Examining health effects of air pollution in India

Summary of recent progress from research studies

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Indian Council of Medical Research
Centre for Advanced Research
On Environmental Health: Air Pollution





Expanding our thinking on exposure environments

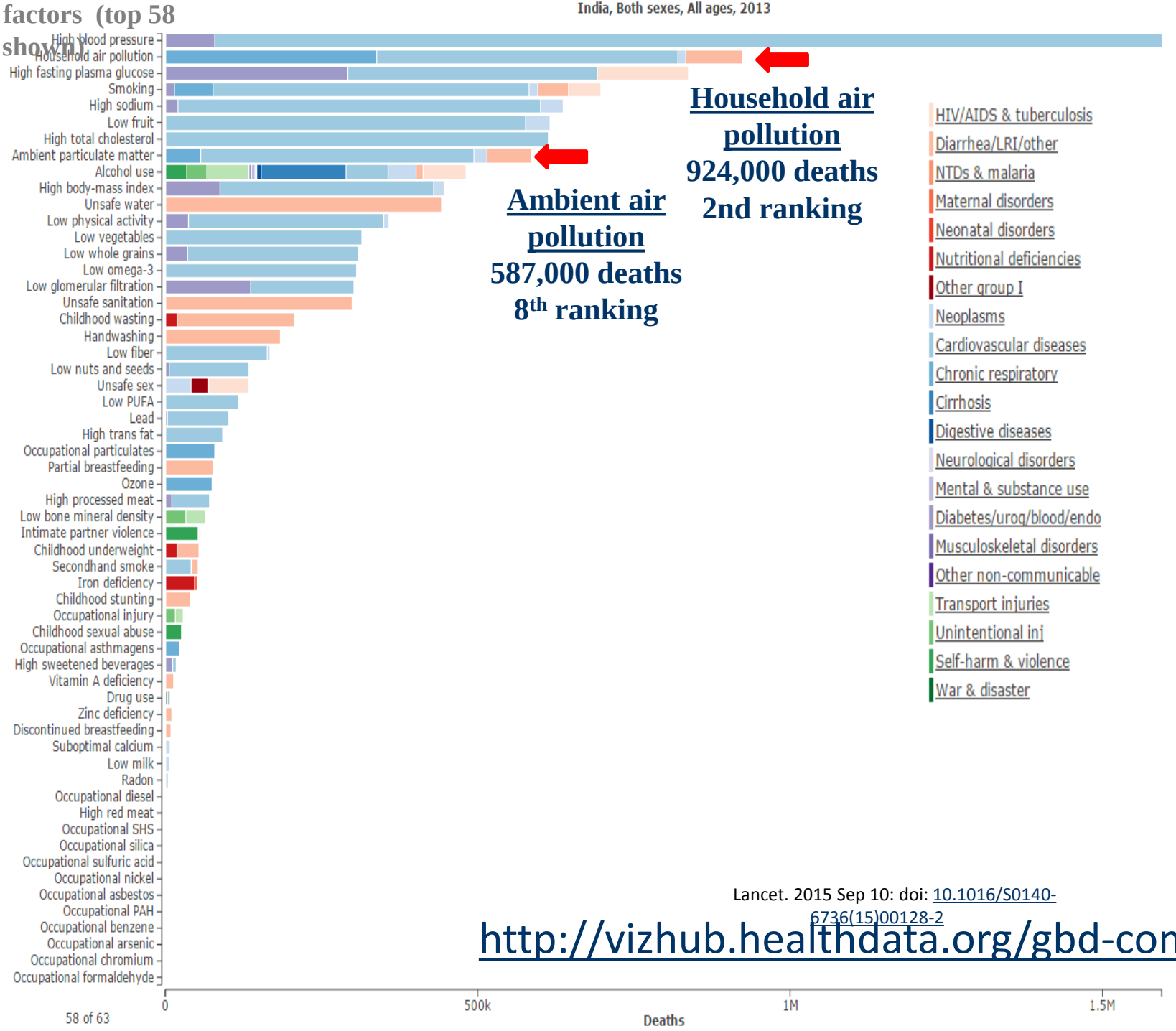


Dimensions of progress in research studies linking air quality and health in India

- Inputs for global/regional efforts
  - Global Burden of Disease 2010, 2013
  - WHO IARC : (HAP 2006); (Diesel 2009); (AAP 2013)
  - WHO-SEAR Action Plan on NCDs
- Inputs for national actions (AQI, MOHFW Report)
  - Sources, emissions, concentrations, exposures and intake fractions
  - Exposure-response relationships
  - Biomarkers
- Inputs for ongoing/future efforts
  - Implementation of WHO-AQGs, WHA 2015 Resolution
  - GBD 2015, GBDMAPS
  - National and State Level Environmental Burden of Disease Efforts
  - Revisions to WHO AQGs

Inputs for recent global efforts

79 risk factors (top 58 shown)



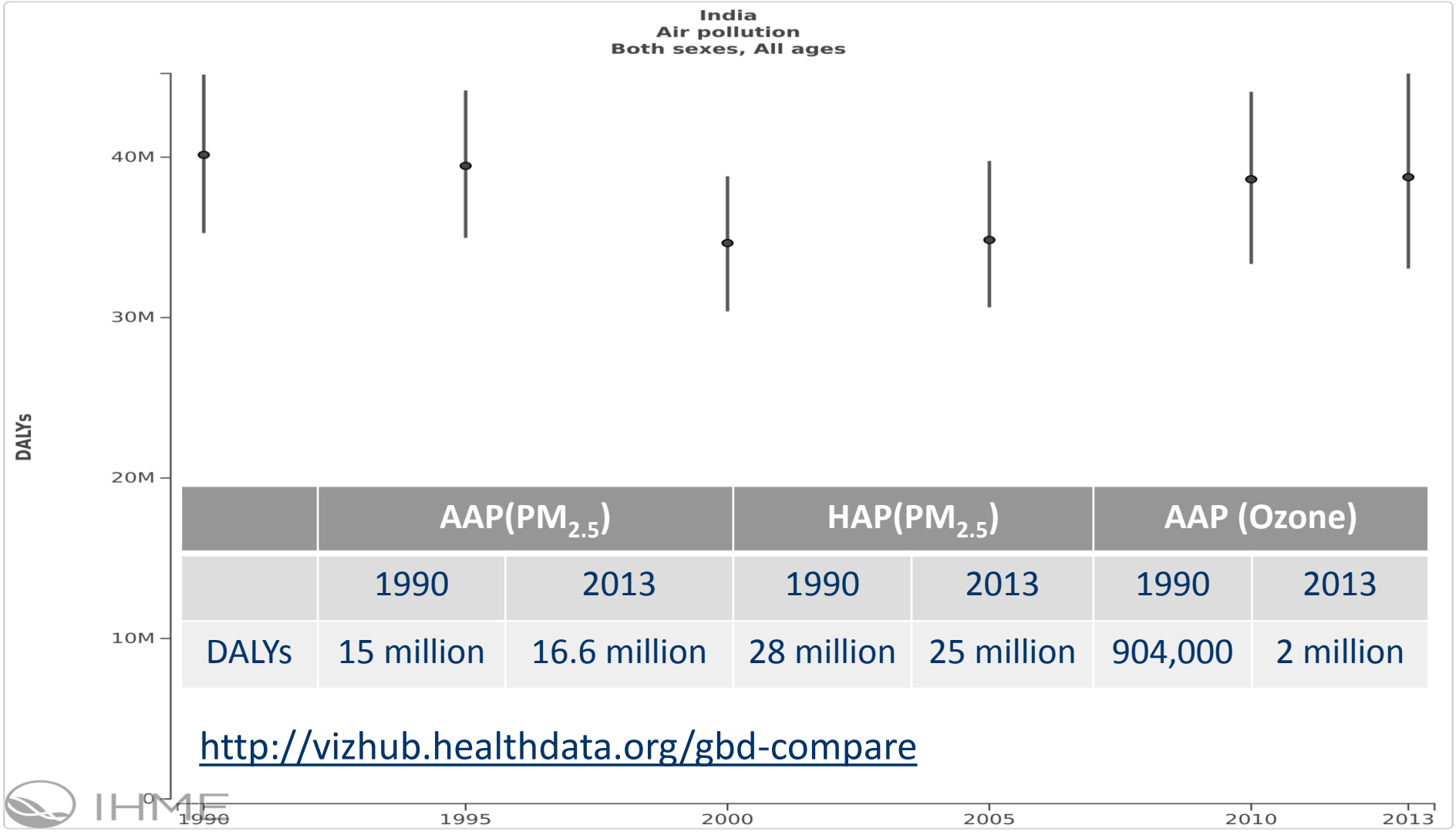
Lancet. 2015 Sep 10: doi: 10.1016/S0140-6736(15)00128-2

