Exposure Assessment Challenges in Air Pollution Related Health Assessments

A perspective from studies in India

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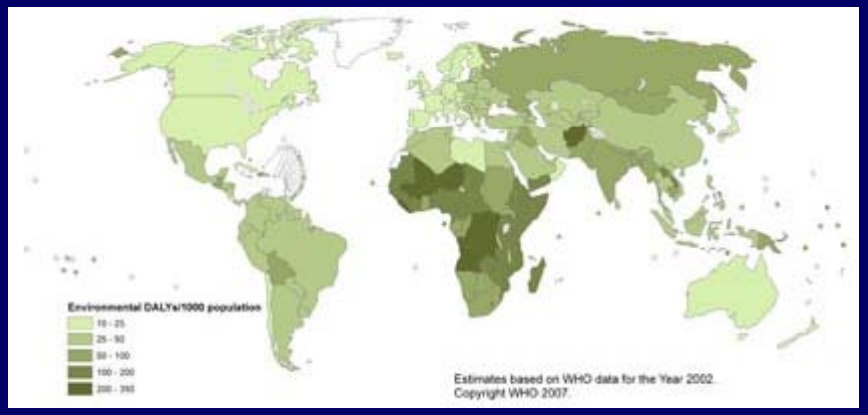

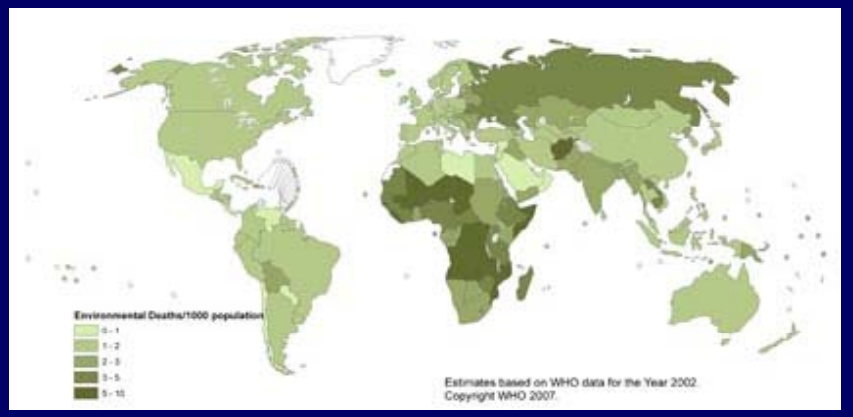

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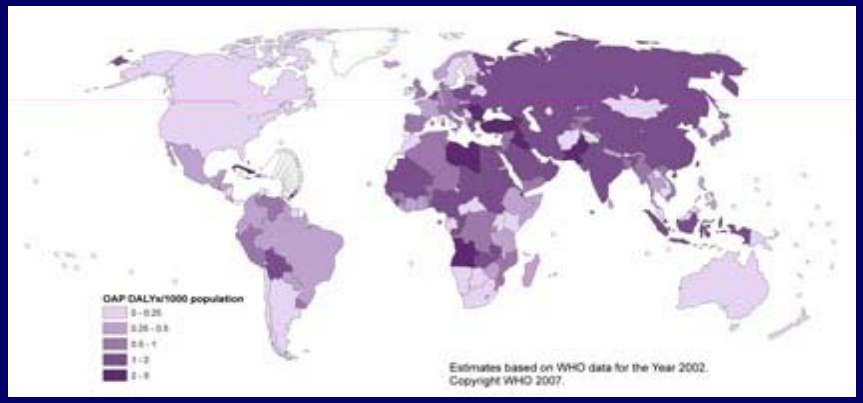
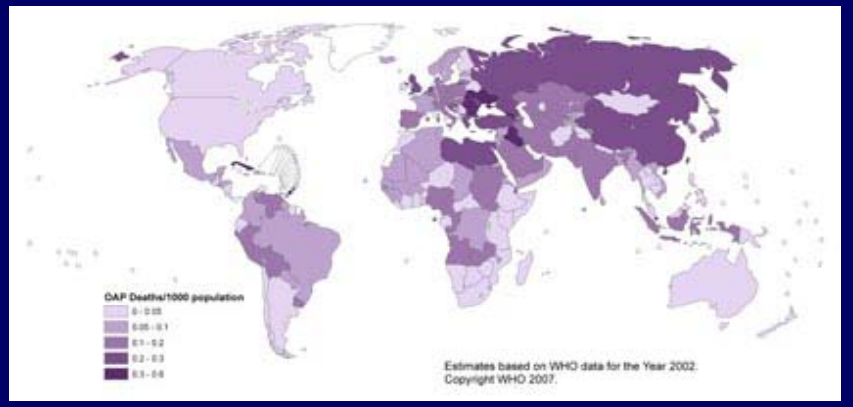
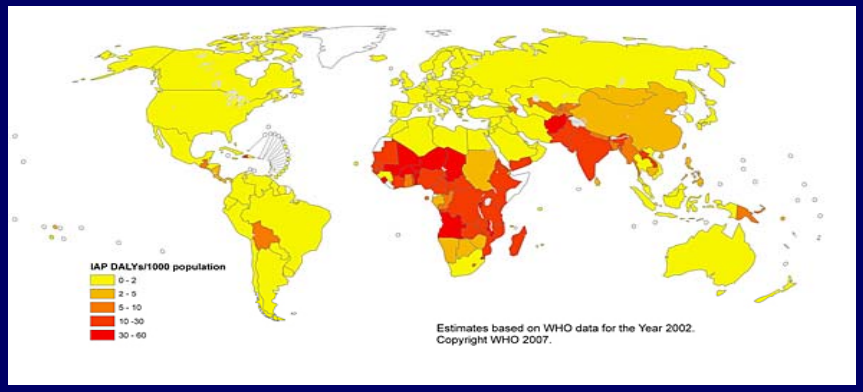
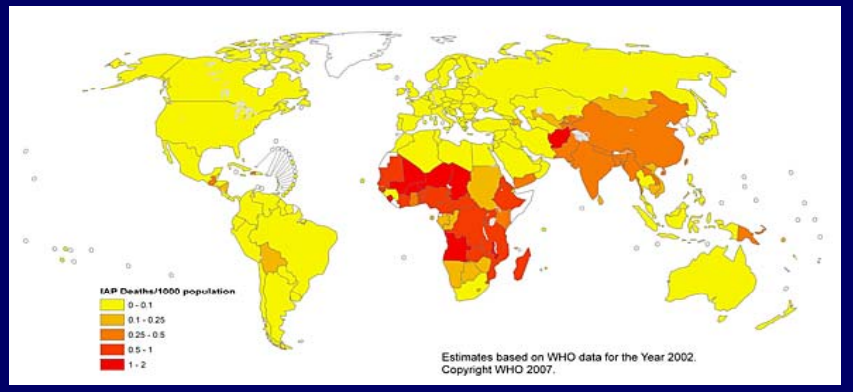




OAP





IAP

From "Environmental burden of disease, WHO 2007"

Competing risk factors

Environmental risks	DALYs (in 1000s) World	India
Unsafe water, sanitation and hygiene	54,158	18,487
Urban air pollution	7,865	1,513
Indoor smoke from solid fuels	38,539	14,237
Lead exposure	12,926	2,687
Climate change	5,517	2,538
Occupational risks		
Risk factors for injury	13,125	3,775
Carcinogens	1,421	177
Airborne particulates	3,038	370
Ergonomic stressors	818	189
Noise	4,151	1,152

From "WHO CRA Report 2002"

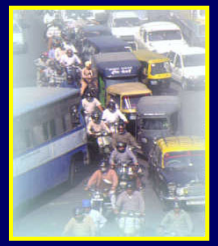
Competing micro-environments (Indoor/Outdoor/Occupational)

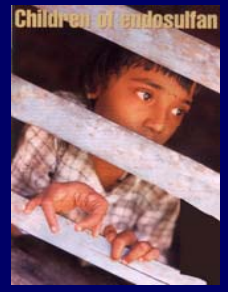








Past status of air pollution related exposure information

Outdoor

- Few cities with few monitors operated on few days monitoring few pollutants in urban outdoor settings
- Limited time and space resolved information
- Limited modeling attempts

