How Environmental Health Risks Change with Development: With Special Attention to China

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(at the 0.03% level)

Beijing Forum 2007
Peking University, Nov 2-4

Environment and Health

- It is quite clear that health issues are very important for general environmental control.
  - Outrage over unhealthy community environments led to modern environmental movement.
  - Most regulations officially based on health criteria
- Natural tendency to think that dirty, ugly, smelly conditions are unhealthy
- Our ability to detect very low exposures and small risks has improved dramatically.
- Sometimes hard to admit, however, that evidence of environmental degradation and risk does not necessarily translate into significant health damage
- In a world with many priorities, we need to show how important environmental risk factors are in the total health picture

Environment and Health (cont.)

- On the one hand, figuring actual health impact often involves a quite different perspective than general environmental quality
  - Exposure rather than environmental quality
  - Vulnerable/sensitive populations, including age and sex
- On the other hand, making the case for a major impact on health requires using different metrics than the environmental health community normally does and remembering that

Risk does not equal burden

Plan of talk: How does one answer questions about the importance of environmental risk factors for health?

- One compared with another, e.g., water versus air pollution?
- Environmental risk factors compared to other important risk factors, such as poor nutrition, smoking, etc.?
- How do environmental health risks tend to change as countries develop?
  - Does environment tend to become more or less important?
  - Do some types of environmental risk rise while others fall?
- How does climate change affect these relationships?

What is health?

- "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."
  - First of nine principles on first page of World Health Organization Constitution adopted in NYC in July 1946 by 61 nations
  - "spiritual well-being" added in 1999 by World Health Assembly, which at that time had 191 member states
    - http://www.ldb.org/iphw/whoconst.htm

Environmental Health Effects

- Example of outdoor air pollution
  - Asthma attacks
  - Missing workdays
  - Missing school days
  - Days with cough
  - Emergency room visits
  - Hospital admissions
  - Physician visits
  - Medication use
  - Daily death rate
  - Lung function
  - Self-reported health status
  - Etc.
- How can these be compared across time, cities, countries, age groups, sectors (e.g., transport versus power plants), etc.?
- Let alone compared with the health impacts from completely different risk factors, such as water pollution, lead exposure, high cholesterol, unsafe sex, etc.?

Single Universal Measure of Ill-health?

- Death is most common
  - Easy to determine
  - Commonly tabulated
- Severe problems as a measure
  - Everyone dies
  - Health never achieved
  - Age is clearly important
- Deaths + Illness = ?

Combined Measure

- What else to use?
  - Money? **Are you kidding?**
  - **Is used in legal and other realms, but not appropriate for public health**
- Most fundamental deprivation is loss of **time**:
  - Same potential life length shared by all humans
  - The degree to which a person does not achieve this life length is a measure of ill-health
  - Can be used for disabilities, as well, but need to weight relative severity of disabilities as well as tabulate their duration

Quality Adjusted Life Years QALY

- Basically the number of fully healthy life years lost to a particular disease or risk factor.
- Considers the age at which the disease or death occurs and the duration and severity of any disability created.
- Type of QALY used here is the Disability Adjusted Life Year (DALY), which is used widely in international health assessments

Disability Adjusted Life Year
The DALY, a kind of QALY

- Principle #1: The only differences in the rating of a death or disability should be due to age and sex, not to income, culture, location, social class.
- Principle #2: Everyone in the world has right to best life expectancy in world
- DALY = YLL + YLD
  - Years of Lost Life (due to mortality)
  - Years Lost to Disability (due to injury & illness)

Finally, a C^4 Database in Health
(Which we have had in many other fields for long periods)

- Combined mortality and morbidity: lost life years
- Complete
  - Much of the world unrepresented in past databases
  - Many important disabilities unaccounted
- Consistent definitions of disease states
- Coherent
  - Deaths by disease need to add to total
    - By age and sex
    - Match with demographic stats
  - No natural discipline, i.e. no import stats from the afterlife tabulating how many died of what

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Code	Cause	Total	Male 0-4	Male 5-14	Male 15-29	Male 30-44	Male 45-59	Male 60-69	Male 70-79	Male 80+	Male Total	Female 0-4	Female 5-14	Female 15-29	Female 30-44	Female 45-59	Female 60-69
Population (thousands)		*6224984.81*	*317077.27*	*622741.70*	*617442.67*	*663966.38*	*427071.29*	*166160.20*	*90443.11*	*26143.24*	*3131052.05*	*301091.73*	*583223.34*	*782026.21*	*646513.90*	*427846.34*	*181908.42*
GBD 2002: DALYs by age, sex and cause for the year 2002																	
WORLD																	
U000	**All Causes**	1430125643	222552079	56142418	141637847	130501742	115374678	60641455	36229210	9832834	772912264	211279454	54559890	141633214	108257333	90621463	53460940
U001	***I. Communicable, maternal, perinatal and nutritional conditions***	*610319250*	*******	*20979612*	*29721689*	*36148773*	*16631072*	*5676034*	*2913759*	*649689*	*******	******	*23248712*	*59740250*	*35979204*	*11499502*	*4476964*
U002	**A. Infectious and parasitic diseases**	350332571	87977510	12810197	25516201	33372707	14085712	3710016	1519252	315539	179307135	89749119	13534884	31549467	23070592	8616676	2658113
U003	1. **Tuberculosis**	34735908	839261	782431	5497848	7335503	4868489	1832663	658401	90612	21905208	738745	821735	4163278	3822011	2041939	833205
U004	2. **STDs excluding HIV**	11347067	1521528	26245	1080828	660600	423721	103004	31641	7415	3854983	1726606	97221	4158088	1147558	260537	71612
U005	a. Syphilis	4200039	1039452	2292	151945	285546	354596	99162	30394	6987	1970375	1265722	3432	521758	262487	107605	42492
U006	b. Chlamydia	3571404	1199	7209	241593	50929	1169	136	0	0	302234	1152	69338	2635460	439449	109658	14084
U007	c. Gonorrhoea	3365159	463945	16559	683964	301215	6664	719	91	3	1473160	447789	24323	989323	422675	6262	1616
U008	d. Other STDs	210465	16932	185	3327	22911	61292	2987	1157	425	109215	11943	127	11546	22947	37012	13420
U009	3. **HIV/AIDS**	84457784	6215039	1923486	11002792	18824803	4373213	299351	23497	420	42662599	5985984	1878957	17299389	13746555	2624463	230670
U010	4. **Diarrhoeal diseases**	61966183	29217337	800330	791539	721612	446922	197262	122248	55269	32352519	26863437	754533	652616	545936	373258	201900
U011	5. **Childhood-cluster diseases**	41479543	19033686	1422740	174377	55101	19437	4748	1821	613	20712522	19065281	1447659	172987	53966	19174	4837
U012	a. Pertussis	12594810	6231695	50837	44	0	0	0	0	0	6282575	6261471	50717	34	0	13	0
U013	b. Poliomyelitis	150660	15348	9021	29583	17300	3733	643	460	123	76211	15357	8675	28237	16931	3822	615
U014	c. Diphtheria	184710	83919	8085	1348	1346	1207	206	21	11	96143	67627	19365	523	386	572	29
U015	d. Measles	21475463	9387297	1255475	84251	83	20	23	0	0	10727148	9394304	1269212	84741	29	30	0
U016	e. Tetanus	7073899	3315427	99323	59152	36372	14477	3876	1340	479	3530446	3326522	99690	59452	36620	14737	4192
U017	6. **Meningitis***	6191790	1504271	596798	445433	257091	184063	53527	33371	6998	3081551	1676034	734345	341757	167759	110215	48775
U018	7. **Hepatitis B**	2170326	105358	137204	275807	430017	397164	82713	26027	4975	1459264	188406	62506	173729	115391	110437	36630
U019	**Hepatitis C**	1003682	35920	56182	100610	192346	210317	48794	20514	3442	668127	72373	24200	67867	53705	61307	30322
U020	8. **Malaria**	46485868	20191868	607710	620617	438228	247611	87288	40647	9444	22243414	22056596	601958	689661	453207	280704	99111
U021	9. **Tropical-cluster diseases**	12245452	311034	2512134	3070382	1576828	643186	115534	37265	6156	8272521	266359	1203242	1297027	593336	496341	75537
U022	a. Trypanosomiasis	1525287	75814	412367	236703	148103	84732	6426	1970	54	966168	41943	237244	149181	79329	46509	3694
U023	b. Chagas disease	6667													51644	48058	15987
U024	c. Schistosomiasis	17017													128589	58850	17056
U025	d. Leishmaniasis	20898													67203	30097	11647
U026	e. lymphatic filariasis	57774													206680	266630	15772
U027	f. Onchocerciasis	4842													59892	46198	11380
U028	10. **Leprosy**	19877													15828	9135	4389
U029	11. **Dengue**	61552													10408	6396	2644
U030	12. **Japanese encephalitis**	70921													26926	7282	2513
U031	13. **Trachoma**	232878													517423	559520	344796
U032	14. **Intestinal nematode infections**	29513													5192	5921	3469
U033	a. Ascariasis	18169													161	21	111
U034	b. Trichuriasis	10062													388	433	238
U035	c. Hookworm disease	586													4212	4859	2723
U036	Other intestinal infections	695													432	607	397
U037	Other infectious diseases	414453													1795391	1650048	667703
U038	**B. Respiratory infections**	9460334													1481589	1357246	1460806
U039	1. Lower respiratory infections	913735													1434738	1329549	1425397
U040	2. Upper respiratory infections	17952													45228	26339	34405
U041	3. Otitis media	14345													1622	1358	1004
U042	**C. Maternal conditions**	33631593													9947305	403615	19
U043	1. Maternal haemorrhage	4437585	0	0	0	0	0	0	0	0	0	50	332	2359228	1944088	133887	0
U044	2. Maternal sepsis	6903085	0	0	0	0	0	0	0	0	0	0	144	5204511	1625431	72999	0
U045	3. Hypertensive disorders*	2162701	0	0	0	0	0	0	0	0	0	0	975	1398598	722909	40216	0
U046	4. Obstructed labour	3048291	0	0	0	0	0	0	0	0	0	0	0	2241561	794568	12162	0
U047	5. Abortion	4652171	0	0	0	0	0	0	0	0	0	0	223411	3721304	705860	1596	0
U048	Other maternal conditions	12427759	0	0	0	0	0	0	0	0	0	0	1970	8128555	4154451	142755	19
U049	**D. Perinatal conditions***	97335086	53209265	1343	1031	347	89	12	9	0	53212095	44121066	1195	498	158	34	29
U050	1. Low birth weight	46334234	25061999	52	13	20	0	9	0	0	25062092	21272111	31	0	0	0	0
U051	2. Birth asphyxia and birth trauma	34445758	19353003	790	302	73	33	3	0	0	19354204	15090851	573	107	0	15	0
U052	Other perinatal conditions	16555094	8794262	502	716	253	56	0	9	0	8795799	7758104	591	392	158	19	29
U053	**E. Nutritional deficiencies**	34416632	10258276	1921013	1793247	1025783	698252	230984	132831	39983	16100369	10385030	2582483	2149411	1479558	1121930	357998
U054	1. Protein-energy malnutrition	16910328	7556012	560106	156056	69278	103279	71114	45451	18671	8579966	7350453	620870	66437	68728	81418	70683
U055	2. Iodine deficiency	3519322	1283895	471857	528	748	1215	641	236	50	1759171	1305105	450178	1681	1046	1287	439
U056	3. Vitamin A deficiency	792562	257306	84825	3330	6358	7864	3519	983	100	364284	320394	84034	10506	3807	6687	

Global Burden of Disease Database
World Health Organization

Being completely updated
2007-2009

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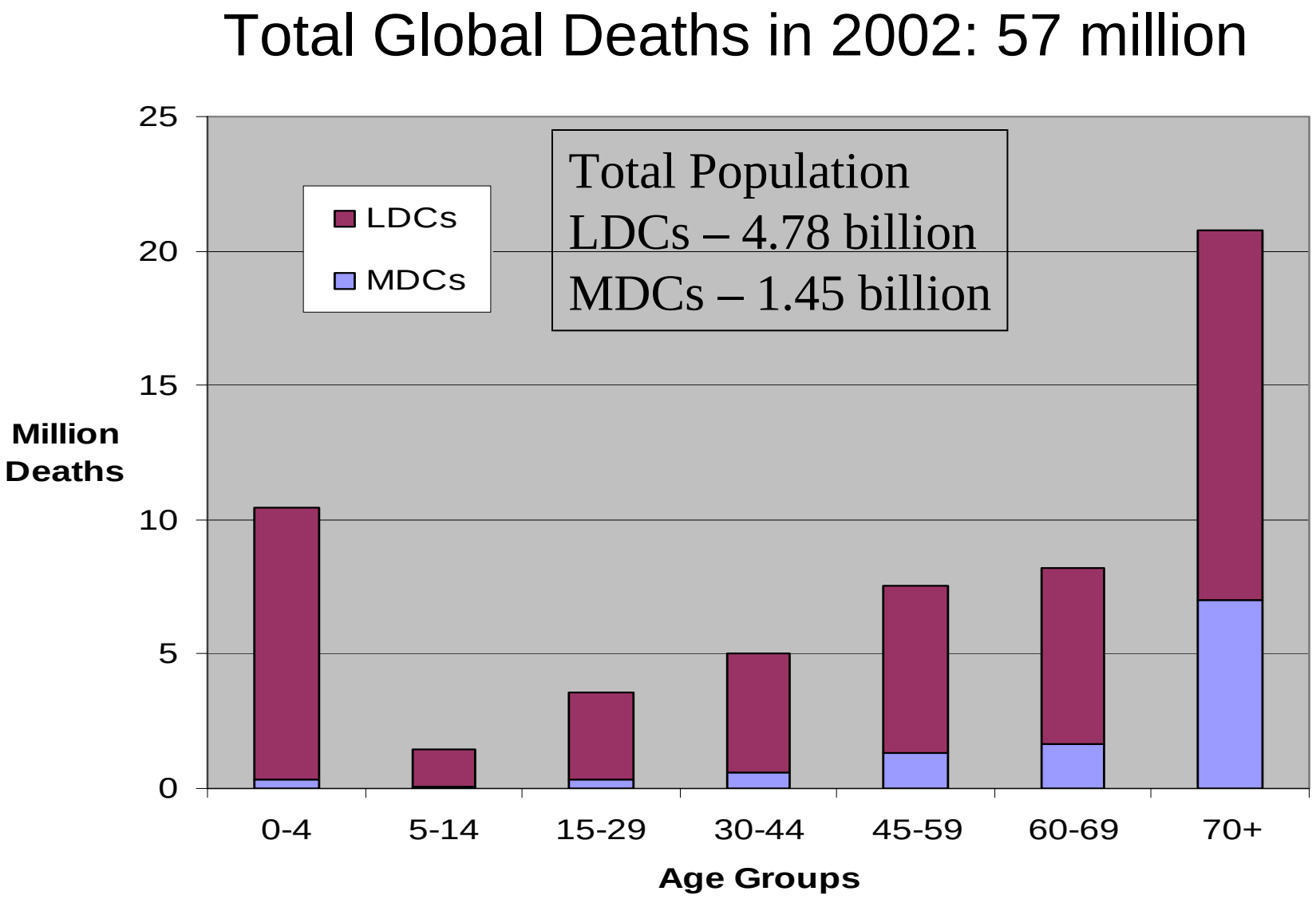
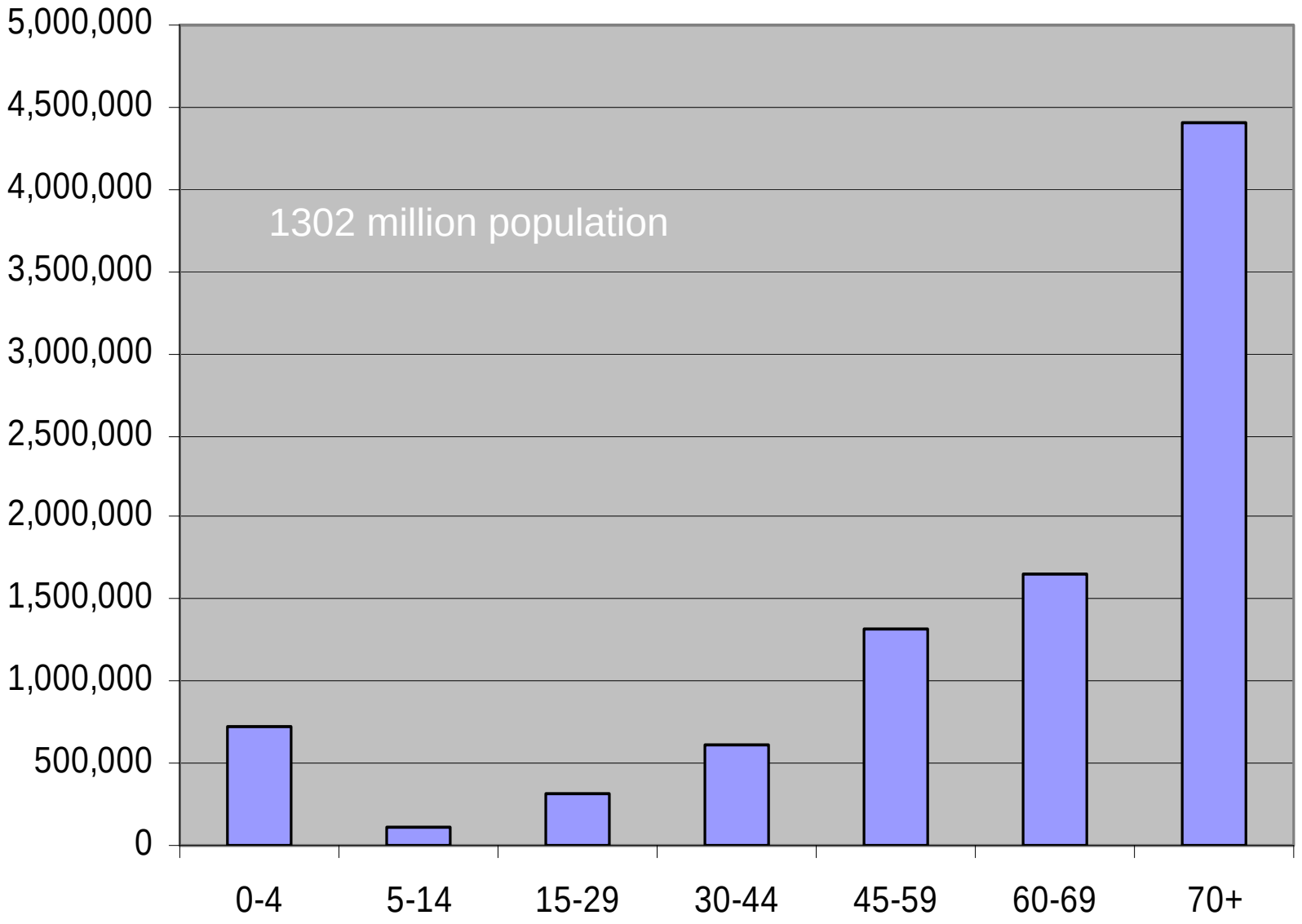
Just having coherence in mortality is valuable

