Supplemental Materials

for

Source contributions and potential reductions to health effects of particulate matter in India

Hao Guo[1], Sri Harsha Kota[2,3,4], Kaiyu Chen[1], Shovan Kumar Sahu[4], Jianlin Hu[2], Qi Ying[5], Hongliang Zhang[1,*]

[1]Department of Civil and Environmental Engineering, Louisiana State University, Baton Rouge LA 70803, USA

[2]Jiangsu Key Laboratory of Atmospheric Environment Monitoring and Pollution Control, Jiangsu Engineering Technology Research Center of Environmental Cleaning Materials, Nanjing University of Information Science & Technology, Nanjing 210044, China

[3]Department of Civil Engineering, Indian Institute of Technology Delhi, 110016, India

[4]Department of Civil Engineering, Indian Institute of Technology Guwahati, 781039, India

[5]Zachry Department of Civil Engineering, Texas A&M University, College Station, TX 77843, USA

[*]Corresponding author: Hongliang Zhang. Email: hlzhang@lsu.edu. Phone: +1-225-578-0140

Table S1. Baseline mortality (y0, $\times 10^5$) for chronic obstructive pulmonary disease (COPD), lung cancer (LC), ischemic heart disease (IHD) and cerebrovascular disease (CEV) for different age groups in India based on the WHO Mortality Database (for year 2000).

Age	COPD		LC		IHD		CEV	
	Male	Female	Male	Female	Male	Female	Male	Female
15-24	2.41	1.58	0.68	0.49	2.58	0.84	3.11	1.29
25-34	5.30	3.71	2.57	1.45	7.88	2.55	6.51	2.92
35-44	10.11	3.99	8.03	3.68	17.02	5.95	12.32	5.62
45-54	20.08	9.49	16.39	4.45	25.44	11.66	18.96	9.49
55-64	118.30	62.59	78.96	21.49	131.31	78.77	87.80	54.38
65-69	397.55	259.99	124.53	44.74	373.88	326.72	231.75	170.67
70+	397.55	259.99	124.53	44.74	373.88	326.72	231.75	170.67

Table S2. Population age distribution for India, 2015.

Age group	Male	Female
15-24	20.60%	20.60%
25-34	17.50%	17.70%
35-44	13.00%	13.10%
45-54	9.60%	9.50%
55-64	6.41%	6.90%
65-69	2.10%	2.20%
70+	3.00%	3.50%

Data source: United Nations, Department of Economic and Social Affairs, Population Division

58 (2015). World Population Prospects: The 2015 Revision, custom data acquired via website.

Table S3. Comparison of the cause of excess mortality by disease and sources from this study with those from other studies in India.

	This study	Lelieveld et al. (2015)	Ghude et al.(2016)
Excess mortality (million deaths)	1.04 (0.53,1.54)	0.65	0.57
COPD (%)	17.7	17.3	
LC (%)	1.3	2.1	
IHD (%)	38.8	45.7	
CEV (%)	42.4	34.9	
Source Contributions (%)			
Energy	6.8	14	
Industry	19.7	7	
Residential	55.5	50	
Agriculture	11.9	6	
Traffic	1.9	5	
Dust	4	11	

Table S4. Source contributions of each source types to premature mortality due to COPD, LC, IHD and Stroke due to long term exposure of ambient PM$_{2.5}$ based on predicted 2015 annual average concentrations.