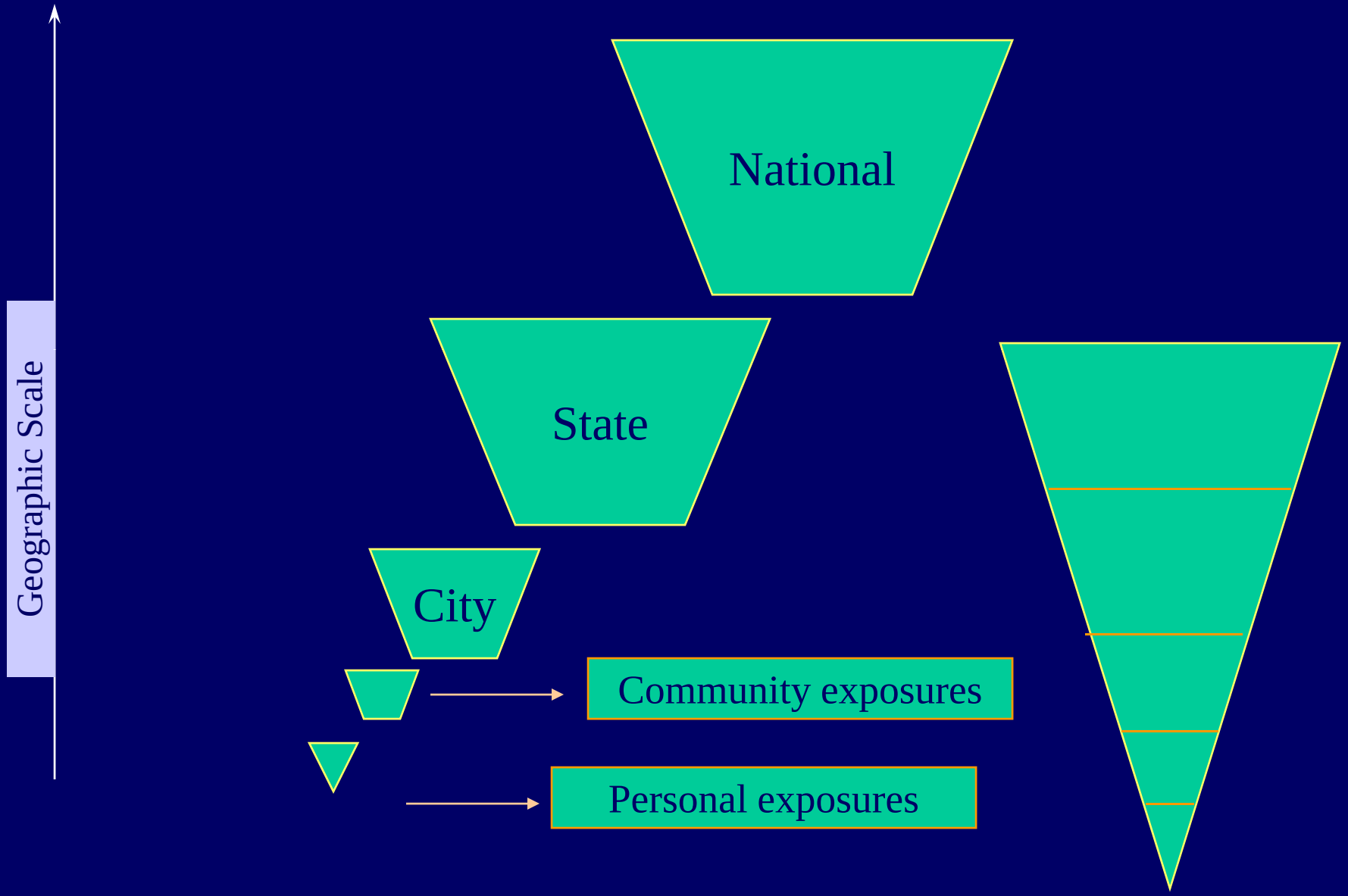
Indoor

- No routine monitoring information on indoor air pollution related to solid fuel use
- Extensive range of exposure determinants

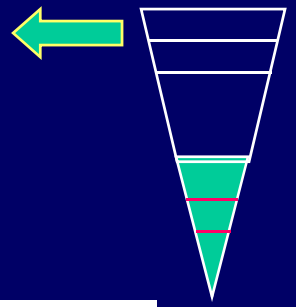
Occupational

- Limited datasets on occupational hygiene
- No routine data on non-industrial and industrial SMEs not covered by regulation

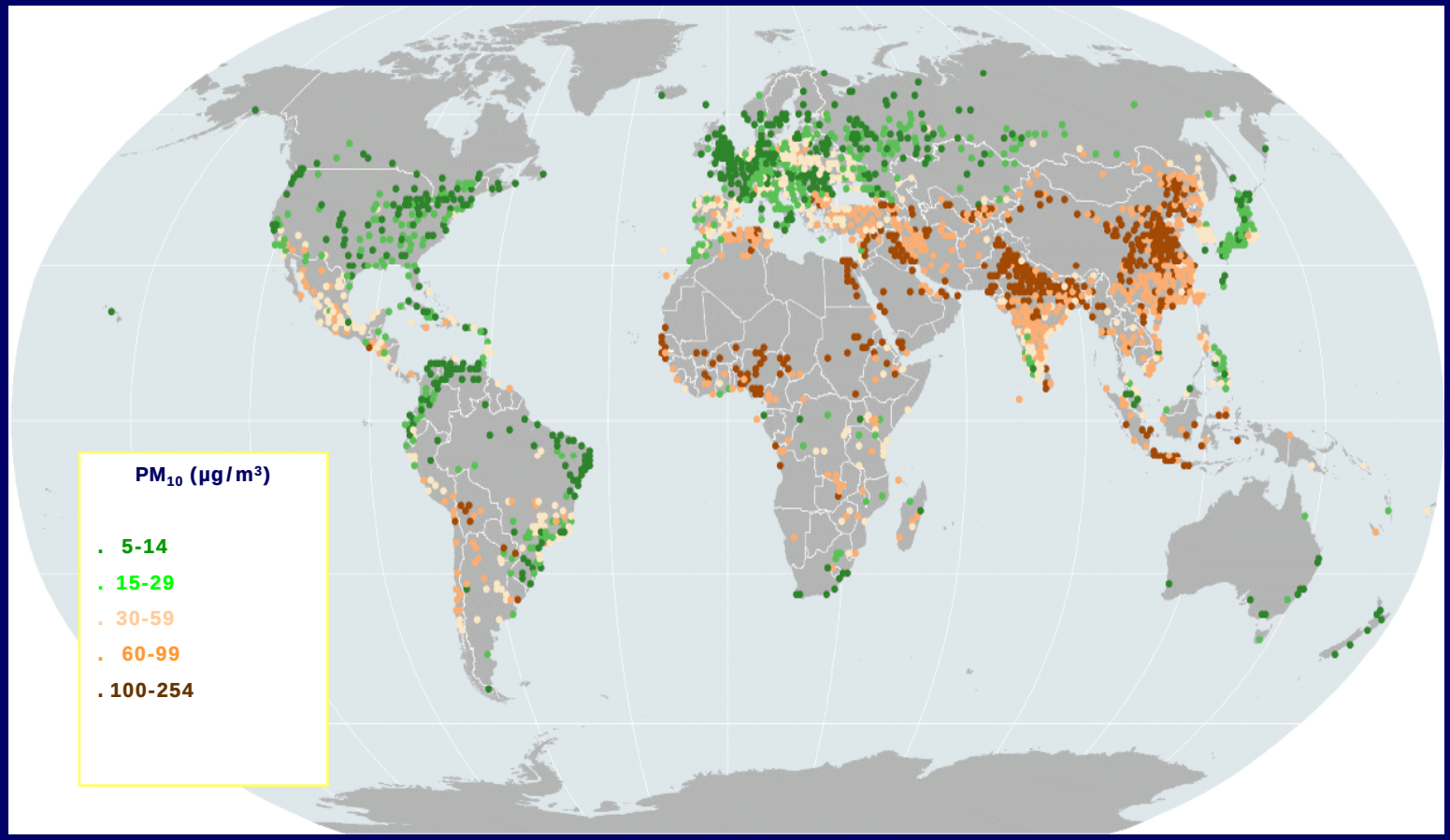
Framework for tiered exposure assessment