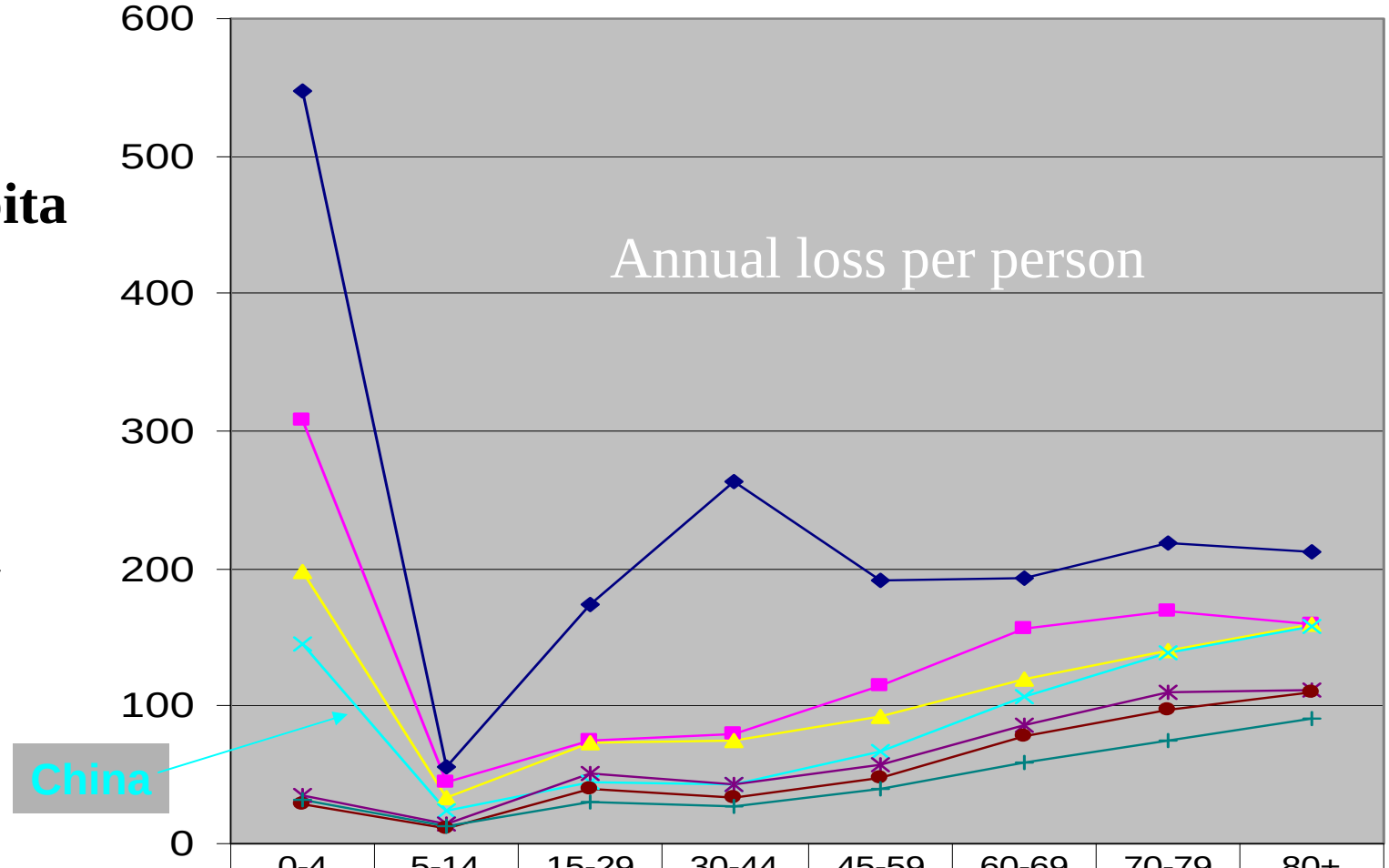


Chinese Deaths in 2002: Total = 9.1 million



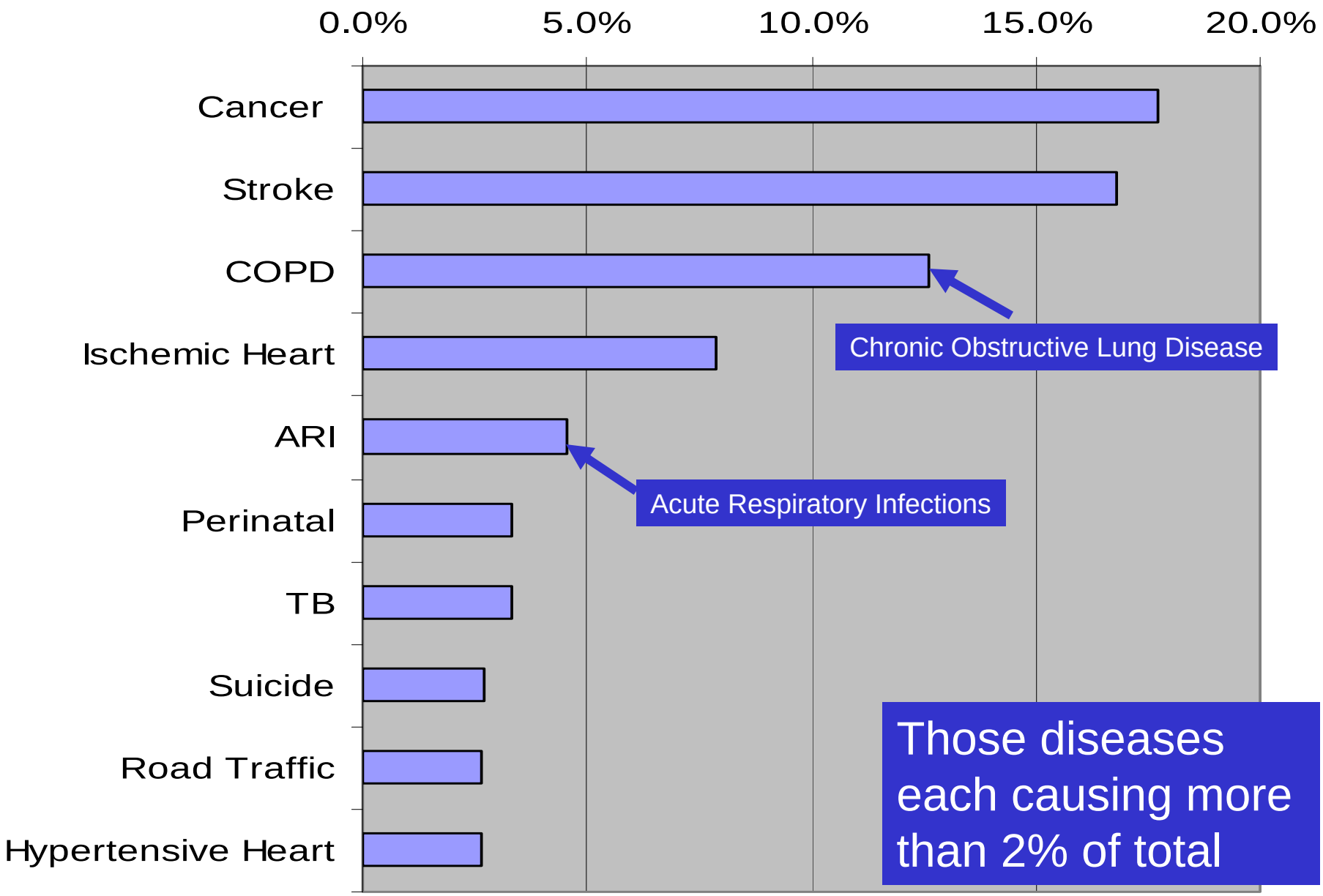
DALDs Per Capita by Age Group

Selected World Regions

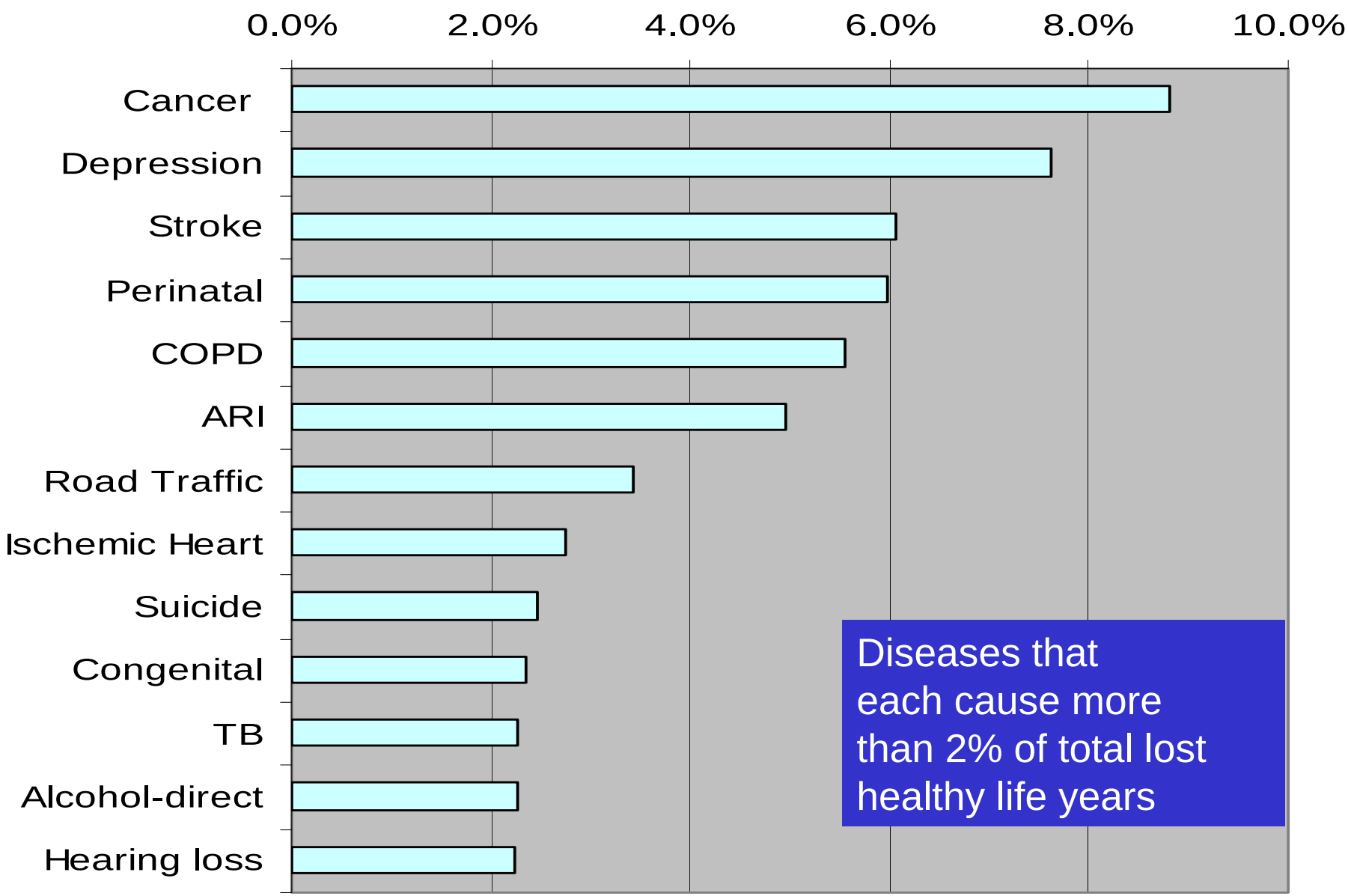


	0-4	5-14	15-29	30-44	45-59	60-69	70-79	80+
Very poor Africa	548	57	174	264	191	193	218	212
Poor South Asia	307	44	75	80	114	157	169	159
Poor Latin America	198	34	74	75	93	120	140	160
Middle Income East Asia	146	24	44	43	67	107	139	158
North America	35	14	51	43	58	87	110	111
Western Europe	29	11	39	33	48	79	98	110
Japan/Australia	32	13	31	27	41	59	75	91

Major Causes of Death in China



Chinese Burden of Disease



Comparative Risk Assessment Project
2-year 30-institution study organized by WHO

Disease, injury, and death due to major risk factors calculated by age, sex, and 14 global regions.

Fully Published in 2 vols, Fall 2004

Now being updated for year 2005

WHO-led Program to Develop Global Burden of Disease Estimates for 26 Major Risk Factors

- More policy relevant and, usually, more distal risk factors than disease or cause of death.
- Represent viable interventions for which cost-effectiveness can be determined.
- Common methods and criteria for including evidence used across risk factors.

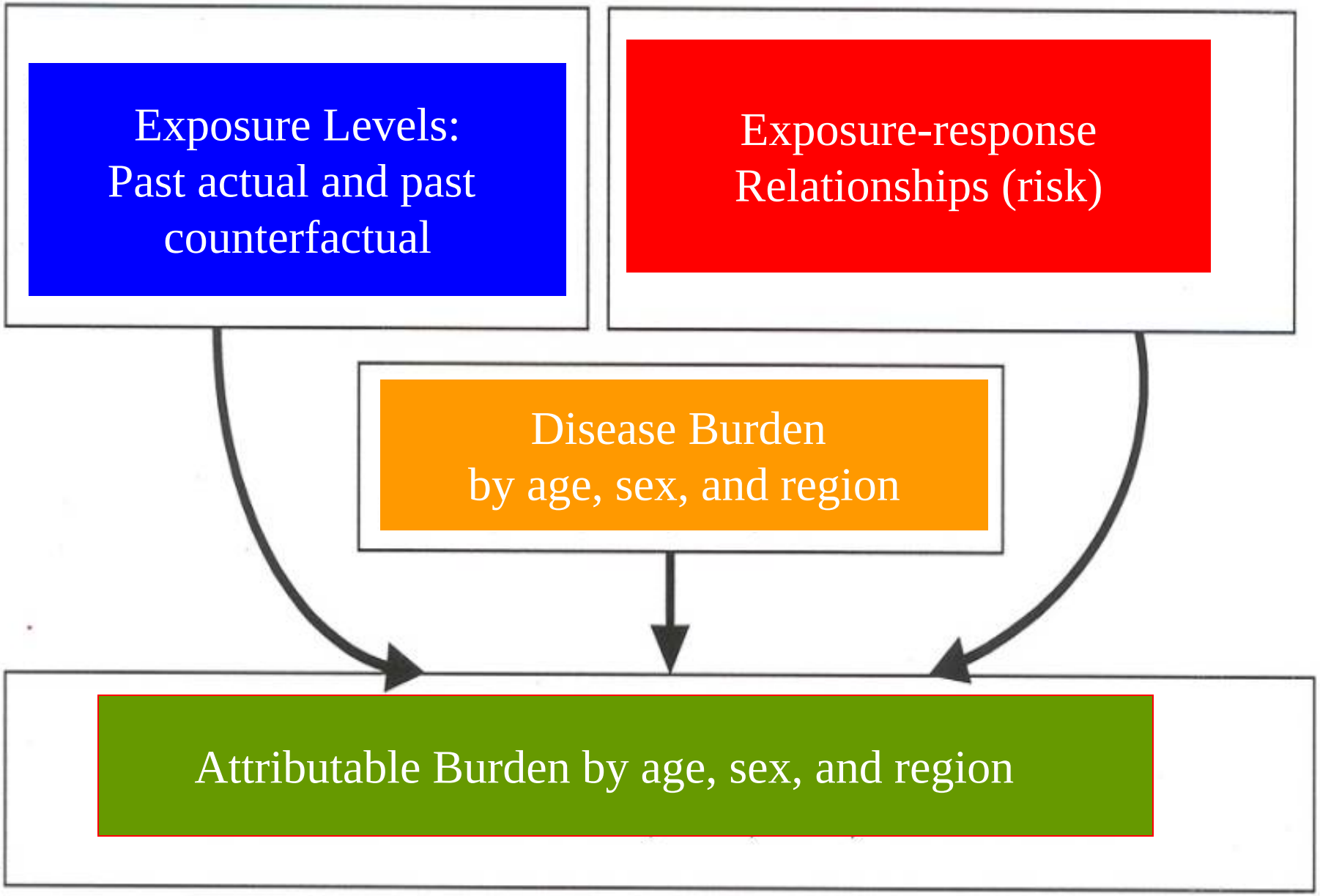
Risk Factors in WHO Comparative Risk Assessment

- Malnutrition (underweight)
- Micronutrient deficiency (Zn, Fe, Vit-A)
- Hypertension
- Cholesterol
- Obesity/BMI
- Lack of fruit & veg
- Physical inactivity
- Lack of contraception
- Unsafe sex
- Unsafe medical injection
- Childhood sexual abuse
- Tobacco (active smoking)
- Illicit drugs
- Alcohol
- Lead (Pb)
- Water/hygiene/sanitation
- Climate change
- Indoor air pollution
- Urban outdoor air pollution
- Occupational hazards (several types)

Attributable Risk?

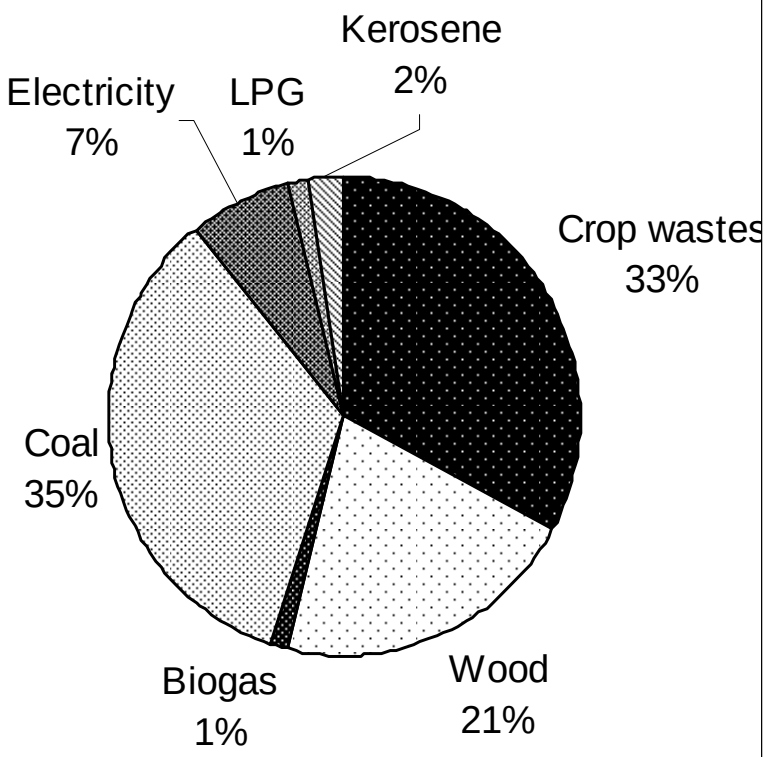
- The amount of ill-health that would not exist today if the exposure to the risk factor had not occurred in the past.
- Assumes all other risk factors remain constant
- Counter-factual level important, i.e., what lower exposure level would have been possible?