http://vizhub.healthdata.org/gbd-compare

	CHINA OUTDOOR PM	CHINA HOUSEHOLD	INDIA OUTDOOR PM	INDIA HOUSEHOLD	USA OUTDOOR PM
IHD	**236,926** **17%**	**151,722** **11%**	**296,489** **19%**	**315,039** **20%**	**43,160** **7.9%**
Stroke	**363,494** **19%**	**256,674** **13%**	**139,941** **20%**	**166,871** **23%**	**10,881** **6.6%**
COPD	**75,761** **8%**	**295,786** **32%**	**56,665** **7%**	**338,491** **45%**	**1,710** **1.1%**
Lung Cancer	**201,864** **37%**	**75,050** **14%**	**21,432** **35%**	**12,882** **21%**	**17,363** **9.8%**
ALRI	**38,064** **18%**	**28,041** **13%**	**72,041** **18%**	**90,878** **22%**	**5,718** **6.7%**
	916,102	**807,238**	**586,788**	**924,550**	**78,814**

http://vizhub.healthdata.org/gbd-com

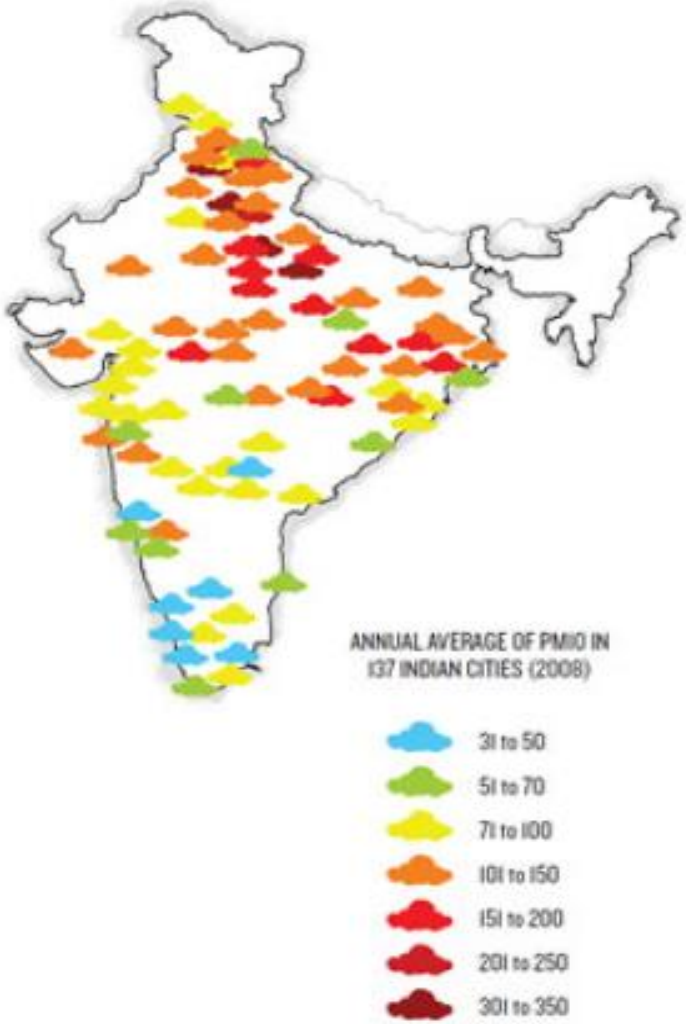
Air Pollution Attributable Burdens in India (1990-2013)

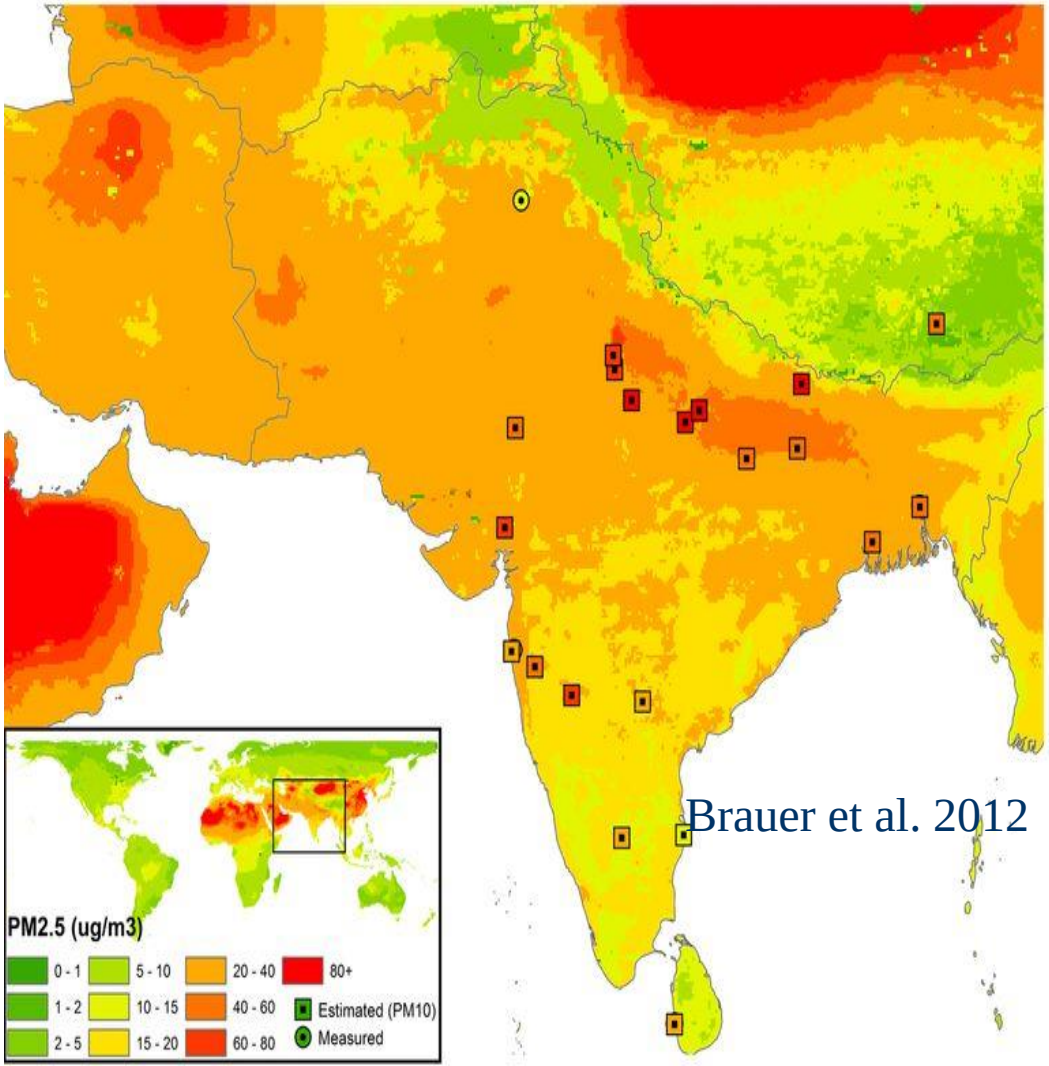


	AAP($PM_{2.5}$)		HAP($PM_{2.5}$)		AAP (Ozone)	
	1990	2013	1990	2013	1990	2013
DALYs	15 million	16.6 million	28 million	25 million	904,000	2 million

http://vizhub.healthdata.org/gbd-compare

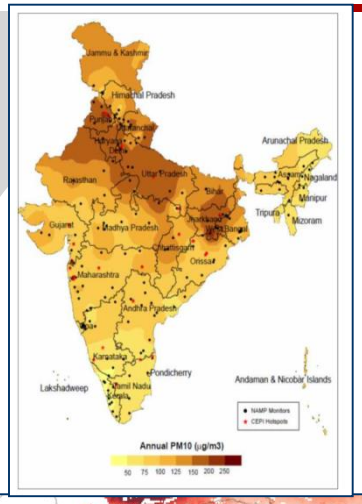
AAP($PM_{2.5}$)exposure estimates for India (GBD 2010, 2013)

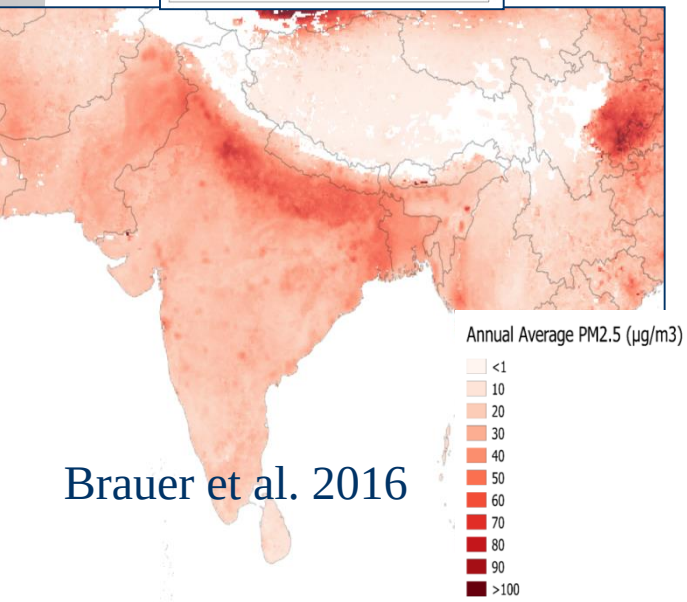




Brauer et al. 2012

AAP($PM_{2.5}$)exposure estimates for India (GBD 2010, 2013)