Outdoor Air Pollution

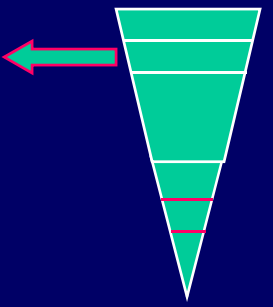


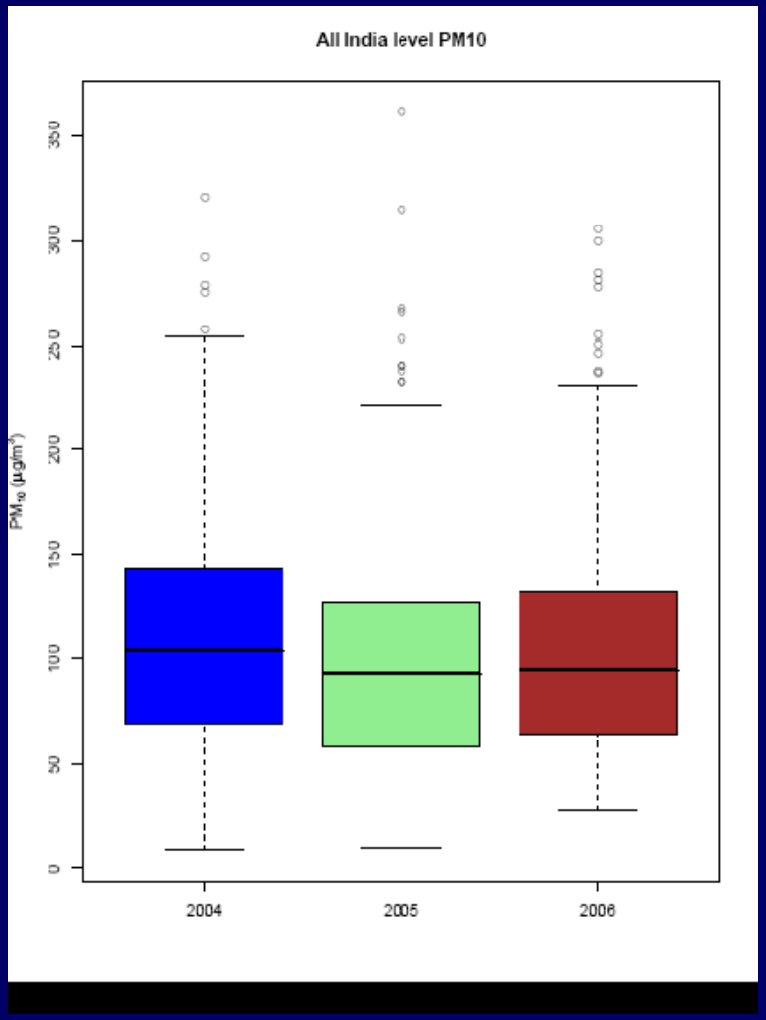
Estimated PM10 Concentration in World Cities (pop >=100,000)



Cohen et al., WHO CRA Report 2002

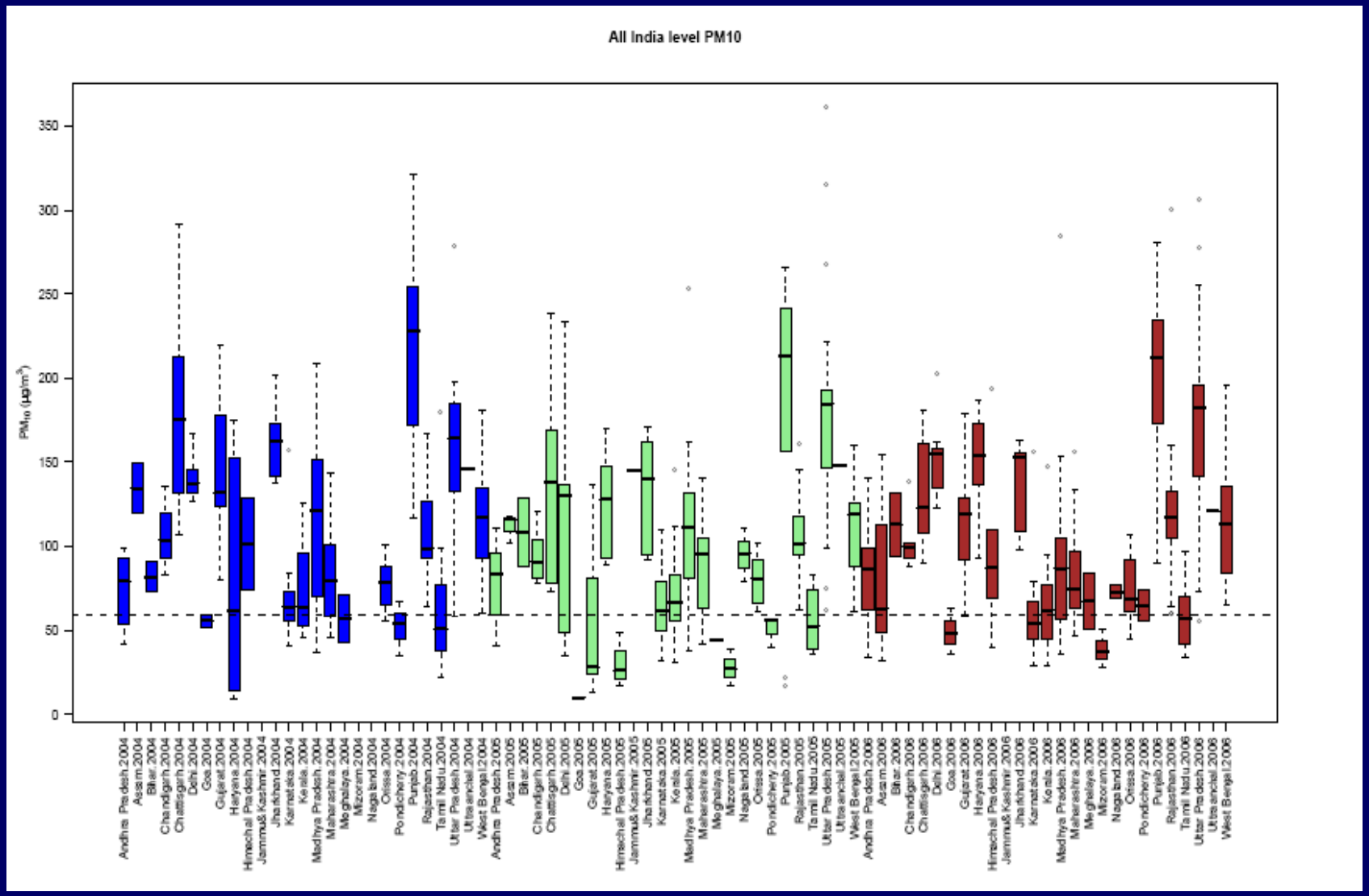
Urban Outdoor Air Pollution





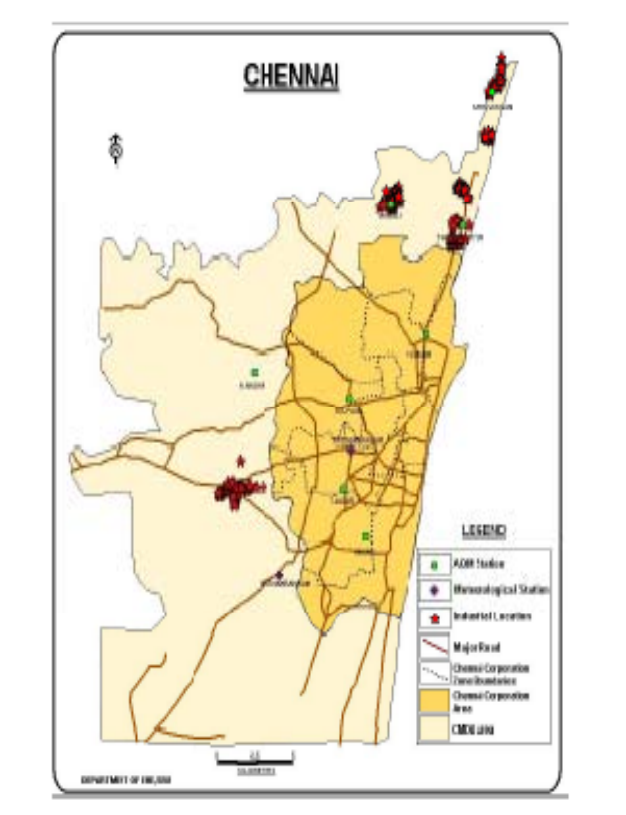
341 stations across 126 cities in 25 states and 4 UTs
78 non-attainment cities,24 critically polluted areas

