



Health Impacts of Air Quality Measures

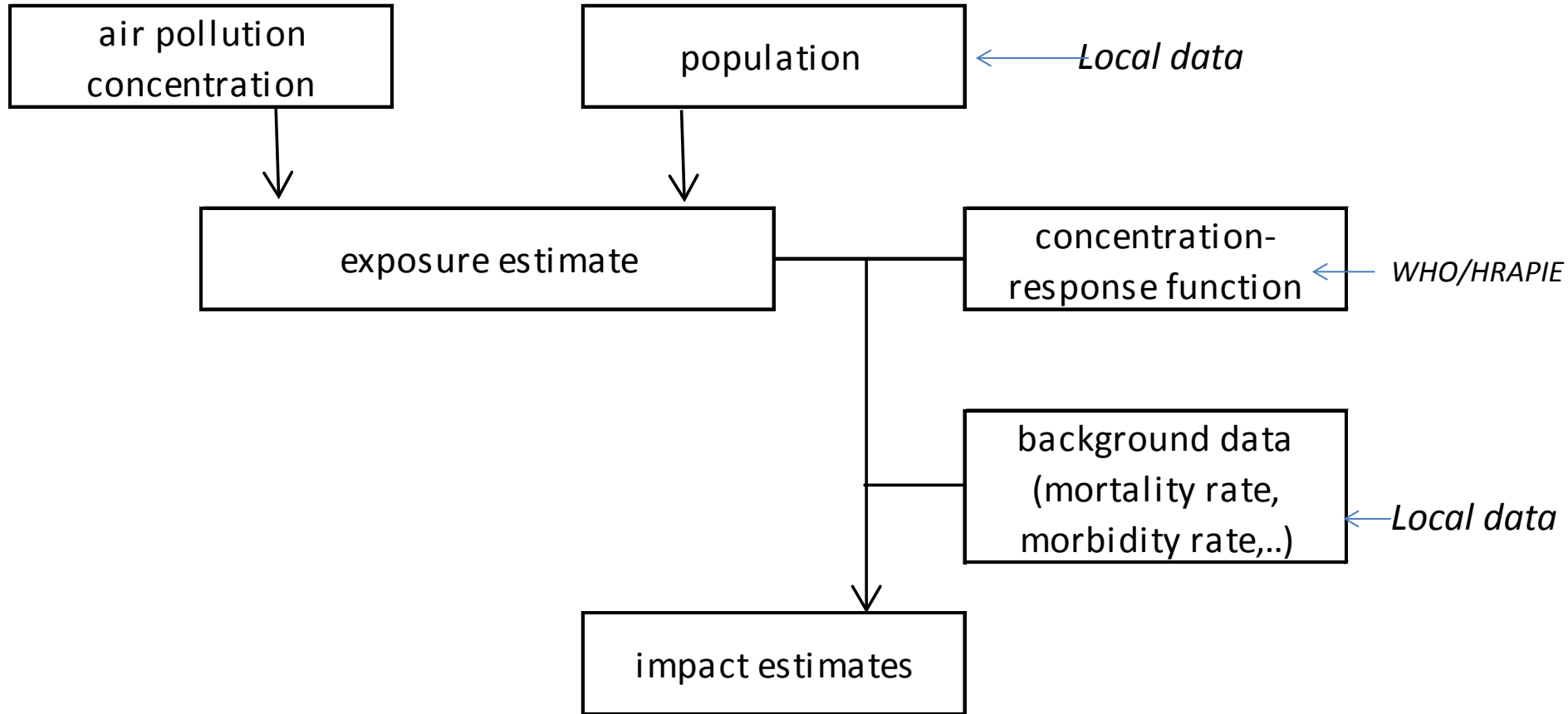
Shift from a focus on exceedances of limit values to improvement of citizens' health

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From concentrations to health impacts



General health impact approach

Relative Risk:

RR = relative risk (of mortality or morbidity) associated with a level of exposure
(e.g 1.06 per 10 $\mu\text{g}/\text{m}^3$ PM2.5)

