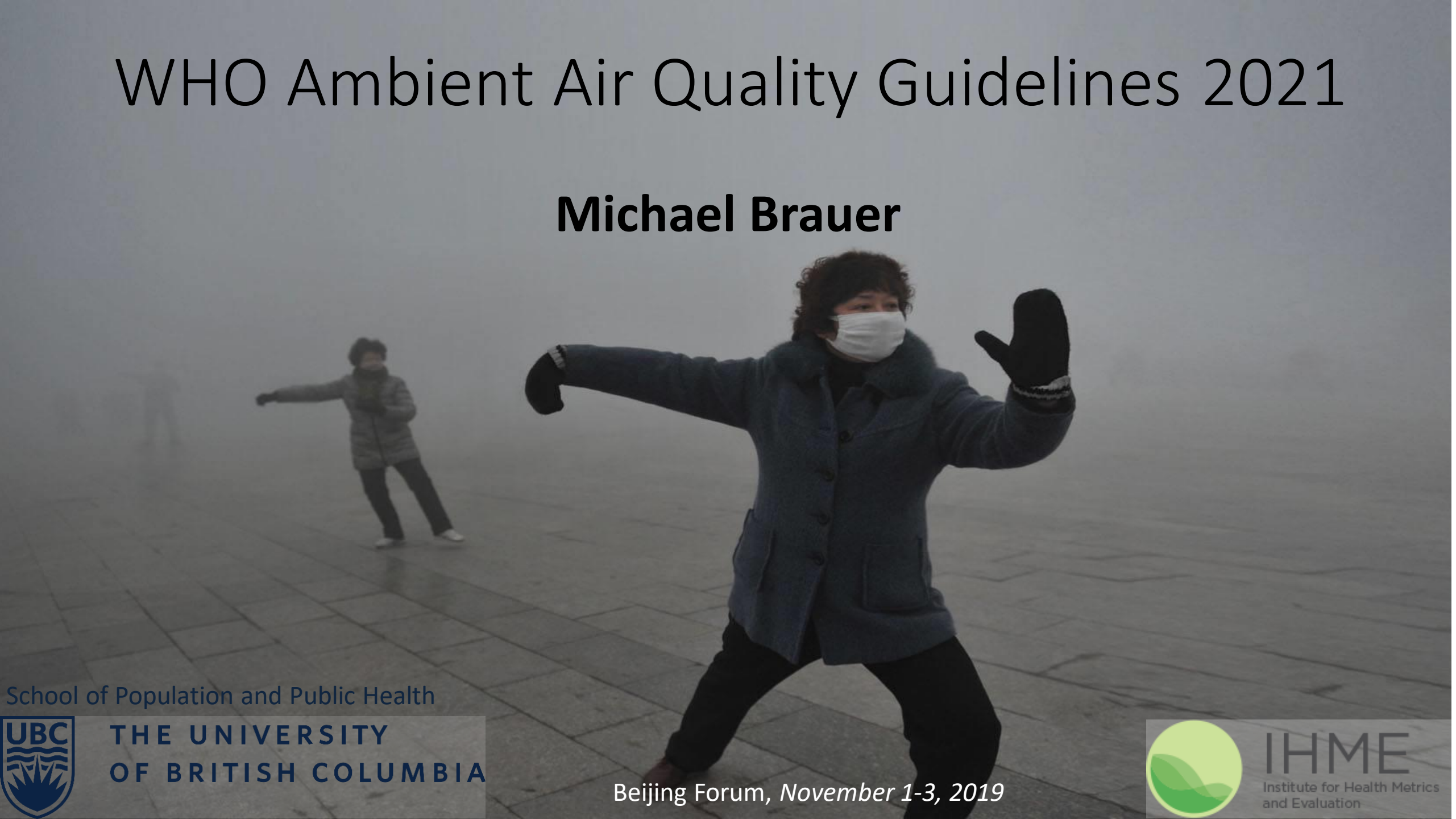
WHO Ambient Air Quality Guidelines 2021



Michael Brauer

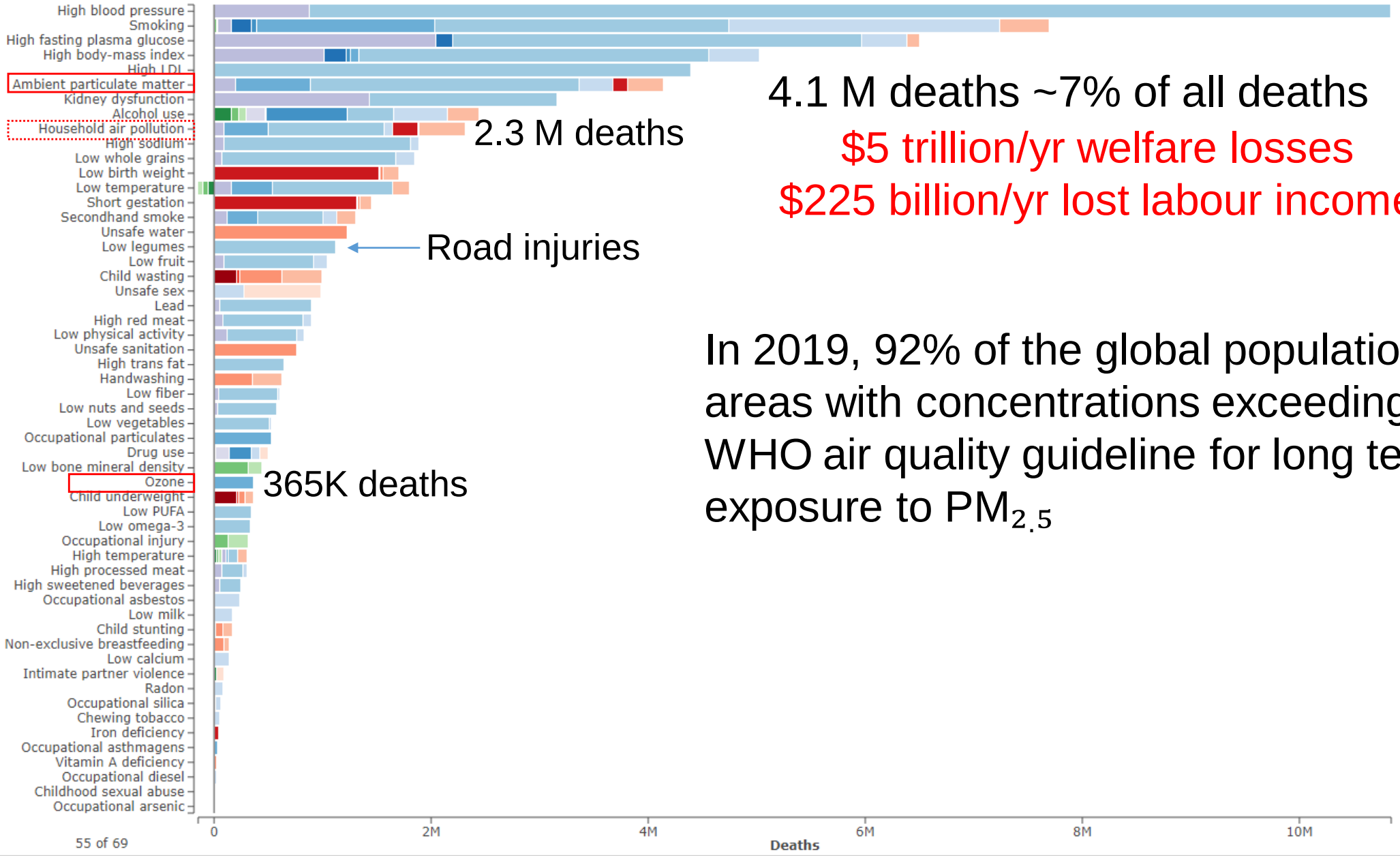
School of Population and Public Health

THE UNIVERSITY OF BRITISH COLUMBIA

IHME Institute for Health Metrics and Evaluation

Beijing Forum, *November 1-3, 2019*

Air pollution is a major risk factor for global health



2.3 M deaths

Road injuries

365K deaths

4.1 M deaths ~7% of all deaths

$5 trillion/yr welfare losses

$225 billion/yr lost labour income

In 2019, 92% of the global population lived in areas with concentrations exceeding 2005 WHO air quality guideline for long term exposure to $PM_{2.5}$