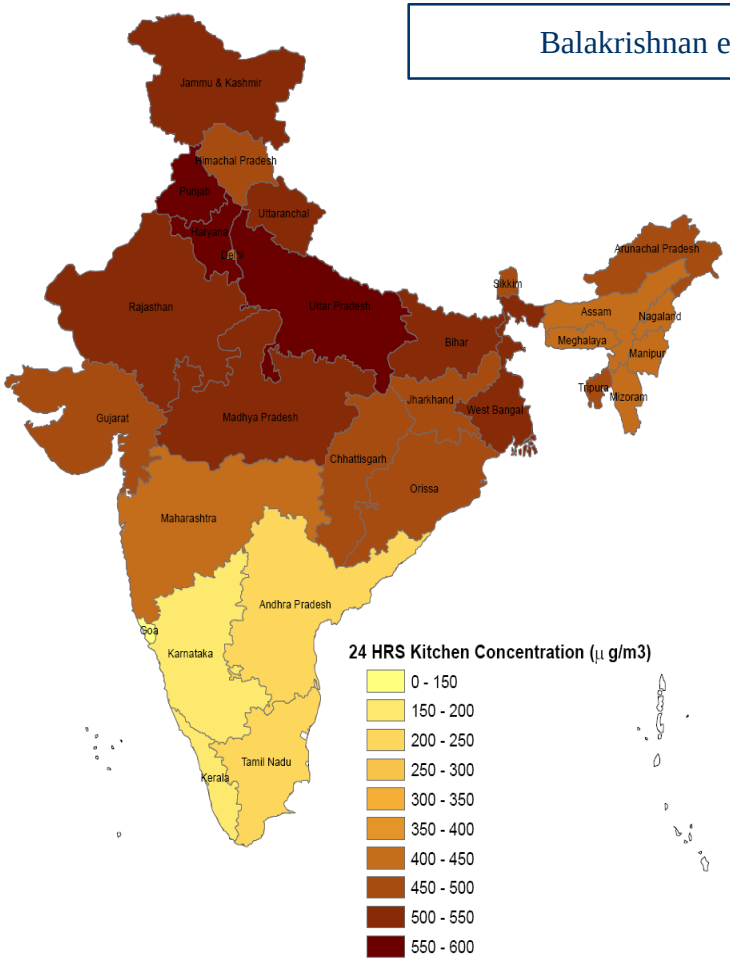
Brauer et al. 2016

Country	1990 $PM_{2.5}$	2013 $PM_{2.5}$	% Change	1990 Ozone	2013 Ozone	% Change
Global	26.4	31.8	20.4	57.3	62.4	8.9
China	39.3	54.3	38.0	57.0	64.5	13.2
India	30.2	46.7	54.3	61.5	74.0	20.2
United States	16.4	10.7	-34.5	70.3	67.0	-4.7
Indonesia	21.0	14.8	-29.7	47.3	39.6	-16.1
Brazil	9.7	16.5	70.4	43.4	51.0	17.3
Pakistan	36.5	46.2	26.3	59.0	68.8	16.5
Nigeria	31.0	29.5	-4.7	66.3	67.5	1.9
Bangladesh	29.9	48.3	61.6	59.4	72.0	21.3
Russia	19.7	14.2	-27.6	48.6	48.3	-0.6
Japan	19.4	16.0	-17.5	56.8	60.5	6.7

Sri

HAP($PM_{2.5}$) estimates for India (GBD 2010, 2013)

Balakrishnan et al. 2013



HH Concentrations

Kitchen: 450µg/m^3 (95% CI: 318,640)

Living: 113µg/m^3 (95% CI: 102,127)

Exposures

Children: 285µg/m^3 (95% CI: 201,405)

Women: 337µg/m^3 (95% CI: 238,479)

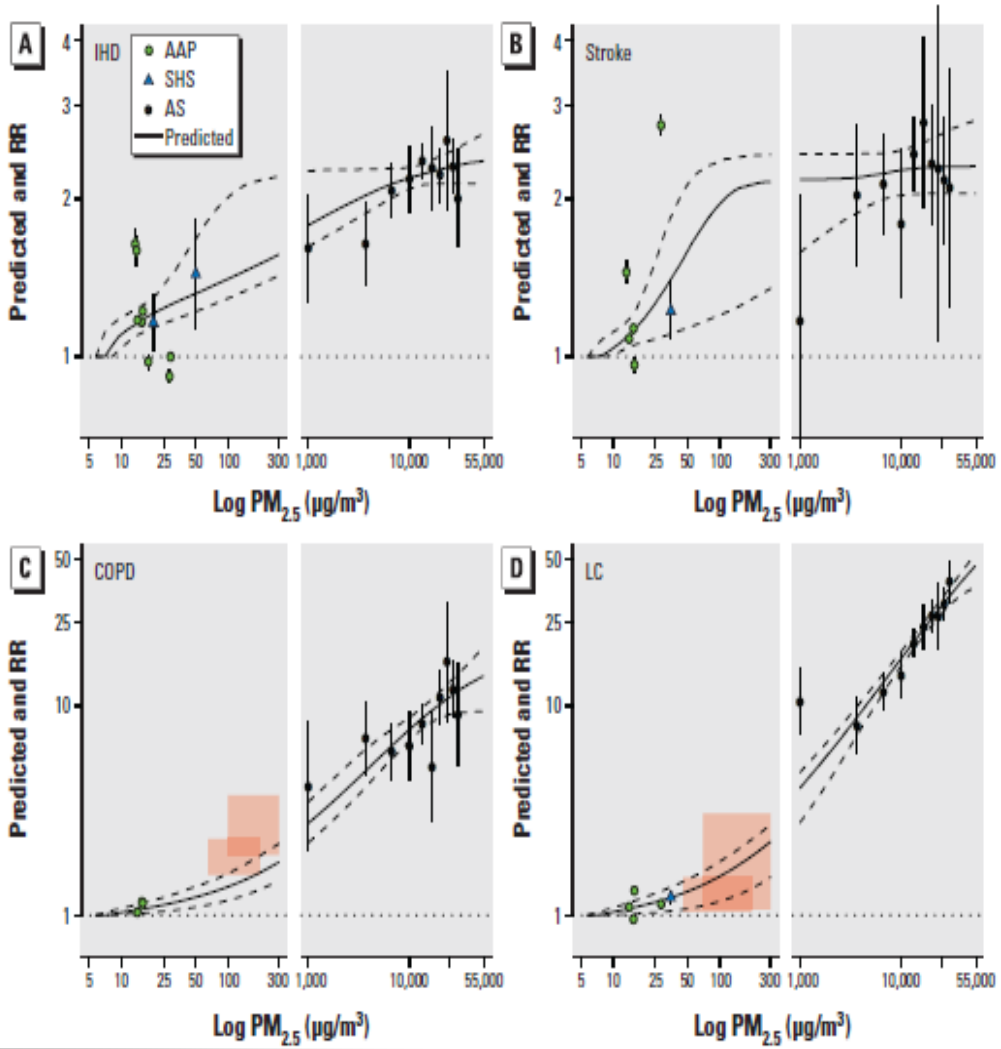
Men: 204µg/m^3 (95% CI: 144, 290)