State	Energy	Industry	Residential	On-road	Off-road	Agriculture	Open-burning	Dust
Andhra Pradesh	13.50%	18.75%	48.50%	1.25%	1.25%	9.75%	0.25%	6.75%
Arunachal Pradesh	0%	0%	50%	0%	0%	50%	0%	0%
Assam	1.88%	6.88%	61.25%	0.63%	1.25%	24.37%	2.50%	1.25%
Bihar	2.32%	18.70%	62.01%	0.66%	0.66%	13.96%	0.08%	1.24%
Chandigarh	0%	0%	100%	0%	0%	0%	0%	0%
Chhattisgarh	22.625	13.13%	40.87%	0.73%	0.73%	0.73%	16.78%	5.10%
Dadra & Nagar Haveli	0%	0%	100%	0%	0%	0%	0%	0%
Daman & Diu	0%	0%	100%	0%	0%	0%	0%	0%
Goa	14.28%	14.28%	57.14%	0%	0%	14.28%	0%	0%
Gujrat	10.23%	17.40%	53.24%	1.70%	1.02%	5.11%	0%	11.26%
Haryana	6.42%	25.71%	52.14%	1.42%	0.71%	9.28%	0.24%	4.28%
Himachal Pradesh	9.67%	12.90%	54.83%	3.22%	0%	12.90%	0%	6.45%
Jammu & Kashmir	0%	9.09%	68.18%	0%	0%	13.63%	0%	9.09%
Jharkhand	10.06%	26.29%	48.05%	0.65%	0.97%	12.01%	0.32%	2.27%
Karnataka	9.40%	14.35%	54.95%	3.46%	1.48%	8.91%	0.49%	6.93%
Kerala	3.41%	26.13%	62.50%	1.70%	1.13%	3.40%	0%	0.56%
Lakshadweep	0%	0%	0%	0%	0%	0%	0%	0%
Madhya Pradesh	10.85%	10.59%	55.29%	1.03%	1.03%	12.14%	0.26%	9.04%
Maharashtra	11.44%	23.87%	49.01%	1.13%	0.98%	7.76%	0.14%	5.64%
Manipur	0%	12.50%	50%	0%	0%	12.50%	12.50%	0%
Meghalaya	5.55%	11.11%	55.55%	0%	0%	22.22%	0%	0%
Mizoram	0%	0%	50%	0%	0%	25%	0%	0%
Nagaland	0%	12.50%	62.50%	0%	0%	12.50%	12.50%	0%
Delhi	5.83%	40%	45.83%	0.83%	0.83%	4.16%	0%	2.50%
Odisha	17.39%	14.62%	45.45%	0.79%	0.79%	17%	0.39%	3.95%
Puducherry	12.50%	25%	50%	0%	0%	12.50%	0%	0%
Punjab	3.75%	14.28%	57.51%	1.50%	0.75%	17.67%	0.38%	4.51%
Rajasthan	4.88%	9.19%	57.47%	2.01%	1.14%	7.75%	0.28%	17.24%
Sikkim	7.40%	38.88%	46.29%	1.85%	0%	3.70%	0%	1.85%
Tamil Nadu	15.11%	19.55%	52.88%	1.77%	0.88%	7.55%	0%	1.77%
Tripura	5.26%	5.26%	63.15%	0%	0%	21.05%	0%	0%
Uttar Pradesh	4.03%	18.75%	61%	0.83%	0.83%	12%	0.08%	2.45%
Uttarakhand	2.63%	10.52%	65.78%	2.63%	2.63%	13.15%	0%	5.26%
West Bengal	5.21%	26.68%	49.54%	0.60%	0.70%	15.84%	0.10%	1.30%
India	6.80%	19.66%	55.45%	1.05%	0.85%	11.90%	0.23%	4.02%

Table S5. Premature mortality reduction in percentage attributable to $PM_{2.5}$ exposure in 2015 and premature mortality when $PM_{2.5}$ reduced to $40\mu g/m^3$, $15\ \mu g/m^3$, $12\mu g/m^3$ and $10/\mu g\ m^3$ (WHO guideline level) at highly polluted states (Annual average concentration $\geq 40\mu g/m^3$).