Population Attributable Fraction:

$$\text{PAF} = [p \times (\text{RR} - 1)] / [p \times (\text{RR} - 1) + 1]$$

p = proportion of people exposed certain exposure levels

Attributable mortality or morbidity:

$$N = \text{PAF} \times \text{total mortality or morbidity}$$

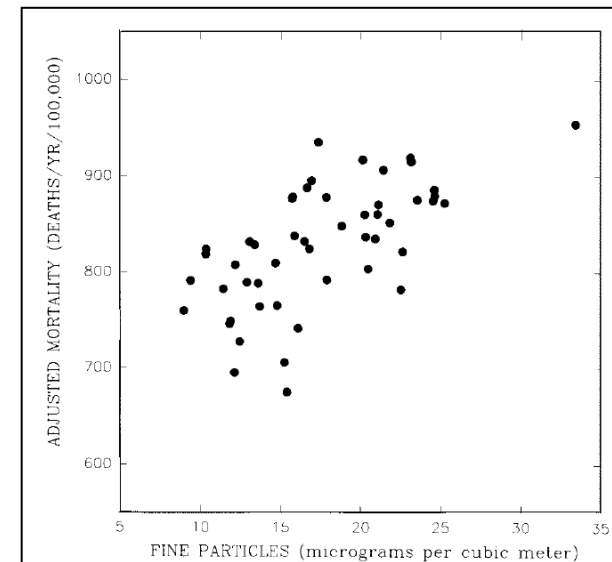


Figure 2. Age-, sex-, and race-adjusted population-based mortality rates for 1980 plotted against mean fine particulate air pollution levels for 1979 to 1983. Data from metropolitan areas that correspond approximately to areas used in prospective cohort analysis.

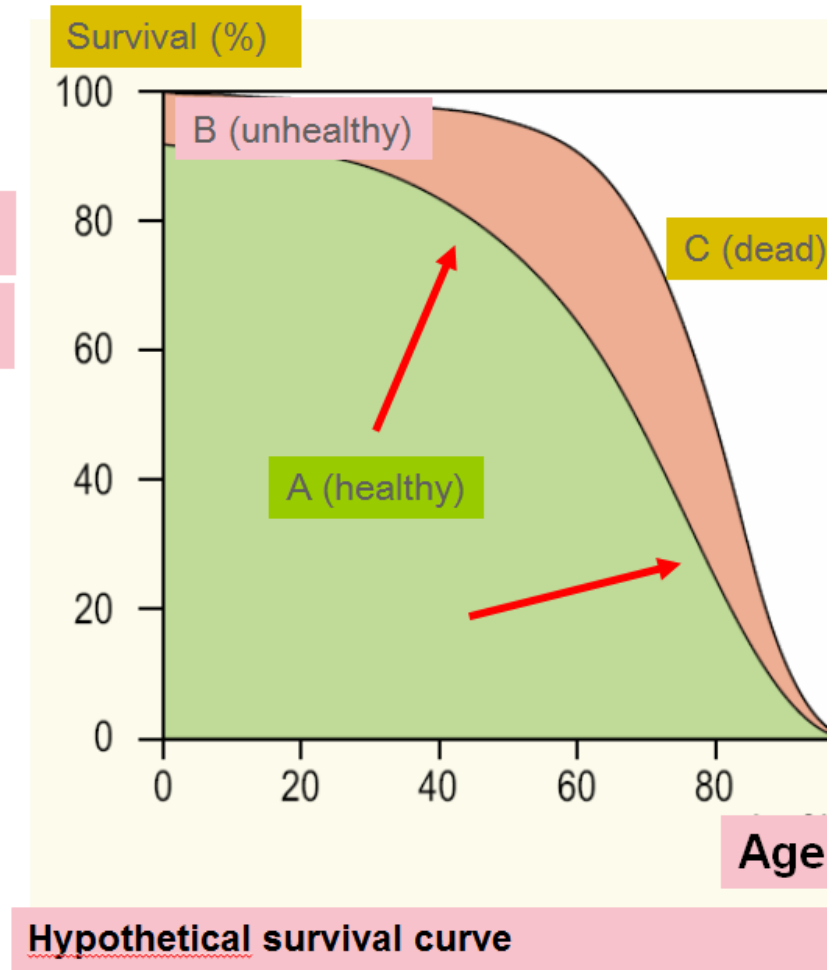
Choice of indicators

- Premature deaths (N)
- $YLL = N * LLE$
- YLD
- DALY
- ΔLLE

C = YLL

B = YLD

B+C = DALY



Morbidity

YLD = Incidence x Disability Weight x Length of period until death or recovery

Health impacts	Unit	Disability Weight per unit	Monetary damage per unit
Days with bronchitis in children (age 6-12 years)	Days/year	0.00062	€ 49
Incidence of asthma symptoms in asthmatic children (age 5-19 years)	Days/year	0.00019	€ 49
Incidence chronic bronchitis in adults (age 18+ years)	Number/year	0.99	€ 62712
Hospitalizations, cardiovascular diseases, all ages	Number/year	0.02255	€ 2574
Hospitalizations, respiratory diseases, all ages	Number/year	0.01565	€ 2574
Restricted activity days (RADs)	Days/year	0.00027	€ 108
Work days lost, population 20-65 years	Days/year	0.00027	€ 152
Years of Life Lost (YLL)	Number/year	1	€ 67500

Which tools are available?

