science and Technology. 2007; 41 (7):2422 -2428; Gan WQ et al. <u>Changes in residential proximity to road traffic and the risk of death from corofilery heart</u> <u>disease</u>. Epidemiology. 2010 Sep;21(5):642-9.

### Air pollution and health

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### Lung growth and decline



Air pollution reduces lung function growth in children...

Gauderman et al. NEJM. 2004.

...which leads to earlier than normal disability/death



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#### Beyond the heart and lung

Size Fraction	Health Effect Category <sup>a</sup> and Exposure Duration	Causality	Determination	
		2009 PM ISA	Current Draft PM ISA	
PM2.5	Respiratory Effects—Short-term exposure Section <u>5.1.12</u> , <u>Table 5-18</u>	Likely to be a causal relationship	Likely to be a causal relationship	
	Respiratory Effects— Long-term exposure Section <u>5.2.13, Table 5-28</u>	Likely to be a causal relationship	Likely to be a causal relationship	
USEPA	Cardiovascular Effects— Short-term exposure Section <u>6.1.16</u> , <u>Table 6-33</u>	Causal relationship	Causal relationship	Pregnancy and Birth
	Cardiovascular Effects— Long-term exposure Section <u>6.2.18, Table 6-52</u>	Causal relationship	Causal relationship	Outcomes: Suggestive of, but not sufficient
	Nervous System Effects— Long-term exposure Section <u>8.2.9</u> , <u>Table 8-20</u>	Not evaluated	Likely to be a causal relationship	
	Cancer— Long-term exposure Section <u>10.2.6, Table 10-8</u>	Suggestive of, but not sufficient to infer, a causal relationship	Likely to be a causal relationship	
	Total mortality— Short-term exposure Section <u>11.1.12</u> , <u>Table 11-4</u>	Causal relationship	Causal relationship	
	Total mortality— Long-term exposure Section <u>11.2.7</u> , <u>Table 11-8</u>	Causal relationship	Causal relationship	

**WHO REVIHAAP** (2013): Cardiovascular and Respiratory Mortality and Morbidity

Growing evidence for birth outcomes and childhood respiratory disease

Possible links with neurodevelopment and cognitive function, diabetes

IARC (2013): Air pollution (and PM specifically) carcinogenic (lung cancer)



#### 95% of population exposed above WHO Guideline



Brauer et al., 2012; Brauer et al., 2016; Shaddick et al. 2017. Shaddick et al., 2018.



https://vizhub.healthdata.org/gbd-compare/

World Bank. 2016. The cost of air pollution : strengthening the economic case for action

Global, Both sexes, All ages, 2017



https://vizhub.healthdata.org/gbd-compare/



Apte JS, Brauer M, Cohen AJ, Ezzati M, Pope CA. Ambient PM2.5 Reduces Global and Regional Life Expectancy. Environ. Sci. Technol. Lett., 2018, 5 (9), pp 546–551.DOI: 10.1021/acs.estlett.8b00360



#### stateofglobalair.org





#### stateofglobalair.org

### Demographics plays a key role



Cohen, Brauer, et al., Lancet 2017.



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### Adverse reproductive outcomes



Birthweight



Preliminary Results, GBD 2019

# What's missing?



Larrieu et al. Am J Epidemiol, 2009



### Incident childhood asthma and NO<sub>2</sub>

				Odds Ratio	Odds Ratio
Study or Subgroup	log[Odds Ratio]	SE	Weight	IV, Random, 95% CI	IV, Random, 95% Cl
Carlsten et al. 2010 - at 7 y.o.	0.2253	0.1448	0.6%	1.25 [0.94, 1.66]	
Clark et al. 2010 LUR - at mean age of 4 y.o.	0.0489	0.0171	9.5%	1.05 [1.02, 1.09]	-
Dell et al. 2014 LUR - 5 to 9 y.o.	0.039	0.04	5.0%	1.04 [0.96, 1.12]	
Deng et al. 2016 - 3 to 6 y.o.	0.1374	0.0689	2.4%	1.15 [1.00, 1.31]	
Gehring et al. 2015 b - BAMSE birth to 16 y.o.	0.0397	0.0498	3.8%	1.04 [0.94, 1.15]	- <del>-</del>
Gehring et al. 2015 b - PIAMA birth to 14 y.o.	0.0665	0.0246	7.8%	1.07 [1.02, 1.12]	
Gehring et al. 2015b - GINI&LISA North birth to 15	-0.0679	0.1235	0.8%	0.93 [0.73, 1.19]	
Gehring et al. 2015b - GINI&LISA South birth to 15	-0.0252	0.0602	2.9%	0.98 [0.87, 1.10]	
Jerret et al. 2008 - 10 to 18 y.o.	0.0874	0.033	6.1%	1.09 [1.02, 1.16]	
Kim et al. 2016 - 6 to 7 y.o.	-0.0214	0.0219	8.4%	0.98 [0.94, 1.02]	
Krämer et al. 2009 - 4 to 6 y.o.	0.0698	0.069	2.3%	1.07 [0.94, 1.23]	
Liu et al. 2016 - 4 to 6 years old	0.0877	0.0215	8.5%	1.09 [1.05, 1.14]	-
MacIntyre et al. 2014 - CAPPS&SAGE only birth to 8	0.1111	0.1268	0.8%	1.12 [0.87, 1.43]	
McConnell et al. 2010 - 4th to 6th grade	0.0698	0.0281	7.1%	1.07 [1.01, 1.13]	
Mölter et al. 2014 b - MAAS only birth to 8 y.o.	0.574	0.2374	0.2%	1.78 [1.11, 2.83]	
Nishimura et al. 2013 - 8 to 21 y.o.	0.0632	0.0269	7.3%	1.07 [1.01, 1.12]	
Oftedal et al. 2009 - birth to 10 y.o.	-0.0359	0.0196	8.9%	0.96 [0.93, 1.00]	-
Ranzi et al. 2014 - birth to 7 y.o.	0.0289	0.0701	2.3%	1.03 [0.90, 1.18]	
Shima et al. 2002 - 6 to 12 y.o.	0.1136	0.0534	3.5%	1.12 [1.01, 1.24]	
Tétreault et al. 2016 - birth to 12 y.o.	0.0153	0.0048	11.6%	1.02 [1.01, 1.03]	•
Total (95% CI)			100.0%	1.05 [1.02, 1.07]	•
Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 54.38, df = 19 (P < 0 Test for overall effect: Z = 3.76 (P = 0.0002)	0.0001); l² = 65%			per 4 $\mu$ g/m <sup>3</sup> NO <sub>2</sub> 0.5	0.7 1 1.5 2 Decreased risk Increased risk