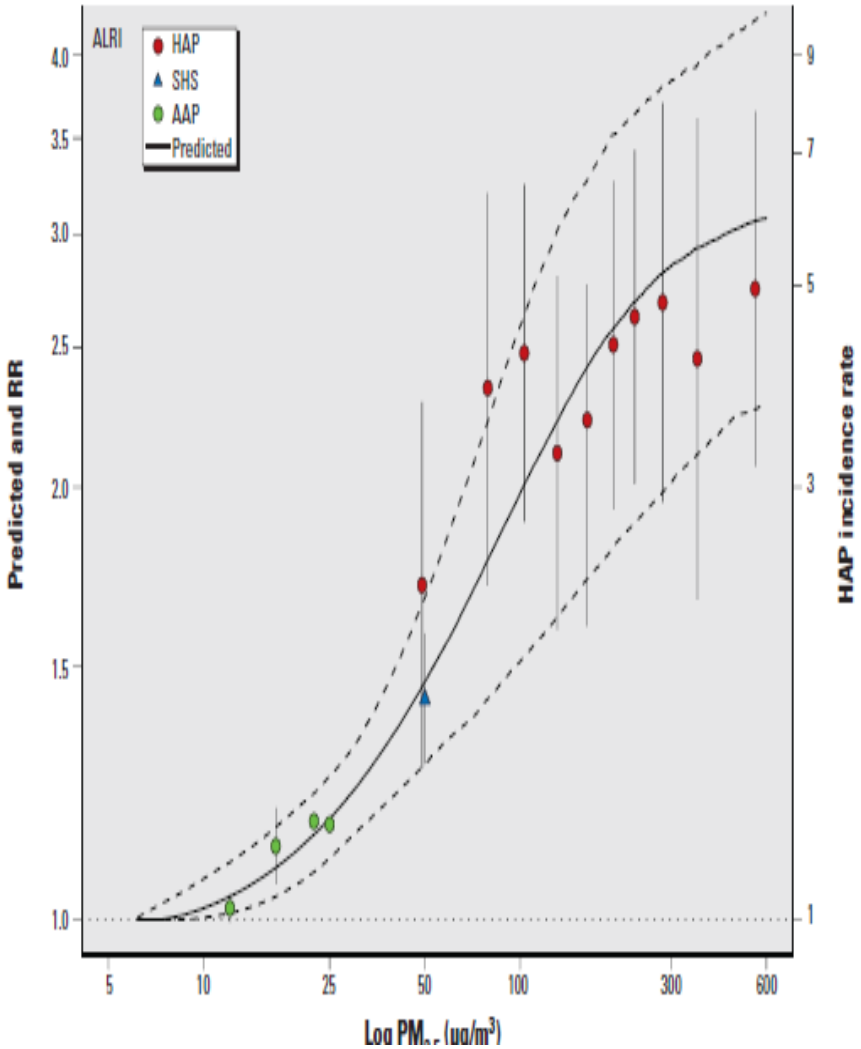
Forouzanfar,, Balakrishnan et al. 2016 (In preparation)

Representation of air pollution related health effects studies from India in GBD related meta-analyses, IERs

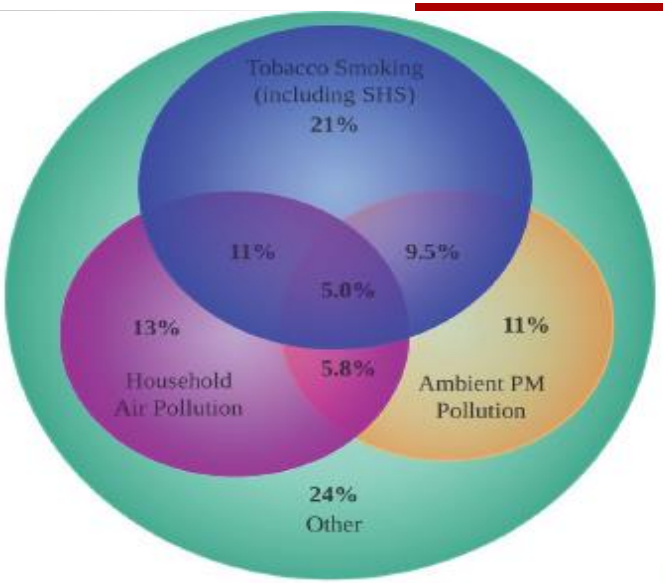
Health Outcome		India studies	Reported ORs	Meta-analysis estimate	
COPD	HAP	Behera et al (1991)	3.04 (2.15-4.31)	Kurmi et al	2.80 (1.85–4.0)
		Qureshi et al (1994)	2.10 (1.50 to 2.94)	Hu et al	2.44(1.9-3.33)
				PO et al	2.4(1.47-3.93)
		Dutt et al (1996)	2.8(0.61-12.85)	Smith et al 2014	1.93(1.61-2.92)
		Malik et al(1985)	2.95(1.6-5.44)		
		Pandey et al(1984)	4.05(3.23- 4.16)		
		Jindal et al(2006)	1(0.79-1.27)		
Child ALRI	HAP	Pandey et al (1989)	2.45(1.43-4.19)	Dherani et al(2008)	
		Mishra et al (2004)	2.2(1.16-4.18)	Smith et al(2014)	1.78 (1.45–2.18)
		Kumar et al (2004)	3.67(1.42-10.57)		
		Mishra et al (2005)	1.58 (1.28–1.95)		
Lung Cancer (Biomass)	HAP	Gupta et al (2000)	1.52 (0.33–6.98)	Smith et al (2014)	1.18(1.03-1.35)
		Sapkota et al(2008)	3.76 (1.64–8.63)		
		Behera et al (2005)	3.59(1.08-11.67)		
Cataracts	HAP	Mohan et al (1989)	1.61 (1.02–2.50)	Smith et al (2014)	2.46(1.74-3.5)
		Badrinath(1996)	4.91(2.82-8.55)		
		Sreenivas(1999)	1.82(1.13-2.93)		
		Saha(2005)	2.4(0.9-6.38)		
		Zodpey et al (1999)	2.37 (1.44–4.13)		
Lung Cancer(Coal)	HAP	Not available		Hosgood et al (2011)	2.15(1.61-2.89)
				Bruce (2015)	1.17 (1.01 to 1.37)
ALRI, IHD, Stroke, Lung Cancer, COPD	AAP	Not Available		Burnett et al (2014)	
				Mehta et al (2011) (PM 2.5)	1.12 (1.03, 1.30)
Asthma	AAP	Not Available		Anderson et al (2009) (PM2.5)	1.16 (0.98 to 1.37)
Low Birth Weight	AAP	Not Available		Sapkota et al (2011) (PM 2.5)	1.09 (0.90–1.32)

IERS used in GBD 2010

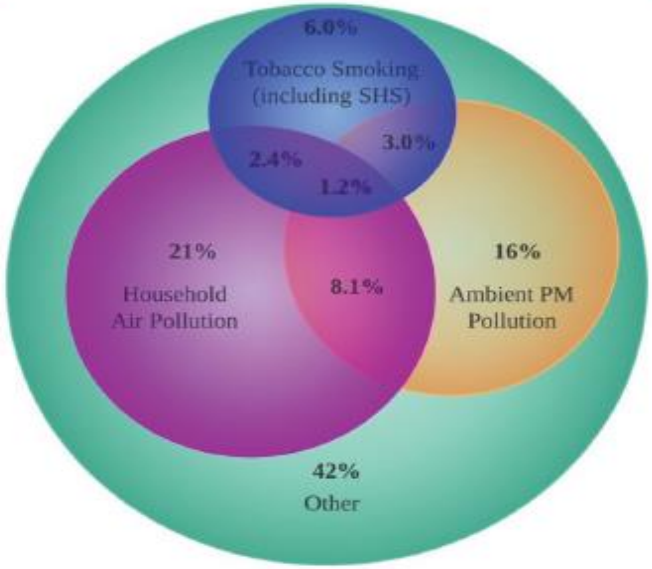




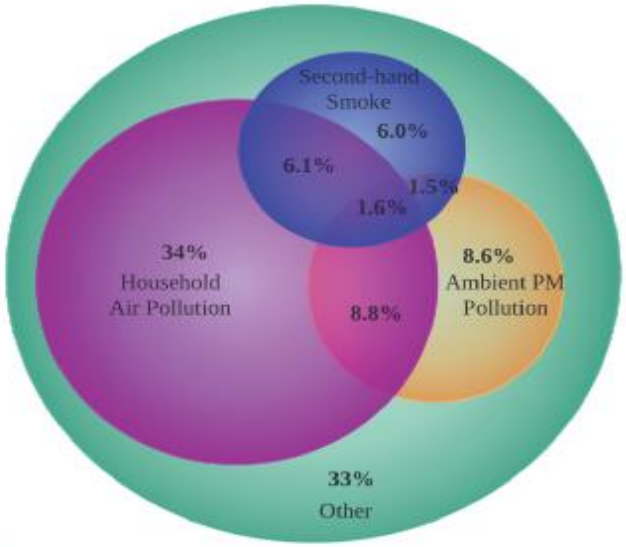
Percent Risk Factor Attributions for Air Pollution (India GBD 2010 Results)



A. Male IHD:
17,100,000
DALYs



B. Female IHD
9,090,000
DALYs

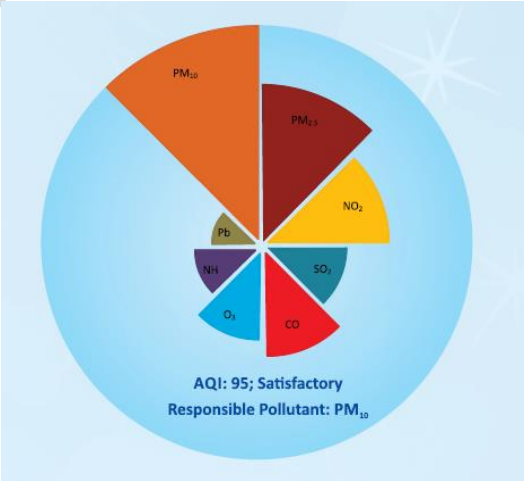


C. Child ALRI
17,100,000
DALYs

Smith-Bruce, Balakrishnan 2014

Inputs for recent national efforts/actions

Exposure Inputs for National AQI (AAP)