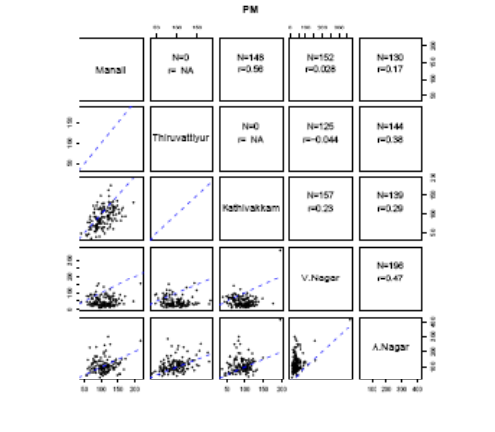
Urban Outdoor Air Pollution

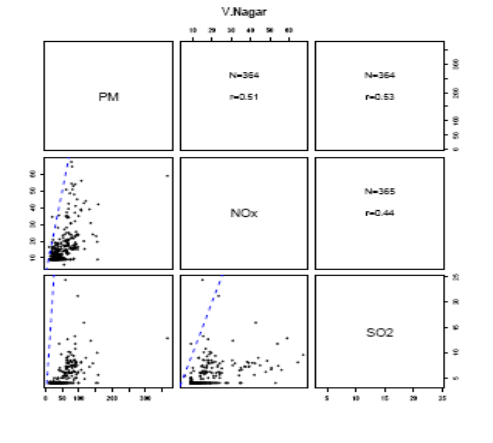


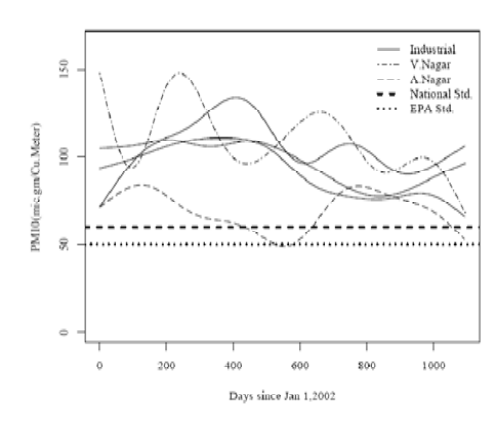
Challenges for time-series analysis

- Most cities have multiple monitors but regulation requires only 108 days /year for routine air quality monitoring.
- Many monitors do not follow a regular monitoring schedule
- Direct readout instruments seldom used in the routine network (Short-term averages are usually not available)
- Measurement error issues (such as related to wet chemical methods for gases, cyclone selection for PM measurements)
- Small monitor footprints (few meet the criteria of a true background monitor)
- No monitoring on weekends (limiting examination of lag effects in models)
- Mixed land use patterns –i.e. classification as industrial, commercial and residential areas often not based on source profiles or emission inventories
- Limited data available in electronic format







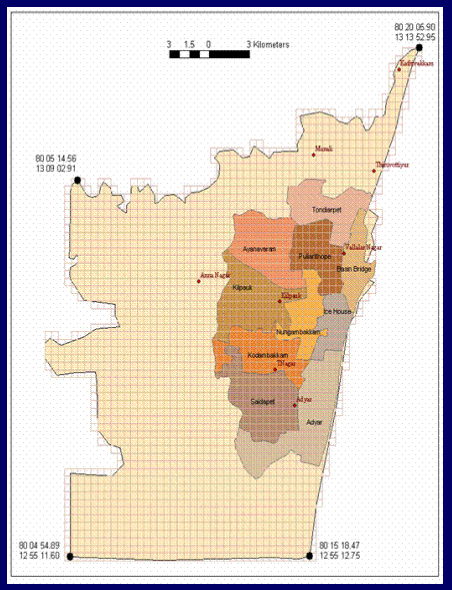


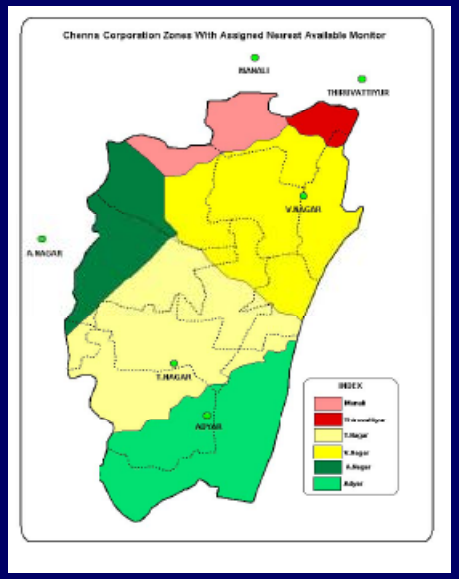
Chennai air quality monitoring data (2002-2004)
(single pollutant (PM) across multiple monitors/
multiple pollutants at a single monitor/
smoothed time-series data for PM across monitors)

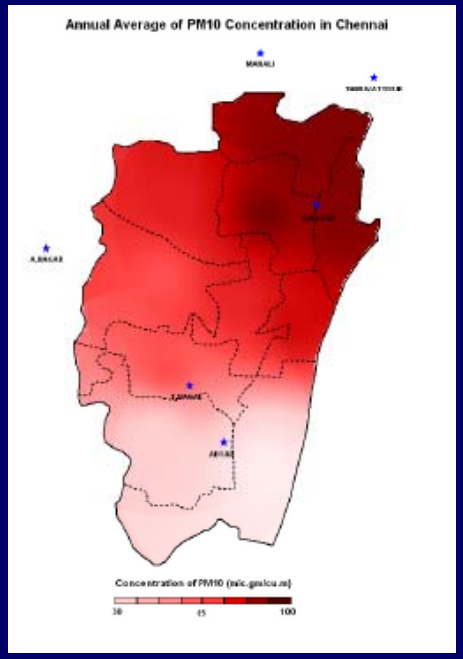
% missing-ness across air quality monitors in Chennai (2002-2004)

Day of week	Manali (Ind)	Thiruvot (Ind)	Kathivak (Ind)	T.Nagar (Com)	V.Nagar (Com)	A.Nagar (Res)	Adyar (Res)
Sunday	100	100	100	99	98	99	98
Monday	17	100	100	50	58	49	49
Tuesday	92	100	4	51	52	53	52
Wednesday	100	7	100	57	54	48	54
Thursday	12	100	8	47	58	58	58
Friday	100	10	100	62	53	54	61
Saturday	100	100	100	99	97	98	99

Zonal model for air pollution exposure in Chennai



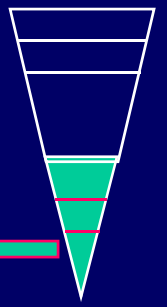


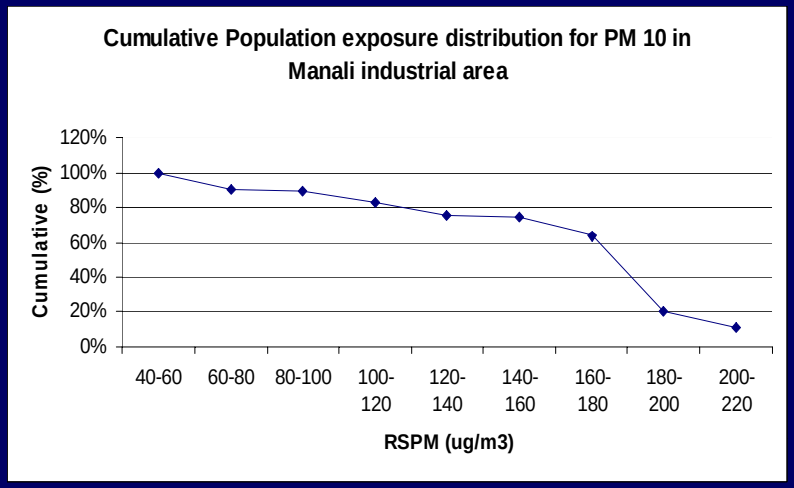


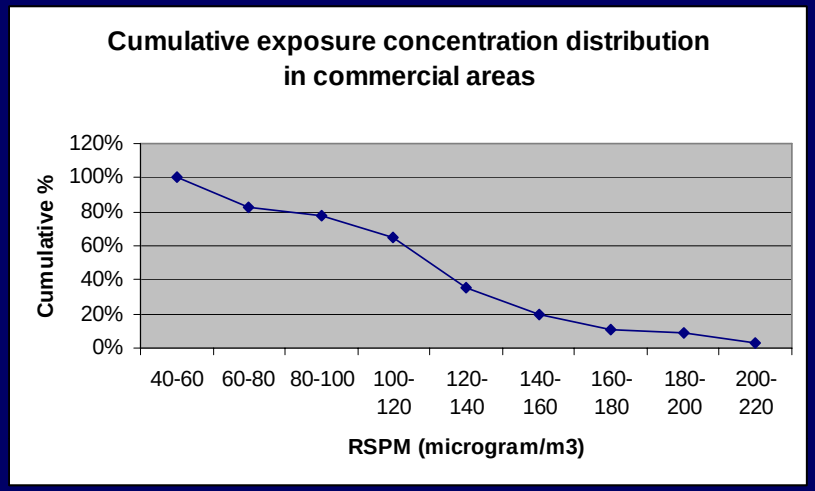
Sensitivity analysis for effects estimates from alternative exposure series for PM 10 in Chennai