Comparative Risk Assessment Method



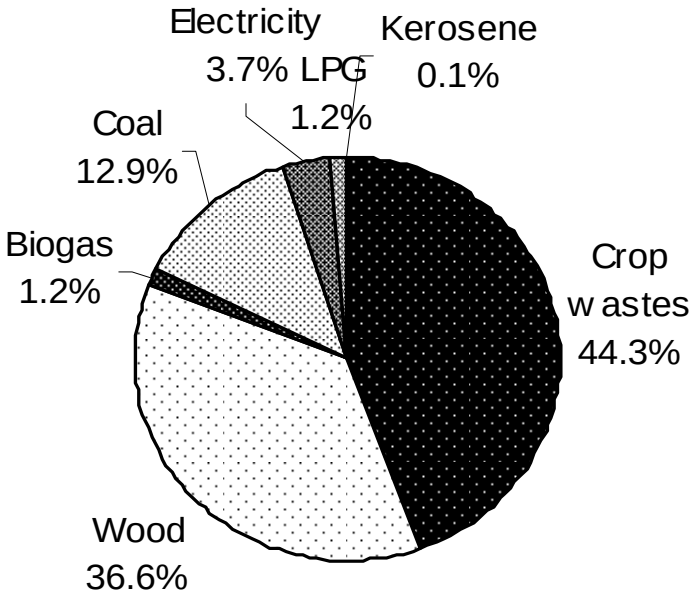
Rural Energy in China: 2004
Rural population ~ 65% of populations

Total



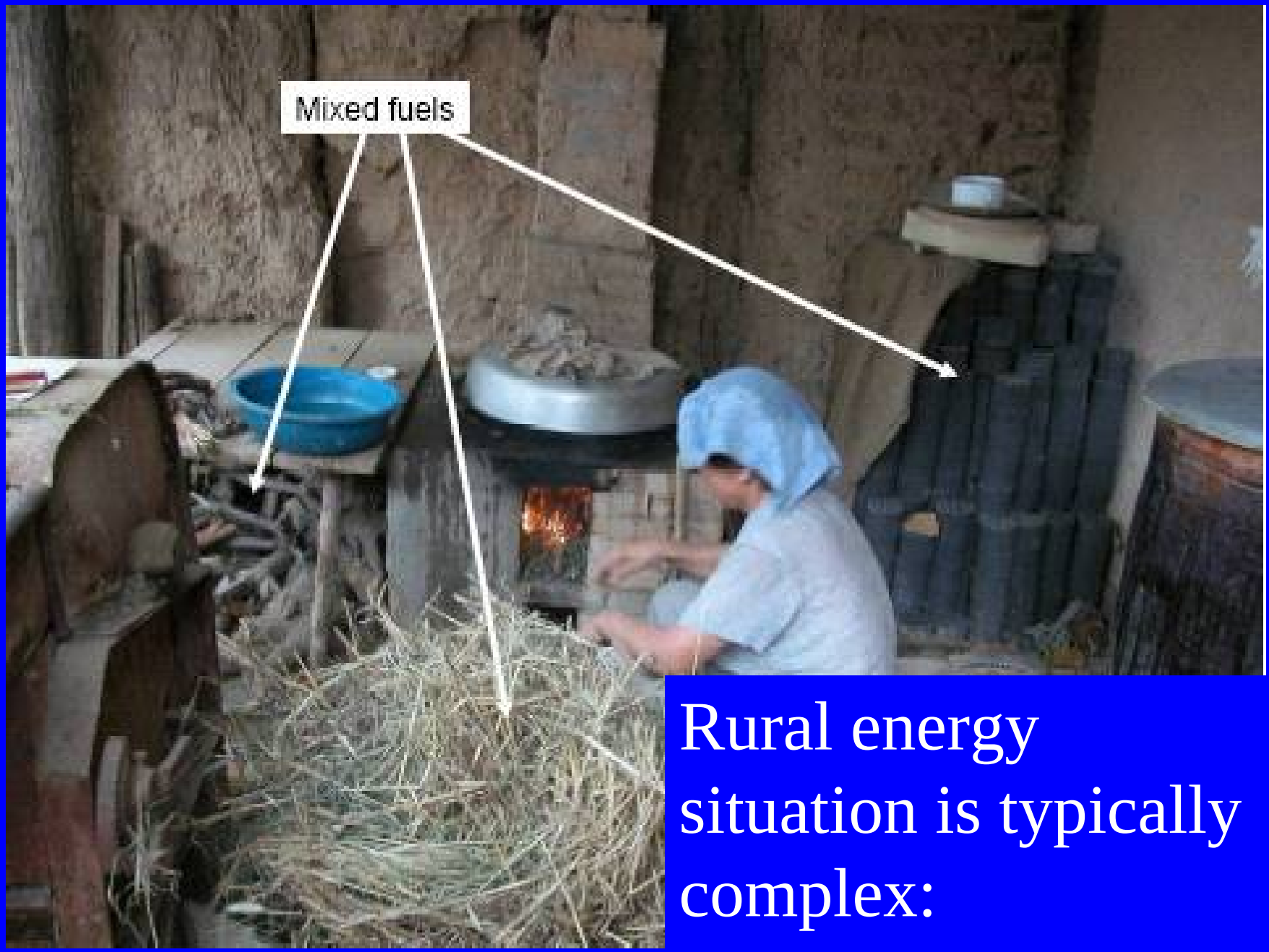
Ministry of Agriculture

Households



70% of total

National Bureau of Statistics



Rural energy situation is typically complex:

Toxic Pollutants in Biomass Fuel Smoke from Simple (poor) Combustion

- Small particles, CO, NO_2
- Hydrocarbons
  - 25+ saturated hydrocarbons such as *n-hexane*
  - 40+ unsaturated hydrocarbons such as *1,3 butadiene*
  - 28+ mono-aromatics such as *benzene & styrene*
  - 20+ polycyclic aromatics such as *benzo(α)pyrene*
- Oxygenated organics
  - 20+ aldehydes including *formaldehyde & acrolein*
  - 25+ alcohols and acids such as *methanol*
  - 33+ phenols such as *catechol & cresol*
  - Many quinones such as *hydroquinone*
  - Semi-quinone-type and other radicals
- Chlorinated organics such as *methylene chloride* and *dioxin*

Source: Naeher et al, *J Inhal Tox*, 2007

Pollution and health effects of indoor fuel smoke exposure in China*

- Lung cancer
- Respiratory illnesses
- Lung function impairment
- Immune system weakening
- CO poisoning
- Endemic arsenism and fluorosis

*120+ publications from studies conducted in China

China:

Interpretation:
Women who live in households using coal have about 2 times more lung cancer compared to those living with other fuels

[illegible]	[illegible]	-2.46)
Women	1.17 (1.02-1.35)	1.94 (1.09-3.47)
Combined	1.86 (1.48-2.35)	2.55 (1.58-4.10)

*Adjusted for smoking and chronic respiratory disease.

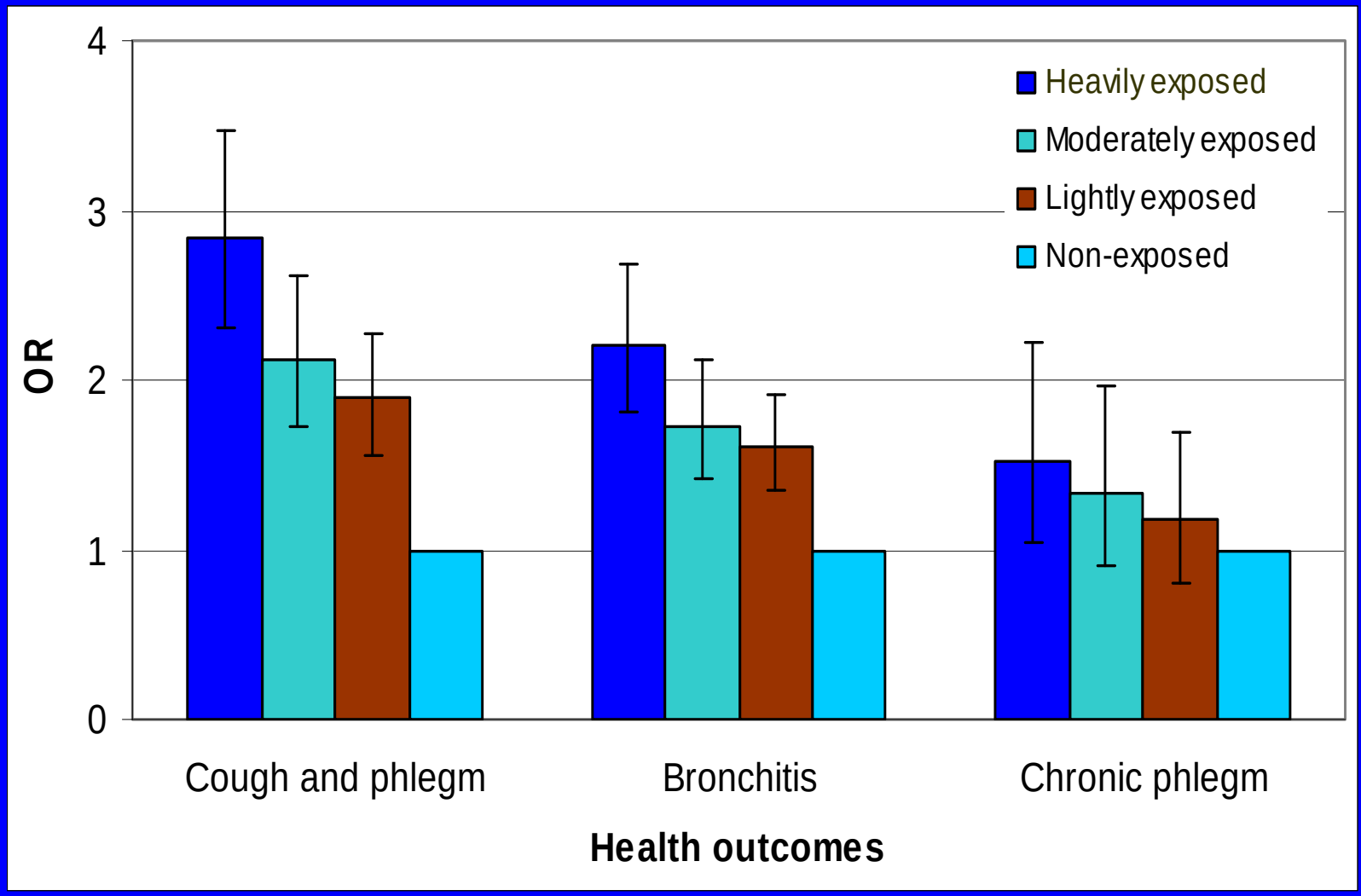
(Smith et al. 2004)

Children's Respiratory Illness (Salo et al. 2004, Zheng et al. 2002)

Odds Ratios	Coal for cooking/ heating	Coal for heating	Coal for cooking w/o vent
Wheezing w/ colds	1.57 (1.07-2.29)		
Wheezing w/o cold	1.44 (1.05-1.97)		
Asthma		1.5 (1.1-1.9)	2.3 (1.5-3.5)

Other illnesses reported include: rhinitis, faucitis, tonsillitis, and pneumonia (Cheng et al. 2002, Zhou et al. 1994).

Lifetime exposure to heating coal smoke and health outcomes children (Qian and Zhang et al, 2004)



n = 7,058 school children in four Chinese cities.

Adults' Respiratory Illnesses

(Zhou et al. 1995)

Odds Ratios	"Smoky" coal vs. "smokeless" coal	"Smokeless" coal vs. wood
Shortness of breath	1.73	
Cough	3.30	1.35
Phlegm	4.23	1.67

*Coal and passive smoking together increase prevalence rates of chest illness, cough, phlegm, and shortness of breath in women (Pope and Xu 1993).

Health Benefits of Fuel/stove Intervention

Best published studies in the world were done by examining introduction of improved coal stoves in China

Improved Stoves Brought to Xuanwei County in early 1980s

- The reduction in particle levels was ~a factor of about three.
- Reduction in lung cancer was ~40% in men and ~45% in women. (*Journal of the National Cancer Institute)*
- Reduction in COPD rates was also significant at about 50% in both men and women (*British Medical Journal*)
- Reduction in lung cancer and COPD took 10 years to fully develop after IAQ improvement.

Diseases for which we have epidemiological studies, but very few in China

ALRI/ Pneumonia (meningitis)

Asthma

Low birth weight & stillbirth

Early infant death

Cognitive Effects?

Chronic obstructive lung disease

Interstitial LD

Cancer (lung, NP, cervical, aero-digestive)

Blindness (cataracts, trachoma)

Tuberculosis

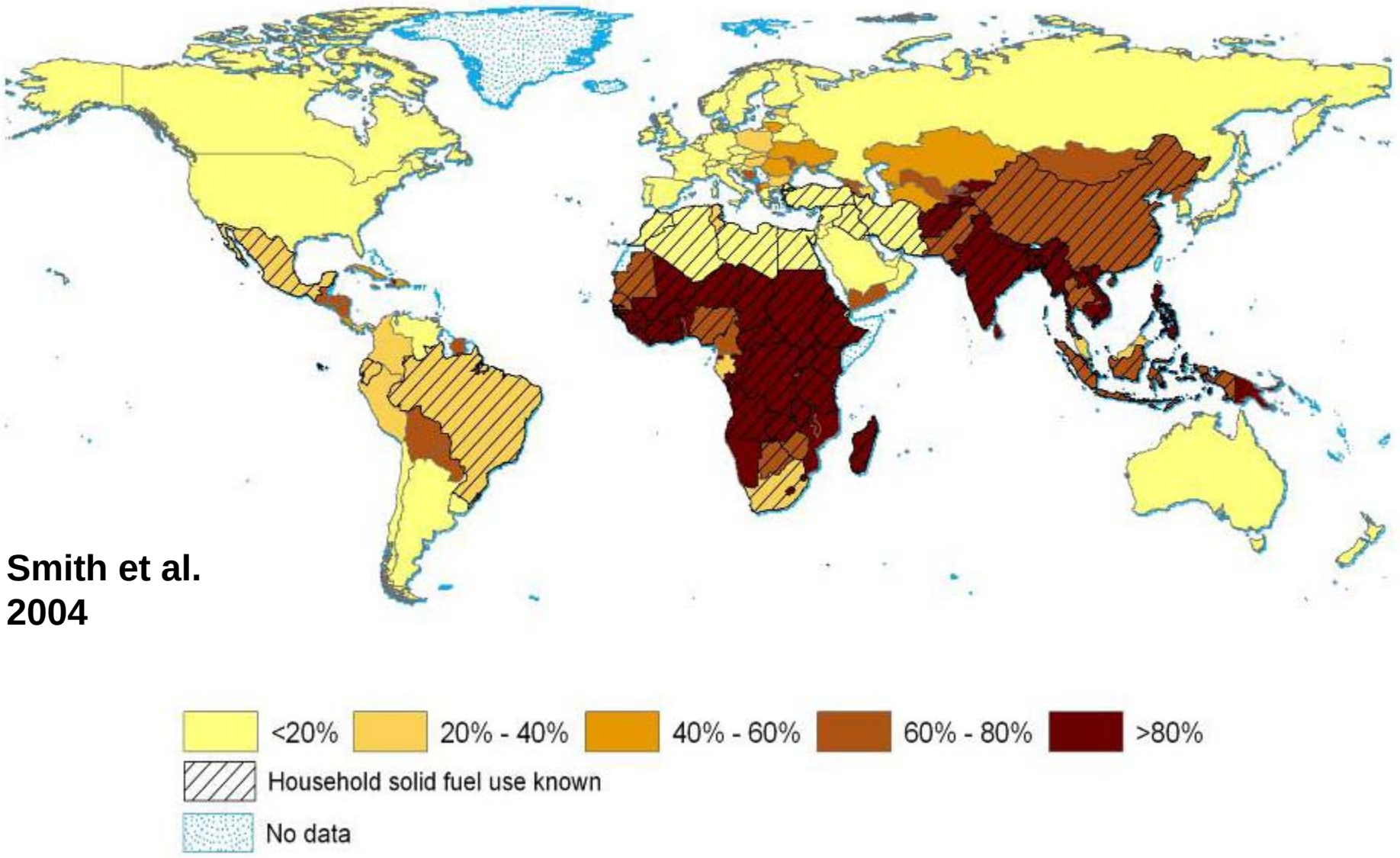
Heart disease?

Health Effects of Indoor Biomass Combustion: Major impacts based on systematic reviews and meta-analyses of dozens of studies

Use of biomass fuels in households increases risk of

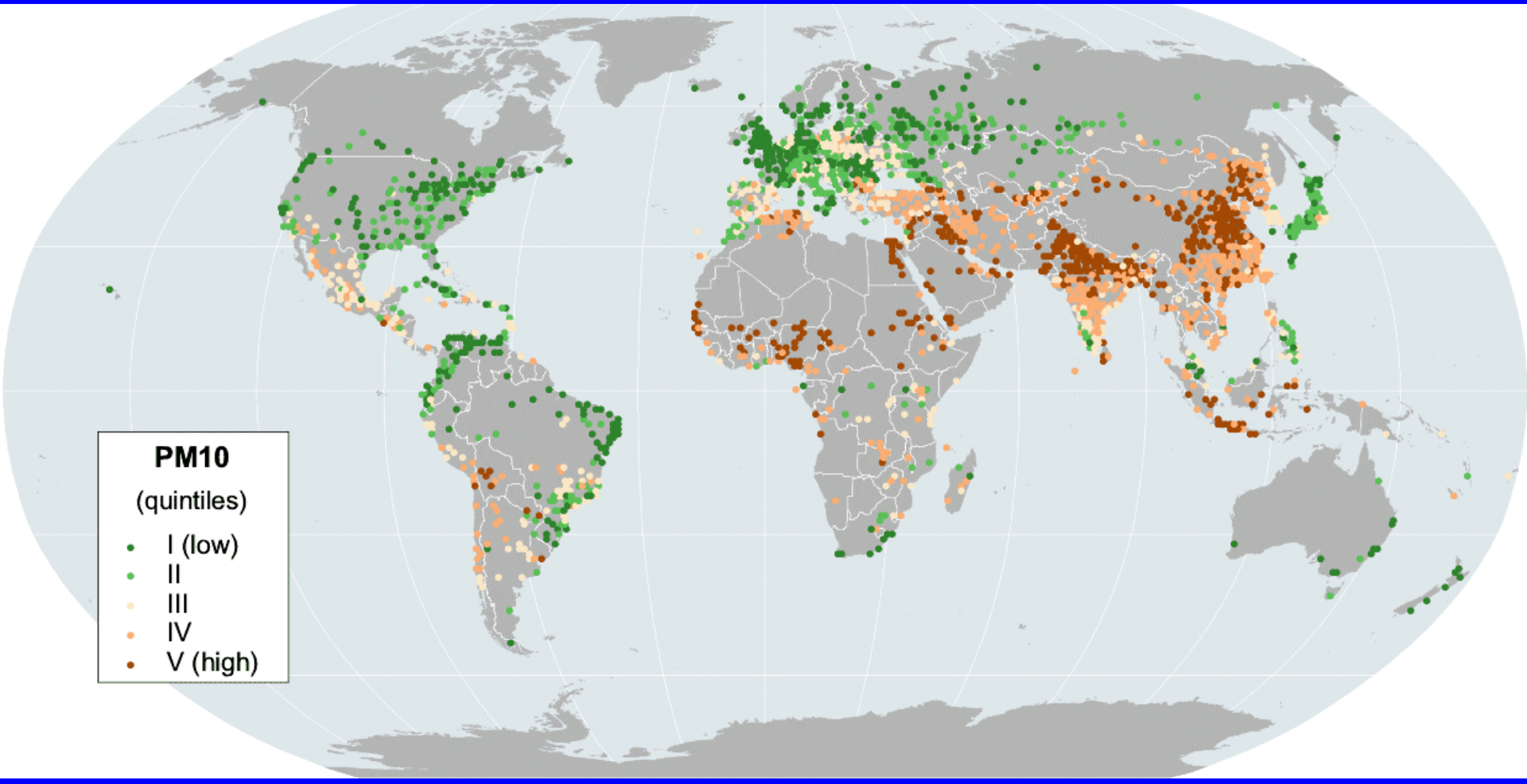
- Chronic Obstructive Pulmonary Disease in adult women by a factor of 3.2 (95% CI: 2.3-4.8) .
- Pneumonia in children under 5 years old by a factor of 2.0 (95% CI: 1.7-2.5).

