For our Environment

Workshop:
Environmental burden of disease: methods and applications

Burden of disease due to nitrogen dioxide exposure in Germany

A case study

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German Environment Agency
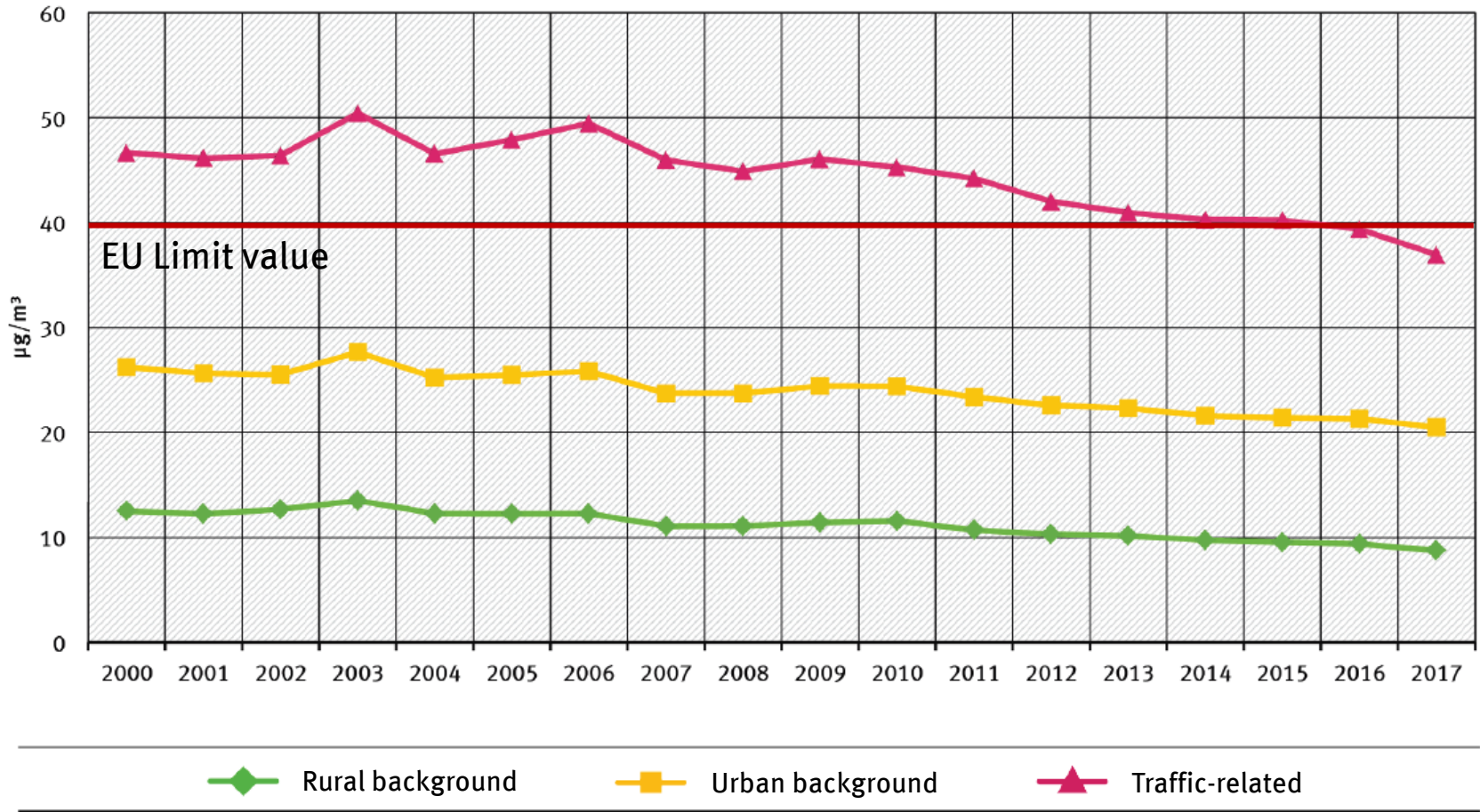Section: Exposure Assessment and Environmental Health Indicators