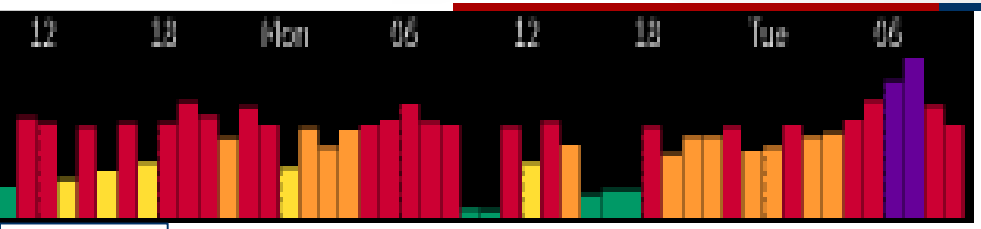
- Builds on earlier AQI related efforts in Pune and Delhi (Beig et al 2010)
- Uses expanded continuous (real to near – real time) air quality monitoring data from CPCB on eight pollutants
- Uses breakpoints based on review/synthesis across available Global AQIs

Sharma et al; CPCB, 2014

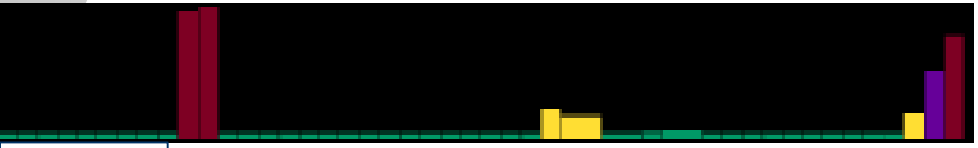
http://aqicn.org/map/india/

Good (0-50)	Satisfactory (51-100)	Moderately polluted (101-200)	Poor (201-300)	Very poor (301-400)	Severe (> 401)

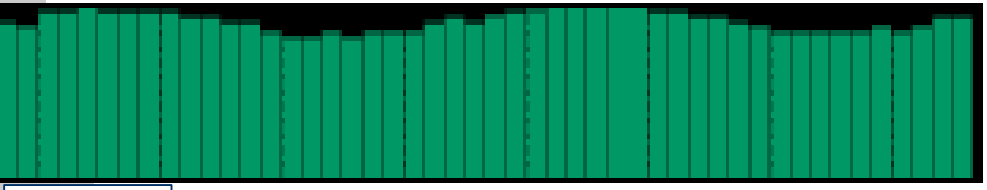
Exposure Inputs for National AQI (AAP)



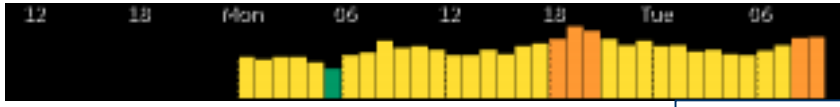
PM 2.5



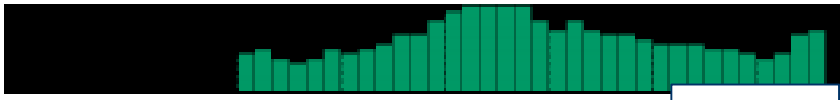
SO2



CO



PM 10



O_3

SO2

CO

NO2

Good (0-50)	Satisfactory (51-100)	Moderately polluted (101-200)	Poor (201-300)	Very poor (301-400)	Severe (> 401)

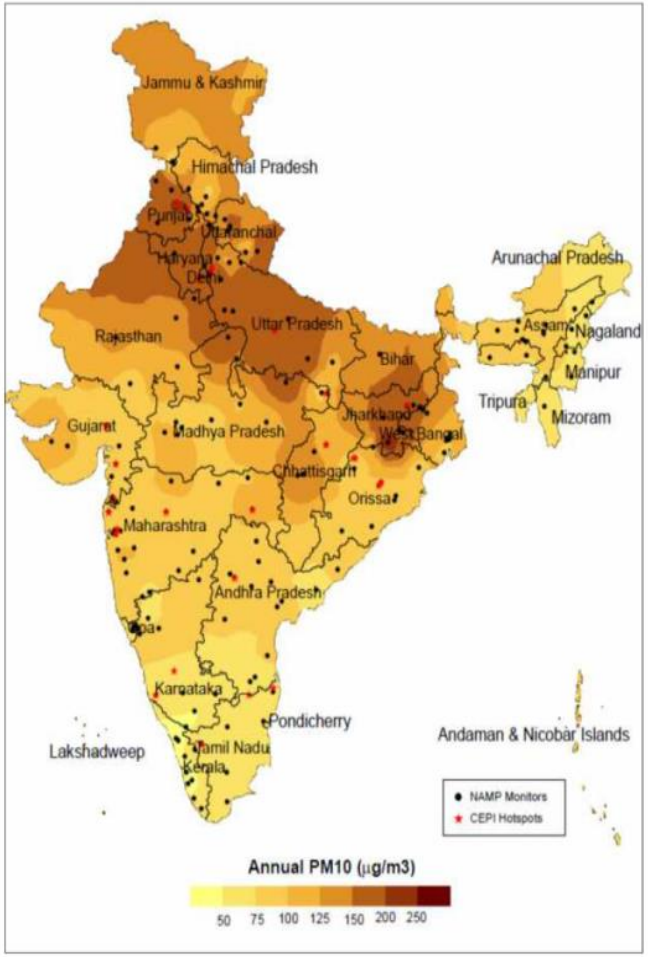
http://aqicn.org/map/india/

Tuesday May 23,2016

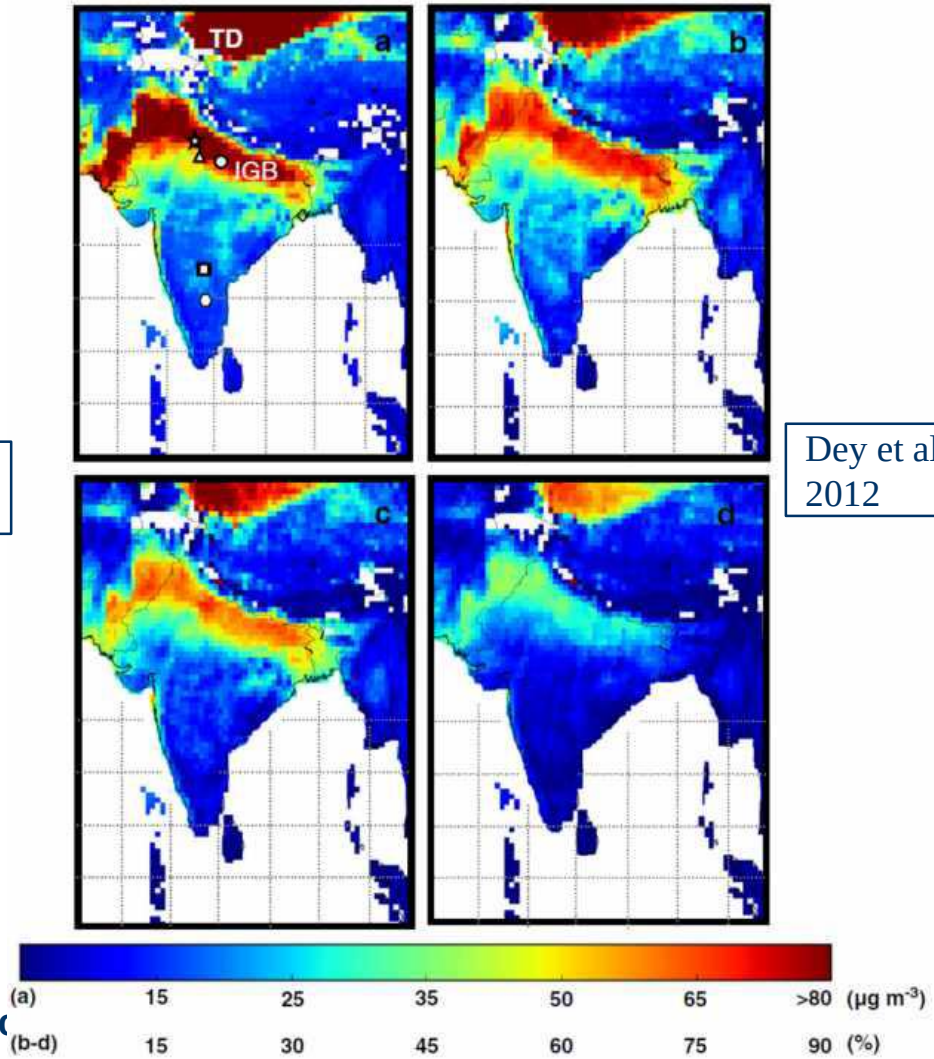
AQI:312
Hazardous

AQI:103
Unhealthy for sensitive groups

Exposure Inputs for the MOHFW Report (AAP)



