

ECONOMIC IMPACTS OF POLLUTION

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- Goal: To value the mortality and morbidity associated with pollution
 - For each category of pollution
 - For each country
- Estimates of mortality and morbidity associated with pollution come from the 2015 GBD (IHME)
- GBD reports estimates of deaths by pollutant; little information on morbidity
 - 97% of DALYs lost due to pollution are life-years lost (YLLs)—only 3% years lost to disability
- Focus is on valuing mortality—so an underestimate of total health impacts

Global Burden of Disease: Deaths Due to Pollution

	2015 GBD	2013 GBD
Traditional Pollution Problems:		
Unsafe water source	1,250,000	1,250,000
Unsafe sanitation	808,000	816,000
Household air pollution from solid fuels	2,850,000	2,890,000
Modern Pollution Problems:		
Ambient particulate matter pollution	4,240,000	2,920,000
Ambient ozone pollution	254,000	217,000

Percent of Deaths by Country Group, 2015

	Low income	Lower middle income	Upper middle income	High income	Total
Traditional Pollution Problems:					
Unsafe water source	25%	71%	4%	--	100%
Unsafe sanitation	29%	69%	2%	--	100%
Household air pollution from solid fuels	17%	58%	25%	--	100%
Modern Pollution Problems:					
Ambient particulate matter pollution	6%	44%	39%	11%	100%
Ambient ozone pollution	2%	52%	34%	12%	100%

Valuing Lives Lost Due to Pollution

- Want to measure what people are willing and able to pay for reductions in their risk of dying
 - Measures to control modern pollution will be paid for by individuals themselves—via higher electricity prices, cleaner cars and fuels
 - Solutions to traditional problems (unsafe water and sanitation, indoor air pollution) may come in the form of foreign aid
 - But there are tradeoffs in what foreign aid is spent on—don't want to over-value reductions in pollution relative to improvements in education

How to Measure WTP to Reduce Risk of Death?

- Many studies in high-income countries based on both hypothetical and actual tradeoffs between risk and money
- Results summarized using the “Value per Statistical Life” (VSL)
 - VSL is the sum of what people are willing and able to pay for small reductions in risk of death that sum to 1 life saved
 - Official VSL used by OECD is \$3.7 million, implying that a person would pay \$370 per year to reduce their risk of dying during the year by 1 in 10,000

How Should the VSL Vary Across Countries?

- Typically transfer the VSL from high to lower-income countries based on per capita GNI
- What studies exist in LMICs suggest that the ratio of the VSL to per capita income falls as income falls
 - VSL is ~ 100 times per capita income (Y) in OECD
 - We implement transfers that imply:

World Bank Income Region	Median VSL/Y Ratio
Upper middle income	96
Lower middle income	64
Low income	50

Valuing Lives Lost Due to Pollution

- Calculate welfare damages due to pollution in 2013 = Deaths due to pollution x VSL
 - Table 1 shows results by pollutant and World Bank Income Group
 - Total welfare damages = \$4.3 trillion (5.6% of world output)
- Can also calculate willingness to pay per person to reduce risk of death to zero
 - Measures what a person exposed to the pollution source would be willing to pay to reduce risk to zero
 - Table 2 shows this by pollutant and WB income group

Table 1 - Welfare Damages in 2013 in Billion Dollars and as a Percentage of GDP

World Bank Income Region	AAP and HAP Combined	UW and US Combined	Lead Exposure	Total
High income	1,746 (3.5%)	36 (0.1%)	212 (0.4%)	1,994 (4.0%)
Upper middle income	1,341 (7.4%)	45 (0.2%)	285 (1.6%)	1,670 (9.2%)
Lower middle income	285 (5.5%)	96 (1.8%)	27 (0.5%)	408 (7.8%)
Low income	23 (4.2%)	15 (2.6%)	4 (0.7%)	42 (7.5%)
Total	3,395 (4.6%)	191 (0.3%)	528 (0.7%)	4,113 (5.6%)

