Setting Ambient Air Quality Standards
The role of Air Pollution and Health Research in Informing Policy Action

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Health Effects Institute

Workshop on Air Pollution and Health in East Africa
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Setting Ambient Standards is a Key First Step

- Assessing Status
- Measuring Progress
  - AQ Monitoring
  - Health Effects

- Designing and Implementing Control Strategies
  - Identifying key sources
  - Controlling Emissions
  - Anticipating Growth

- Setting Standards and Objectives
  - Ambient AQ Standards
  - Critical Ecosystem Loads

US National Academy of Sciences Report Air Quality Management in the United States
http://books.nap.edu/catalog/10728.html
1. Is there a Health Hazard From Exposure to Air Pollution?

Many forms of studies can help inform this:

- *Daily population studies* examining relationship between exposures and certain health outcomes:
  - E.g., asthma hospitalization, premature birth, mortality (deaths), and more

- *Studies of Long-term Effects (e.g. cohort and panel studies)* examining how exposures do or do not affect a population of carefully selected set of participants:
  - E.g., children, pregnant mothers, older people
Example: Recent Global Mortality Studies Provide Consistent Evidence of Long-Term Effects

2. At what **exposure level** do effects occur?

This requires evidence of the *Concentration Response (C-R)* relationship:

- **Detailed estimates of:**
  - Exposures across an entire population
  - Health status and outcomes
  - E.g., mortality, lung cancer incidence

**Draws on a large worldwide data set, but gaps remain in Africa**
One example of the “Concentration Response Relationship”

• Recent paper from Liu et al in the New England Journal of Medicine

• Times series studies in 652 cities in 24 countries
  • including China, Africa, Latin America

• Strong PM2.5 associations below US NAAQS, WHO AQG
  • Steeper curve at lowest levels
Using Evidence to Set Air Quality Standards and Guidelines
US, WHO, India, and Much of the Rest of the World, has set PM and Ozone Ambient Air Quality Standards (in $\mu$g/m$^3$)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>WHO AQG (Interim Targets)</th>
<th>US EPA</th>
<th>EU</th>
<th>China Revised 2016</th>
<th>India Revised 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10 Annual</td>
<td>10 (70-50-30-20)</td>
<td>---</td>
<td>40</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>PM10 Daily</td>
<td>45 (150-100-75-50)</td>
<td>150</td>
<td>50</td>
<td>150</td>
<td>\</td>
</tr>
<tr>
<td>PM2.5 Annual</td>
<td>5 (35-25-15-10)</td>
<td>12~8-10?</td>
<td>25\10</td>
<td>35</td>
<td>40?</td>
</tr>
<tr>
<td>PM2.5 Daily</td>
<td>15 (75-50-37.5-25)</td>
<td>35</td>
<td>---</td>
<td>7</td>
<td>60</td>
</tr>
<tr>
<td>Ozone 8-hour</td>
<td>100 (160-120)</td>
<td>~140 (70ppb)</td>
<td>100***</td>
<td>160</td>
<td>100</td>
</tr>
</tbody>
</table>

***target value, not limit value
WHO Global Air Quality Guidelines

Scientific evidence and decision-making process

Dr Dorota Jarosinska, WHO European Centre for Environment and Health
HEI Annual Conference, 26-28 June 2022
What are the WHO Global AQGs

• Based on extensive scientific evidence, the AQGs identify the levels of air quality necessary to protect public health worldwide.

• Provide recommendations on air quality guideline levels (and interim targets) for PM$_{2.5}$, 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 an evidence-informed reference to help decision-makers in setting legally binding standards and goals for air quality management.

• They are an instrument to design effective measures to achieve reduction of air pollution and, therefore, protect human health.