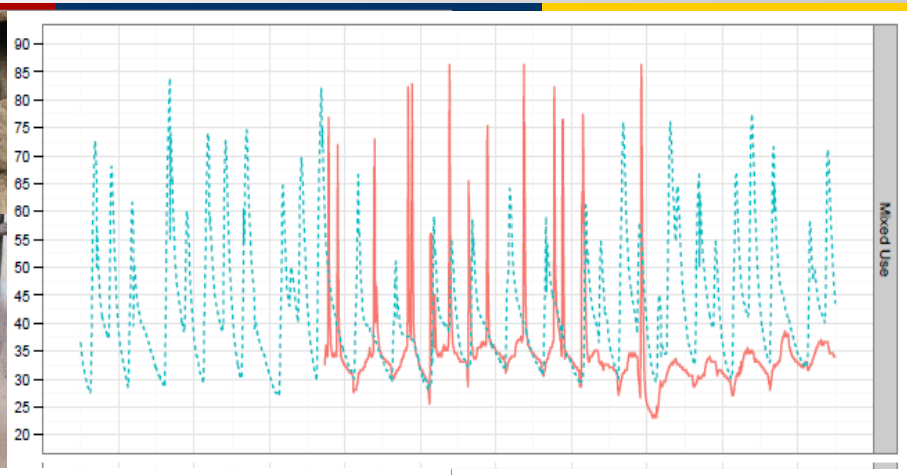
Ghosh et al 2014

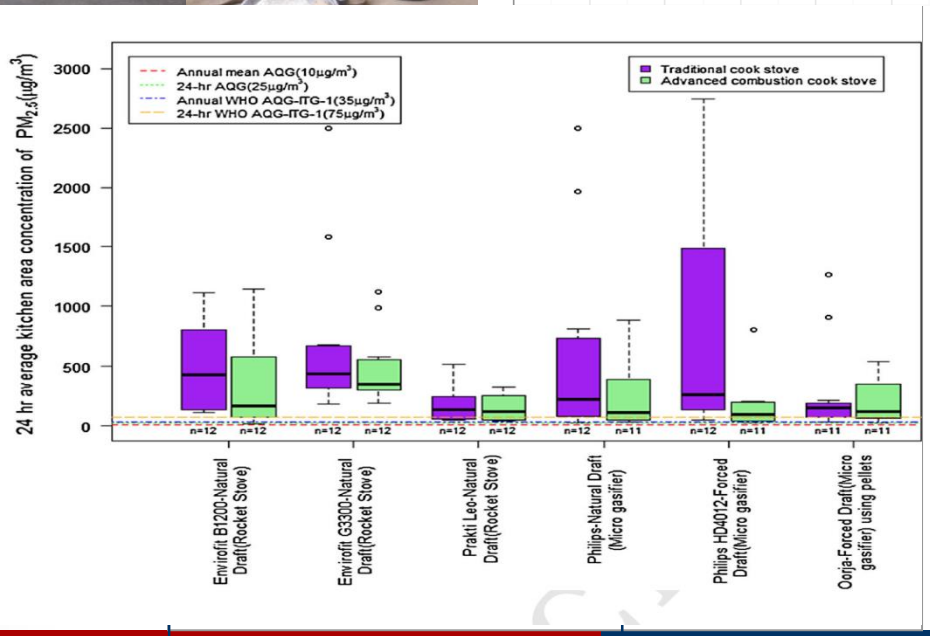


Dey et al 2012

Sri Ramac

Exposure Inputs for the MOHFW Report (HAP)

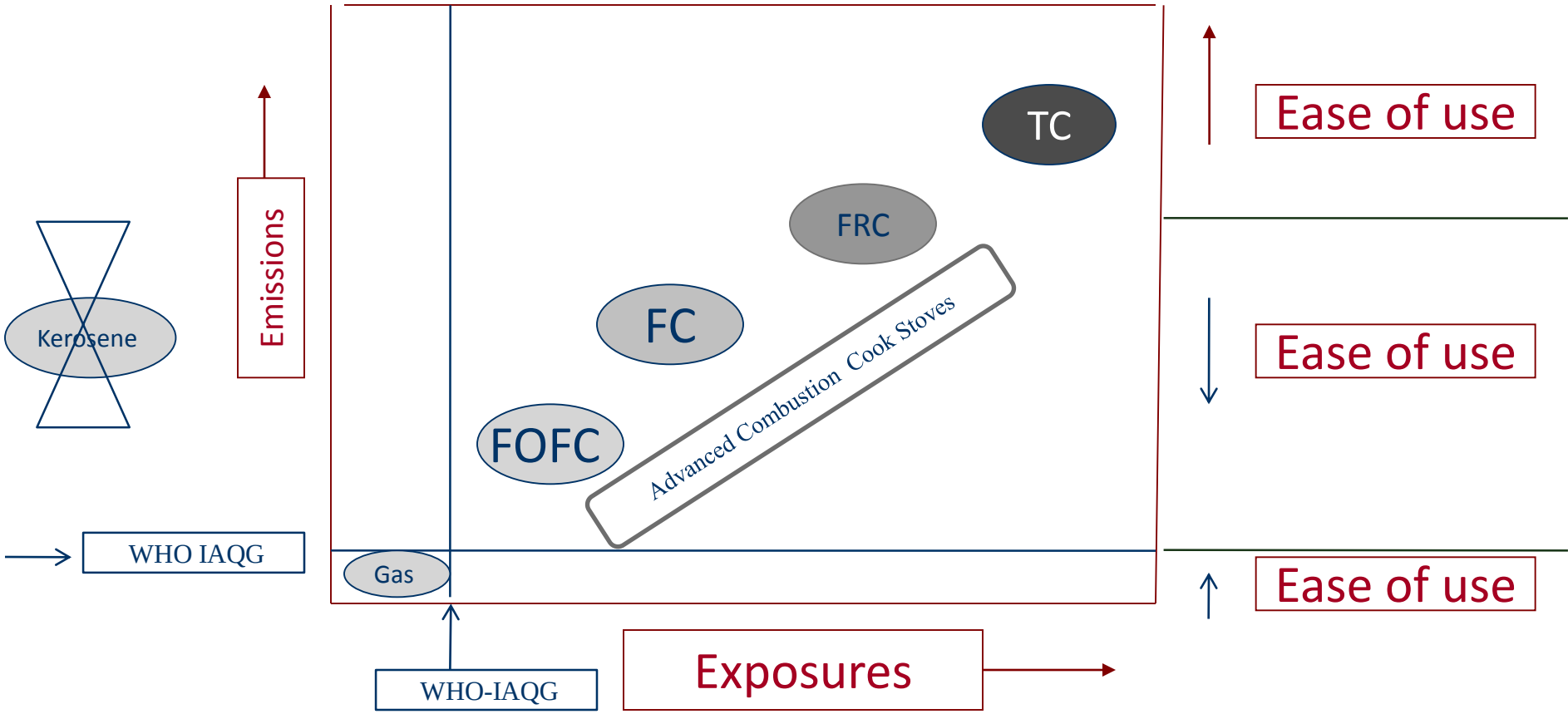




Mukhopadhyay et al 2012
Sambandam et al 20114
Pillariseti et al 2014
Balakrishnan et al 2015