Exposure to traffic-related air pollution and risk of development of childhood asthma: A systematic review and meta-analysis. Khreis H, et al. Environ Int. 2017. doi: 10.1016/j.envint.2016.11.012.

# Ambient NO<sub>2</sub> and Pediatric Asthma

- 4.0 (1.8 5.2) million new pediatric asthma cases annually
- 13% (5.8 16%) of global incidence

![](_page_28_Figure_3.jpeg)

Number of new asthma cases due to NO<sub>2</sub> exposure (per 100 000)

![](_page_28_Figure_5.jpeg)

Achakulwisut et al. Global, national, and urban burdens of paediatric asthma incidence attributable to ambient NO2 pollution: estimates from global datasets. Lancet Planetary Health DOI: (10.1016/S2542-5196(19)30046-4)

# In high and low income country cities, NO<sub>2</sub> pollution is an important risk factor for pediatric asthma incidence

![](_page_29_Figure_1.jpeg)

125 major cities, % of new pediatric asthma cases attributable to NO<sub>2</sub>:

- Range: 6% (Orlu, Nigeria) to 48% (Shanghai, China).
- Exceeded 20% in 92 cities, in high and low income countries.
- Highest in 8 cities in China, in Moscow, and Seoul.

#### Traffic proximity and dementia

![](_page_30_Figure_1.jpeg)

#### Non-Alzheimer's dementia

Non-Alzheimer's dementia

![](_page_30_Figure_4.jpeg)

#### Non-Alzheimer's dementia

![](_page_30_Figure_6.jpeg)

Chen H et al. Living near major roads and the incidence of dementia, Parkinson's disease, and multiple sclerosis: a population-based cohort study. Lancet. 2017 Feb 18;389(10070):718-726. doi: 10.1016/S0140-6736(16)32399-6.

#### Autism Spectrum Disorder

![](_page_31_Figure_1.jpeg)

Vancouver BC: 132,256 births, 1307 children (1.0%) diagnosed with ASD by age 5

Pagalan L, Bickford C, Weikum W, Lanphear B, Brauer M, Lanphear N, Hanley GE, Oberlander TF, Winters M. <u>Association of Prenatal Exposure to Air Pollution With</u> <u>Autism Spectrum Disorder</u>. JAMA Pediatr. 2019 Jan 1;173(1):86-92. doi: 10.1001/jamapediatrics.2018.3101.

#### Traffic-related air pollution: Health Impacts

HEI		Health Outcome	Causality (strength of association)	
HEALTH EFFECTS INSTITUTE January 2010	SPECIAL REPORT 17 Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects of Traffic-Related Air Pollution	Asthma exacerbation	Sufficient	
		Asthma onset Children Adults	<b>Sufficient</b> Suggestive, but insufficient	
		Lung function decrements (children, chronic exposure)	Suggestive, but insufficient	
		Lung Cancer	Suggestive, but insufficient	
A.	The state	CVD mortality (chronic and acute exposure)	Suggestive, but insufficient	
		CVD morbidity MI onset Atherosclerosis progression	Suggestive, but insufficient Suggestive, but insufficient	
HE	El 2010	Pregnancy outcomes	Inadequate and insufficient	
		Allergy	Inadequate and insufficient	
		childhood leukemia, cancer	Inadequate and insufficient	
		COPD	Inadequate and insufficient	

#### Traffic-related air pollution: Health Impacts

![](_page_33_Picture_1.jpeg)

Health Effects Institute

Protocol for a Systematic Review and Meta–Analysis of Selected Health Effects of Long–Term Exposure to Traffic–Related Air Pollution

JULY 31, 2019

#### HEI 2020

#### Selected health outcomes:\*

#### All cause and cause-specific mortality

•Respiratory (Chronic Obstructive Pulmonary Disease, Acute Lower Respiratory Infections)

- •Circulatory (Ischemic Heart Disease, Stroke)
- Diabetes
- •Lung cancer

#### **Respiratory effects**

•Asthma

Chronic Obstructive Pulmonary DiseaseAcute Lower Respiratory Infections

Cardiovascular effects •Coronary events

- •Stroke
- •Hypertension
- •Type 2 diabetes

Birth outcomesLow birth weight

•Preterm

![](_page_34_Picture_0.jpeg)

![](_page_34_Picture_1.jpeg)

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