• Different Countries have taken different approaches to setting standards
## Summary of recommended AQG levels and interim targets

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging time</th>
<th>IT1</th>
<th>IT2</th>
<th>IT3</th>
<th>IT4</th>
<th>AQG level</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{2.5}$, µg/m³</td>
<td>Annual</td>
<td>35</td>
<td>25</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>PM$_{2.5}$, µg/m³</td>
<td>24-hour$^a$</td>
<td>75</td>
<td>50</td>
<td>37.5</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>PM$_{10}$, µg/m³</td>
<td>Annual</td>
<td>70</td>
<td>50</td>
<td>30</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>PM$_{10}$, µg/m³</td>
<td>24-hour$^a$</td>
<td>150</td>
<td>100</td>
<td>75</td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>O$_3$, µg/m³</td>
<td>Peak season$^b$</td>
<td>100</td>
<td>70</td>
<td>–</td>
<td>–</td>
<td>60</td>
</tr>
<tr>
<td>O$_3$, µg/m³</td>
<td>8-hour$^a$</td>
<td>160</td>
<td>120</td>
<td>–</td>
<td>–</td>
<td>100</td>
</tr>
<tr>
<td>NO$_2$, µg/m³</td>
<td>Annual</td>
<td>40</td>
<td>30</td>
<td>20</td>
<td>–</td>
<td>10</td>
</tr>
<tr>
<td>NO$_2$, µg/m³</td>
<td>24-hour$^a$</td>
<td>120</td>
<td>50</td>
<td>–</td>
<td>–</td>
<td>25</td>
</tr>
<tr>
<td>SO$_2$, µg/m³</td>
<td>24-hour$^a$</td>
<td>125</td>
<td>50</td>
<td>–</td>
<td>–</td>
<td>40</td>
</tr>
<tr>
<td>CO, mg/m³</td>
<td>24-hour$^a$</td>
<td>7</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4</td>
</tr>
</tbody>
</table>

### 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

On the management of certain types of particulate matter for which evidence is insufficient to derive quantitative air quality guideline levels, but points to their health relevance

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China chose an interim target

|  | China’s Class 2 Annual AQ Standard |

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Different uptake of AQGs in AAQS across the world

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

Kutlar Joss et al., 2017
Growing Evidence of Air Pollution and Health in East Africa

Over 80 studies in HEI’s new interactive data base

https://www.healtheffects.org/global/interactive-database/east-africa
3. How can we test which **sources** contribute to health hazards?

- Requires source-specific estimates of emissions
- And populations that are, *and are not*, exposed to the source
- May be challenging in high pollution environments where there are *many* sources, and everyone is exposed

**But ultimately such studies can play a key role in targeting source controls.**
Informing Solutions: Global Burden of Disease from Major Air Pollution Sources (GBD MAPS)

GBD-MAPS Global is identifying which sources/sectors contribute most to air pollution and health in 195 countries.

Relies on AQ monitors, satellite data and models.

Local data is key to informed air quality management.

Full Data Available through State of Global Air 2021.
Setting Standards Sets the Stage for the Next Step:

Assessing Status
Measuring Progress
- AQ Monitoring
- Health Effects

Setting Standards
and Objectives
- Ambient AQ Standards
- Critical Ecosystem Loads

Designing and
Implementing
Control Strategies
- Identifying key sources
- Controlling Emissions
- Anticipating Growth
China took action starting in 2013

Air Pollution went Down

Deaths declined and Years of life were saved

Lancet Planetary Health July 2018
Conclusions

• Achieving Clean Air Through Effective Air Quality Management is a Long-term Commitment

• Setting AQ Standards relies on a combination of global and local studies and international assessments (WHO AQG’s, Euro limit values, US EPA NAAQS)

• Understanding emissions and population exposures at the regional and local levels key to targeting sources of greatest concern to public health

• Assessing progress over time is key to ensuring that regulatory and other interventions are working to protect public health

• Enhanced air quality monitoring needed to inform better health studies, exposure assessment, source contributions and track progress.
THANK YOU!

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A Recent Example: HEI’s Report on CA Goods Movement (Meng et al May 2021)

Compare changes in 10 California counties from pre-policy to post-policy comparing:

- **Goods Movement Corridors** to **Non-Goods Movement Corridors**
- **NO2 Exposures** went down
- **Hospitalizations** went down

[Commentary Figure 1](https://www.healtheffects.org/publication/improvements-air-quality-and-health-outcomes-among-california-medicaid-enrollees-due)
Health Effects of exposure to PM$_{2.5}$

Longstanding concern about effects on the lung

But strong evidence of an association between long- and short-term exposure to PM$_{2.5}$ and heart disease, stroke, brain disease, birth outcomes

Growing evidence from India, China, elsewhere in Asia
State of Global Air 2020

www.stateofglobalair.org

Based on the Annual Global Burden of Disease 2019*

Making data available on air pollution and health
   For every country in the world
   From 1970 to 2019