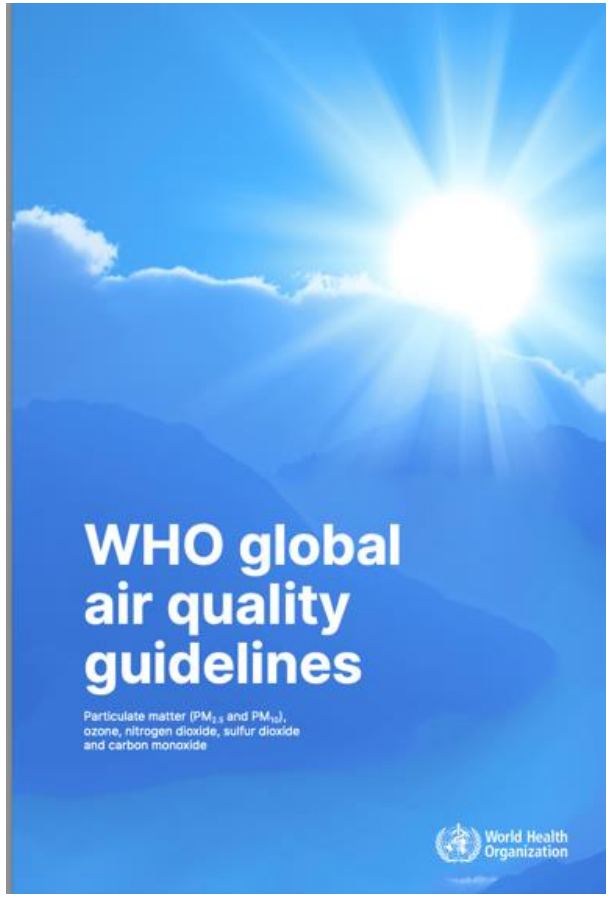
2019

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

What are the WHO Air Quality Guidelines?

- AQGs identify levels of air quality to **protect public health worldwide**
  - Applicable to both outdoor and indoor environments
- **Air quality guideline levels** (and interim targets) for **$PM_{2.5}$ and PM_{10}, O_3, NO_2, SO_2** and **CO,** and qualitative good practice statements for certain types of particulate matter
- Guideline levels can be used as **evidence-informed reference** to help set legally binding **standards** and goals for air quality management.
- An **instrument to design effective measures** to reduce air pollution protect human health

What's new in the AQGs 2021?



- Since 2005 update, increases in quality and quantity of evidence of air pollution impacts on health
  - Studies of short-term exposure impacts from locations outside of North America, western Europe
  - Studies of long-term exposure impacts at low levels
  - Expanding health outcomes affected by air pollution
  - Scientific methodology and scale of studies
- Improved insight on sources of emissions and the contribution of air pollutants to the global burden of disease.
- After a systematic review of the accumulated evidence, **several updated AQG levels are now lower than 15 years ago.**
- New AQG levels for **peak-season O_3**; **24-h NO_2 and CO**; **new interim targets.**

What the AQGs provide...

Summary of recommended AQG levels and interim targets

Pollutant	Averaging time	IT1	IT2	IT3	IT4	AQG level
$PM_{2.5}$, µg/m³	Annual	35	25	15	*10*	**5**
$PM_{2.5}$, µg/m³	24-hour[a]	75	50	37.5	*25*	**15**
PM_{10}, µg/m³	Annual	70	50	30	*20*	**15**
PM_{10}, µg/m³	24-hour[a]	150	100	75	*50*	**45**
O_3, µg/m³	Peak season[b]	100	70	–	–	**60**
O_3, µg/m³	8-hour[a]	160	120	–	–	**100**
NO_2, µg/m³	Annual	*40*	30	20	–	**10**
NO_2, µg/m³	24-hour[a]	120	50	–	–	**25**
SO_2, µg/m³	24-hour[a]	125	50	–	–	**40**
CO, mg/m³	24-hour[a]	7	–	–	–	**4**

Air quality guideline levels for both long- and short-term exposure in relation to critical health outcomes.

Interim targets to guide reduction efforts for the achievement of the air quality guideline levels.

Good practice statements for management of **Black Carbon, Ultrafine particles, Desert Dust**: types of health-relevant PM (evidence insufficient for quantitative guideline levels

Interim Targets

- Intended to guide reduction efforts for the achievement of air quality guideline levels
- Previously have been used by countries as national standards
  - e.g. $PM_{2.5}$ IT-1 (35 µg/m^3) = China (Class 2) standard

Continuous improvement of air quality

Good practice statements

For the management of certain types of particulate matter

SAND AND DUST STORM

- Maintain suitable air quality management and **dust forecasting** programmes.
- Maintain air quality **monitoring** programmes and reporting procedures.
- Conduct epidemiological studies and **research** activities aimed at better understanding toxicity.
- Implement **wind erosion control** through the carefully planned expansion of green spaces.