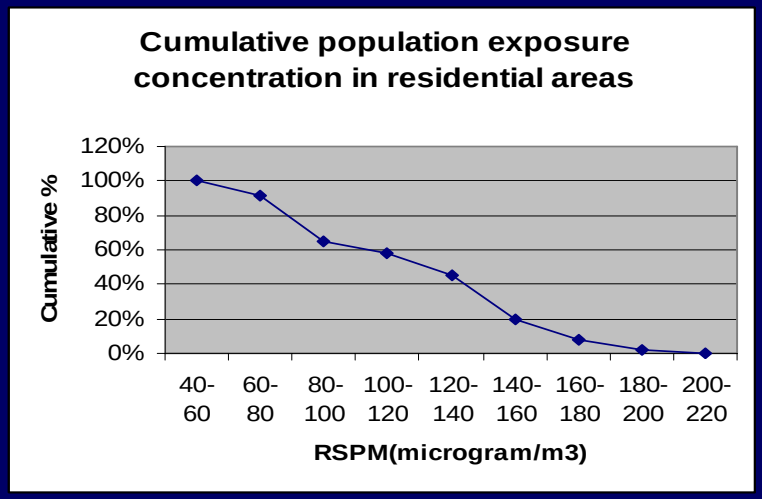
Model	N	Estimate(β) (S.E.)	RR for 10$\mu g/m^3$ increase of PM(95% CI)	Est.of over dispersion	Dev.Expl. (%)
Zonal model(core)	742	0.00044(0.00014)	1.0044(1.002,1.007)	1.25	50
Single monitor					
A.Nagar	375	0.00033(0.00022)	1.003(0.999,1.008)	1.54	48.7
V.Nagar	358	0.00043(0.00016)	1.004(1.001,1.008)	1.40	49.5
Ind.Avg	712	0.00030(0.00021)	1.003(0.999,1.007)	1.58	43.8
Multiple monitor					
Without Ind.	512	0.00039(0.00011)	1.004(1.002,1.006)	1.49	45
With Ind.	731	0.00030(0.00010)	1.003(1.001,1.005)	1.66	45.1
Imputed	731	0.00040(0.00010)	1.004(1.002,1.006)	1.62	44.5

Personal exposure measurements in Chennai









Commuting and /or staying close to high traffic areas contributed the most to population exposures in Chennai, with population in slums using solid fuels and children in schools using solid fuels experiencing the greatest peak exposures

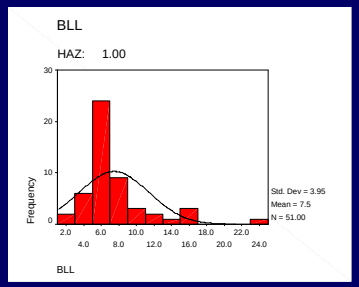
Cohort Study/ Characteristics	Pollutant	Number of Subjects	Follow up Period	Geographic Coverage	Hazard Ratio (95% Confidence Interval)
American Cancer Society (ACS) - National	$PM_{2.5}$	486,133	1982-2004	United States (116 MSAs)	1.08 (1.04, 1.12)
Medicare (National)	$PM_{2.5}$	13,200,000	2000-2005	United States (668 Counties)	1.06 (1.04, 1.07)
Veterans	$PM_{2.5}$	70,000	1997-2001	United States (774 Counties)	1.06 (0.93, 1.22)
Netherlands Study on Diet and Cancer (NLCS)	$PM_{2.5}$ (converted from PM_{10})	120, 852	1987-1996	Netherlands	1.06 (0.97, 1.16)
Six Cities (SCS)	$PM_{2.5}$	8,111	1979-1998	Northeast and Midwest US (6 Counties)	1.16 (1.07, 1.26)
Medicare (SCS)	$PM_{2.5}$	341,099	2000-2002	Northeast and Midwest US (6 Counties)	1.21 (1.15, 1.27)
American Cancer Society - Regional	$PM_{2.5}$	301,045	1982-2004	Northeast and Midwest US (68 MSAs)	1.13 (1.07, 1.18)
Nurses Health Study (NHS)	PM_{10}	66,250	1992-2002	Northeast and Midwest US (11 States)	1.15 (1.04, 1.28)
Medicare (Regional)	$PM_{2.5}$	Not Reported	2000-2005	Eastern US (421 Counties)	1.11 (1.08, 1.13)
Medicare (Regional)	$PM_{2.5}$	Not Reported	2000-2005	Central US (185 Counties)	1.09 (1.05, 1.13)
American Cancer Society - Regional	$PM_{2.5}$	182,284	1982-2004	Southern and Western US (48 MSAs)	1.04 (1.00, 1.08)
Medicare (Regional)	$PM_{2.5}$	Not Reported	2000-2005	Western US (62 Counties)	1.00 (0.98, 1.02)
Adventist Health Study of Smog (AHSMOG)	PM_{10}	6, 338	1977-1992	California	1.00 (0.96, 1.04)

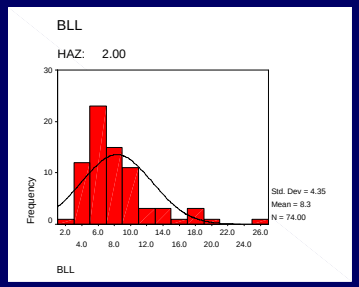
Cause of Death /Cohort	ACS (National)	ACS (South& West)	ACS (East& Midwest)	SCS	WHI (BetweenCities)	NL	Nurses (PM_{10})	AHSMOG (PM_{10})
Cardio-vascular	1.17 (1.11, 1.24)	1.11 (1.05, 1.17)	1.21 (1.11, 1.31)	1.28 (1.13, 1.44)	1.63 (1.10, 2.40)	1.11 (0.93, 1.33)		
Ischemic /Coronary Heart Disease	1.29 (1.18, 1.41)	1.23 (1.12, 1.34)	1.23 (1.08, 1.39)	1.26 (1.08, 1.47)	1.67 (0.98, 2.85)	0.96 (0.75, 1.22)	1.43 (1.09, 1.88)	
Cerebro-vascular	1.14 (1.02, 1.26)	1.14 (1.01, 1.29)	1.11 (0.94, 1.32)	0.96 (0.70, 1.31)	1.58 (0.90, 2.78)	1.62 (1.07, 2.44)		
CV-IHD-CER*	0.99 (0.88, 1.13)	0.86 (0.71, 1.04)	1.25 (1.04, 1.51)					
Respiratory	1.02 (0.93, 1.13)	1.06 (0.95, 1.18)	1.07 (0.92, 1.24)	1.08 (0.79, 1.49)		1.07 (0.87, 1.52)		1.06 (0.99, 1.14)
Lung Cancer	1.14 (1.06, 1.23)	1.10 (0.98, 1.21)	1.17 (1.03, 1.33)	1.27 (0.96, 1.69)		1.06 (0.82, 1.38)		1.38 (1.10, 1.73)
Others**	0.98 (0.94, 1.03)	0.93 (0.88, 0.99)	1.03 (0.98, 1.09)	1.02 (0.90, 1.17)		1.08 (0.96, 1.23)		

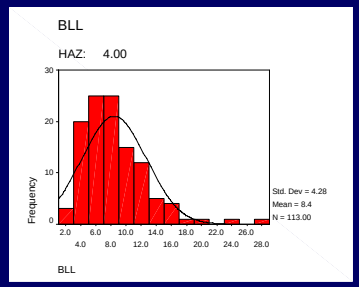
Requirements for additional exposure data