Tools for local assessments:

- AIR-Q+
- HRAPIE-based variants
- APHEKOM → total and cardiovascular mortality & hospitalization (RRs 2004/2005)
- HEAT → cost-benefit assessment of walking and cycling

National health impact estimates by:

IIASA-GAINS, EMRC, EEA/ETC-ACM, JRC-FASST, OECD, WHO

AIR-Q+

Results Impact Evaluation Long-term effects of Ambient Air Pollution

City of 300 000 citizen				
PM2.5				
Cut-off value = 5µg/m ³				
Age structure of the Netherlands				
Incidence of the Netherlands				
Coordinates of Europe				
Mortality, all (natural) causes (adults age 30+ years)				
	10 µg/m³	15 µg/m³	20 µg/m³	25 µg/m³
Estimated Attributable Proportion	2.96	5.84	8.63	11.34
Estimated # of Attributable Cases	90	176	261	343
Estimated # of Attributable Cases per 100 000	45.93	90.49	133.73	175.70

Average YLL per case of premature death: ~ 10

Total YLL: 900 (10 ug/m³) – 3430 (25 ug/m³)

HRAPIE-based tool (GGD-RIVM)

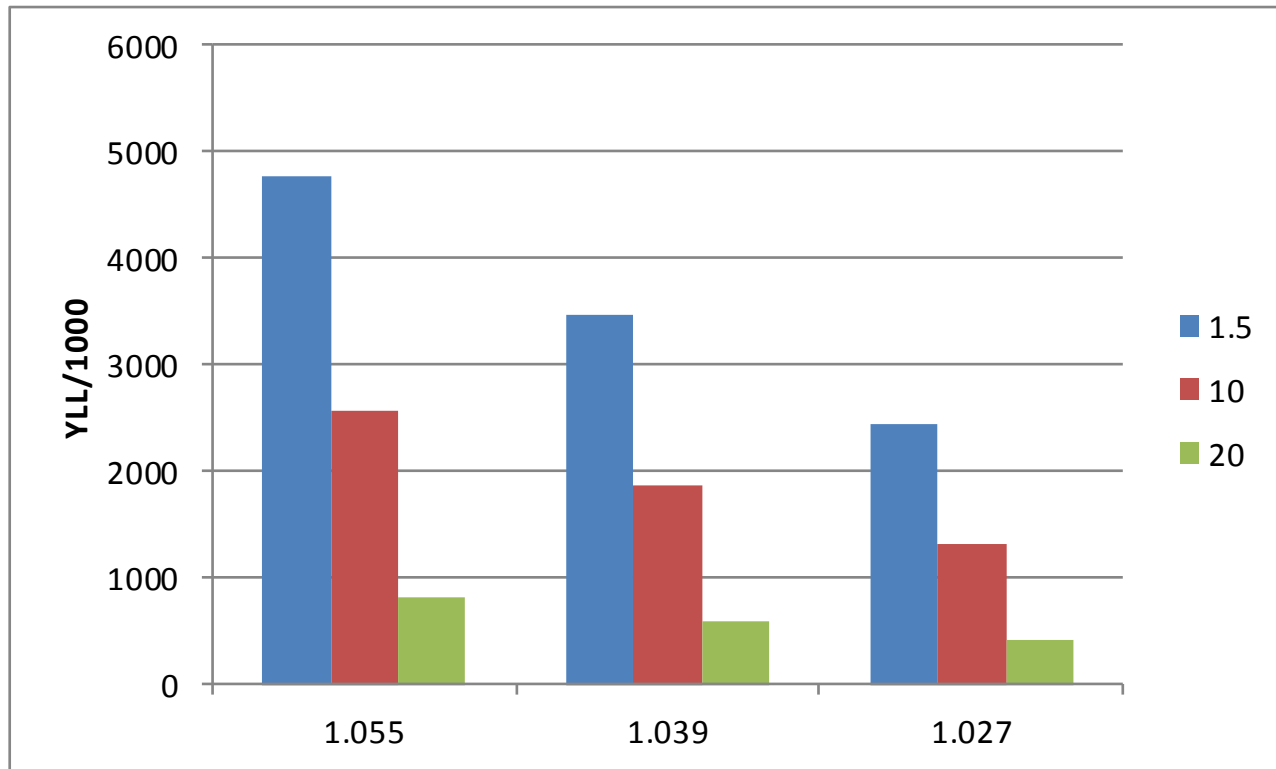
Utrecht 2015 (343.000 inhabitants)