Background

- Air pollution is an important risk factor for population health
- According to GBD 2017 around 2.9 Million deaths in 2017 attributable to ambient particulate matter pollution ($PM_{2.5}$)
- Using the summary measure DALY, particulate matter globally ranks 10th among the 84 considered risk factors in GBD

- In Germany particulate matter is the most relevant environmental risk factor
- Current estimates of the GBD-Study do not consider nitrogen dioxide (NO_2) as a risk factor
- Studies indicate numerous adverse health effects of NO_2

(GBD 2017 Risk Factor Collaborators 2018, Atkinson 2018)

Air quality in Germany – NO$_2$-measurements

EU Limit value

Legend:
- Rural background
- Urban background
- Traffic-related

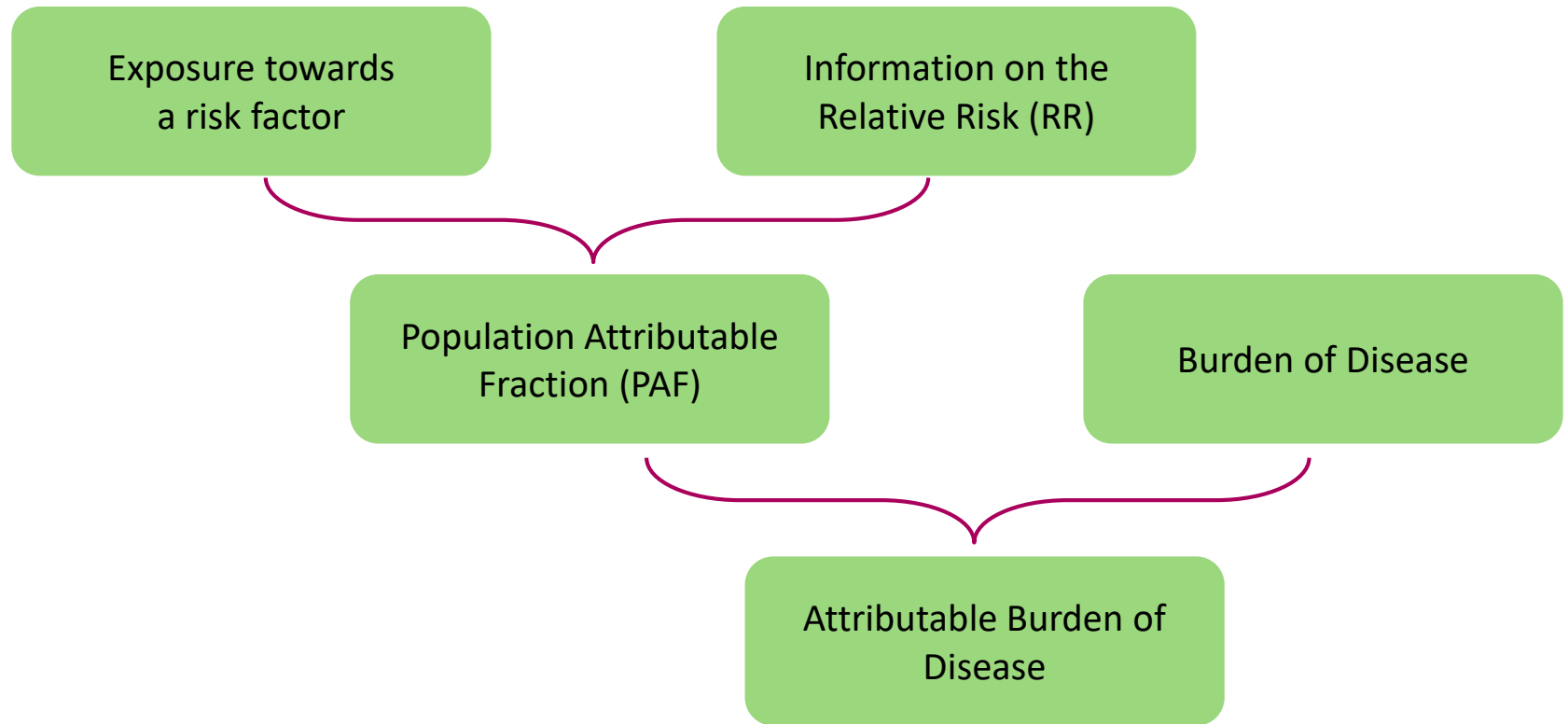*(https://www.umweltbundesamt.de/publikationen/luftqualitaet-2017)*