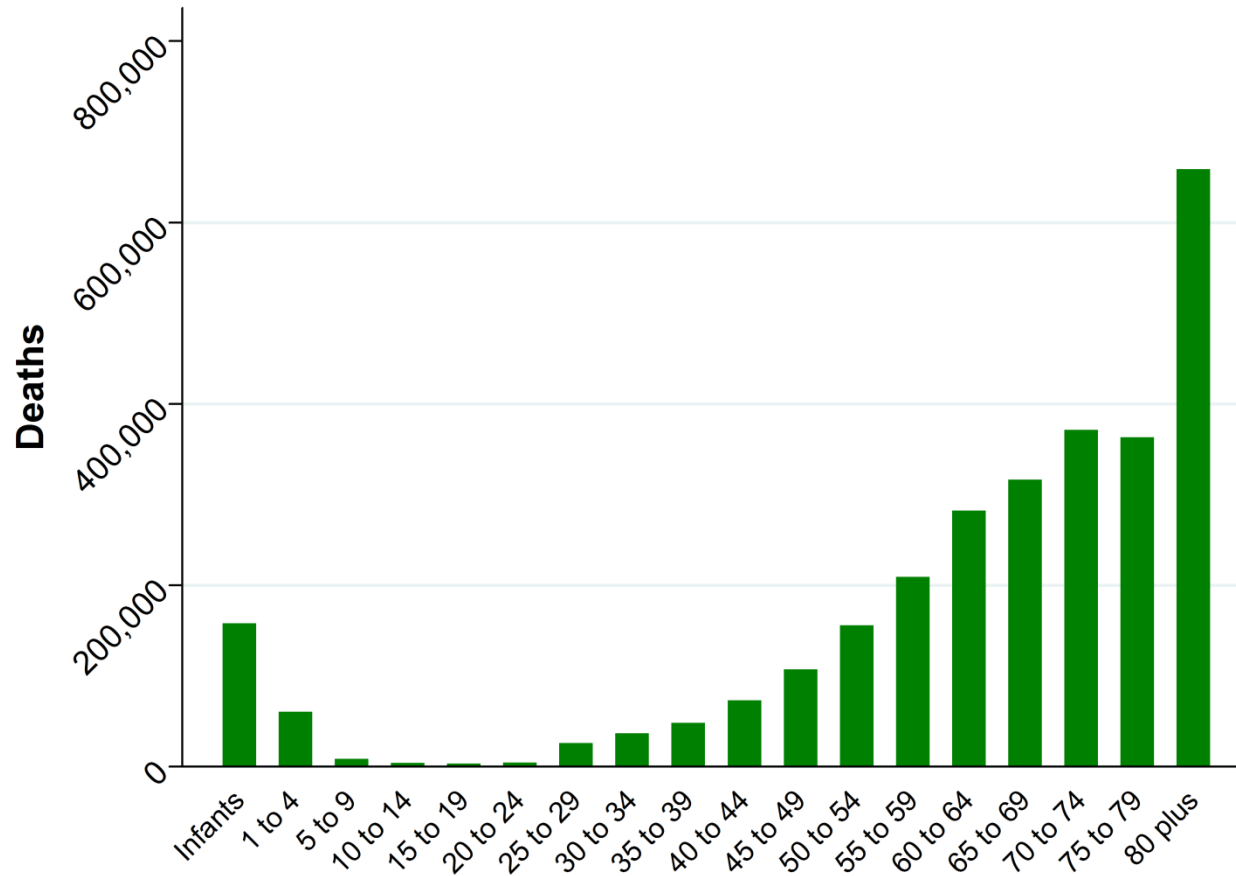
Table 2 - Willingness to Pay Per Person to Reduce Death Risks due to Pollution and Death Risk Reduced (per 10,000)

World Bank Income Region	Ambient Air Pollution (AAP)	Household Air Pollution (HAP)	Unsafe Water Source	Unsafe Sanitation	Lead Exposure
High income	1,373 (4.03)	41 (0.27)	14 (0.073)	4 (0.010)	167 (0.47)
Upper middle income	371 (5.41)	267 (4.03)	18 (0.23)	6 (0.083)	123 (1.84)
Lower middle income	55 (4.24)	69 (5.63)	33 (2.85)	20 (1.78)	11 (0.84)
Low income	10 (2.72)	22 (5.92)	17 (5.36)	13 (4.01)	5 (1.47)
Average	398 (4.42)	141 (4.96)	24 (2.02)	13 (1.32)	76 (1.18)

Productivity Losses

- Measure present value of loss in future GDP when a person dies before age 65
 - Depends on rate at which future output is discounted
- Assumes working age is 15-64
- GDP per worker based on labor's share of GDP
- Does not capture all output losses (home production, informal sector output not in GDP)
- Places no value on deaths after age 65
- An incomplete measure of economic impact, but losses are substantial in low income countries