National Household Solid Fuel Use, 2000

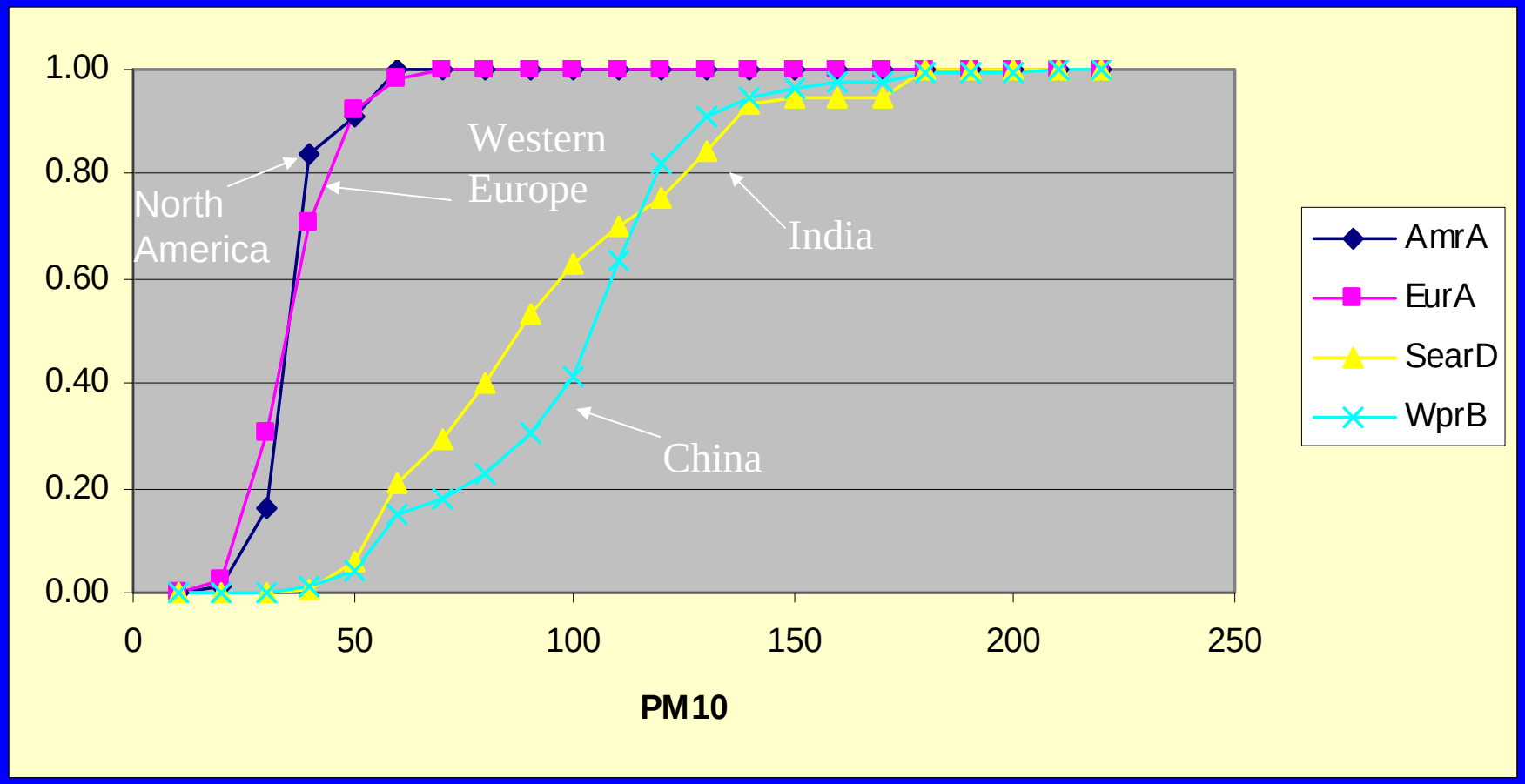


Smith et al. 2004

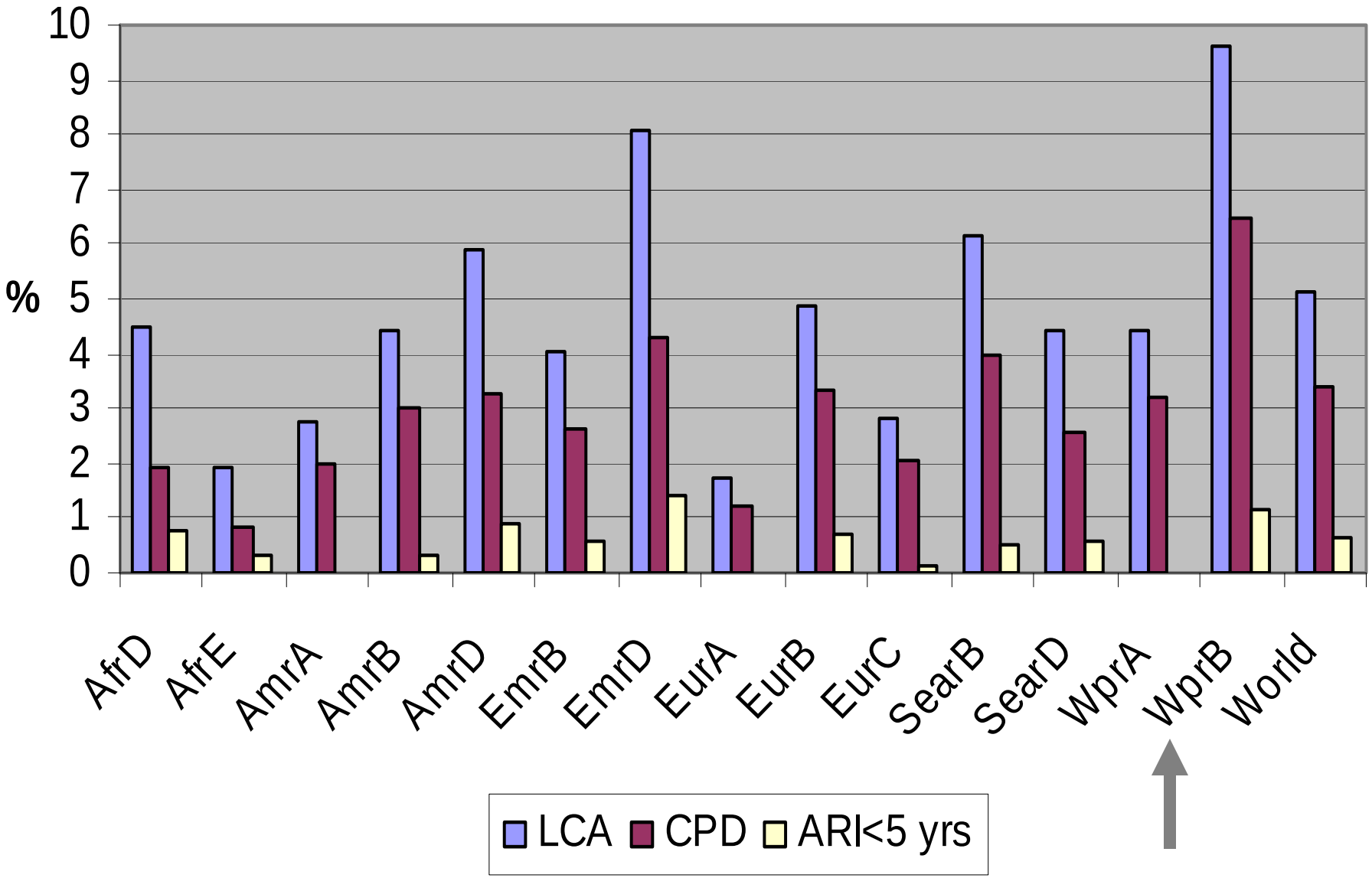
Estimated Particle Concentration in World Cities (pop=100,000+)



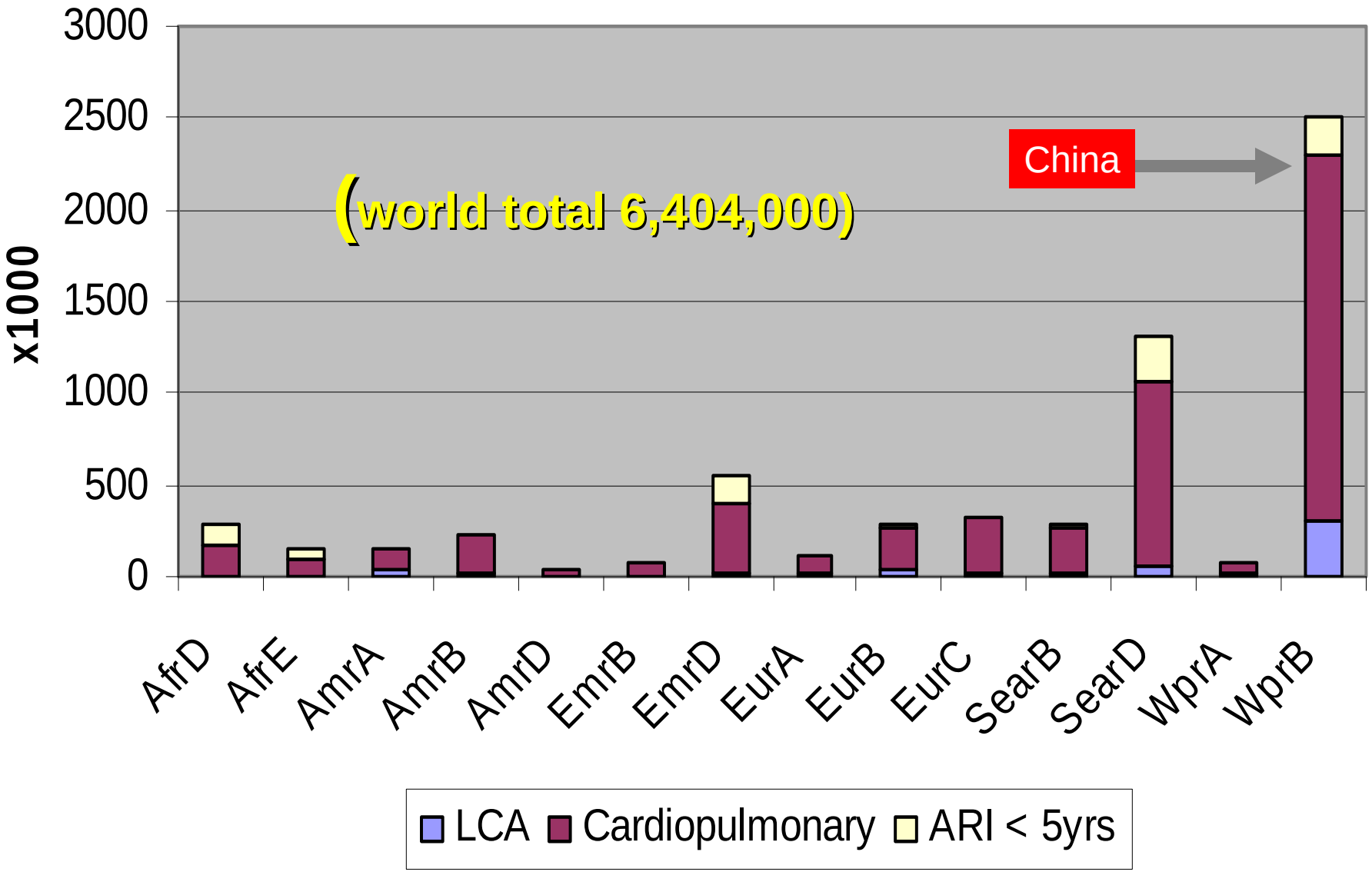
Cumulative distribution of particle concentrations in cites Selected World Regions



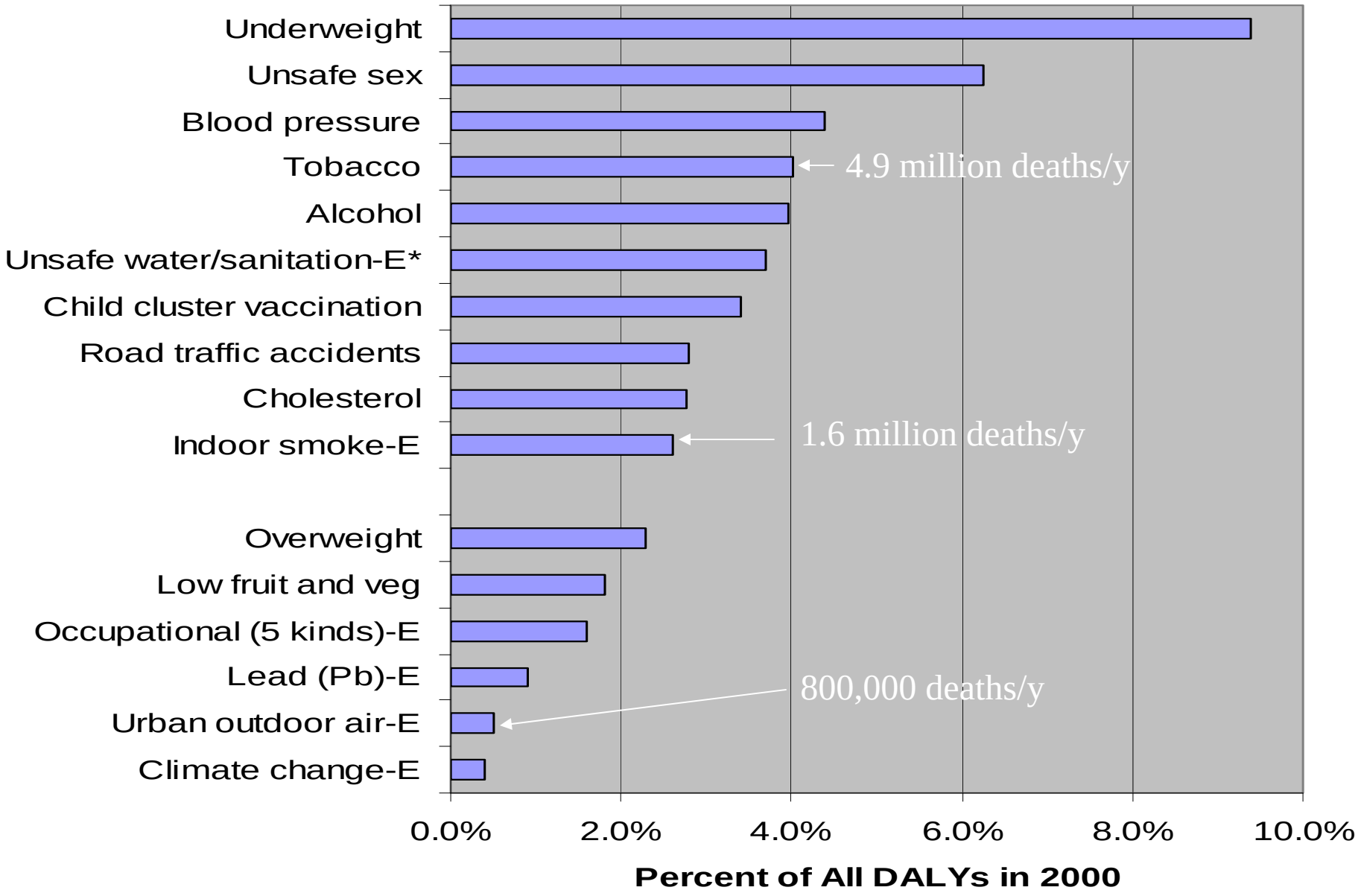
Fraction of mortality attributable to outdoor air pollution



DALYs attributable outdoor AP

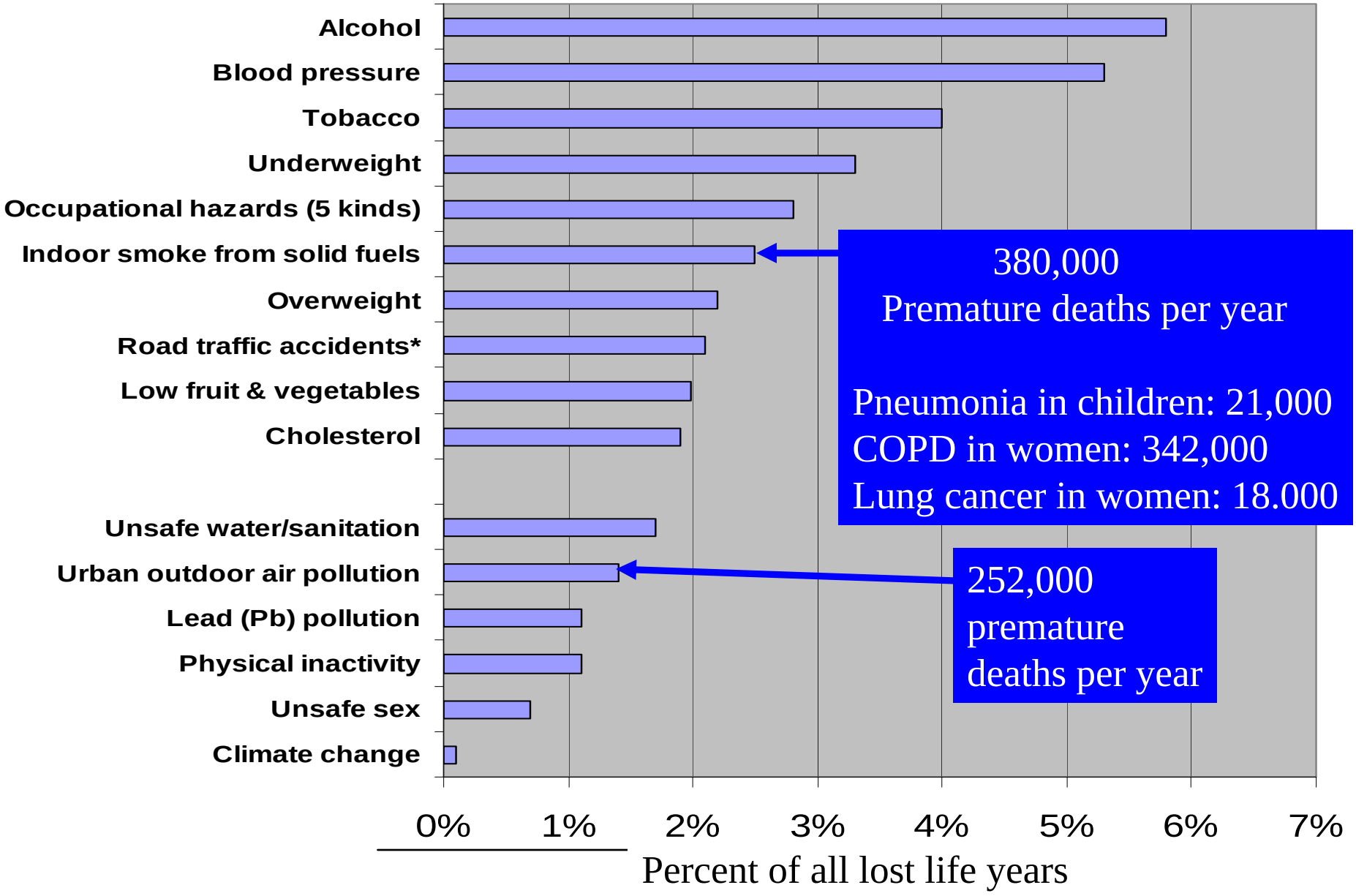


Global Burden of Disease from Top 10 Risk Factors
plus selected other risk factors