Project motivation and study objectives
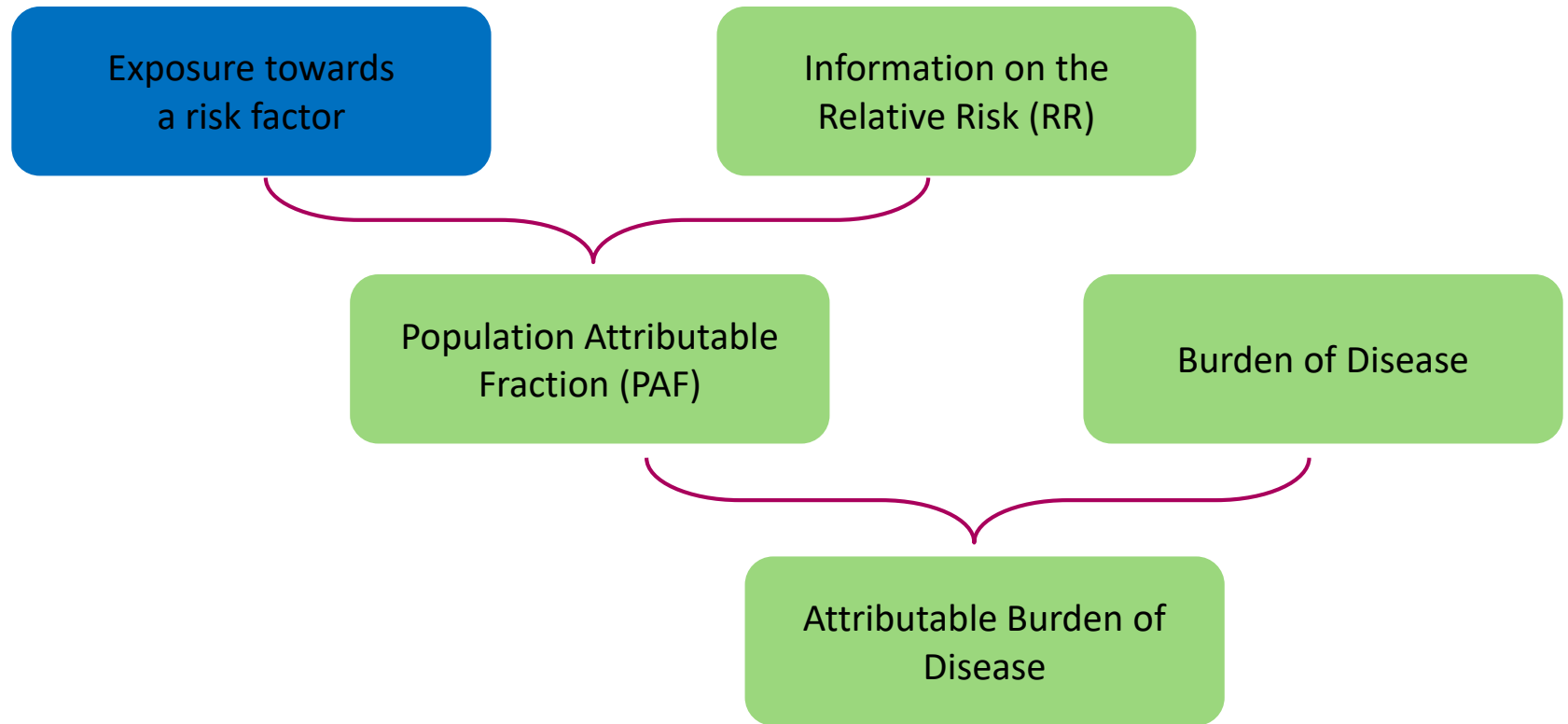
- Regular exceedances of NO_2 limit values in urban areas with intense traffic
    - e. g. in 2018 → 39% of traffic sites above 40 µg/m³