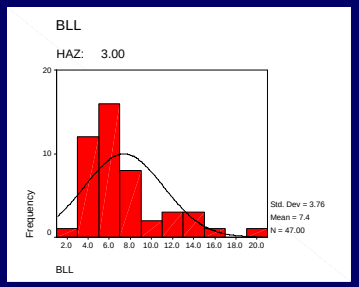
- Simultaneous data on multiple pollutants
- Greater spatial and temporal resolution
- Land-use regression models
- GIS and satellite data interfaces for spatial interpolation
- Larger databases on personal exposures

Children's blood lead levels across zones in Chennai



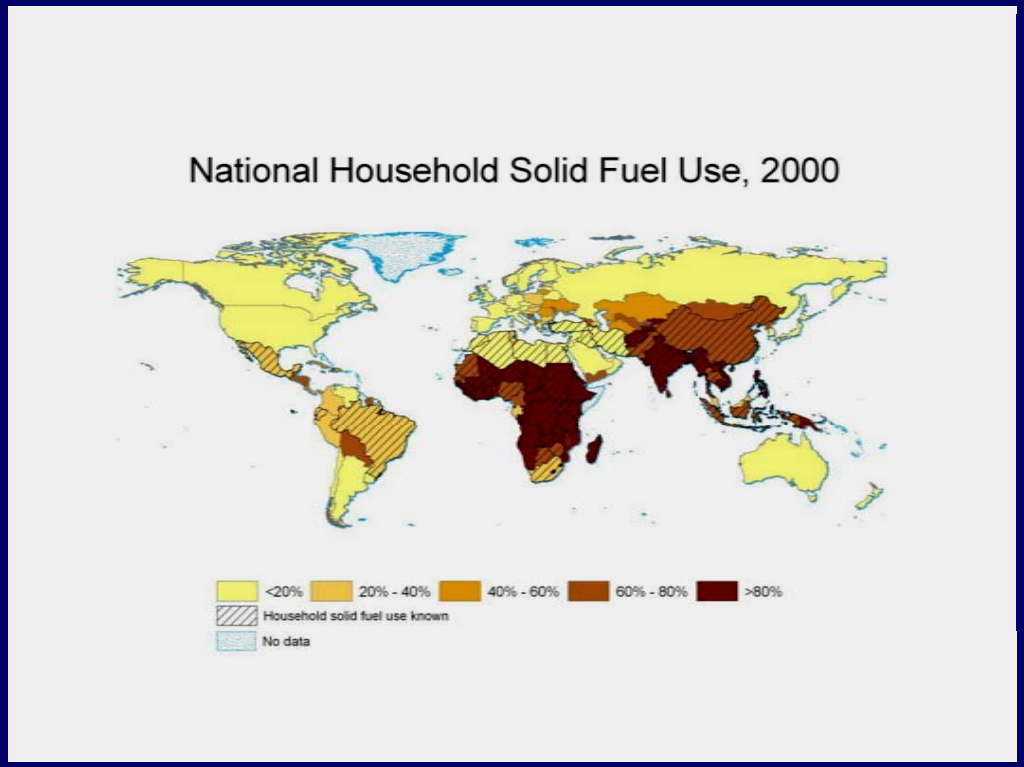


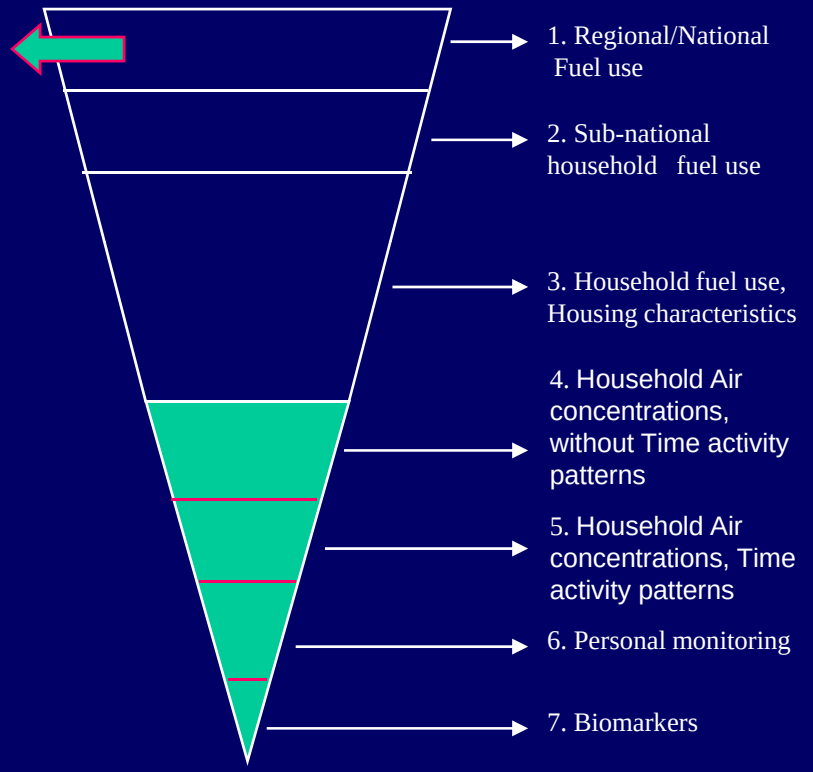




Zones	Blood lead levels			
	<10 µg/dL		≥10 µg/dL	
	N	%	N	%
Industrial	175	50.87	250	57.67
Commercial	64	18.6	98	23.78
Residential	105	30.52	64	15.53

Indoor Air Pollution

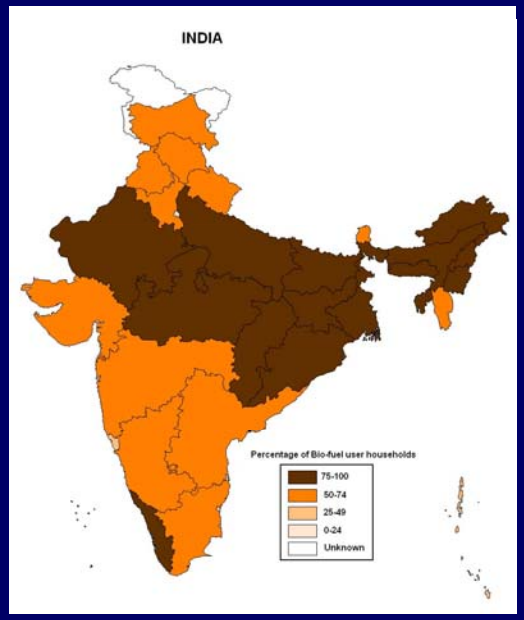




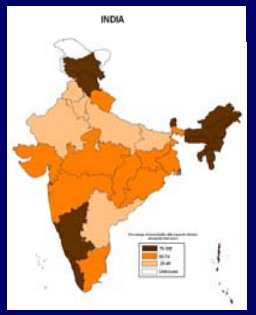
Indoor air pollution, biomass fuel use and national burden of disease

- ARI : 290,000- 440,000 premature deaths in children under 5
- COLD : 19,000-34,000 cases in women under 45
- Lung Cancer : 400-800 cases in women under 45