BLACK/ELEMENTAL CARBON

- Make systematic **measurements**.
- Undertake production of **emission inventories, exposure assessments and source apportionment**.
- Take measures to **reduce emissions and develop standards** (or targets).

ULTRAFINE PARTICLES

- **Quantify ambient** UFP in terms of PNC for a size range with a lower limit of ≤ 10 nm and no restriction on the upper limit.
- Expand the common air quality **monitoring** strategy by integration of UFP monitoring.
- Distinguish between low and high PNC to guide decisions on the priorities of **UFP source emission control.**
- Utilize emerging science and technology for the **assessment of exposure.**

Guideline development

Main steps

1. Systematic review process
2. Grading the evidence
3. Developing recommendations

Involved Groups

Systematic Review Team

- External Review Group

Guideline Development Group

- External Review Group

WHO Steering Group

WHO Methodology

- Systematic reviews (GRADE process) of epidemiologic studies of specific “critical health outcomes”
- Assessment of the certainty of the body of evidence resulting from systematic reviews
- Short-term and long-term exposures
  - *In any population, including subgroups, what is the increase in risk per unit increase observed in studies relevant for the health outcome and exposure duration of interest?*

Systematic reviews of evidence

World Health Organization
REGIONAL OFFICE FOR Europe

Short-term exposure to O_3, NO_2 and SO_2 and asthma

Long-term exposure to O_3 and NO_2 and all-cause and cause-specific mortality

Long-term exposure to PM and all-cause and cause-specific mortality

Short-term exposure to SO_2 and all-cause and cause-specific mortality

Short-term exposure to CO and ischaemic heart disease

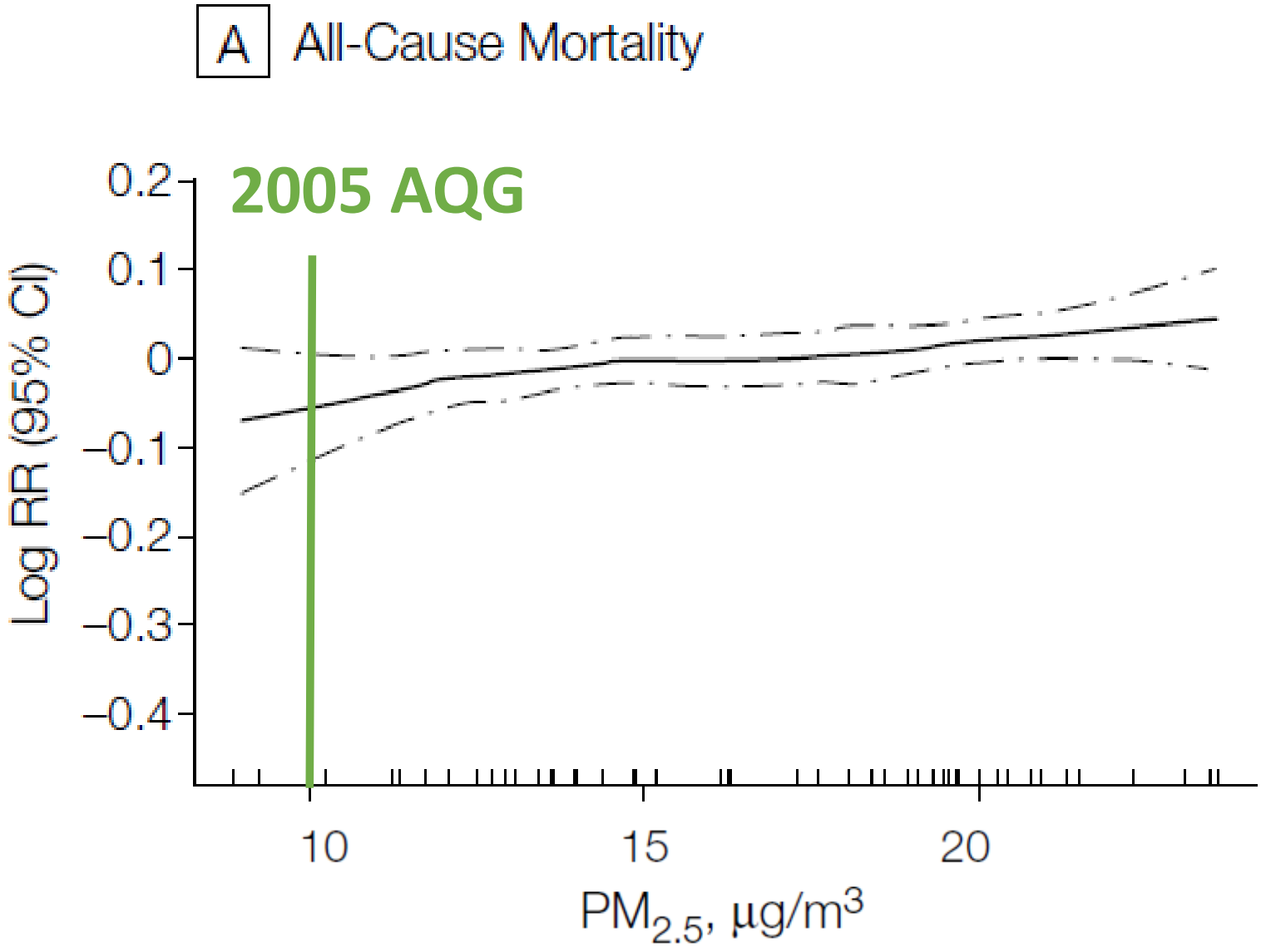
Short-term exposure to PM, NO_2 and O_3 and all-cause and cause-specific mortality

