Lancet
Commission on Pollution and Health:
A Brief Description of Methods

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Briefing for India
India Habitat Centre
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How would we answer this question?

- What is the total impact of disease and injury in the population? -- the overall target for public health interventions?
  - Which diseases are most important for which groups?
  - Are things getting better or worse?

- This is answered by the Global Burden of Disease
What is the most commonly reported measure of ill-health?

- Number of deaths
- Has advantages
  - Related to disease and injury
  - Easy to determine
  - Commonly tabulated
- But has severe problems as a measure
  - Everyone dies; health never achieved
  - Age is clearly important
  - Deaths + Illness = ?
Combined Measure of Ill-health

- Most fundamental metric 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 (illness and injury), as well, but need to weight the relative severity of disabilities as well as tabulate their duration
Disability Adjusted Life Year

The DALY

- Principle #1: The only differences in the rating of a death or disability should be due to age, not to income, culture, location, sex, 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)
## Years of Lost Life - YLLs

<table>
<thead>
<tr>
<th>Age at Death</th>
<th>YLLs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>86</td>
</tr>
<tr>
<td>1</td>
<td>85.3</td>
</tr>
<tr>
<td>5</td>
<td>81.5</td>
</tr>
<tr>
<td>15</td>
<td>71.5</td>
</tr>
<tr>
<td>25</td>
<td>61.7</td>
</tr>
<tr>
<td>35</td>
<td>51.9</td>
</tr>
<tr>
<td>50</td>
<td>37.5</td>
</tr>
<tr>
<td>80</td>
<td>12.4</td>
</tr>
<tr>
<td>100</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Based on composite best life expectancy in the world for men and women – 86 years at birth.
<table>
<thead>
<tr>
<th>1990 Rank</th>
<th>2015 Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrheal diseases</td>
<td>Ischemic heart disease</td>
</tr>
<tr>
<td>Lower respiratory infect</td>
<td>COPD</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>Neonatal preterm birth</td>
</tr>
<tr>
<td>Neonatal preterm birth</td>
<td>Cerebrovascular disease</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>Lower respiratory infect</td>
</tr>
<tr>
<td>COPD</td>
<td>Neonatal encephalopathy</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>Diarrheal diseases</td>
</tr>
<tr>
<td>Neonatal encephalopathy</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>Iron-deficiency anemia</td>
<td>Sense organ diseases</td>
</tr>
<tr>
<td>Asthma</td>
<td>Diabetes</td>
</tr>
<tr>
<td>Measles</td>
<td>Low back &amp; neck pain</td>
</tr>
<tr>
<td>Sense organ diseases</td>
<td>Iron-deficiency anemia</td>
</tr>
<tr>
<td>Low back &amp; neck pain</td>
<td>Road injuries</td>
</tr>
<tr>
<td>Road injuries</td>
<td>Chronic kidney disease</td>
</tr>
<tr>
<td>Meningitis</td>
<td>Depressive disorders</td>
</tr>
<tr>
<td>Tetanus</td>
<td>Self-harm</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Congenital defects</td>
</tr>
<tr>
<td>Intestinal infectious</td>
<td>Other musculoskeletal</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>Skin diseases</td>
</tr>
<tr>
<td>Congenital defects</td>
<td>Migraine</td>
</tr>
<tr>
<td>Depressive disorders</td>
<td>Asthma</td>
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<td>Migraine</td>
<td>Tetanus</td>
</tr>
</tbody>
</table>
How would we answer this second question?

- How do we compare the impacts of different risk factors and potential interventions that affect different populations?
  - For example, what is the burden of disease from environmental factors?
  - How does the impact of tobacco smoking compare to that from pollution?

- This is answered by the Comparative Risk Assessment of the Global Burden of Disease
Environmental Health Effects

• Example of results from outdoor air pollution studies
  – 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.?
Disability Adjusted Life Year: the DALY and Premature Deaths

These are the metrics used in the Commission Report
What do we mean by pollution?

No pesticide exposures, No endocrine disruptors, No climate change, Etc.
METHODOLOGY

• Review restricted to combinations of pollution risk factors and disease for which there is convincing or probable evidence of causal association

• Likely to be underestimates of the full burden of disease attributable to the pollution exposures
METHODOLOGY

• Soil pollution caused by toxic chemicals and heavy metals at contaminated sites

• Blacksmith Institute/ Pure Earth Toxic Sites Identification program
METHODOLOGY

Common types of contaminated sites

• Used lead-acid battery recycling

• Artisanal and small-scale gold mining where elemental mercury is used
POLLUTION RISK FACTORS

- Pollution (PM2.5), and tropospheric ozone pollution

- Water pollution: unsafe sanitation, and unsafe water sources

- Soil, chemical, and heavy metal pollution: lead (including contaminated sites polluted by lead from battery recycling operations), and mercury from gold mining