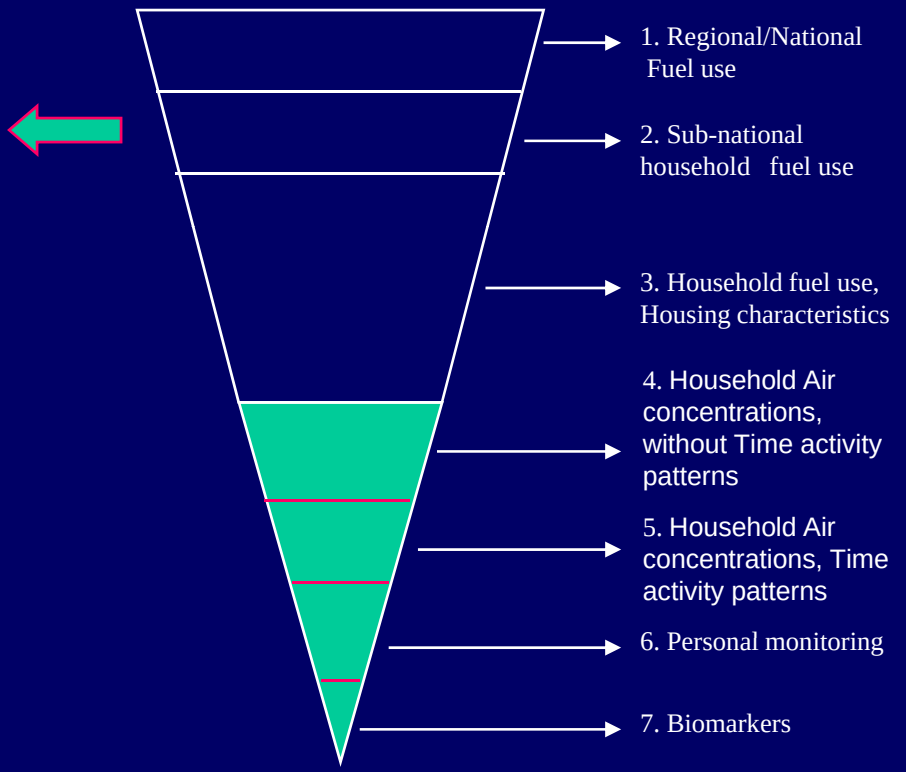
Indoor Air Pollution



Prevalence of fuel use

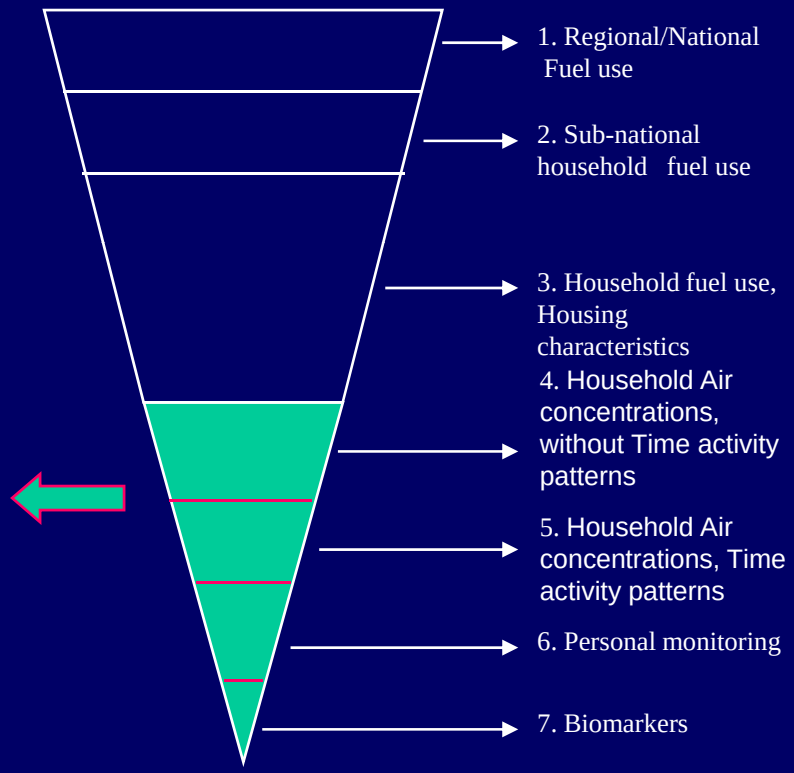


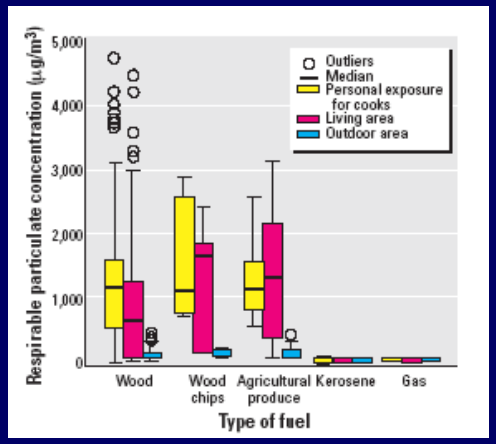
Prevalence of kitchen types

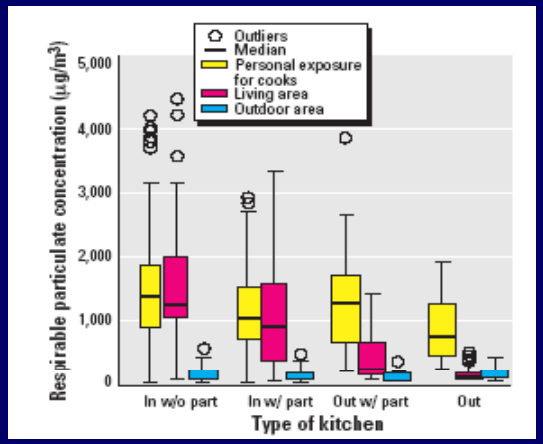


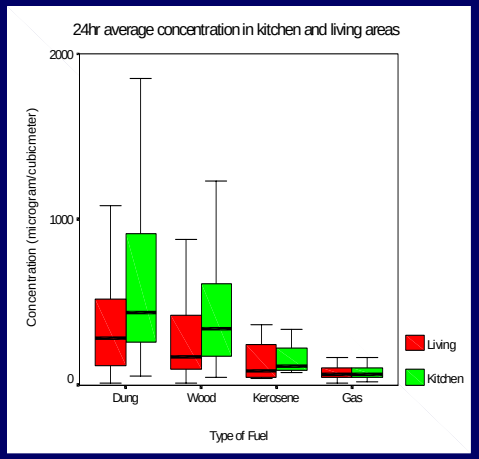
Recent large-scale IAP measurement studies

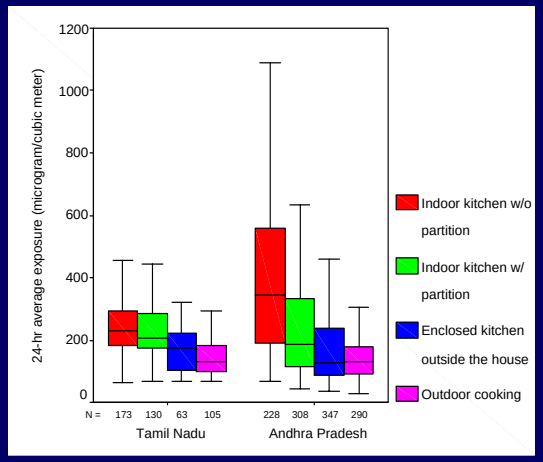
Tamil Nadu(412)	PM (G)
Andhra Pradesh (436)	PM (G)
Tamil Nadu, West Bengal, Uttaranchal, Madhya Pradesh (600)	PM (G) PM (UCB) CO
Haryana (150)	PM (G)
Karnataka, Tamil Nadu (68) Improved stoves	PM (G) PM (UCB) CO
Maharashtra (Pune, Urban, 61)	PM (G) CO
Delhi (40, Urban)	PM

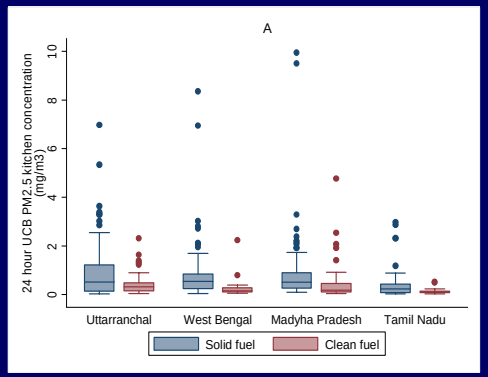


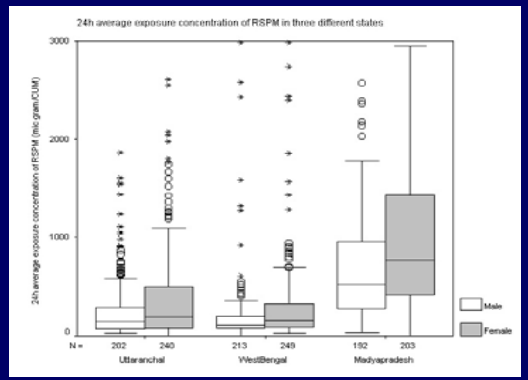

Respirable particulate concentration (µg/m³)
5,000
4,000
3,000
2,000
1,000
0
Outliers
Median
Personal exposure for cooks
Living area
Outdoor area
Wood
Wood chips
Agricultural produce
Kerosene
Gas
Type of fuel