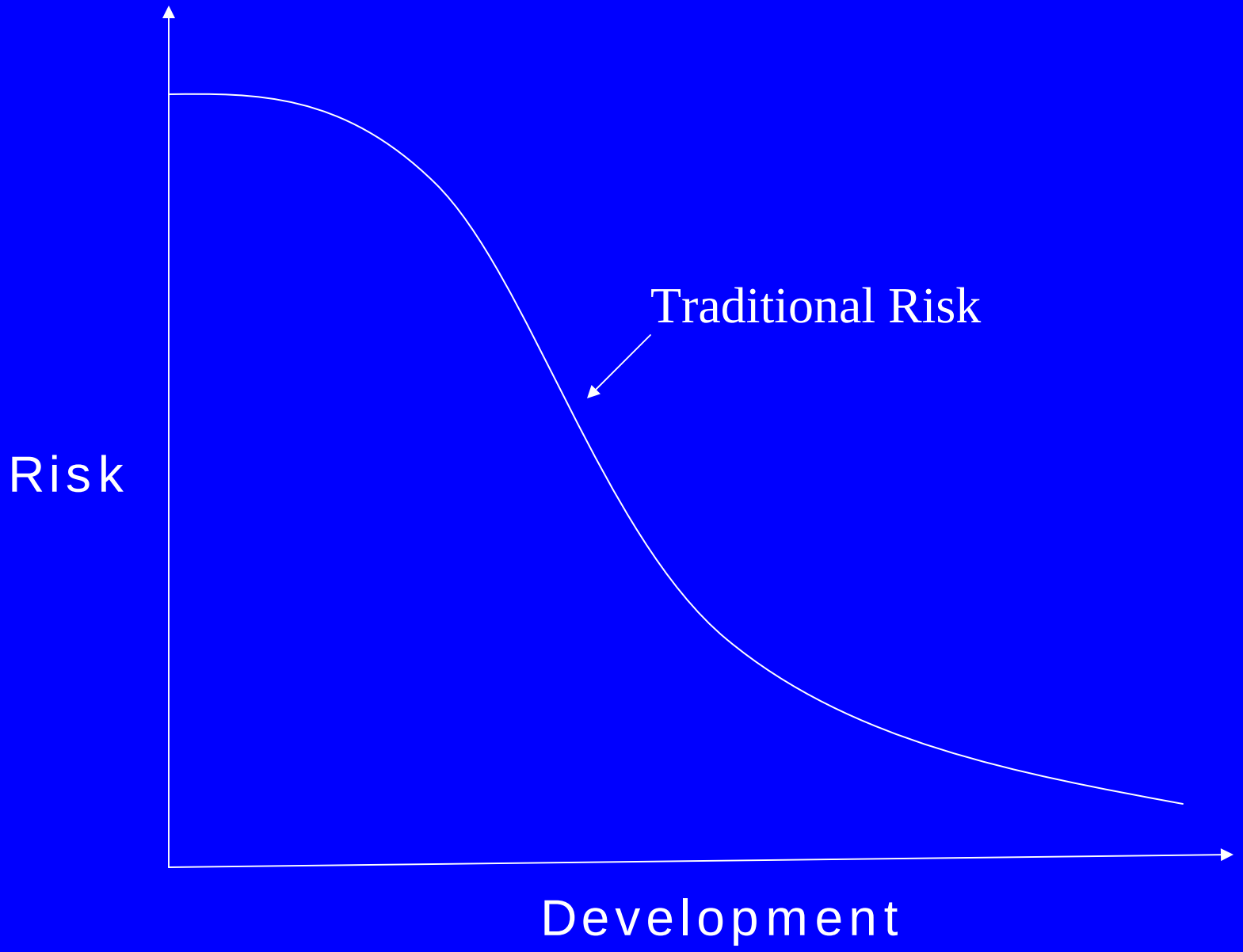


Chinese Burden of Disease from Top 10 Risk Factors

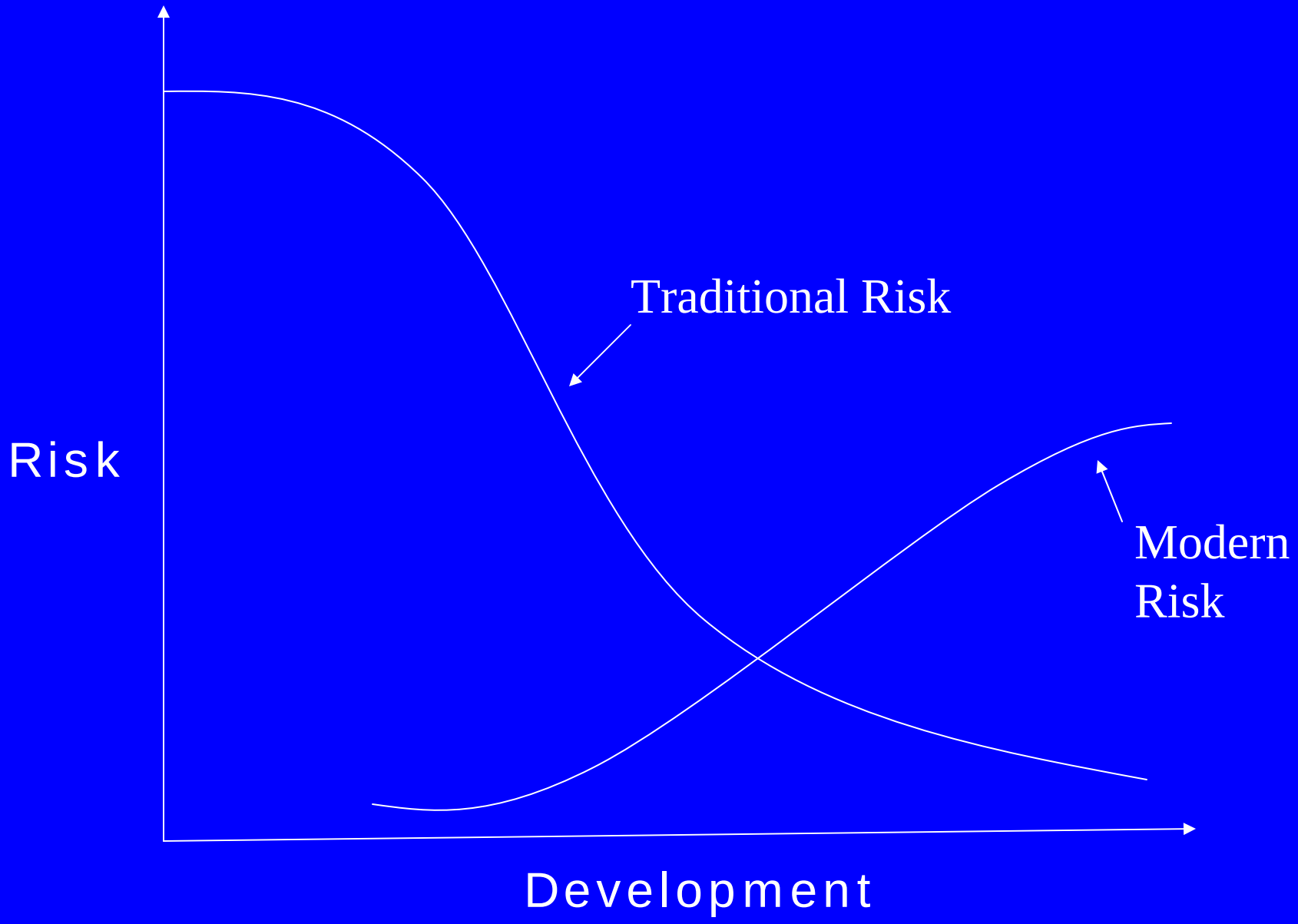
Plus Selected Other Risk Factors



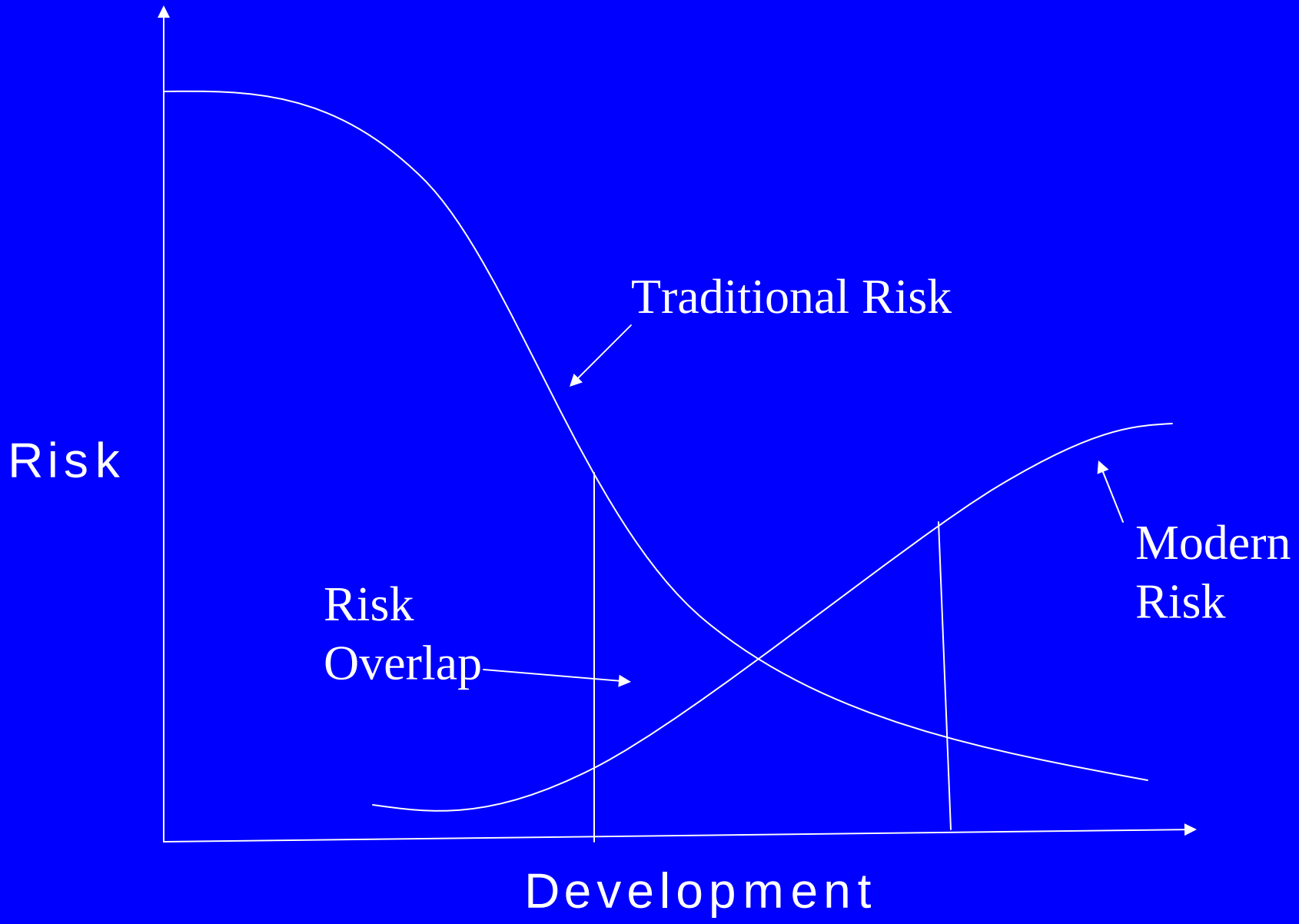
The Environmental Risk Transition



The Environmental Risk Transition



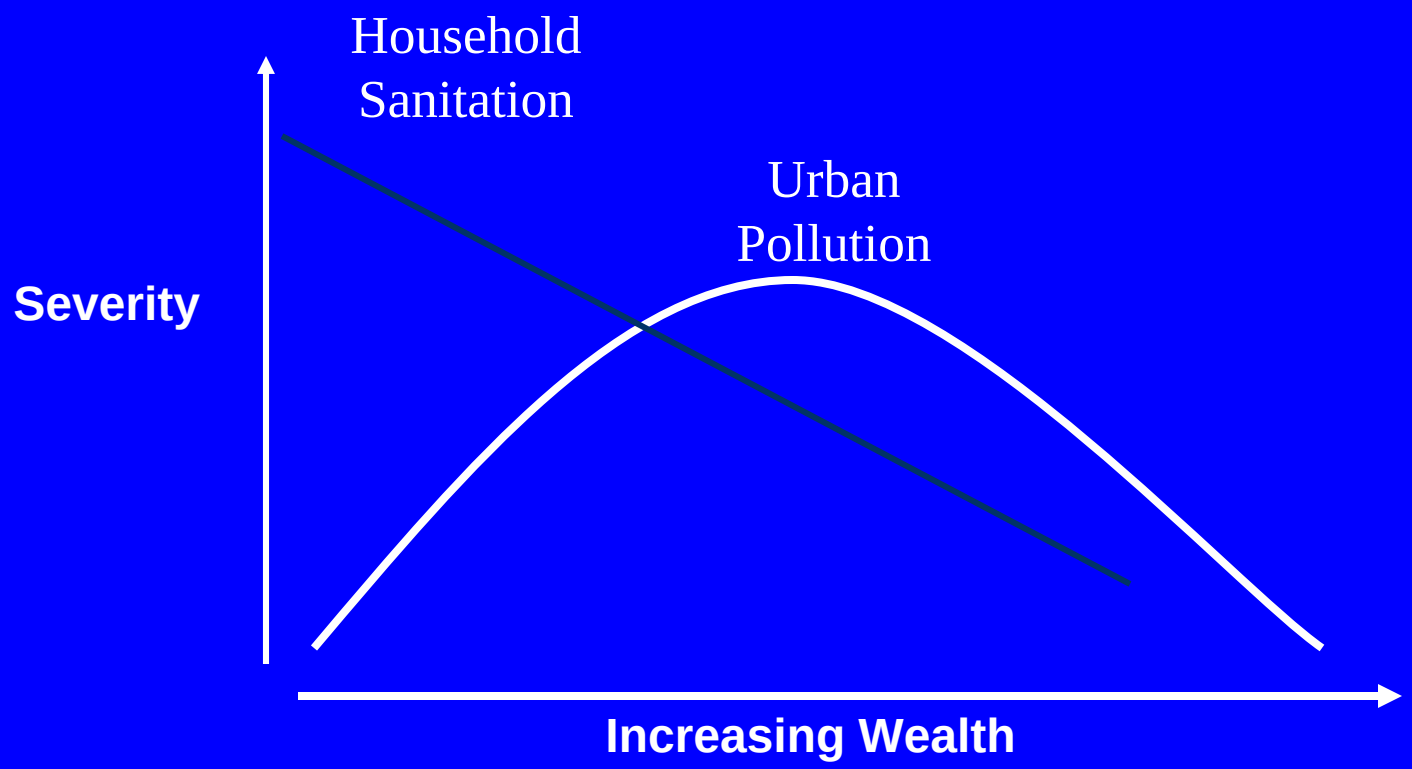
The Environmental Risk Transition



The Risk Overlap

- Risk Genesis: new types of risk created
- Risk Transfer: attempts to control one type can make other types worse
- Risk Synergism: risk of one type changes sensitivity to other risks

