Health Risk – Air Pollution

Health Risk Factors in Rapidly Changing Economies
Swiss Re Centre for Global Dialogue
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School was canceled, traffic was nearly paralyzed and the airport was shut down in the northeast Chinese city of Harbin on Monday as off-the-charts pollution dropped visibility to less than 10 meters in parts of the provincial capital.

A dark, gray cloud that the local weather bureau described as “heavy fog” has shrouded the city of 10 million since Thursday, but the smoke thickened significantly on Sunday, soon after the government turned on the coal-powered municipal heating system for the winter.

“You can’t see your own fingers in front of you,” the city’s official news site explained helpfully. In the same vein, a resident of Harbin commented on Sina Weibo, the popular microblog platform, “You can hear the person you are talking to, but not see him.” Another resident added that he couldn’t see the person he was holding hands with.

The Harbin government reported an air quality index (AQI) score of 500, the highest possible reading, with some neighborhoods posting concentrations of PM2.5 — fine particulate matter that are 2.5 microns in diameter or smaller and especially harmful to health — as high as 1,000 micrograms per cubic meter, according to the China News Service.
Choking smog returned to blanket Beijing and surrounding areas yesterday, four days after a dangerous smog alert was lifted. Meteorologists said pollution levels were likely to remain high until after the National Day "golden week" ends tomorrow - and the traffic crush as people returned from holiday would not help the problem.

The capital's air quality index registered above 300 for most of the day, according to the Beijing Municipal Environmental Monitoring Centre. That means the air was "severely polluted", the highest on the six-level scale. The National Meteorological Centre issued a yellow alert for haze for Beijing, Tianjin and parts of Shanxi and Hebei yesterday evening.

The US embassy’s air-quality monitoring station showed that Beijing’s air had been "very unhealthy" or "hazardous" since Friday night, with the level of PM2.5 - tiny particles that pose the highest health risks - reaching 372 per cubic metre at 9am yesterday. The World Health Organisation recommends a daily limit of 20.
Ambient (outdoor) air pollution in cities database 2014

The database contains results of ambient (outdoor) air pollution monitoring from almost 1600 cities in 91 countries. Air quality is represented by annual mean concentration of fine particulate matter (PM10 and PM2.5, i.e. particles smaller than 10 or 2.5 microns).

The database covers the period from 2008 to 2013, with the majority of values for the years 2011 and 2012. The primary sources of data include publicly available national/subnational reports and websites, regional networks such as the Asian Clean Air Initiative and the European Airbase, and selected publications. The database aims to be representative for human exposure, and therefore primarily captures measurements from monitoring stations located in urban background, residential, commercial and mixed areas.

The world's average PM10 levels by region range from 26 to 208 µg/m³, with a world's average of 71 µg/m³.

PM10: Fine particulate matter of 10 microns or less; Amr: America; Afr: Africa; Emr: Eastern Mediterranean; Sear: South-East Asia; Wpr: Western Pacific; LMI: Low- and middle-income; HI: high-income. PM10 values are regional/urban population-weighted.
India's state air monitoring centre has admitted that pollution in Delhi is comparable to that of Beijing, but disputed a World Health Organisation (WHO) finding that the Indian capital had the dirtiest atmosphere in the world.

A study of 1,600 cities across 91 countries released on Wednesday by the WHO showed Delhi had the world's highest annual average concentration of small airborne particles (known as PM2.5) of 153.
What is Fine Particulate Air Pollution (PM$_{2.5}$)?

- Anything collected on a filter
  - Solid particles or liquid droplets
  - Not gases

![Diagram showing deposition potential for particles of varying sizes.](image-url)
Global Satellite-Derived PM$_{2.5}$: 2001–2006 Average

Von Donkelaar et al Envir Hlth Pers 2010;118:847
WHO Tabulation of PM$_{2.5}$
2012 Means by Country

http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/
WHO Tabulation of PM$_{2.5}$
2012 Means – Cities

Annual Mean PM$_{2.5}$ (g/m$^3$)

- Delhi
- Beijing
- Rio de Janeiro
- Mexico City
- Zurich

http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/
Beijing still struggling to deal with traffic congestion.

South China Morning Post Nov 10, 2013
Coal and cars combine to increase pollution in North

By Wang Qian 2010-12-08
Household Air Pollution - a Major Avoidable Risk Factor for Cardiorespiratory Disease

An Indian woman trying to ignite dried dung in a brick stove

A Malawian woman cooking over a three-stone fire in building used as living and sleeping quarters

An Ethiopian woman preparing to cook over a three-stone fire in a wooden outbuilding

A Peruvian mother holding a young child while cooking in a smoky kitchen blackened by soot
Cooking with Solid Fuels
*Biomass and Coal*
Comparative Risk Assessment
Global Burden of Disease Study 2010
Burden of disease attributable to 20 leading risk factors in 2010

3.5 million deaths, 108 Million DALY

3.2 million deaths, 76 Million DALY
Burden of Disease: India, China, Brazil, and Mexico
Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of China DALYs.

http://www.healthmetricsandevaluation.org/gbd/country-profiles
Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of India DALYs.

http://www.healthmetricsandevaluation.org/gbd/country-profiles
Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of Mexico DALYs.

http://www.healthmetricsandevaluation.org/gbd/country-profiles
Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of Brazil DALYs

http://www.healthmetricsandevaluation.org/gbd/country-profiles
How do they estimate these numbers?