Interfacing National Policy with WHO Air Quality Guidelines

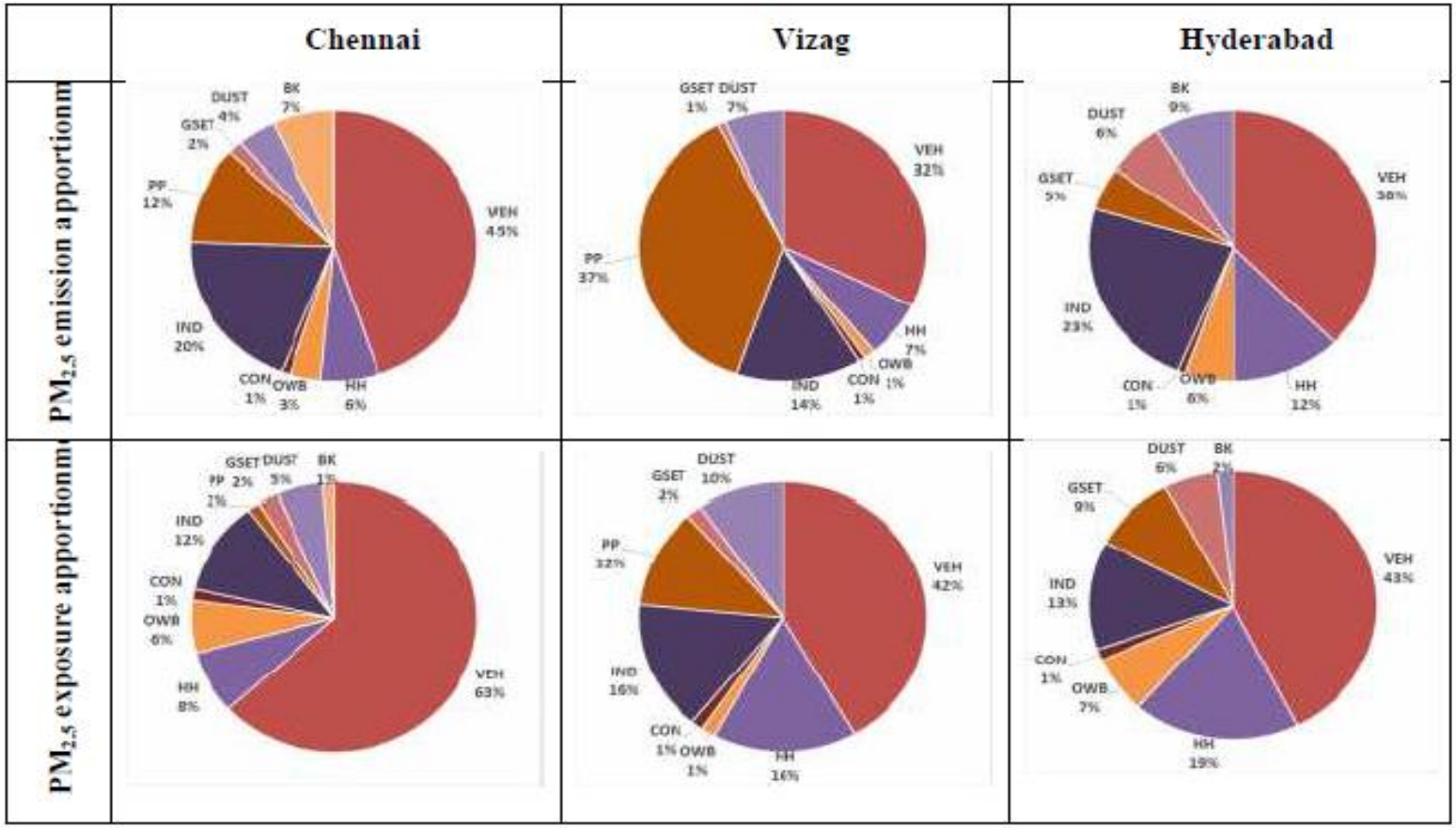
Our aim is to achieve the quality of energy services from cook stoves comparable to that from other clean energy sources such as LPG: MNRE, 2009



TC-Traditional cook stove; FRC-Free convection cook stove; FC-Forced convection; FOFC : Fuel optimized forced convection

Note: The chosen guideline is arbitrary on this scale as are the relative positions of the stoves. It is shown to merely illustrate the need to integrate multiple inputs for choosing a technology to confer a required degree of exposure reduction

Exposure Inputs for MOHFW Report



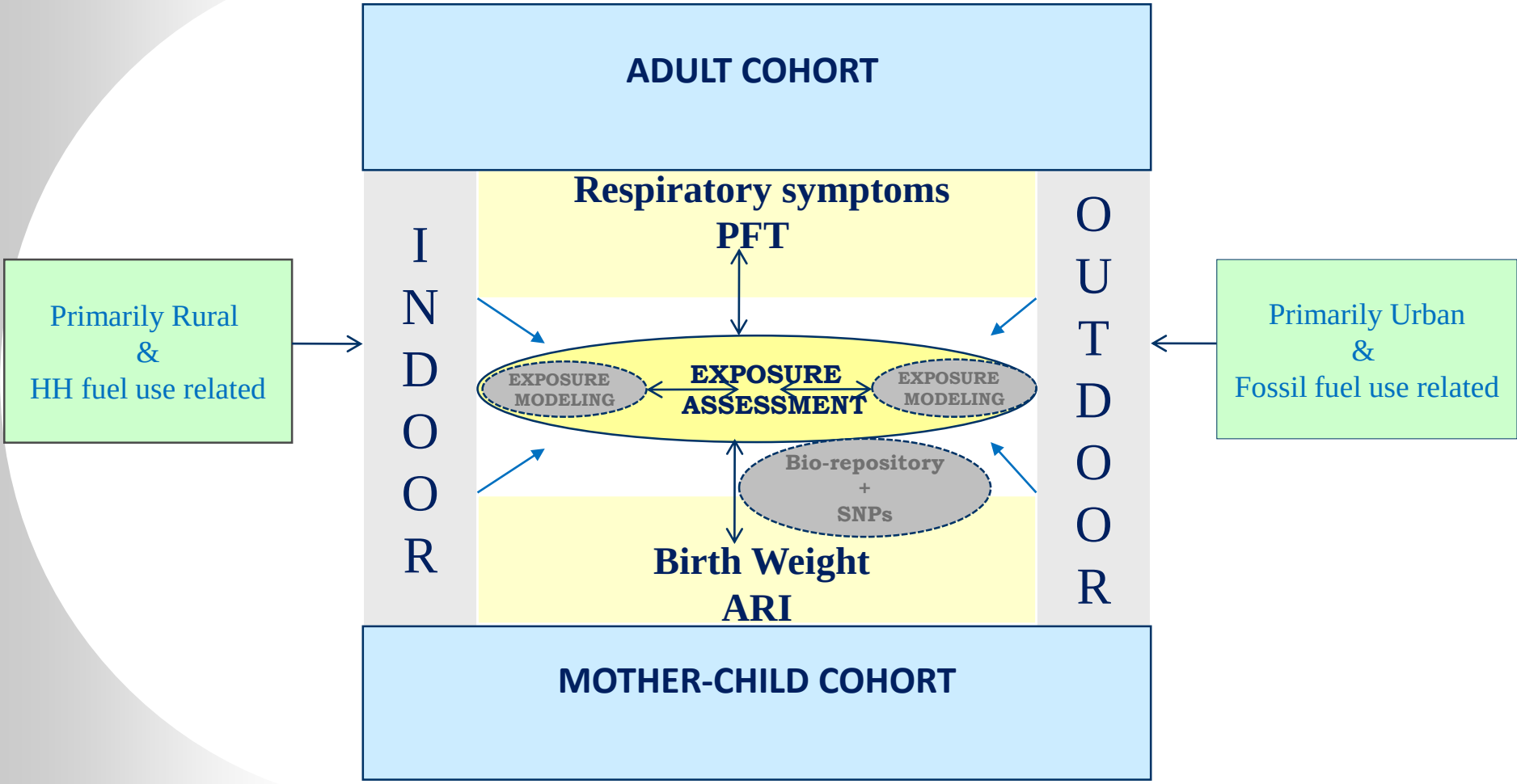
Guttikunda 2014

Health Inputs for AQI and MOHFW Report

- Relies primarily on global pool of exposure-response studies with limited representation from India, but an increasing representation from countries with overlapping exposure configurations
- Included end points beyond what was considered in GBD efforts
- Informed by multiple health impact assessment studies

New/On-going Efforts

The TAPHE Cohort Study in Southern India

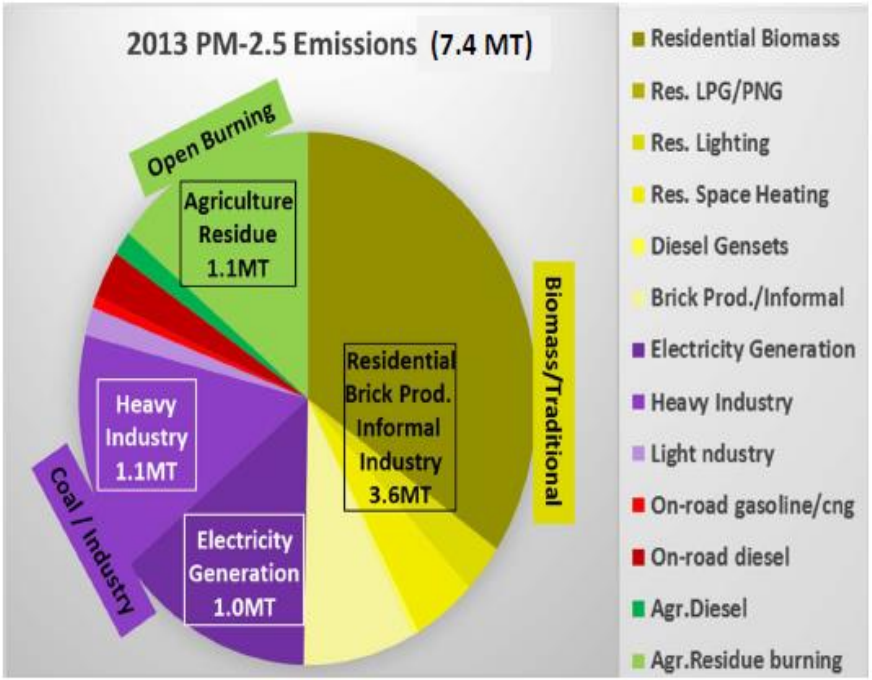


TAPHE Study Outputs

- Provides some of the first quantitative exposure-response functions centered on more proximal (household) measures of PM 2.5 exposure for birthweight , ARI, respiratory symptoms and lung function.
- Provides some of the first integrated rural urban E-R estimates
- Large emphasis on reducing exposure misclassification and confounding
- Uses well validated study instruments/protocols while developing a parsimonious and yet reliable framework of data collection