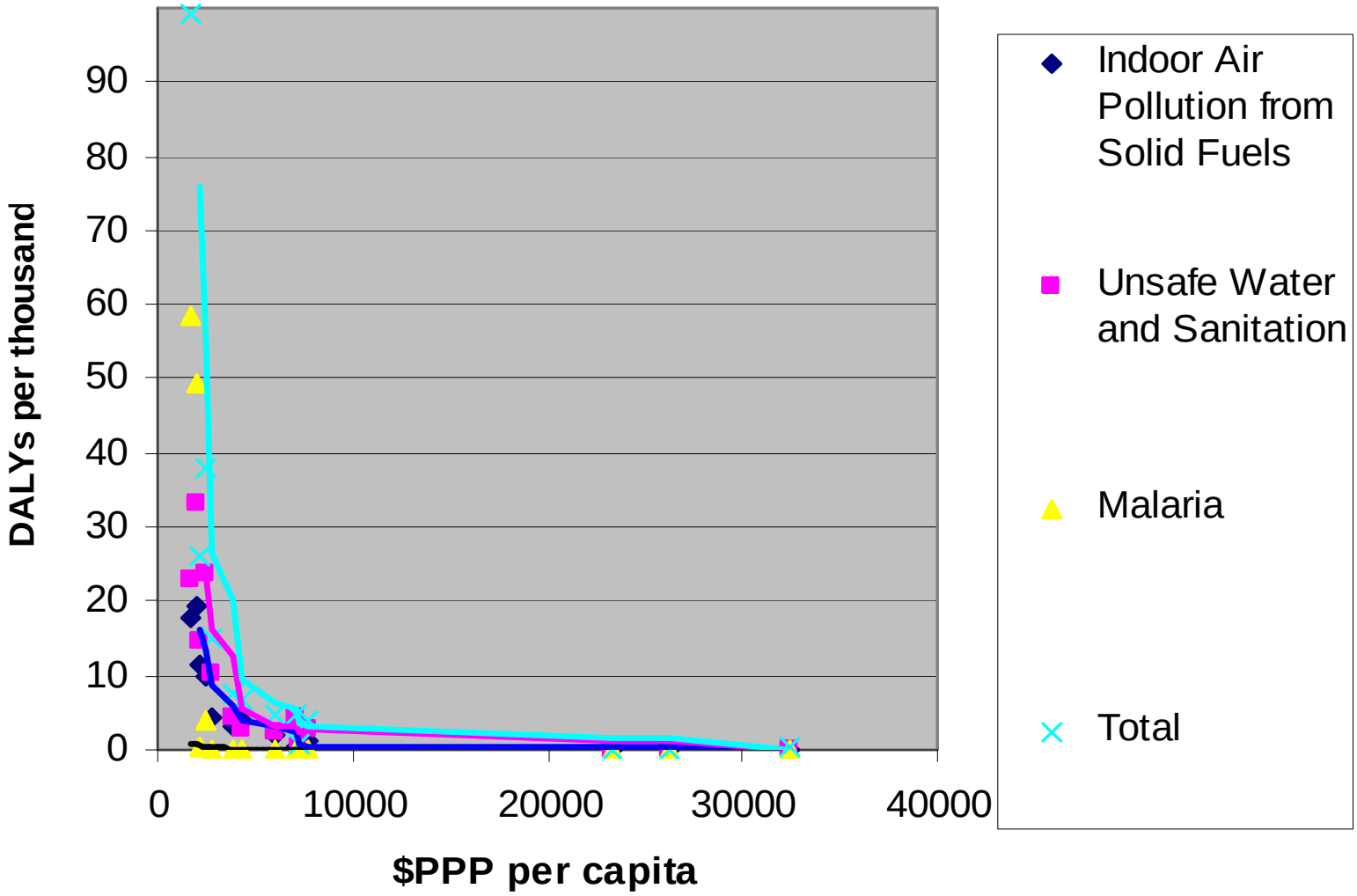
The Environmental Risk Transition

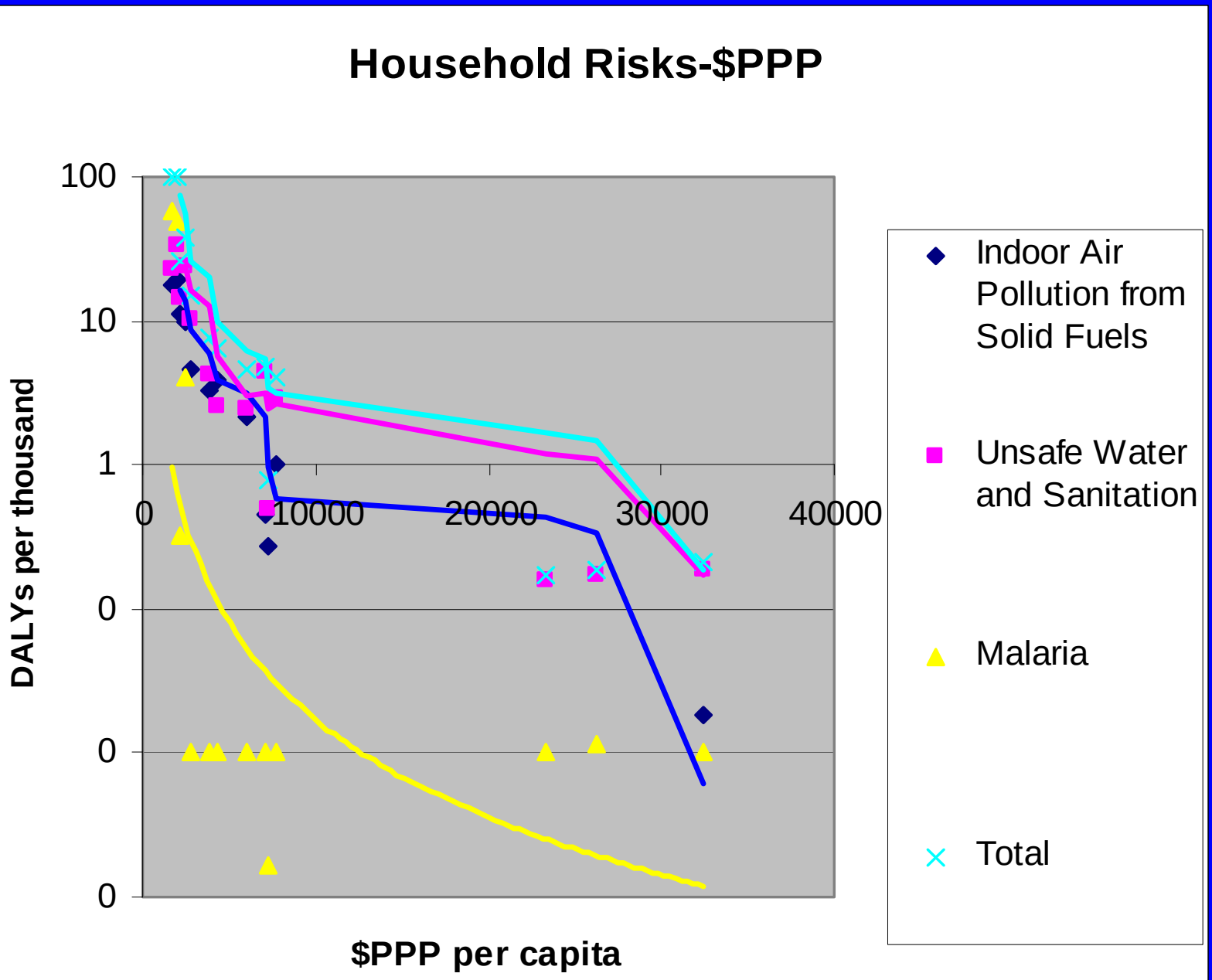


Shifting Environmental Burdens

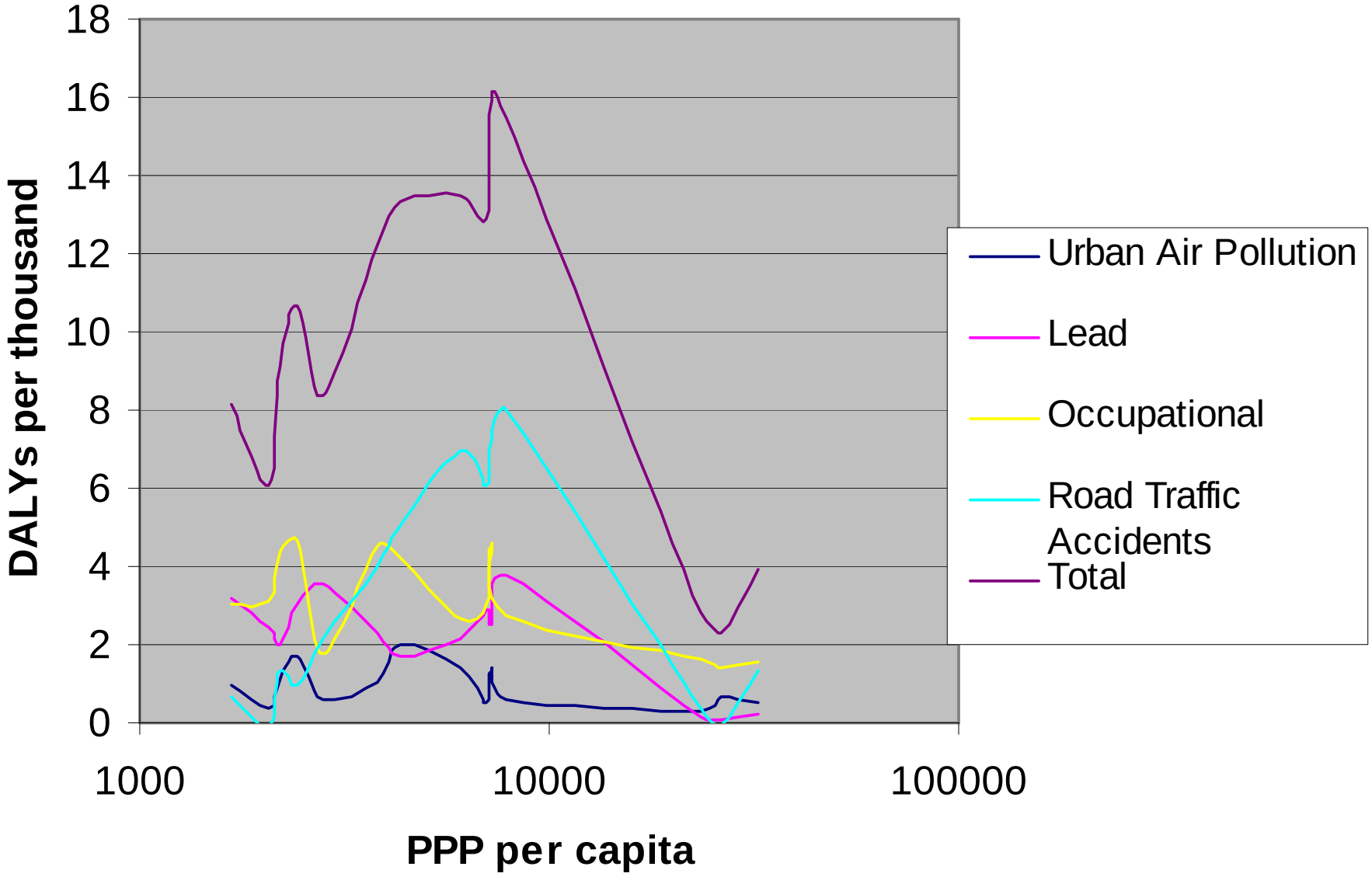
Local	→	Community
Immediate	→	Delayed
Risks to Human Health	→	Risks to Life Support Systems

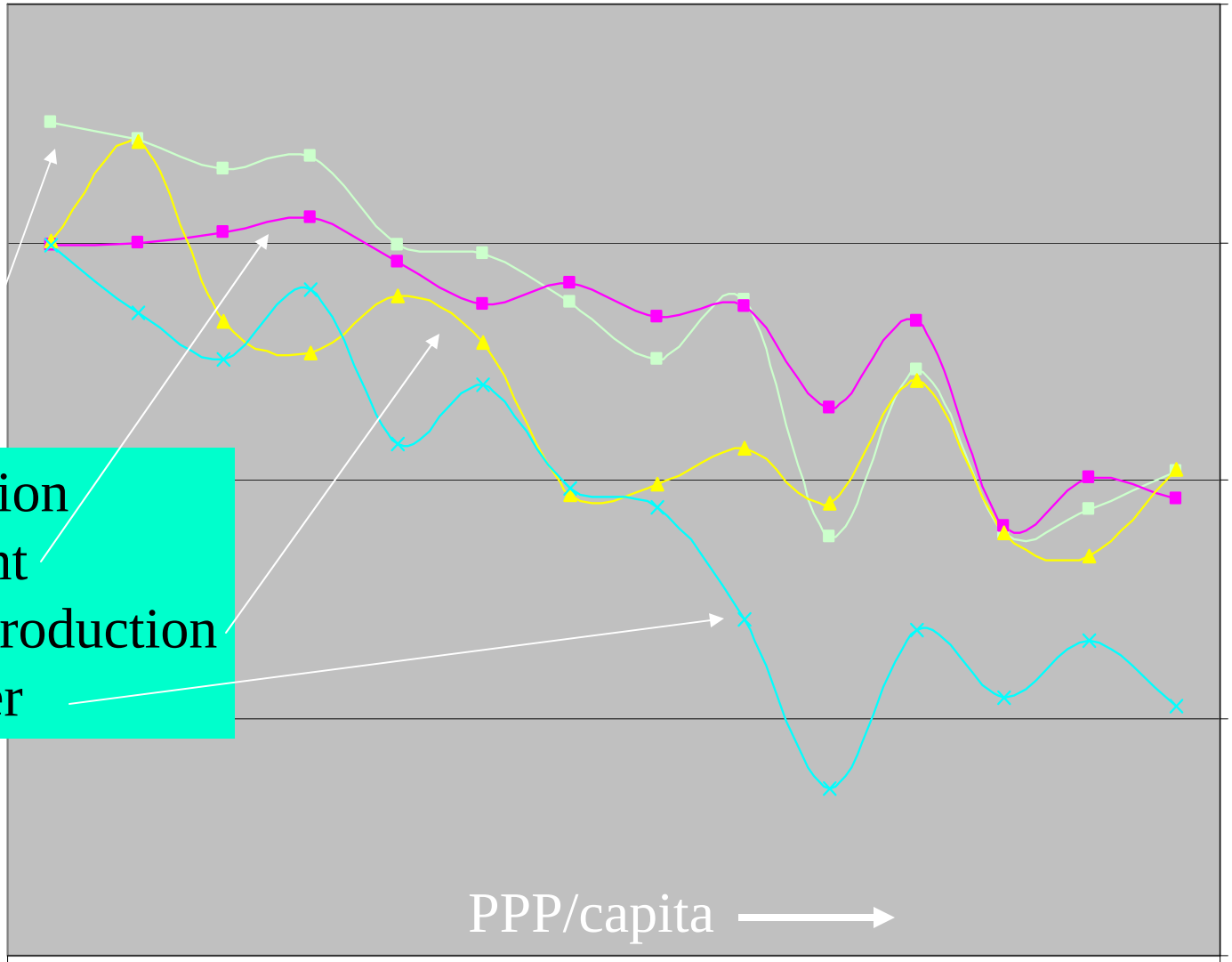
Household Risks-$PPP



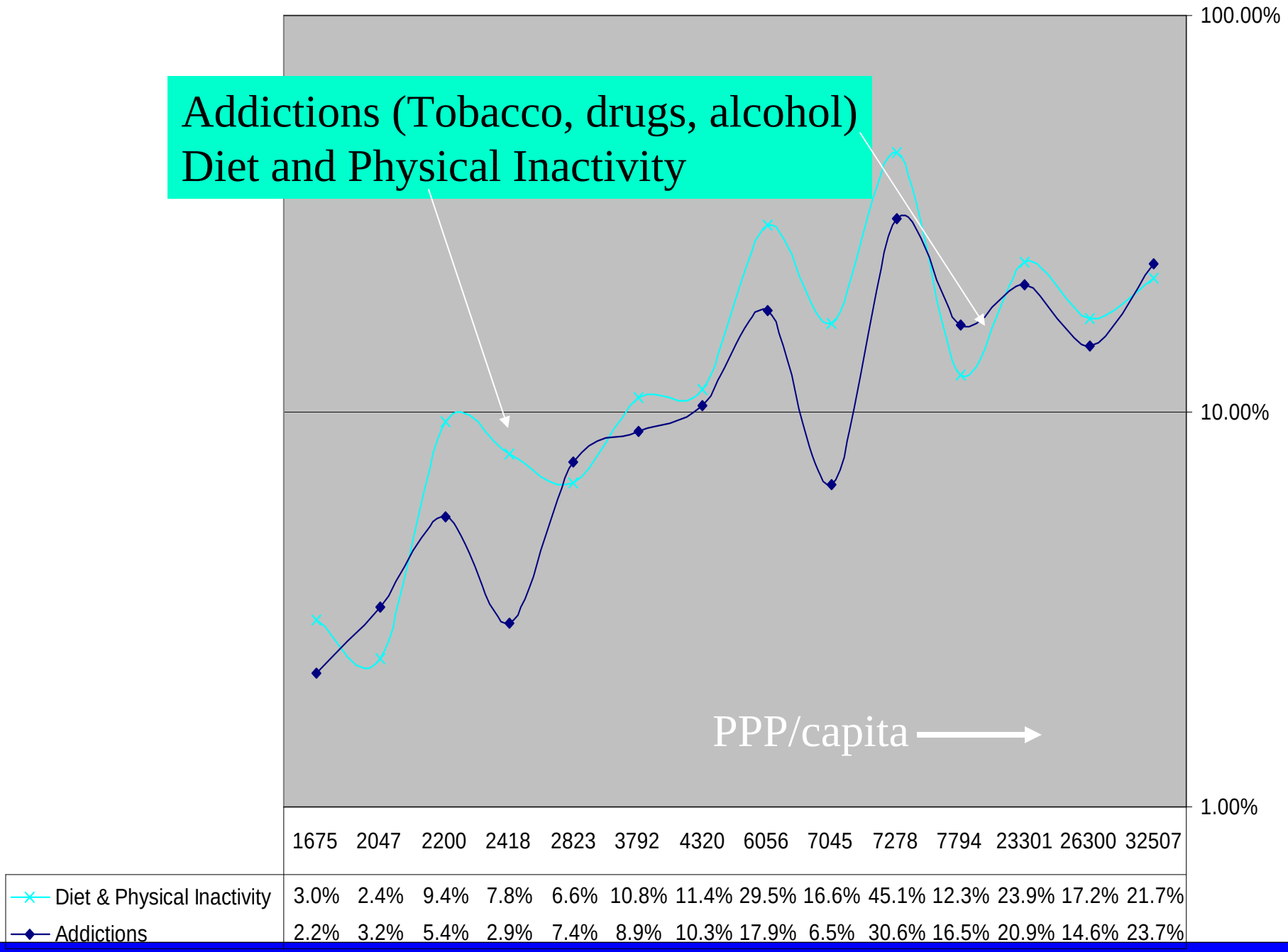

Household Risks-$PPP
100
10
1
0
0
0
10000
20000
30000
40000
DALYs per thousand
$PPP per capita
Indoor Air Pollution from Solid Fuels
Unsafe Water and Sanitation
Malaria
Total