https://www.sciencedirect.com/journal/environment-international/special-issue/10MTC4W8FXJ

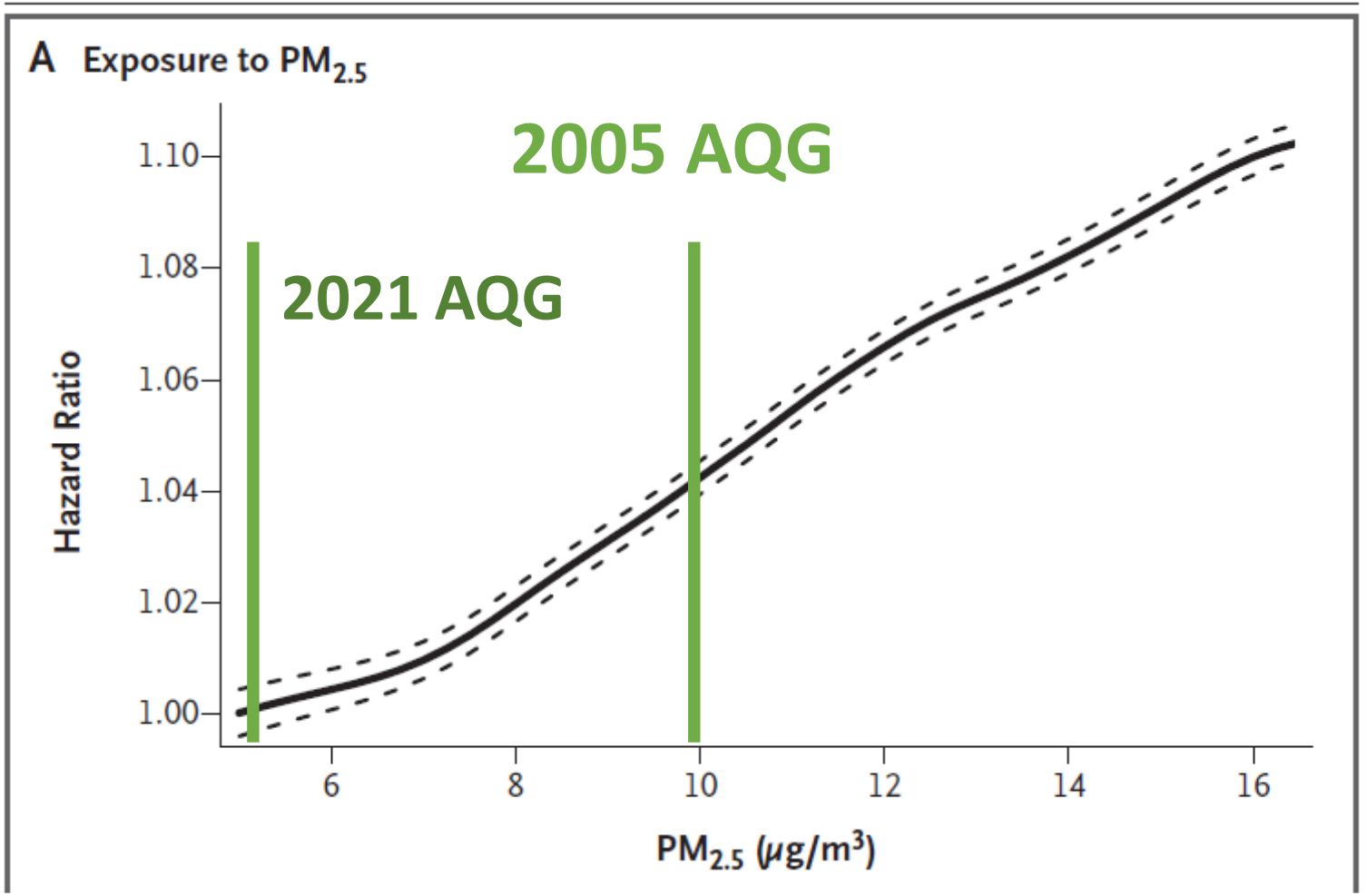
What is the lowest concentration that produces a measurable increase in risk?