- Occupational pollution: occupational carcinogens, and occupational particulates, gases, and fumes
Comparative Risk Assessment Method

Exposure Levels: Past actual and past counterfactual

Exposure-response Relationships (risk)

Disease Burden by age, sex, and region

Attributable Burden by age, sex, and region
Source of Data

1. Exposures – population-weighted surveys, measurements, and modeling

2. Risks – epidemiological studies of exposure/health outcome to obtain relative risks (RR) by disease

3. Counterfactual – depends on risk factor

4. Background Disease Rate from GBD
Annual Average PM2.5 ($\mu$g/m³)

- <1
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80
- 90
- >100

Brauer et al., EST, 2015
State-wise estimates of 24-h kitchen concentrations of PM$_{2.5}$ in India

Solid-fuel using households

Balakrishnan et al., 2013
Generalized Exposure-Response: Outdoor Air, SHS, and Smoking

IHD risks from combustion particles
Annual average PM2.5 in μg/m³

Relative Risk

Smokers

Solid Fuel Zone

Secondhand Tobacco Smoke

Outdoor Air Pollution

CRA
Table 2. Adjusted relative risk estimates\(^a\) for various increments of exposure from cigarette smoking (versus never smokers), second hand cigarette smoke, and ambient air pollution from the present analysis and selected comparison studies.

<table>
<thead>
<tr>
<th>Source of risk estimate</th>
<th>Increments of Exposure</th>
<th>Adjusted RR (95% CI)</th>
<th>Estimated Daily Dose PM(_{2.5}) (mg)(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lung Cancer</td>
<td>IHD</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>≤3 (1.5) cigs/day</td>
<td>10.44 (7.30-14.94)</td>
<td>1.61 (1.27-2.03)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>4-7 (5.5) cigs/day</td>
<td>8.03 (5.89-10.96)</td>
<td>1.64 (1.37-1.96)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>8-12 (10) cigs/day</td>
<td>11.63 (9.51-14.24)</td>
<td>2.07 (1.84-2.31)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>13-17 (15) cigs/day</td>
<td>13.93 (11.04-17.58)</td>
<td>2.18 (1.89-2.52)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>18-22 (20) cigs/day</td>
<td>19.88 (17.14-23.06)</td>
<td>2.36 (2.19-2.55)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>23-27 (25) cigs/day</td>
<td>23.82 (18.80-30.18)</td>
<td>2.29 (1.91-2.75)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>28-32 (30) cigs/day</td>
<td>26.82 (22.54-31.91)</td>
<td>2.22 (1.97-2.49)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>33-37 (35) cigs/day</td>
<td>26.72 (18.58-38.44)</td>
<td>2.58 (1.91-3.47)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>38-42 (40) cigs/day</td>
<td>30.63 (25.79-36.38)</td>
<td>2.30 (2.05-2.59)</td>
</tr>
<tr>
<td>ACS- present analysis</td>
<td>43+ (45) cigs/day</td>
<td>39.16 (31.13-49.26)</td>
<td>2.47 (2.12-2.48)</td>
</tr>
<tr>
<td>ACS-air pol. original</td>
<td>24.5 μg/m(^3) ambient PM(_{2.5})</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>ACS-air pol. extend.</td>
<td>10 μg/m(^3) ambient PM(_{2.5})</td>
<td>1.14 (1.04-1.23)</td>
<td>1.18 (1.14-1.23)</td>
</tr>
<tr>
<td>HSC-air pol. original</td>
<td>18.6 μg/m(^3) ambient PM(_{2.5})</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>HSC-air pol. extend.</td>
<td>10 μg/m(^3) ambient PM(_{2.5})</td>
<td>1.21 (0.92-1.69)</td>
<td>-----</td>
</tr>
<tr>
<td>WHI-air pol.</td>
<td>10 μg/m(^3) ambient PM(_{2.5})</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>SGR-SHS</td>
<td>Low- moderate SHS exp.</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>SGR-SHS</td>
<td>Moderate-high SHS exp.</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>SGR-SHS</td>
<td>Live with smoking spouse</td>
<td>1.21 (1.13-1.30)</td>
<td>-----</td>
</tr>
<tr>
<td>SGR-SHS</td>
<td>Work with SHS exposure</td>
<td>1.22 (1.13-1.33)</td>
<td>-----</td>
</tr>
<tr>
<td>INTERHEART</td>
<td>1-7 hrs/wk SHS exp.</td>
<td>-----</td>
<td>1.24 (1.17-1.32)(^d)</td>
</tr>
<tr>
<td>INTERHEART</td>
<td>Live with smoking spouse</td>
<td>1.28 (1.12-1.47)(^d)</td>
<td>-----</td>
</tr>
</tbody>
</table>