Dose – Response
Exposure
Population statistics
Six Cities Adult Mortality Study

- 8111 adults in 6 cities
  - Dirty: Steubenville & St. Louis
  - Moderate: Watertown & Kinston/Harriman
  - Clean: Topeka & Portage
- Enrolled starting in 1974
- 14-16 years of mortality follow-up

Dockery et al, NEJM 1993;329:1753
Follow-up

HARVARD LUNG STUDY

IS THE LABEL BELOW CORRECT? □ YES □ NO
IF NO, PLEASE MAKE CORRECTIONS.

Home phone #

Has the person named below died? □ No □ Yes Date of Death ___________

Thank you for keeping in touch

RECEIVED OCT 04 1990
0192-5-A

Lake Hills TX

This card was completed by: □ Person named above
□ Spouse □ Other Relative or Friend □ Other
Follow-up

HARVARD LUNG STUDY

Is the label below correct?  □ YES  □ NO
If no, please make corrections.

Is the person named below too ill to complete this card?  □ No  □ Yes

Has the person named below died?  □ No  □ Yes
If yes, specify ____________________

Date of Death  Feb. 12
City/State of Death  Steubenville, Ohio

9042-5

STEUBENVILLE, OH 43952

This card was completed by:  □ Person named above  □ Other above
□ Spouse  □ Other Relative or Friend

□ Other ____________________
Six Cities Adult Mortality

- Steubenville
- Topeka
- Watertown
- Kingston
- St. Louis
- Portage

EPA NAAQS
- Delhi (153 ug/m³)
- Beijing (56 ug/m³)

PM$_{2.5}$ (g/m³)
Comprehensive Dose-Response

- Ischemic heart disease
- Cardiovascular disease
- Cardiopulmonary
- Active smoking
- ETS
- Women’s Health Initiative
- American Cancer Society
- Harvard Six Cities

Adjusted relative risk vs. Estimated daily inhaled dose of PM$_{2.5}$ (mg)

Air Pollution

Active Smoking

Pope et al, Circulation. 2009;120:941-948
Comprehensive Dose-Response

Adjusted relative risk vs. Estimated daily inhaled dose of PM$_{2.5}$ (mg)

Key:
- Ischemic heart disease
- Cardiovascular disease
- Cardiopulmonary
- Active smoking
- ETS
- Women’s Health Initiative
- American Cancer Society
- Harvard Six Cities

Active Smoking

2nd Hand Smoke
Comprehensive Dose-Response

Adjusted relative risk vs. Estimated daily inhaled dose of PM$_{2.5}$ (mg)

WHO AQG

Household Air Pollution

Pope et al, Circulation. 2009;120:941-94
What does this mean for the individual?

What is effect of life expectancy?
Survival curves 18-100 years and estimated life expectancy (LE) for alternative excess risk assumptions

- **Never Smoker**: LE 80.6 years
- **Moderate Smoker**: 7.8 yr reduced LE
- **Living Polluted City**: 3.1 yr reduced LE
Estimated Years reduced life expectancy
- exposures to cigarette smoke and fine particle air pollution

- Years Reduced Life Expectancy

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- Exposure Levels:
  - Heavy
  - Moderate
  - Light
  - Ex (stop age 40)
  - Age 18+
  - Ages 18-65
  - As child
  - 30 ug/m3
  - 60 ug/m3
  - 90 ug/m3
  - 120 ug/m3
WHO Tabulation of PM$_{2.5}$
2012 Means – Cities

- Delhi
- Beijing
- Rio de Janeiro
- Mexico City
- Zurich

Annual Mean PM$_{2.5}$ (g/m$^3$)

http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/
Years Reduced Life Expectancy
- Lifetime Exposure

Cigarette Smoking
Fine Particle Air Pollution*

* Compared to Zurich
Incremental Risk

- Estimate of effect of each year of exposure
- Effect of potential changes in exposures or behaviors.
- Comparative risk for a worker or student who temporarily moves to such an environment.
- Consider 50-year old non-smoker who spends one year in mild, moderate, and high PM$_{2.5}$ air pollution.
Estimated **days** of reduced life expectancy

1 **year** exposures to cigarette smoke and fine particle air pollution

50 years of age

*Compared to 15 ug/m3*
Estimated **days** of reduced life expectancy

1 year exposures to cigarette smoke and fine particle air pollution

50 years of age

*Compared to Zurich*
Effect of Age of living in Delhi?

- Baseline risk goes up with age
- Impact of each year of exposure to high pollution increases with age
  - 35 yrs – 29 days reduced LE
  - 50 yrs – 67 days reduced LE
  - 65 yrs – 116 days reduced LE
What does this mean for the individual?

- Not suggesting that their life is measurably shortened.
  - Rather, these estimates reflect the increase probability of death in each year.

- How would they die?
  - Acute events such as myocardial infarction, stroke, asthma attack, or traffic accident.

- Assume that once the air pollution exposure is removed (for example, by moving to a cleaner city) their excess risk of dying returns to normal.
Summary

- Each year of living in highly polluted city (e.g. Delhi) reduces expected average life expectancy by 30 to 120 days compared to living in cleaner city (e.g. Zurich)
  - Comparable to effects of being moderate smoker
- Over a lifetime, this amounts to up about 7 years lost life expectancy
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