- Long term AQGs: mean of lowest 5th percentiles of study population distributions
- Short term AQGs: 99th percentiles of distributions of 24 hour mean concentrations matching the long term AQGs

Pope JAMA 2002



Di et al., NEJM 2017



Low-level PM2.5 studies

PM2.5 REFERENCE	MEAN	SD	M-1.645*SD	P5	HR	LCL	UCL
Pinault	5.9			3	1.26	1.19	1.34
Cakmak	6.5	2	3.2	3.2	1.16	1.08	1.25
Pinault	7.1			3.5	1.18	1.15	1.21
Weichenthal	9.5	1.7	6.7	6.7	0.95	0.76	1.19
Villeneuve	9.5	3.5	3.7	4.8	1.12	1.05	1.2
Di	11.5	2.9	6.7	7.1	1.08	1.08	1.09
Hart	12.0	2.8		7.8	1.13	1.05	1.22

Result: an annual PM2.5 AQG of 5 µg/m³

Interim Target	$PM_{2.5}$ (µg/m³)
IT1	35
IT2	25
IT3	15
IT4	10 (= 2005 AQG)
AQG	**5**

What can countries do with the AQGs?

Key points

- Countries can **use the AQGs as a tool** to guide, drive and support the selection and adoption of measures to reduce exposure to air pollution:
  - Establish or ***update their legally binding air quality standards and develop policies***.
  - ***Strengthening multisectoral cooperation*** at national, regional, and international levels, and advocating for air quality.
  - Taking effective steps to ***reduce health inequities*** related to air pollution.
- Actions to reduce air pollution require cooperation of various sectors and stakeholders.
- Health sector is crucial in raising awareness, gathering evidence, advising people on how to mitigate impacts, and joining advocacy efforts.

Different uptake of AQGs in AAQS across the world

WHO REGION	COUNTRIES IN THE REGION (N)	COUNTRIES WITH STANDARDS FOR AT LEAST ONE POLLUTANT AND AVERAGING TIME		COUNTRIES WITHOUT STANDARDS		COUNTRIES WITH NO INFORMATION	
		n	%	n	%	n	%
African Region	47	17	36	21	45	9	19
Region of the Americas	35	20	57	13	37	2	6
South-East Asian Region	11	7	64	3	27	1	9
European Region	***53***	***50***	***94***	***2***	***4***	***1***	***2***
Eastern Mediterranean Region	21	11	52	1	5	9	43
Western Pacific Region	27	12	44	13	48	2	7
Total	194	117	60	53	27	24	12

Kutlar Joss et al., 2017

WORLD HEART FEDERATION

EXECUTIVE SUMMARY

CLEAN AIR, SMART CITIES, HEALTHY HEARTS: ACTION ON AIR POLLUTION FOR CARDIOVASCULAR HEALTH

Air pollution is one of the most important risk factors for heart attack, stroke, diabetes and respiratory diseases, and exposure to air pollution has also been linked with increased vulnerability to the more severe consequences of COVID-19. In 2019, an estimated 6.7 million deaths, or 12 percent of all deaths worldwide, were attributable to outdoor or household air pollution. As many as half of these deaths were due to heart disease and stroke.

Air pollution is a complex and dynamic mixture of numerous compounds in gaseous and particle form originating from diverse sources. Three common air pollutants, particulate matter (PM), ozone, and nitrogen dioxide (NO_2), are the focus of most monitoring programs, communication efforts, health impact assessments, and regulatory efforts. Air pollution can also be classified into pollution of outdoor/ambient or indoor origin, both of which have serious health effects.