Concentration PM10 in $\mu\text{g}/\text{m}^3$		15,80
Concentration PM2.5 in $\mu\text{g}/\text{m}^3$		12,40
Concentration NO2 in $\mu\text{g}/\text{m}^3$		25,20
Morbidity	Cases / Burden of Disease	Share of disease burden
<i>Due to PM10:</i>		
Annual number of days with bronchitis in children (age 6-12 years)	2371	8,0%
Incidence chronic bronchitis in adults (age 18+ years)	120	11,3%
Incidence of asthma symptoms in asthmatic children (age 5-19 years)	5315	2,9%
<i>Due to PM2.5:</i>		
Hospitalizations, cardiovascular diseases	52	0,9%
Hospitalizations, respiratory diseases	50	1,8%
Restricted activity days (RADs) (including sick-leave, hospital admission, symptom days)	289803	4,4%
Work days lost, working age population (age 20-65 years)	90440	4,4%
Lung cancer (age 30+ years)	14	8,2%
Low birth weight (< 2500 g at term)	33	15,8%
		Total YLD: 152
Mortality		
Cases of post-neonatal mortality (age 1-12 months) due to PM10	0,1	4,1%
Cases of premature deaths due to PM2.5 (RR = 1,06; Co = 2.5)	106	5,8%
Cases of premature deaths due to NO2 (RR = 1,02; Co = 5)	72	3,9%
		Total YLL: 1840
Decline in average life expectancy in days		
Due to PM2,5	208	(6.9 months)
Due to NO2	139	(4.5 months)

Uncertainties in assessing health impacts of measures

- Cut-off level (Co)
- Direct NO₂ impacts (additional to PM2.5 and ozone)
 - WHO/HRAPIE (2013): RR = 1.055
 - RW Atkinson (July 2018): RR = 1.02
- Double counting NO₂ and PM2.5
- Effectiveness of measures (“Source apportionment”)

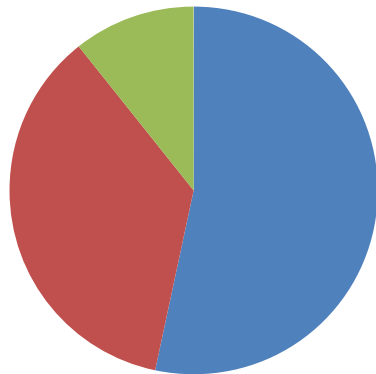
NO₂ : HRAPIE: RR = 1.055 per 10 ug/m³ and Co = 20 ug/m³
but: impacts also at lower concentrations and double counting



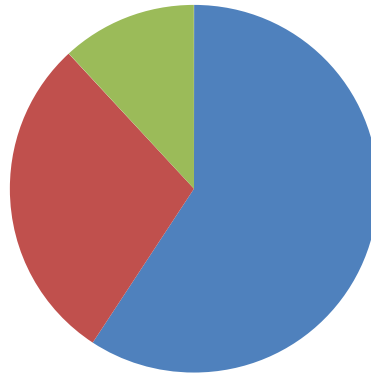
Sensitivity analysis EEA/ETC ACM

Which pollutant to blame?