Community Risks

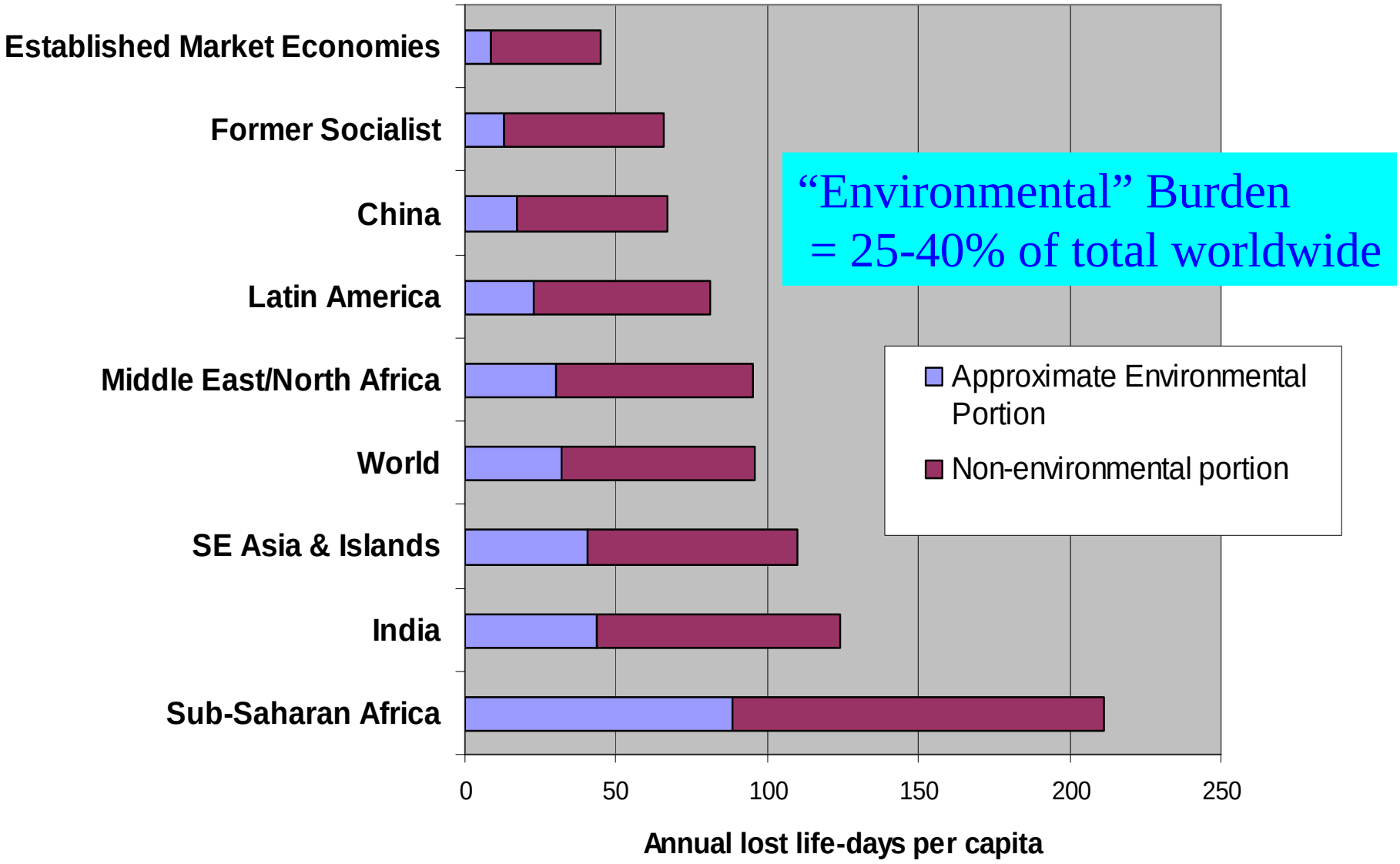




	1675	2047	2200	2418	2823	3792	4320	6056	7045	7278	7794	23301	26300	32507
Undernutrition	31.6%	26.8%	20.1%	22.8%	9.7%	9.0%	5.5%	3.2%	5.6%	0.6%	2.9%	0.6%	0.8%	1.1%
Environment	9.6%	10.0%	11.0%	12.6%	8.2%	5.4%	6.8%	4.8%	5.3%	2.0%	4.7%	0.6%	1.0%	0.8%
Sex and reproduct	10.1%	26.4%	4.7%	3.4%	5.9%	3.8%	0.9%	1.0%	1.4%	0.8%	2.6%	0.6%	0.5%	1.1%
Child Cluster	9.8%	5.0%	3.2%	6.3%	1.4%	2.5%	0.9%	0.8%	0.3%	0.1%	0.2%	0.1%	0.2%	0.1%

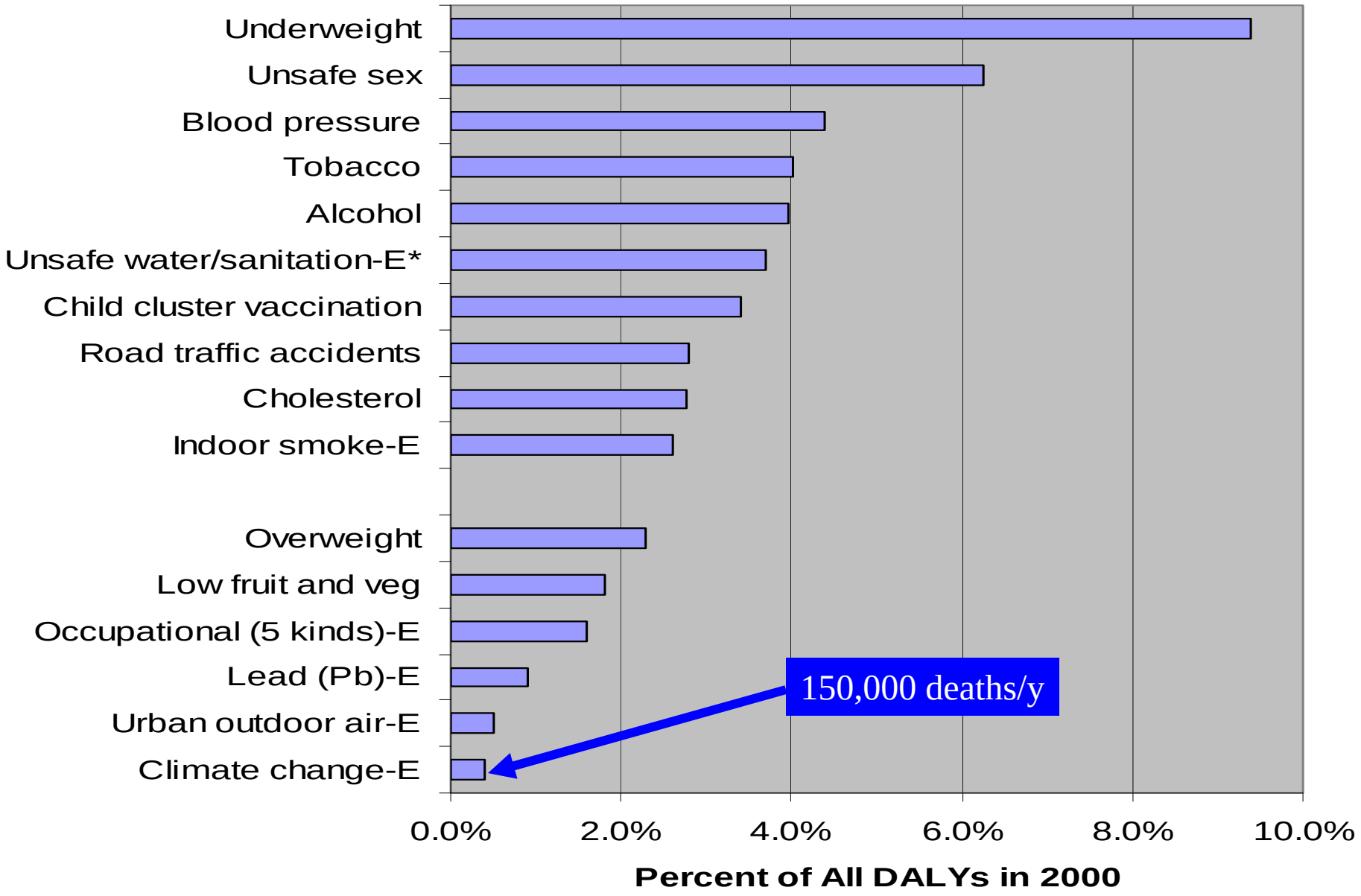

Addictions (Tobacco, drugs, alcohol)
Diet and Physical Inactivity
100.00%
10.00%
1.00%
PPP/capita
1675 2047 2200 2418 2823 3792 4320 6056 7045 7278 7794 23301 26300 32507
Diet & Physical Inactivity 3.0% 2.4% 9.4% 7.8% 6.6% 10.8% 11.4% 29.5% 16.6% 45.1% 12.3% 23.9% 17.2% 21.7%
Addictions 2.2% 3.2% 5.4% 2.9% 7.4% 8.9% 10.3% 17.9% 6.5% 30.6% 16.5% 20.9% 14.6% 23.7%

Burden of Ill-health by Region

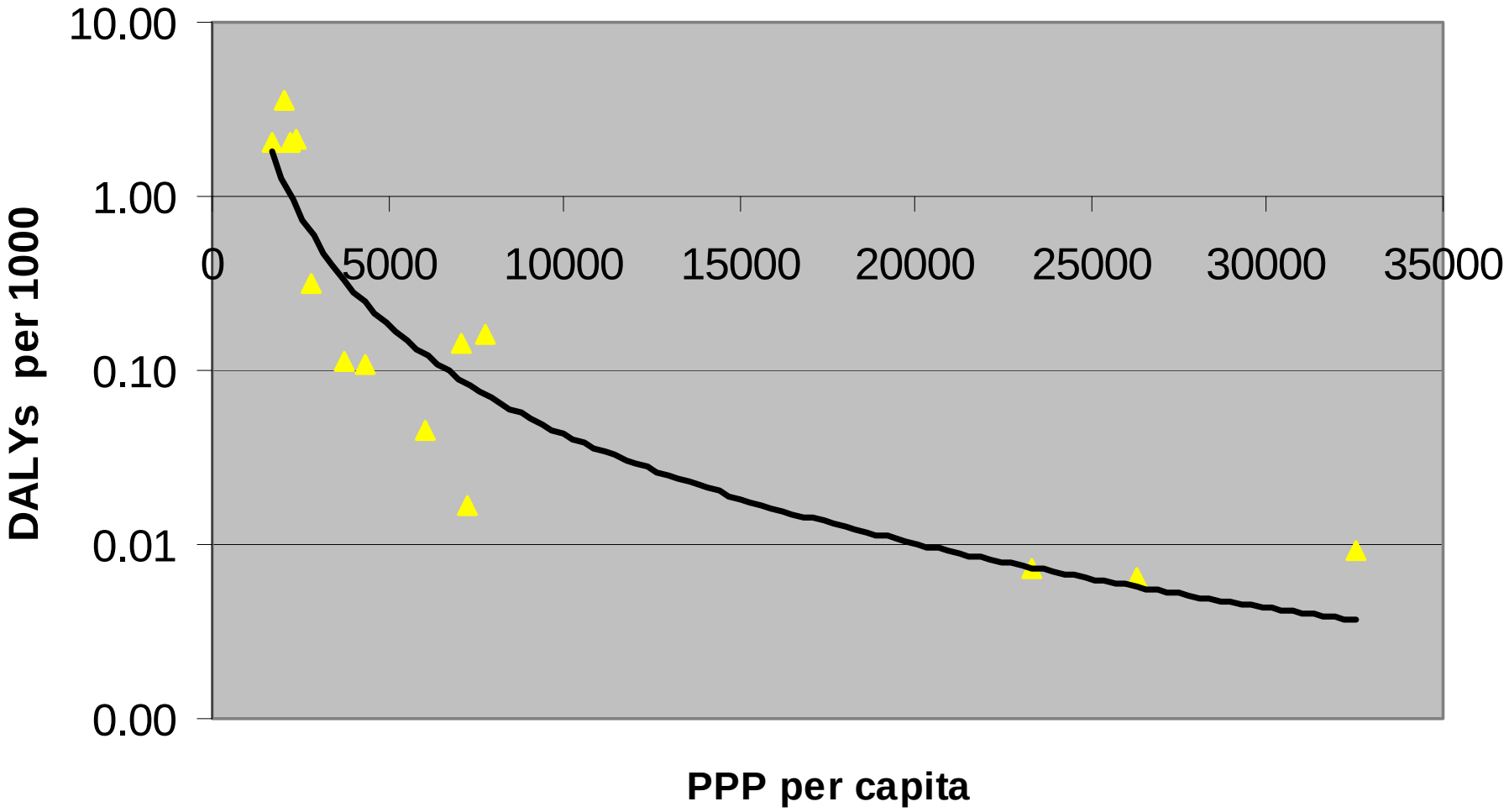


Global Burden of Disease from Top 10 Risk Factors

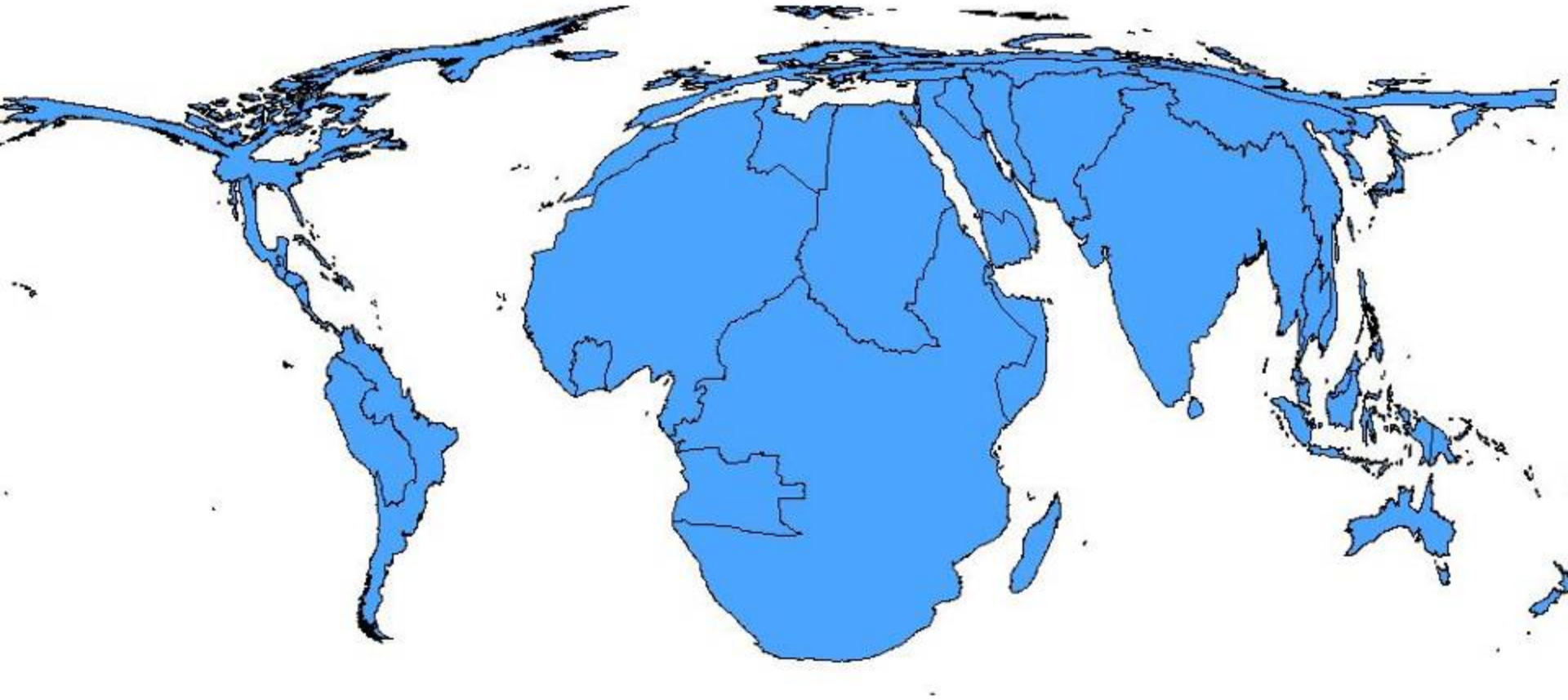
plus selected other risk factors



Global Risk Transition
(Experiencing Risks)



Cartogram of Climate-related Mortality (per million pop) yr. 2000

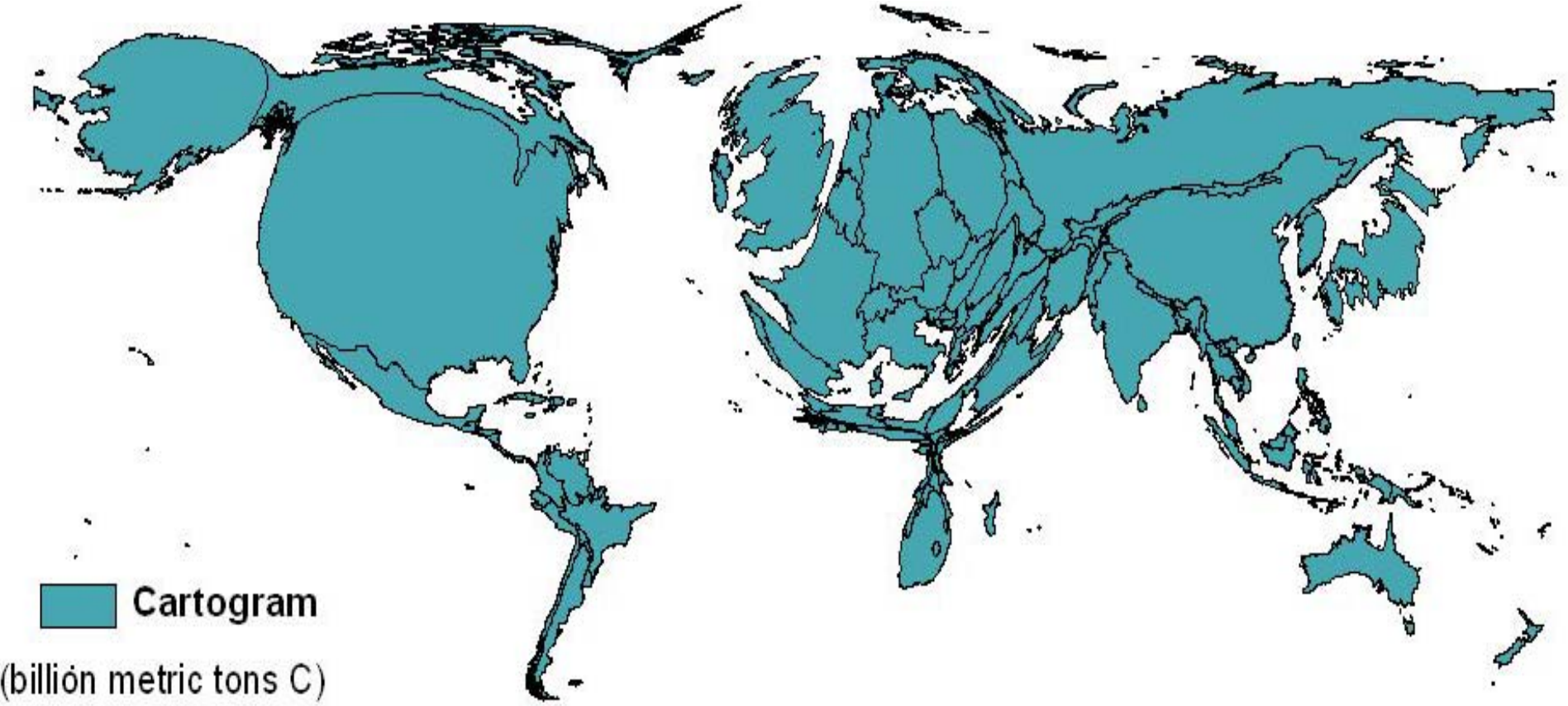


Patz et al. 2007

This map shows estimated mortality (per million people) attributable to climate change by the year 2000. Map is a density-equalizing cartogram in which the sizes of the 14 WHO regions are proportional to the increased mortaility.