The tiny particles that make up air pollution can enter the blood stream and damage the inside walls of the blood vessels, causing them to become narrower and harder. This restricts the movement in the blood vessels, which can increase blood pressure, form blood clots, affect the normal electrical functioning of the heart, and eventually lead to cardiac events.

The complexity and scale of this issue creates an unfortunate lack of understanding among those with the power to make change for good, including doctors and policymakers, which in turn results in a subsequent lack of concerted action.

Political commitments and policy measures to mitigate pollution emissions will ultimately be necessary to reduce harmful exposures. Nevertheless, healthcare providers can play several important roles before, and while, such mitigation is achieved.

TAKING ACTION:

The World Heart Federation recommends the following interventions for key stakeholders, with a sustained focus on cross-sectoral collaboration.

KEY

▲▲▲ **Intervention is recommended.** This intervention is evidence-based, low-risk to individuals, and feasible from a resource perspective.

▲▲ **Intervention should be considered.** This intervention has a growing evidence base, but may pose some challenges from a resource perspective.

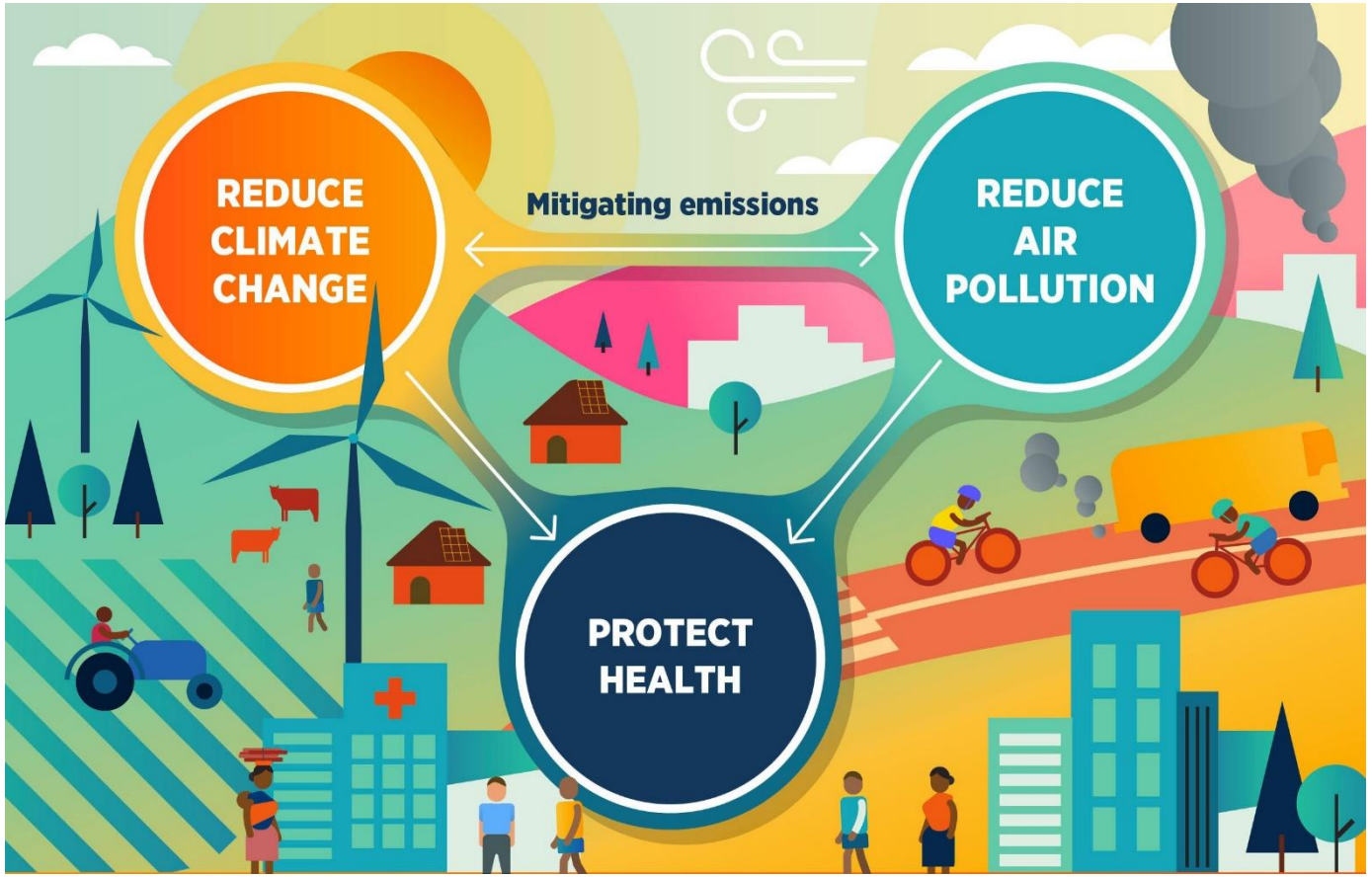
▲ **Intervention may be considered for specific groups,** but requires further evidence before recommending to broader populations.