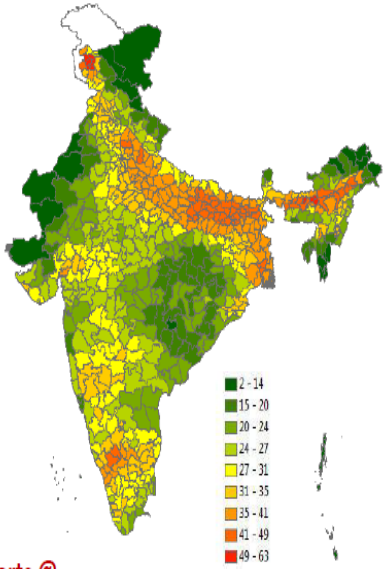
GBDMAPS

Total PM2.5 Emissions in India



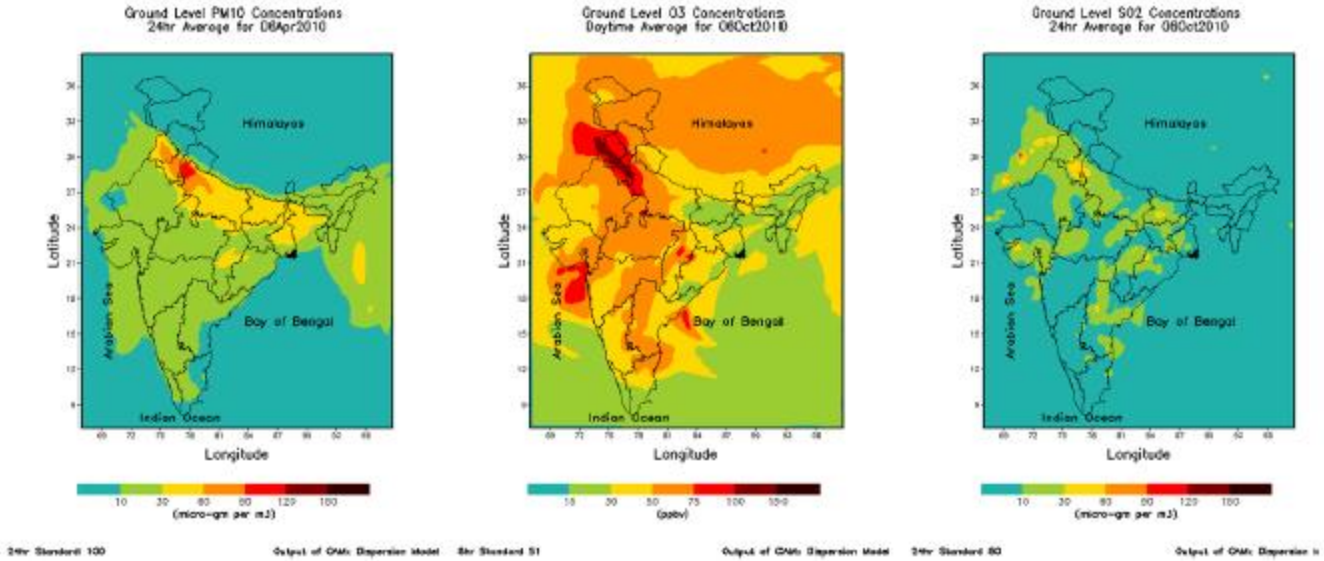
Indian Institute of Technology Bombay, Mumbai, India

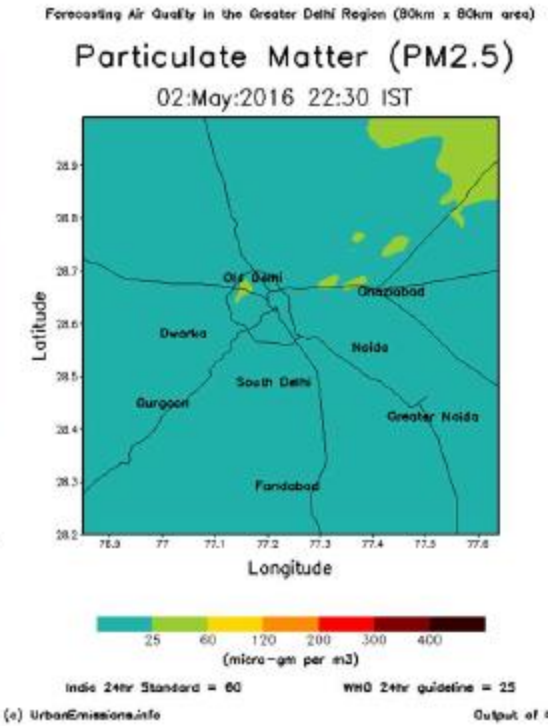
% contribution of household fuels to Ambient PM 2.5 Concentrations

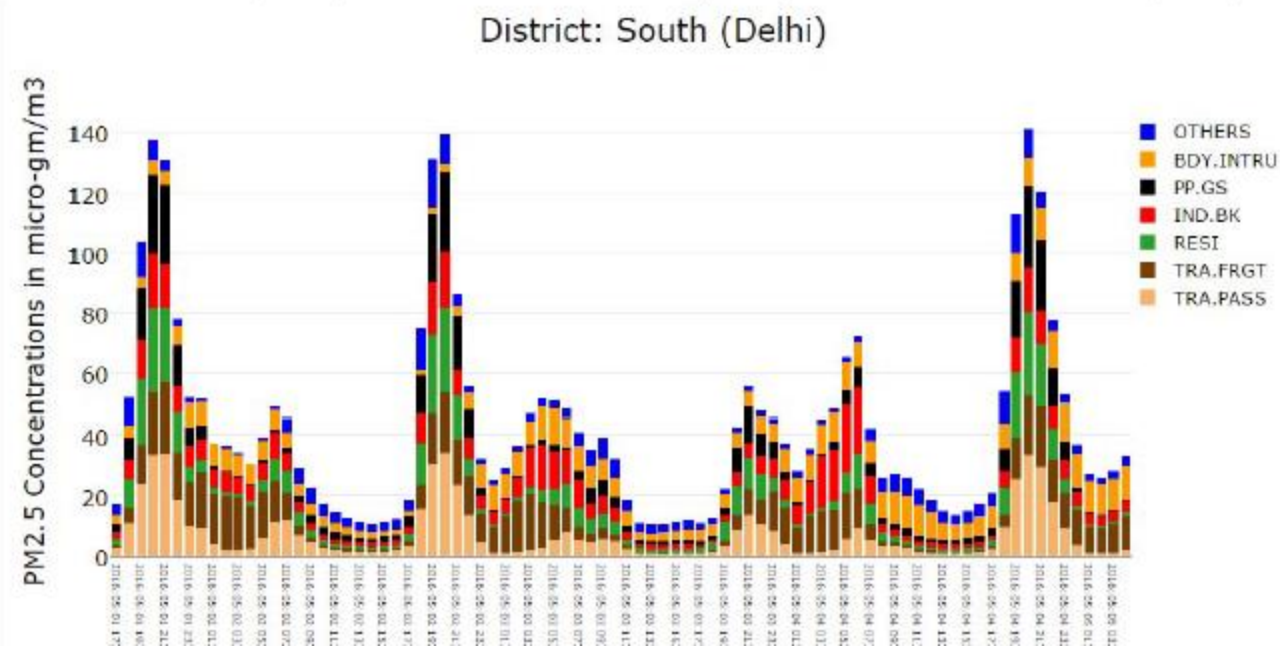


District wise reports @
http://www.urbanemissions.info

regional WRF-CAMx simulations to support health and air quality alerts







Modelled hourly source contributions in forecast mode

The Challenge

- The burden is not decreasing and the evidence is unequivocal !
- The burden is seamless across rural –urban boundaries
- Interventions to tackle OAP and HAP would have to be in sink(at least in some measure)
- WHO-AQGs are universally applicable for defining counterfactuals but NAAQM focused only on the urban
- Density of intervention efforts would need to be substantively increased to achieve and demonstrate health benefits
- Range of health effects are broader and magnitudes bigger than previously estimated (more chronic outcomes included in the ambit)
- Multitude of competing risk factors

Critical Gaps

- Limited focus on exposure-response, exposure modeling (New opportunities provided by on-going cohorts)
- Limited exposure assessment capacities (New capacity building efforts to be launched under GEO-HUB efforts)
- Limited multi-sectoral efforts for interfacing with policy (Facilitated by MOHFW/MOES efforts)

Grateful Thanks

- ICMR
- Offices of the DG and NCD, ICMR
- Departments of Health and Environment , Govt. of Tamil Nadu
- National Collaborators from Calcutta University, IITM, IIT- D, IIT-K, INCLEN, PHFI, NIOH, NIOH-ROHC, NEERI
- International Collaborators from UC Berkeley, GACC, Berkeley Air, Columbia University, CREAL, Tufts University and HEI.

Team EHE at SRU, Chennai, India

Thank you
&
Namaste !