sage

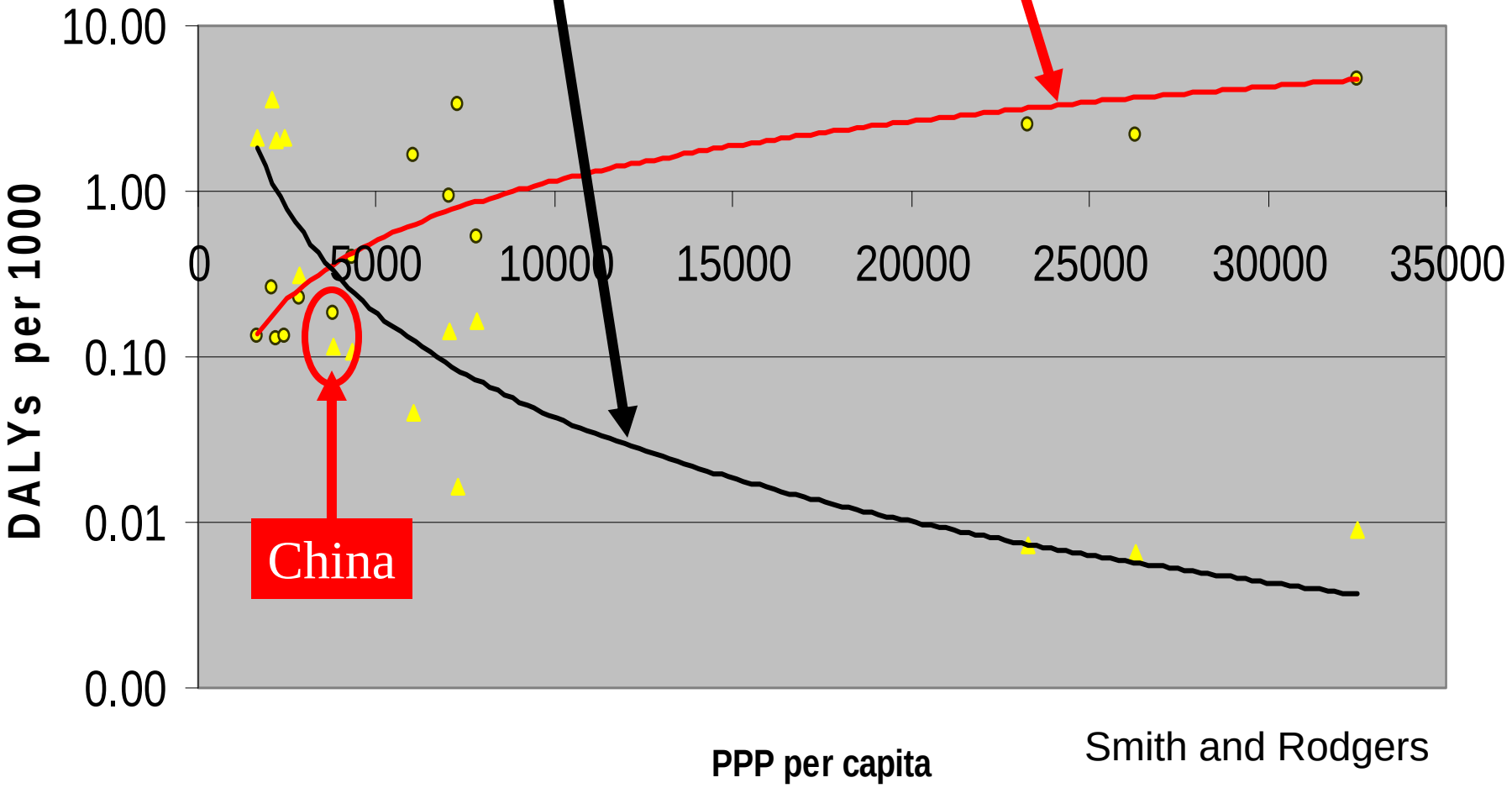
Distribution of Natural Debt by Country: Carbon in Cumulative CO_2 emissions



Patz et al. 2007

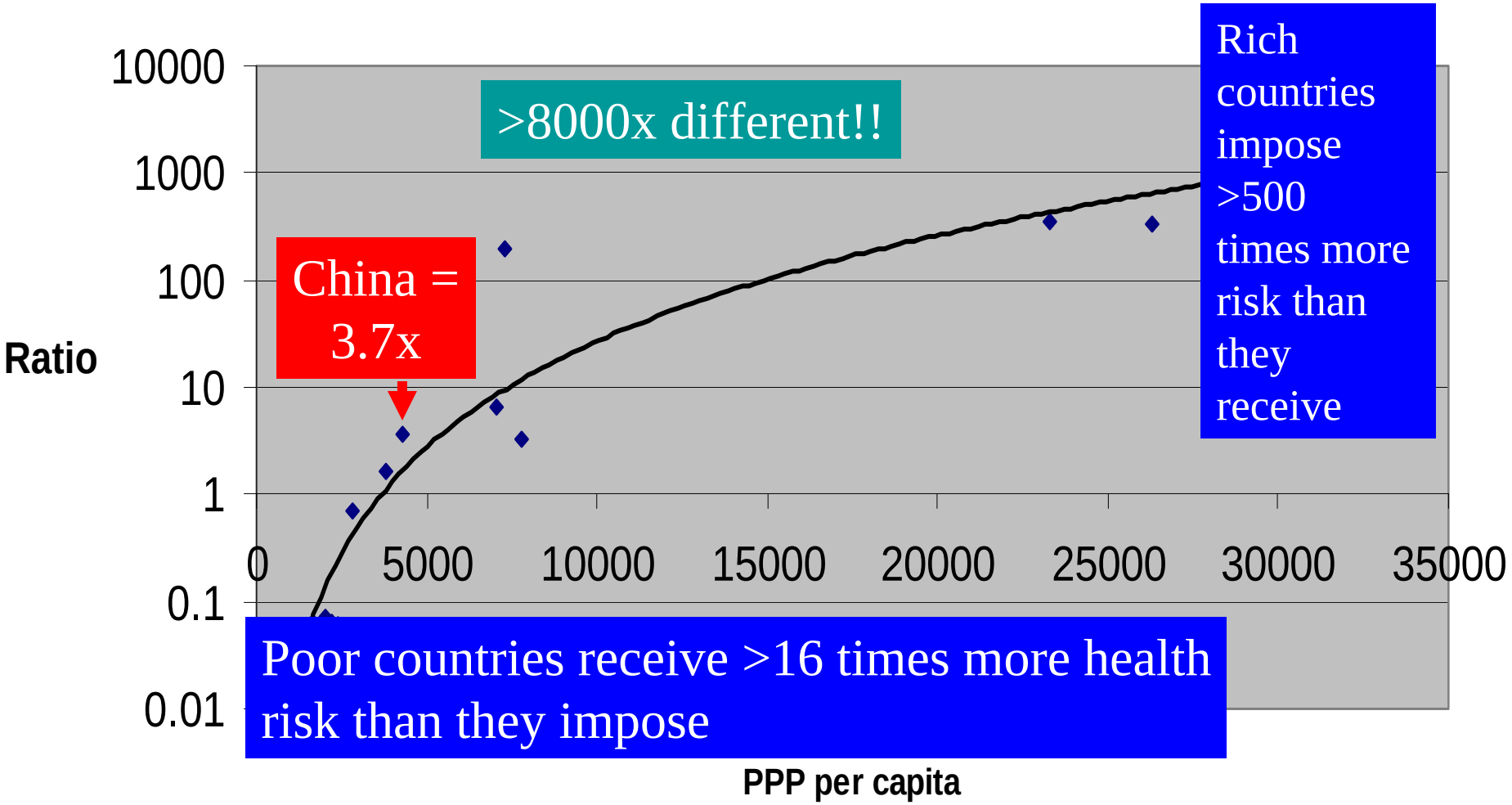
Distribution of Health Impacts from Climate Change

(Experiencing versus Imposing)



Smith and Rodgers

Distribution of Health Impacts from Climate Change (Ratio: Imposing/Experiencing)



WHO Comparative Risk Assessment – 2004 Climate Change Health Impacts as of 2000

- Diarrhea – 2.4% of global burden
- Malaria – 2%; 6% in some regions
- 17% of protein-energy malnutrition
- 7% of dengue fever in some rich countries
- 150,000 deaths, 99% in poor countries (46% in South Asia)
- 0.4% of all DALYs
- Most (88%) of impact in children under 5
- Basically acts as a multiplier of other environmental risks
- Since these are highest at the household level in developing countries, that is where the burden will mostly occur

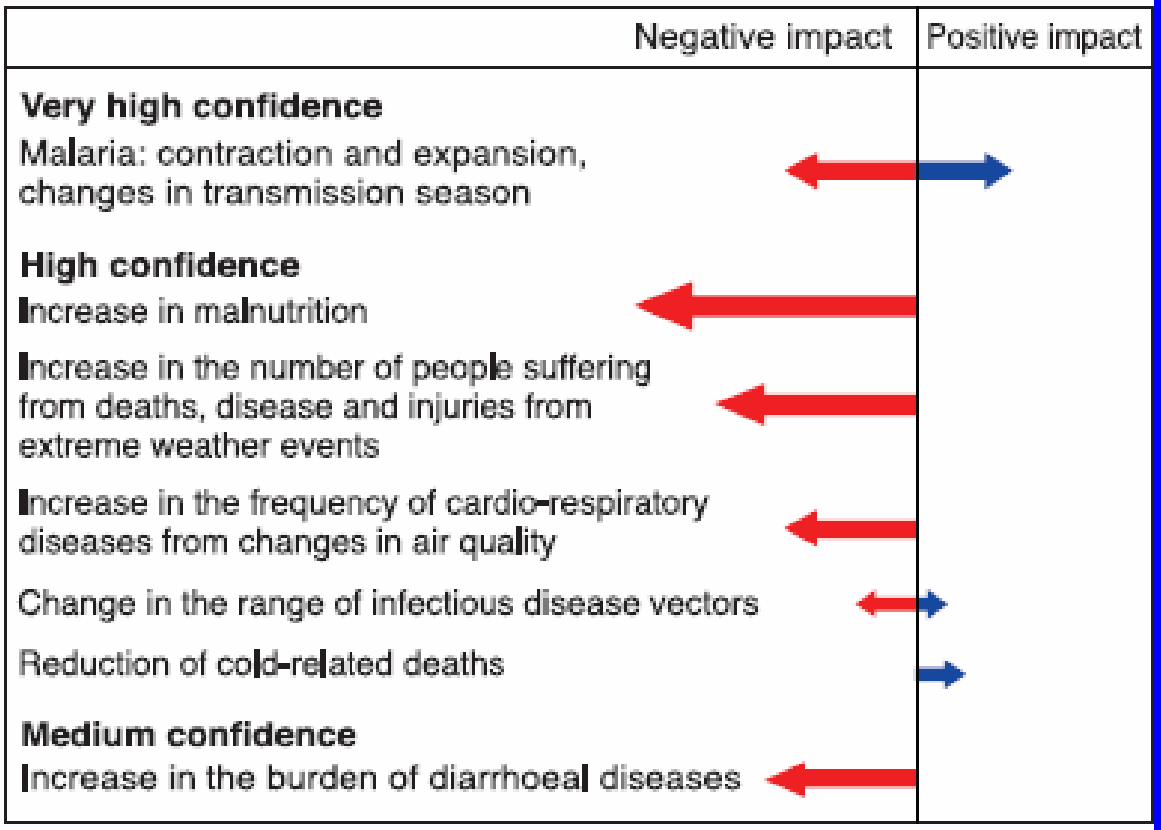
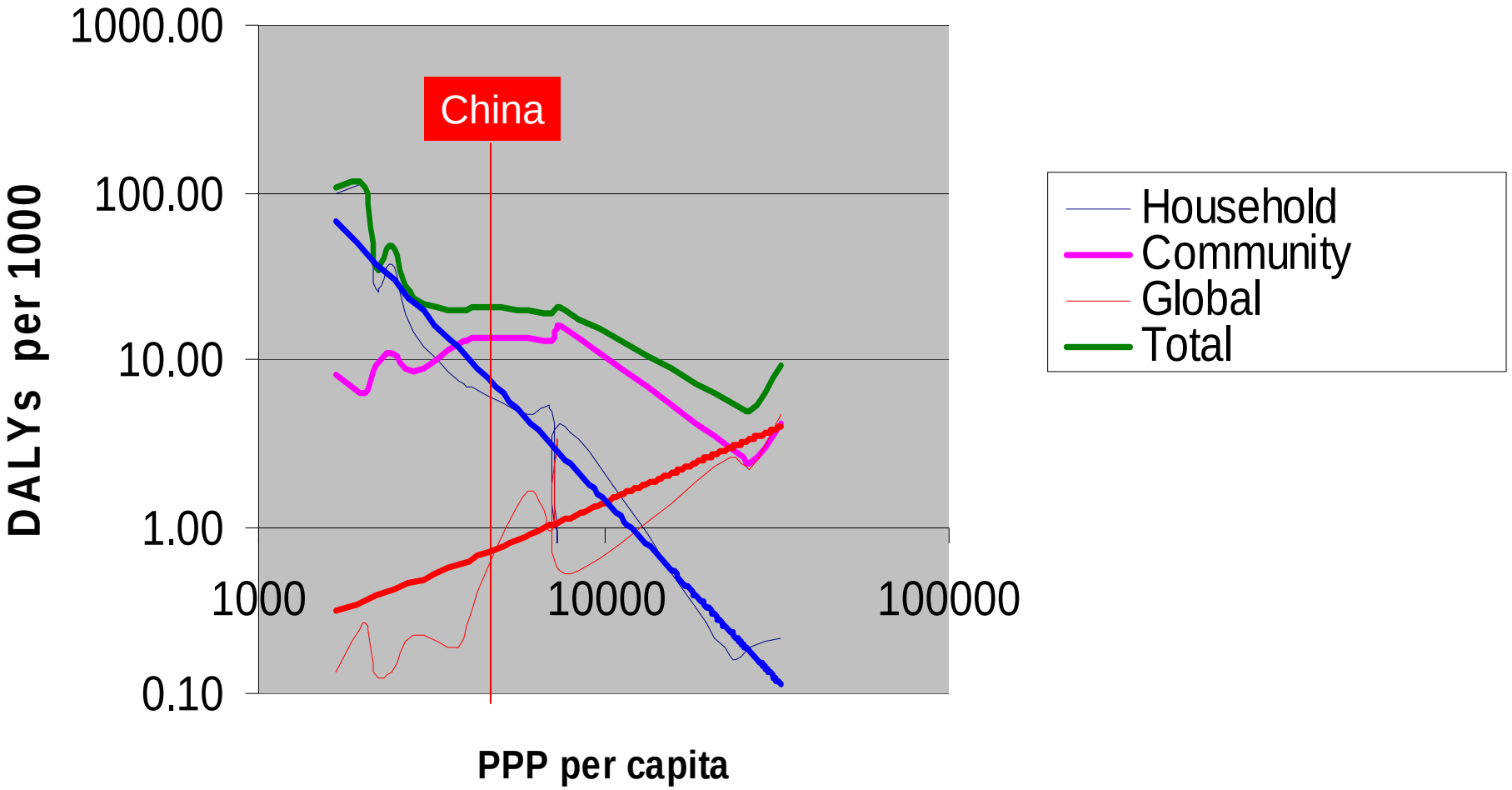


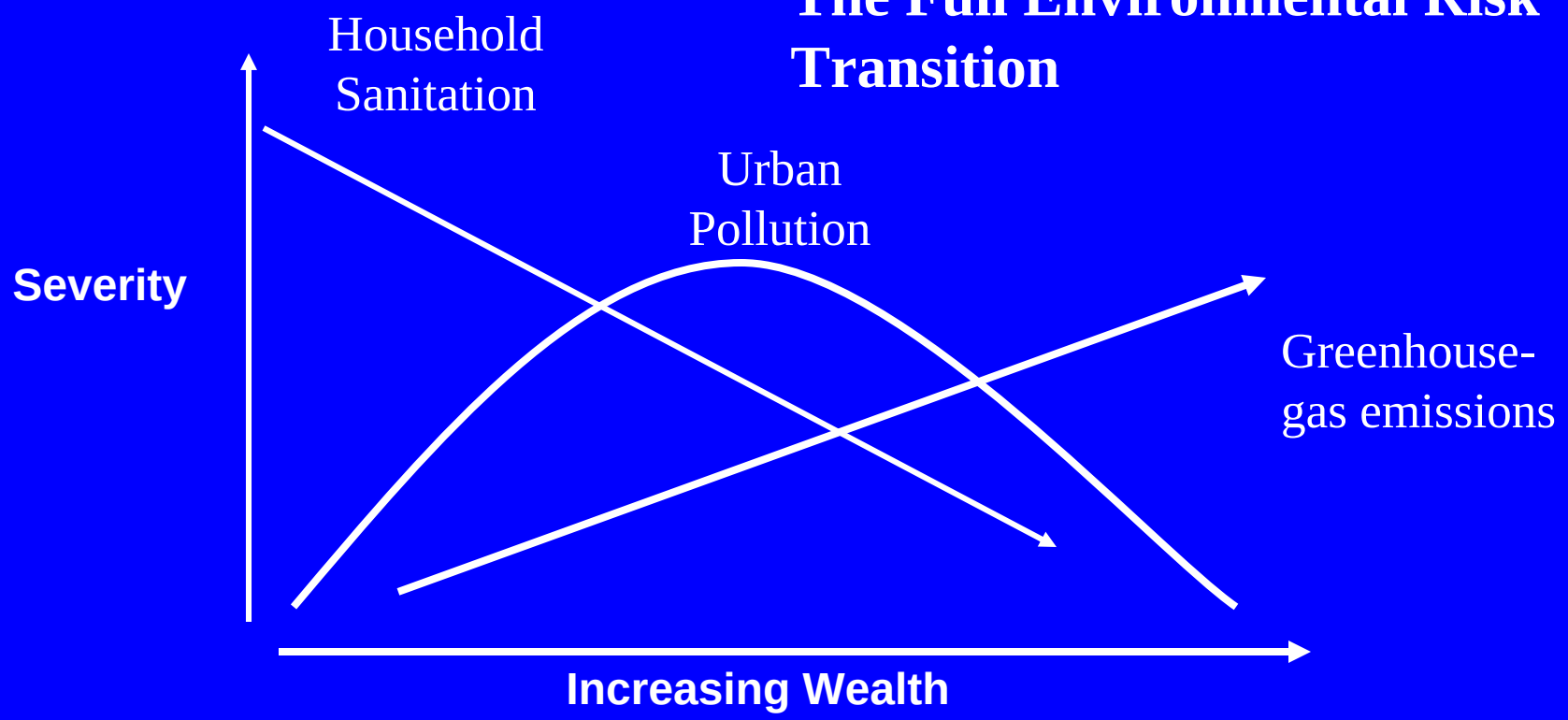
Figure 8.3. *Direction and magnitude of change of selected health impacts of climate change (confidence levels are assigned based on the IPCC guidelines on uncertainty, see http://www.ipcc.ch/activity/uncertaintyguidancenote.pdf).*

IPCC WGII, 2007

Environmental Risk Transition
(Imposed Global Risk)



The Full Environmental Risk Transition



Shifting Environmental Burdens

Local	→	Global
Immediate	→	Delayed
Risks to Human Health	→	Risks to Life Support Systems

Recent references

- Zhang J & Smith KR, **Household Air Pollution from Coal and Biomass Fuels in China: Measurements, Health Impacts, and Interventions**. *Environmental Health Perspectives* 115 (6): 848-855, 2007
- Confalonieri U. and many others, ***Human Health***, Chapter 8 of the IPCC 4th Assessment Report, WGII, **Impacts, Adaptation, and Vulnerability** Cambridge University Press, UK, p. 391-431, 2007
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- Smith KR, Haigler E, **Co-benefits of climate mitigation and health protection in energy systems: Scoping methods**, *ibid.*
- Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, **Climate change and global health: An unprecedented ethical crisis**, *EcoHealth* 4 (in press)

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