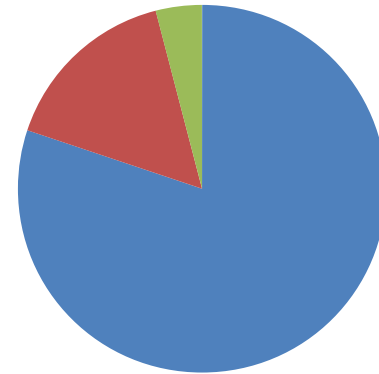
high - 7.1M YLL



mid - 6.4 M YLL



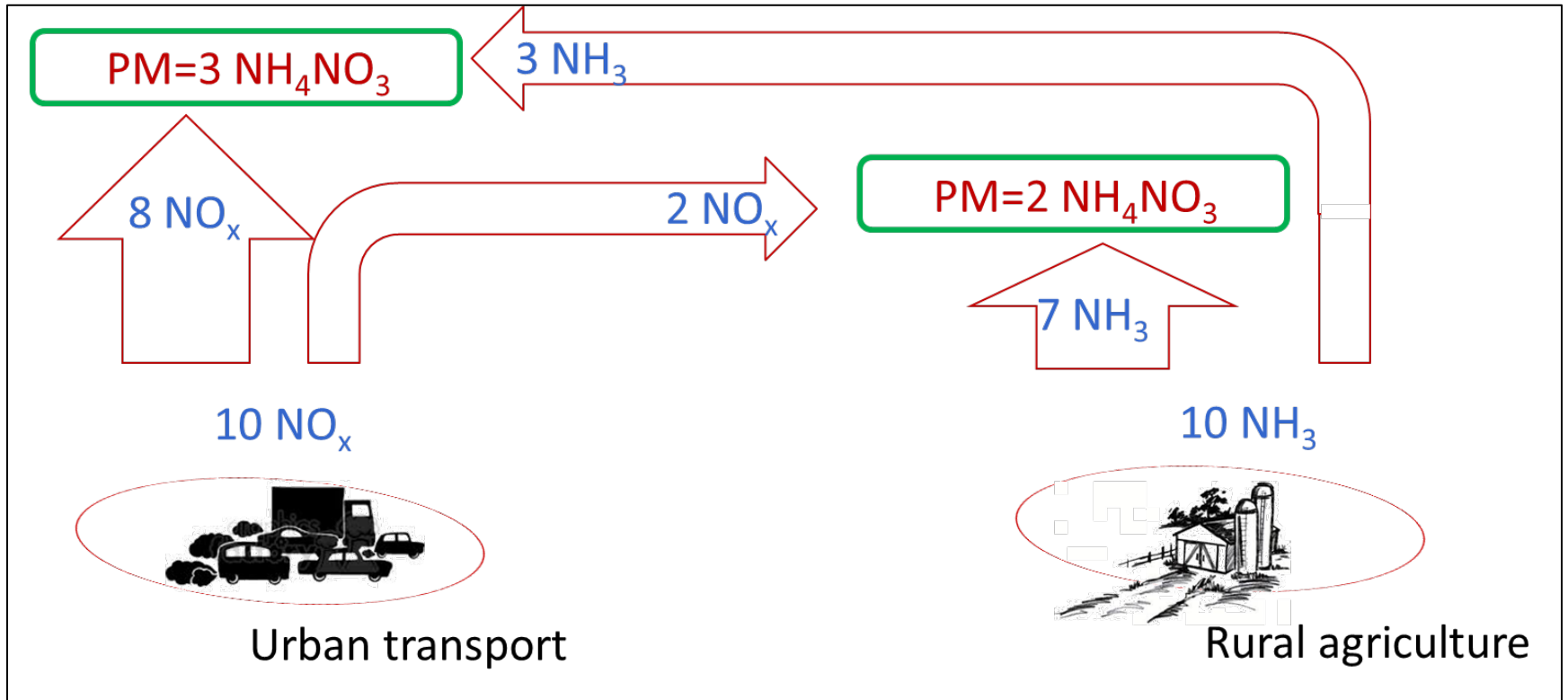
low - 3.8 M YLL



■ PM2.5
■ NO2
■ O3

Co/RR	high	mid	low	GGD/RIVM
PM2.5	2.5/1.062	2.5 /1.062	5/1.062	2.5/1.06
NO2	10/1.055	10/1.039	20/1.039	5/1.02
O3	somo10	somo10	somo35	somo35

Which measures to take?



Health impact assessment of policy measures

a) 100% EV

b) LEZ

Air quality and health impact of measures for Utrecht or Inner City

	Utrecht 2015	100% EV	LEZ	Inner city	100% EV	LEZ
ug/m3						
NO2	25,2	12,6	22,7	28,8	21,6	27,4
PM10	15,8	14,9	15,3	20,8	20,2	20,2
PM2,5	12,4	11,7	12,0	13,0	12,6	12,6
Cases of premature death						
PM2.5	106	-7	-4	6	-0	-0
NO2	72	-44	-9	4	-1	-0
Average loss in life expectancy (days)						
PM2.5	208	-15	-8	221	-8	-8
NO2	139	-87	-17	164	-50	-10
Days with bronchitis (children)	2371	-190	-105	408	-15	-15

- Local measures give more NO2 benefits than PM2.5 benefits
- Full electric gives more health benefits than banning old diesel vehicles in a LEZ
- A larger LEZ is more effective

Take home messages

- No safe concentrations
- Health impact indicators are interrelated: which indicator is preferred depends on target audience
- NO₂ can effectively be influenced by local policy
- Be aware of assumptions and uncertainties in calculations → sensitivity analyses needed for robust policy advice