Age Distribution of Deaths from Household Air Pollution



Age Distribution of Deaths from Ambient PM Pollution

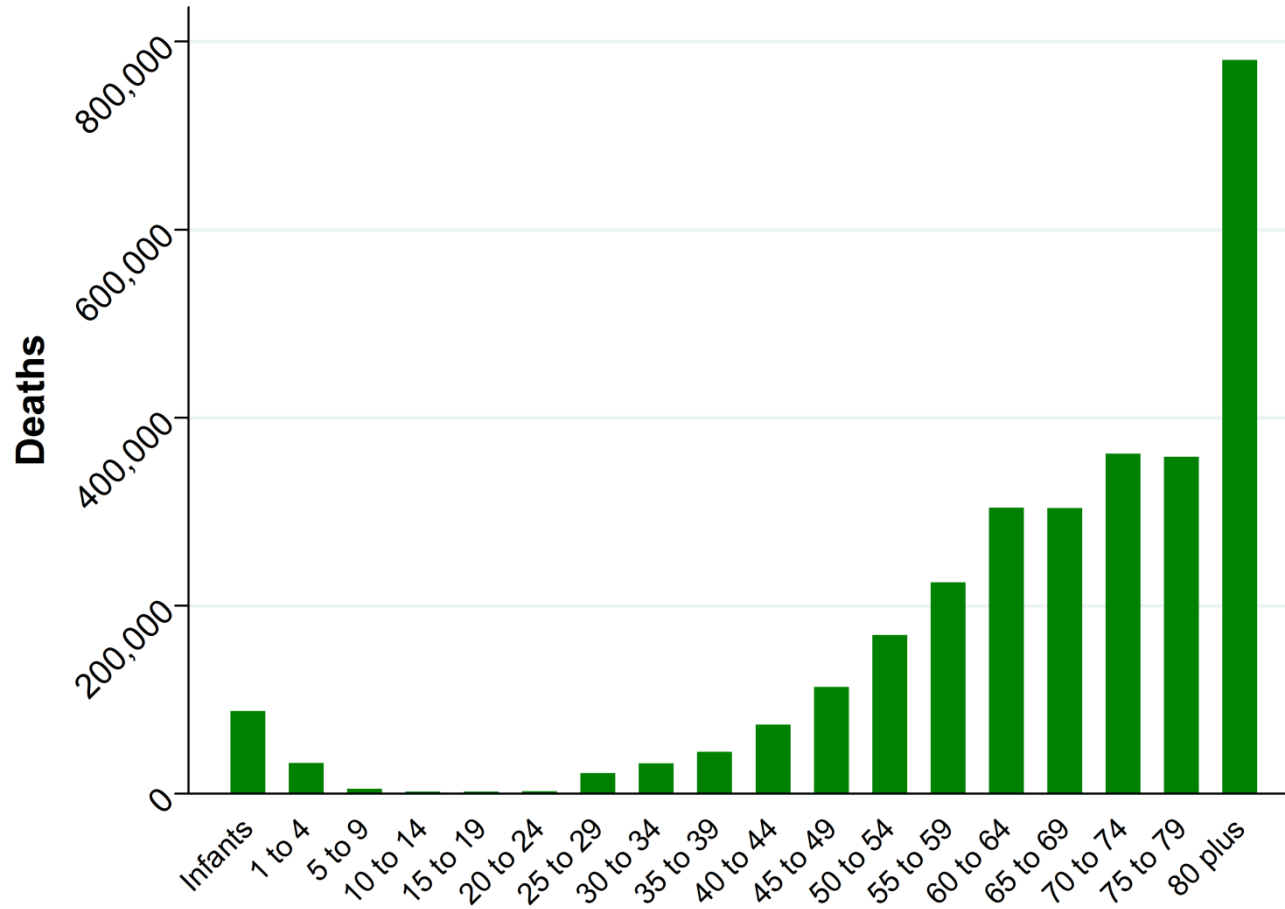


Table 3 – Productivity Losses as a Percentage of GDP by Pollutant and Income Group

World Bank Income Region	Lead Exposure	AAP and HAP Combined	UW and US Combined¹	Total
High income	0.0022 (0.0024)*	0.048 (0.053)	0.0014 (0.0019)	0.052 (0.057)
Upper middle income	0.016 (0.017)	0.11 (0.13)	0.022 (0.032)	0.15 (0.18)
Lower middle income	0.014 (0.016)	0.27 (0.33)	0.21 (0.30)	0.49 (0.65)
Low income	0.042 (0.046)	0.40 (0.54)	0.55 (0.81)	0.99 (1.40)
World	0.0068 (0.0074)	0.083 (0.096)	0.026 (0.037)	0.12 (0.14)

*Base calculations use a discount rate = rate of growth in output + 3%; for numbers in parentheses discount rate = rate of growth in output + 1.5%.

¹ Includes deaths due to lack of handwashing

Health Expenditures

- To calculate fraction of expenditures associated with pollution need
 - Expenditures by disease
 - Fraction of disease associated with pollution
- Expenditures by disease available for some OECD countries and Sri Lanka
- 1.7% of health expenditure associated with air pollution in high income countries
- 7.4% in Sri Lanka

Conclusions

- Economic impacts of pollution deaths in 2013 are substantial
 - Welfare impacts from:
 - Household and ambient air pollution
 - Unsafe water and sanitation
 - Lead exposureexceed 5% of world output in 2013
 - Productivity losses $> 1\%$ of output in low income countries
- This ignores morbidity costs
 - In country studies these range from 25-75% of mortality costs