* Published in The Lancet October 15, 2020
Estimating burden of disease from air pollution

Global population exposures

Exposure-response relationships

Population-attributable fraction due to air pollution

Burden of Disease attributable to Air Pollution

Disease-specific burden

Minimum risk exposure level
Putting air pollution in perspective

How does it compare to other risks

Air pollution is the 4\textsuperscript{th} leading risk factor for premature death and disability;

In 2019, it accounted for 12\% of global deaths.
1) Setting Standards and Objectives
- Emissions standards
- Ambient air quality standards
- Reducing acid deposition
- Reducing regional pollution
- Protecting visibility

2) Designing and Implementing Control Strategies
- Source control technology requirements
- Emissions caps and trading
- Voluntary or incentive-based programs
- Energy efficiency
- Pollution prevention (e.g., product substitution and process alteration)
- Compliance assurance

3) Assessing Status and Measuring Progress
- Emissions trends
- Air quality trends
- Health effects trends
- Ecosystem trends
- Institutional accountability

Science Plays an Important Role in Setting Standards
Many Sources of PM

- Coal-fired power plant emissions
- Household burning
- Vehicle exhaust
- Factory emissions
- Refuse burning
- Smelters
- Crop burning
- Forest fires
India set a standard in 2009; now under review

### TABLE 2: NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Pollutants</th>
<th>Time Weighted Average</th>
<th>Concentration in Ambient Air</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Industrial, Residential, Rural, and Other Areas</td>
</tr>
<tr>
<td>1</td>
<td>Sulphur dioxide (SO$_2$), µg/m$^3$</td>
<td>Annual*</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours**</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>Nitrogen dioxide (NO$_2$), µg/m$^3$</td>
<td>Annual*</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours**</td>
<td>80</td>
</tr>
<tr>
<td>3</td>
<td>Particulate matter (Size &lt;10 µm) or PM$_{10}$ µg/m$^3$</td>
<td>Annual*</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours**</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Particulate matter (Size&lt;2.5 µm) or PM$_{2.5}$ µg/m$^3$</td>
<td>Annual*</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours**</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>Ozone (O$_3$), µg/m$^3$</td>
<td>8 hours**</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 hours **</td>
<td>180</td>
</tr>
<tr>
<td>6</td>
<td>Lead (Pb), µg/m$^3$</td>
<td>Annual*</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours**</td>
<td>1.0</td>
</tr>
<tr>
<td>7</td>
<td>Carbon monoxide (CO), mg/m$^3$</td>
<td>8 hours**</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 hours **</td>
<td>04</td>
</tr>
<tr>
<td>8</td>
<td>Ammonia (NH$_3$), µg/m$^3$</td>
<td>Annual*</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 hours**</td>
<td>400</td>
</tr>
<tr>
<td>9</td>
<td>Benzene (C$_6$ H$_6$), µg/m$^3$</td>
<td>Annual*</td>
<td>05</td>
</tr>
<tr>
<td>10</td>
<td>Benzo(a) pyrene (BaP)-particulate phase only, ng/m$^3$</td>
<td>Annual*</td>
<td>01</td>
</tr>
<tr>
<td>11</td>
<td>Arsenic (As), ng/m$^3$</td>
<td>Annual*</td>
<td>06</td>
</tr>
<tr>
<td>12</td>
<td>Nickel (Ni), ng/m$^3$</td>
<td>Annual*</td>
<td>20</td>
</tr>
</tbody>
</table>

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* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable shall be complied with 98% of the time in a year. 2% of the time may exceed the limits but not on two consecutive days of monitoring.
Setting Ambient Air Quality Standards

• Their key role in making progress on clean air
  
  • Studies Used to Set Standards Around the World
  
  • The Most Recent World Health Organization Air Quality Guidelines
  
  • Source Emissions, Impacts and use in Air Quality Management
  
  • Assessing Progress
4. Assessing whether AQ interventions have actually reduced health impacts:

“Accountability” studies

- To better test and quantify the consequences of policy actions on air quality and health
- Can help inform whether air quality interventions actually reduced exposures and health impacts
- Potential to improve cost-benefit analyses of future actions
- Challenging to account for other changes in exposures and effects over long periods of time and specific source health impacts