Respirable particulate concentration (µg/m³)
5,000
4,000
3,000
2,000
1,000
0
Outliers
Median
Personal exposure for cooks
Living area
Outdoor area
In w/o part
In w/ part
Out w/ part
Out
Type of kitchen


24hr average concentration in kitchen and living areas
Concentration (microgram/cubicmeter)
2000
1000
0
Living
Kitchen
Dung
Wood
Kerosene
Gas
Type of Fuel


24-hr average exposure (microgram/cubic meter)
1200
1000
800
600
400
200
0
Indoor kitchen w/o partition
Indoor kitchen w/ partition
Enclosed kitchen outside the house
Outdoor cooking
N =
173
130
63
105
228
308
347
290
Tamil Nadu
Andhra Pradesh


A
24 hour UCB PM2.5 kitchen concentration (mg/m3)
0
2
4
6
8
10
Uttarranchal
West Bengal
Madyha Pradesh
Tamil Nadu
Solid fuel
Clean fuel


24h average exposure concentration of RSPM in three different states
3000
2000
1000
0
N =
202
240
213
249
192
203
Uttaranchal
WestBengal
Madyapradesh
Male
Female

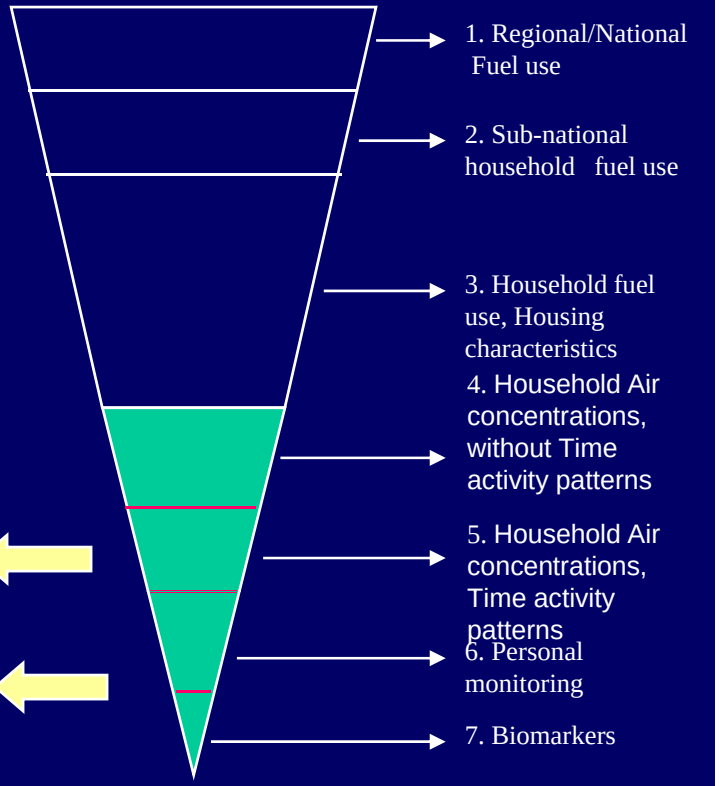
T
N

A
P

U
P

M
P

W
B


1. Regional/National Fuel use
2. Sub-national household fuel use
3. Household fuel use, Housing characteristics
4. Household Air concentrations, without Time activity patterns
5. Household Air concentrations, Time activity patterns
6. Personal monitoring
7. Biomarkers

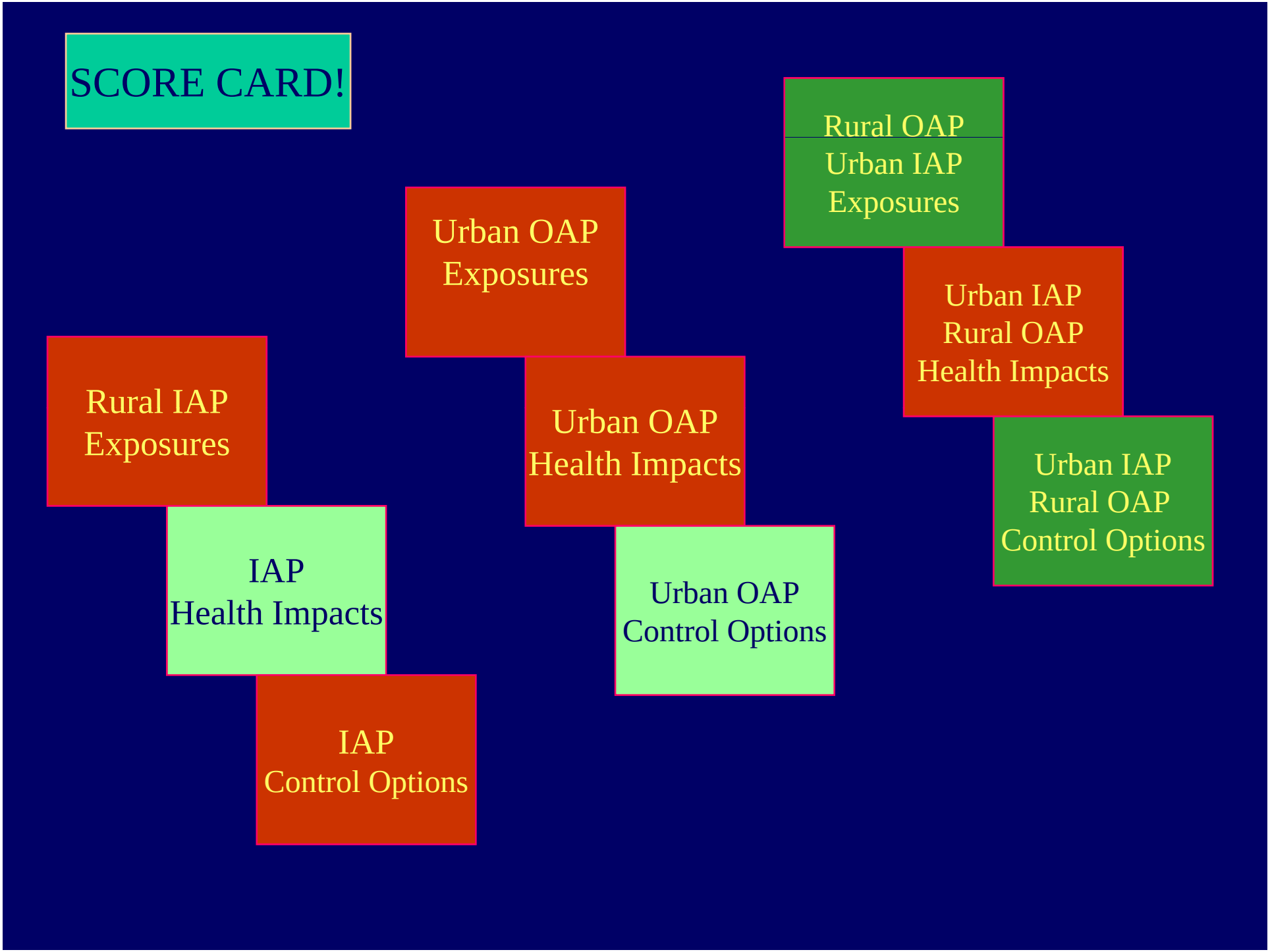
IAP relevant issues

- Exposure implications for rural outdoors
- Exposure transitions accompanying interventions
- Differential effect modification according to exposure status
- Increasing exposure potentials for urban air toxics

Combined Outdoor/Indoor/Occupational Exposures (an example from the stone quarrying/crushing sector)

- Limited information on dust exposures, very sparse information on silica exposures
- Women not considered as workers
- Children are seldom reported as workers
- Many occupational exposures remain un-characterized
- Smoking among women is greatly under-reported
- Efficiency of dust control seldom bench-marked against commonly used standards

- Silica content varies across geographical regions
- Women's exposures to PM exceeded men
- Men's exposures in stone quarrying sector was high but lung function not significantly different from agricultural workers in the same belt (after adjustment for smoking)
- Most dust control devices achieve a 50-60% reduction from a starting level of >er than 10mg/m^3


SCORE CARD!
Rural OAP
Urban IAP
Exposures
Urban OAP
Exposures
Urban IAP
Rural OAP
Health Impacts
Rural IAP
Exposures
Urban OAP
Health Impacts
Urban IAP
Rural OAP
Control Options
IAP
Health Impacts
Urban OAP
Control Options
IAP
Control Options

Thank you!