Target group	Action Items	Relative Strength of Evidence	Justification	Objective
Physicians (I)	**Use risk assessments to identify patients likely to benefit from interventions to reduce air pollution exposures, screening for susceptibility and vulnerability.** Personal measures may be necessary to reduce pollution exposures, particularly as reductions in ambient air pollution are unlikely in the short-term for much of the world; facemasks, particularly properly fit **N95 respirators, can block the majority of PM2.5 inhalation** [37].	▲▲▲	The effects of air pollution on the cardiovascular system are quantifiable and modifiable at the individual level [38]. Reducing air pollution exposures decreases the risk of cardiovascular mortality, acute coronary syndrome, stroke, arrhythmias, heart failure, and atherosclerosis [37]. Clinicians promoting cardiovascular health therefore have an opportunity and responsibility to protect their patients from air pollution.	Physicians and patients become aware of, and empowered, to ameliorate the impacts of air pollution on health. Personal measures are necessary to reduce pollution exposures, particularly as reductions in ambient air pollution continue at a slow rate in the short-term for much of the world [37]. Specific measures include personal masks, air filtration, clean stoves and fuels, behaviour modification, and dietary approaches. Although early trials have shown promising results on surrogate endpoints, large randomized trials are needed to evaluate the efficacy of these, and pharmacologic, interventions on preventing cardiovascular events. As we await additional data, clinicians can recommend these interventions to their most susceptible and vulnerable patients.
	Outdoor air pollution often infiltrates buildings, leading to hazardous indoor exposures [39]. **High-efficiency particulate air (HEPA) filters can remove the majority of indoor PM2.5** [37, 39, 40]. For households burning fossil fuels (e.g., oil, coal) or biomass (e.g., wood, dung) for cooking or heating indoors, key interventions include ventilation, electrification, and access to clean stoves and clean fuels [40]. **Portable HEPA air purifiers can also be considered in cases where preferred interventions cannot be achieved at scale.**	▲▲		
	Behavioural modifications are a simple strategy to reduce air pollution exposures. Advise susceptible individuals to stay indoors and close windows on days with elevated ambient pollution levels [39]. Where outdoor air pollution is low, windows can be opened to ventilate indoor environments. **Patients can be notified of daily levels via air quality alert networks, which provide warnings and recommendations on how to minimize exposures** [38, 39].	▲▲		
	Individuals exposed to vehicular emissions should be counselled to avoid rush hour transit, close/open vehicle windows, and use car air conditioning/purifiers [37, 41-43]. **For susceptible individuals, high-intensity outdoor exercise should be delayed during heavy pollution conditions.** Clinicians can make additional **behavioural recommendations targeting pollution exposures identified in the patient history** [44, 45]. Dietary and pharmaceutical interventions show promise but require further investigation. For example, small trials have demonstrated that antioxidants (e.g., vitamins C and E) and **omega-3 fatty acids may reduce oxidative stress and inflammation** attributed to air pollution exposures [46, 47]. Likewise, a large prospective cohort demonstrated that a Mediterranean diet reduced cardiovascular mortality attributed to air pollution exposure, but it is premature to recommend pharmaceutical interventions at this time [48]. Optimising therapies to treat current cardiovascular conditions may also lessen the risk of air pollution triggering cardiovascular events, although more research is required.	▲▲		
		▲▲▲		
		▲		
	Finally, mitigation of traditional cardiovascular risk factors (e.g., hypertension, diabetes, obesity, atherosclerosis) **can reduce susceptibility to cardiovascular events attributed to air pollution exposures** [37].	▲▲▲		

https://world-heart-federation.org/global-advocacy/air-pollution/

Reducing air pollution and mitigating climate change

World Health Organization
REGIONAL OFFICE FOR Europe



Continuous improvement of air quality

WHO Global Air Quality Guidelines 2021

Setting ambitious goals for air quality to protect public health

- Released September 22, 2021