\(^a\)Adjusted RR relative to HR for smoking status. \(^b\)Accumulated dose in the 3 months preceding the interview. \(^c\)Adjusted RR relative to HR for smoking status, adjusted for age, body mass index, and education. \(^d\)Adjusted RR relative to HR for smoking status, adjusted for age, gender, race, and education.
Figure 14: Model of intelligence losses associated with a mean 5-point drop in IQ of a population of 100 million.
India
Both sexes, Age-standardized, DALYs per 100,000
1990 rank

1 Child and maternal malnutrition
2 Air pollution
3 Unsafe water, sanitation, and handwashing
4 Dietary risks
5 High systolic blood pressure
6 Tobacco smoke
7 High fasting plasma glucose
8 High total cholesterol
9 Occupational risks
10 Alcohol and drug use
11 Impaired kidney function
12 High body-mass index
13 Low physical activity
14 Unsafe sex
15 Sexual abuse and violence
16 Other environmental risks
17 Low bone mineral density

2015 rank

1 Dietary risks
2 Air pollution
3 High systolic blood pressure
4 High fasting plasma glucose
5 Child and maternal malnutrition
6 Tobacco smoke
7 Unsafe water, sanitation, and handwashing
8 High total cholesterol
9 Alcohol and drug use
10 High body-mass index
11 Impaired kidney function
12 Occupational risks
13 Unsafe sex
14 Low physical activity
15 Sexual abuse and violence
16 Other environmental risks
17 Low bone mineral density
<table>
<thead>
<tr>
<th></th>
<th>GBD study best estimate (95% CI)</th>
<th>WHO best estimate (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air (total)</td>
<td>6.5 (5.7–7.3)</td>
<td>6.5 (5.4–7.4)</td>
</tr>
<tr>
<td>Household air</td>
<td>2.9 (2.2–3.6)</td>
<td>4.3 (3.7–4.8)</td>
</tr>
<tr>
<td>Ambient particulate</td>
<td>4.2 (3.7–4.8)</td>
<td>3.0 (3.7–4.8)</td>
</tr>
<tr>
<td>Ambient ozone</td>
<td>0.3 (0.1–0.4)</td>
<td>..</td>
</tr>
<tr>
<td>Water (total)</td>
<td>1.8 (1.4–2.2)</td>
<td>0.8 (0.7–1.0)</td>
</tr>
<tr>
<td>Unsafe sanitation</td>
<td>0.8 (0.7–0.9)</td>
<td>0.3 (0.1–0.4)</td>
</tr>
<tr>
<td>Unsafe source</td>
<td>1.3 (1.0–1.4)</td>
<td>0.5 (0.2–0.7)</td>
</tr>
<tr>
<td>Occupational</td>
<td>0.8 (0.8–0.9)</td>
<td>0.4 (0.3–0.4)</td>
</tr>
<tr>
<td>Carcinogens</td>
<td>0.5 (0.5–0.5)</td>
<td>0.1 (0.1–0.1)</td>
</tr>
<tr>
<td>Particulates</td>
<td>0.4 (0.3–0.4)</td>
<td>0.2 (0.2–0.3)</td>
</tr>
<tr>
<td>Soil, heavy metals, and chemicals</td>
<td>0.5 (0.2–0.8)</td>
<td>0.7 (0.2–0.8)</td>
</tr>
<tr>
<td>Lead</td>
<td>0.5 (0.2–0.8)</td>
<td>0.7 (0.2–0.8)</td>
</tr>
<tr>
<td>Total</td>
<td>9.0</td>
<td>8.4</td>
</tr>
</tbody>
</table>
All in under 5-year-olds:
Declined somewhat due to lower exposures, but mainly due to better nutrition, health care (particularly oral rehydration therapy), and vaccines
DATA SOURCES

• Institute for Health Metrics and Evaluation
  2015 Global Burden of Disease analysis

• World Health Organization
  2012 Burden of Disease analysis

• Pure Earth/GAHP Toxic Sites Inventory
  Soil pollution at contaminated sites
Limitations of the Commission

• Economic analysis does not include information about the costs of environmental damage caused by pollution.
• No cost-effectiveness estimates made (these are available, however, in the Disease Control Priorities project recently published by the World Bank.)
• The results based on data from the 2015 Global Burden of Disease study; information that is now 2 years old
• It does not reflect other estimates in its main conclusion, e.g. WHO
India, Both sexes, All ages, 2016

Malnutrition
Air pollution
Dietary risks
High blood pressure
High fasting plasma glucose
Tobacco
WaSH
High total cholesterol
High body-mass index
Alcohol & drug use
Occupational risks
Impaired kidney function
Unsafe sex
Other environmental
Low physical activity
Low dietary fiber
Iron deficiencies
Hypertension
Diabetes
Other cardiovascular diseases
Other communicable, maternal, neonatal, and nutritional diseases
Liver cirrhosis
Other non-communicable diseases
Other injuries
Total deaths
Total DALYs
Total YLDs
Total YLLs
Total YLD%