
BACKGROUND MATERIAL FOR GREENSTONE AND PANDE INTERNATIONAL NEW YORK TIMES OP-ED OF FEBRUARY 10, 2014: ESTIMATING THE LOSS OF LIFE EXPECTANCY DUE TO PM IN INDIA

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This note explains how information on particulate matter (PM) pollution across Indian cities was combined with estimates of life expectancy impacts of PM pollution to provide an estimate of the loss of life years related to current levels of PM pollution in India. This estimate was incorporated in Greenstone and Pande's February 10, 2014 op-ed in the International New York Times. Our estimate implies that the 200 million Indians who live in localities monitored for particulate matter pollution are projected to lose an average of 3.3 years of life because of PM concentrations in 2010 that exceed India's standards. This translates into the loss of about 650 million life years for just one-sixth of India's population. The loss of life years would be larger if data on ambient particulate matter concentrations were available for the other five-sixths of India's population.

To estimate the loss of life years due to particulate matter pollution, we estimate the population-weighted PM average concentration in 2010, calculate the per-person loss of life expectancy relative to the Indian standards using estimates from Chen, Ebenstein, Greenstone, and Li (2013), and then multiply by the affected population to get the cumulative loss of life years. The details on the calculations and data are below. The note also provides references for other claims in the op-ed.

Estimating the loss of life years related to 2010 PM levels in India

1) Estimating Population-Weighted Pollution Concentration Annual Averages:

First, we estimate the population-weighted average annual concentration levels in 2010 for suspended particulate matter (SPM) and respirable particulate matter (PM10) pollution for monitored Indian cities.

Data:

India's Central Pollution Control Board (CPCB) monitors particulates pollution under the National Air Quality Monitoring Programme. As of March 31st, 2011, the CPCB operated 456 stations in 190 cities (Agrawal et al. 2012). The CPCB 2012 report titled "National Ambient Air Quality Status and Trends in India-2010" (Agrawal et al. 2012) provides monitoring station-level annual average concentrations of PM10 and SPM in 2010. PM10 data is available in Table 5.6 for 432 stations from 180 cities (pages 72-82) and SPM data is available in Table 6.1 for 400 stations from 162 cities (pages 84-94, Agrawal et al., 2012).

For most cities that are monitored for PM pollution, we have population data from the 2011 Census (Census of India 2011). A few monitoring stations are in small towns or villages, in those cases, we utilized the population of the sub-district (Census of India).¹ For one town, we were unable to get population data.

Method:

To calculate the annual average concentration of SPM and PM10 for each city, we took a simple average of the annual average concentrations for the monitoring stations within the city.

There were 19 cities for which we had only PM10 data, and one city for which we had only SPM data. In these cases, we imputed SPM concentration values from PM10 data and vice versa. To do so, we calculated the average ratio of PM10/SPM pollution in cities where full data was available (average ratio=0.5053). We then imputed the missing values using the following formulas for each city:

Imputed Annual Average PM10 Concentration=0.5053*Annual Average SPM Concentration

Imputed Annual Average SPM Concentration= (1/0.5053)*Annual Average PM10 Concentration.

This gave us 181 cities for which we had both SPM and PM10 average concentrations for 2010.

To get the nation-wide figures for SPM and PM10, we then took a population-weighted average of the city-level annual average concentrations for the 180 cities for which both population and pollution data were available.

Outcomes:

The population-weighted annual average PM10 concentration in 2010 for 180 Indian cities was 120.42 $\mu\text{g}/\text{m}^3$. Similarly, the average for SPM was 249.79 $\mu\text{g}/\text{m}^3$. According to the 2011 Indian census 197,626,000 people live in these 180 cities.

The annual city average for Delhi in 2010 was 261.33 $\mu\text{g}/\text{m}^3$.

¹ To find the population of the sub-district, we used the 'Population Finder 2011' tool on the Census of India website.

2) Estimating the Life Years Lost due to Current Levels of Particulate Matter

India's National Ambient Air Quality Standards, as of 2009, set the standard for annual average PM₁₀ concentrations at 60 µg/m³ and for PM_{2.5} at 40 µg/m³ (as per notification B-29016/20/90/PCI-I, 18th November 2009) (Central Pollution Control Board). The previous standards, set in 1994, included an annual average standard of 140 µg/m³ for SPM pollution in residential areas (as per notification S.O.384(E), 11th April 1994) (India Environmental Portal).²

Chen et al. (2013) estimate that “long-term exposure to an additional 100 µg/m³ of total suspended particulates (TSPs) is associated with a reduction in life expectancy at birth of about 3.0 years”. As total suspended particulates (TSPs) and suspended particulate matter (SPM) are defined in the same way (i.e. particles <100 µm), and China's TSPs concentrations are similar to India's SPM concentrations, we assume that the Chen et al. elasticity applies in the Indian context³.

To estimate the life expectancy consequences of SPM levels in India, we consider a decline in the population-weighted 2010 average concentration of SPM, 250 µg/m³, to the SPM standard of 140 µg/m³, which is a decline of 110 µg/m³. Using Chen et al.'s estimates, this translates to an increase of 3.3 years of life expectancy at birth in the parts of India where PM is monitored.

As per Census 2011 data, 197,626,000 people live in the 180 cities for which India's Central Pollution Control Board publishes 2010 PM data and population data is available. Using the estimate of 3.3 years of increased life expectancy for each person, **the cumulative loss of life years for these individuals is 652,166,000 life years.**

Additional References Mentioned in the Op-Ed:

In Greenstone and Pande's February 2014 Op-Ed, the following references are mentioned.

- a) On February 10th, 2014, India's Supreme Court will hear an amicus plea on pollution levels in Delhi (Press Trust of India, 2014).
- b) The World Health Organization's Air Quality Guideline (AQG) value for PM₁₀ is 20 µg/m³ (annual mean). The AQG value for PM_{2.5} is 10 µg/m³ (annual mean). (World Health Organization, “Air Quality and Health”).
- c) Satellite imagery shows high levels of PM₁₀ across India: Dey et al (2012).

² The revised standards as of 2009 have replaced the SPM standard with a PM_{2.5} standard.

³ For example, India defines Suspended Particulate Matter (SPM) as “SPM are particulate/aerosol having diameter less than 100µm that tend to remain suspended in the atmosphere for a long period of time.” (Agrawal et al. 2012). The United States Environmental Protection Agency defines Total Suspended Particulate Matter as “particle size of <100 µm” (United States Environmental Protection Agency 1999).

- d) The World Health Organization shows that India has the highest rate of death caused by chronic respiratory diseases (World Health Organization. "NCD Mortality, 2008. Chronic Respiratory Diseases, death rates per 100 000 population, age standardized: Female".)
- e) The 1990 Clean Air Act Amendments enhanced the U.S. Environmental Protection Agency's ability to levy civil fines on environmental violators. (United States Environmental Protection Agency. "Permits and Enforcement")

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