States	$40\mu g/m^3$	$15\mu g/m^3$	$12\mu g/m^3$	$10\mu g/m^3$
Assam	3.51%	37.54%	53.68%	67.02%
Bihar	18.77%	61.58%	71.73%	79.88%
Chhattisgarh	3.97%	40.79%	56.68%	68.95%
Haryana	14.71%	59.00%	69.72%	78.55%
Jharkhand	7.17%	55.23%	67.05%	76.55%
Madhya Pradesh	1.46%	34.31%	51.60%	65.56%
Maharashtra	5.29%	42.22%	57.47%	69.75%
Delhi	25.68%	64.86%	74.32%	81.76%
Odisha	2.90%	46.91%	60.81%	72.20%
Punjab	5.18%	52.59%	65.03%	75.13%
Rajasthan	2.07%	29.19%	46.73%	62.20%
Uttar Pradesh	15.12%	59.34%	70.03%	78.68%
West Bengal	19.70%	61.36%	71.49%	79.68%
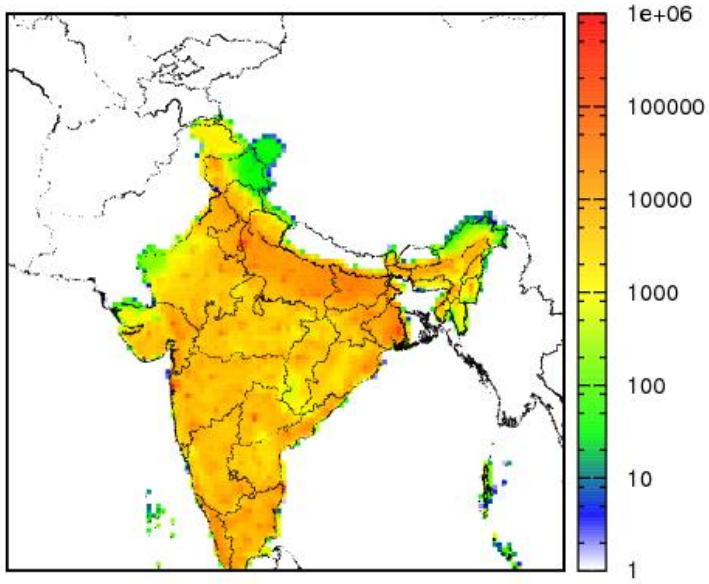
Figure S1. Design of 36×36 km^2 India domain with colorbar represent population density in each grid.
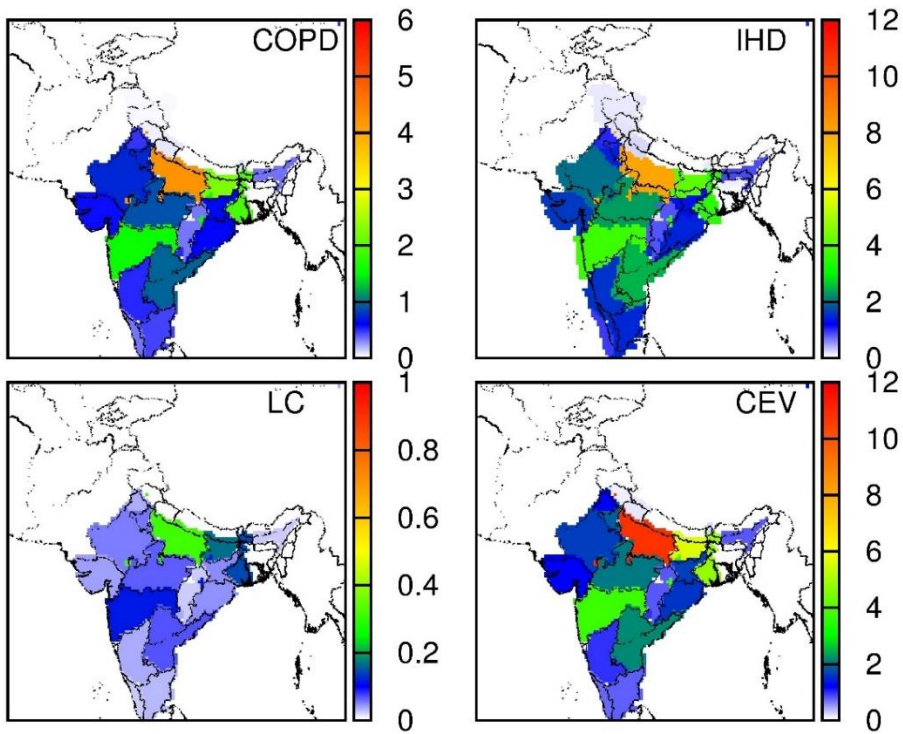
Figure S2. State-level disease specific mortality (x10^4 deaths) in 2015 due to COPD, LC, IHD and CEV.