- <u>Objective:</u> to assess the disease burden attributable to the NO_2 exposure of the German population

- Based on current evidence on exposure-response functions

- Application of the Environmental Burden of Disease (EBD) concept as introduced by the WHO

- Project conducted by the German Research Center for Environmental Health

Pathway of an EBD-Assessment

Exposure towards a risk factor

Information on the Relative Risk (RR)

Population Attributable Fraction (PAF)

Burden of Disease

Attributable Burden of Disease

(based on Prüss-Ustün et al. 2003)

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Exposure assessment for the years 2007 to 2014 (I)

- Maps of the annual spatial 1 km by 1 km distribution of population weighted NO_2 background concentrations
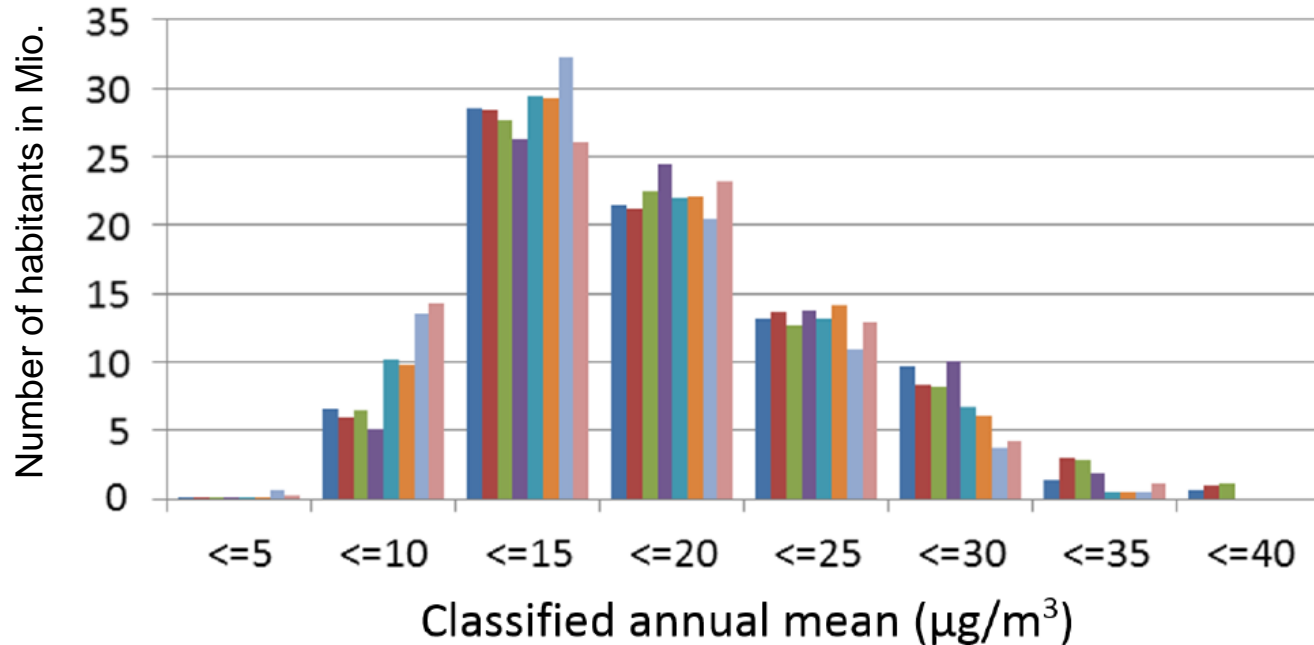
Based on:

→ Assimilated modelling data of background NO_2-concentrations on a 7 km by 8 km spatial grid
→ Population density on a 250 m by 250 m spatial grid

Result:

- Population distributions for different concentration classes

Exposure assessment for the years 2007 to 2014 (II)

Cave: Measuring sites close to traffic hot spots not considered due to methodological restrictions

(Schneider et al. 2018)

Pathway of an EBD-Assessment

Exposure towards a risk factor

Information on the Relative Risk (RR)

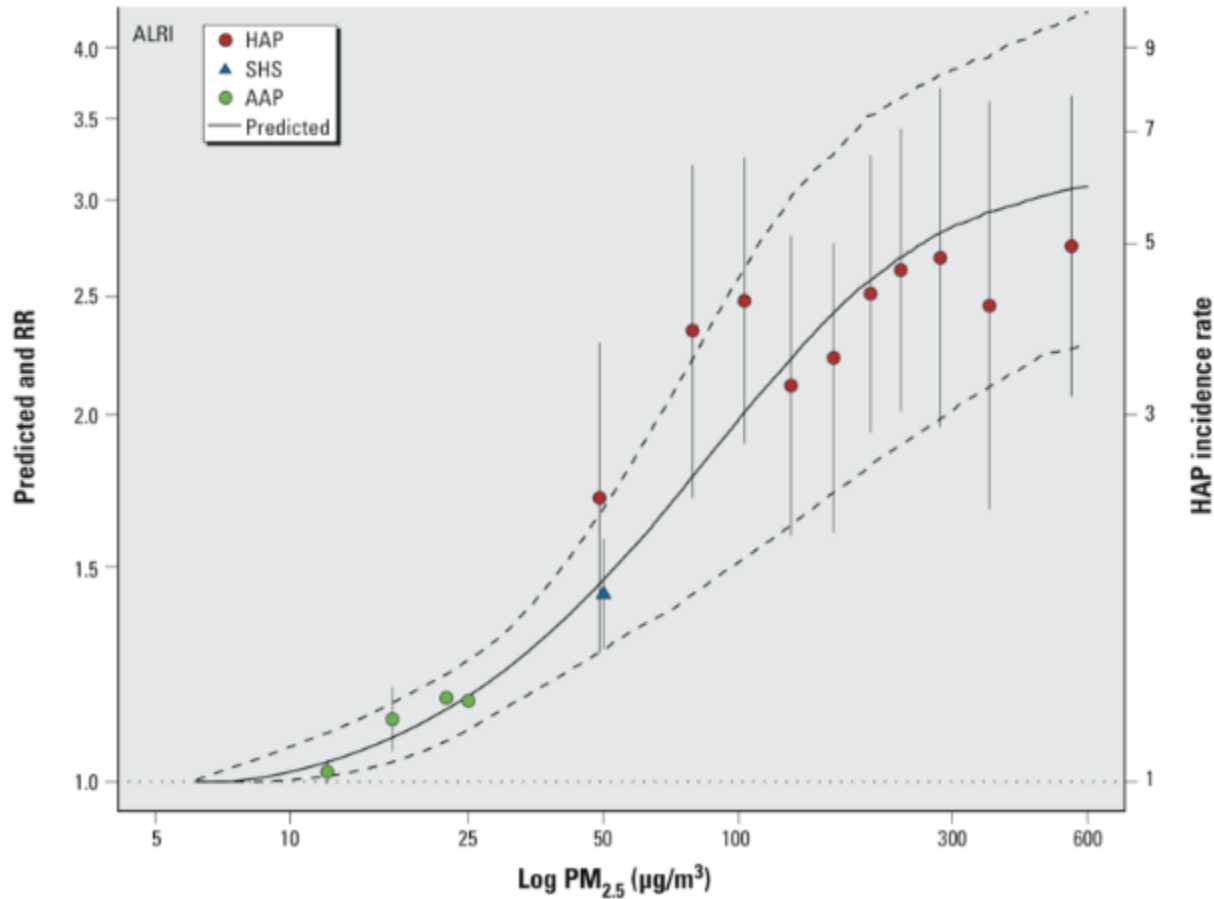Population Attributable Fraction (PAF)

Burden of Disease

Attributable Burden of Disease

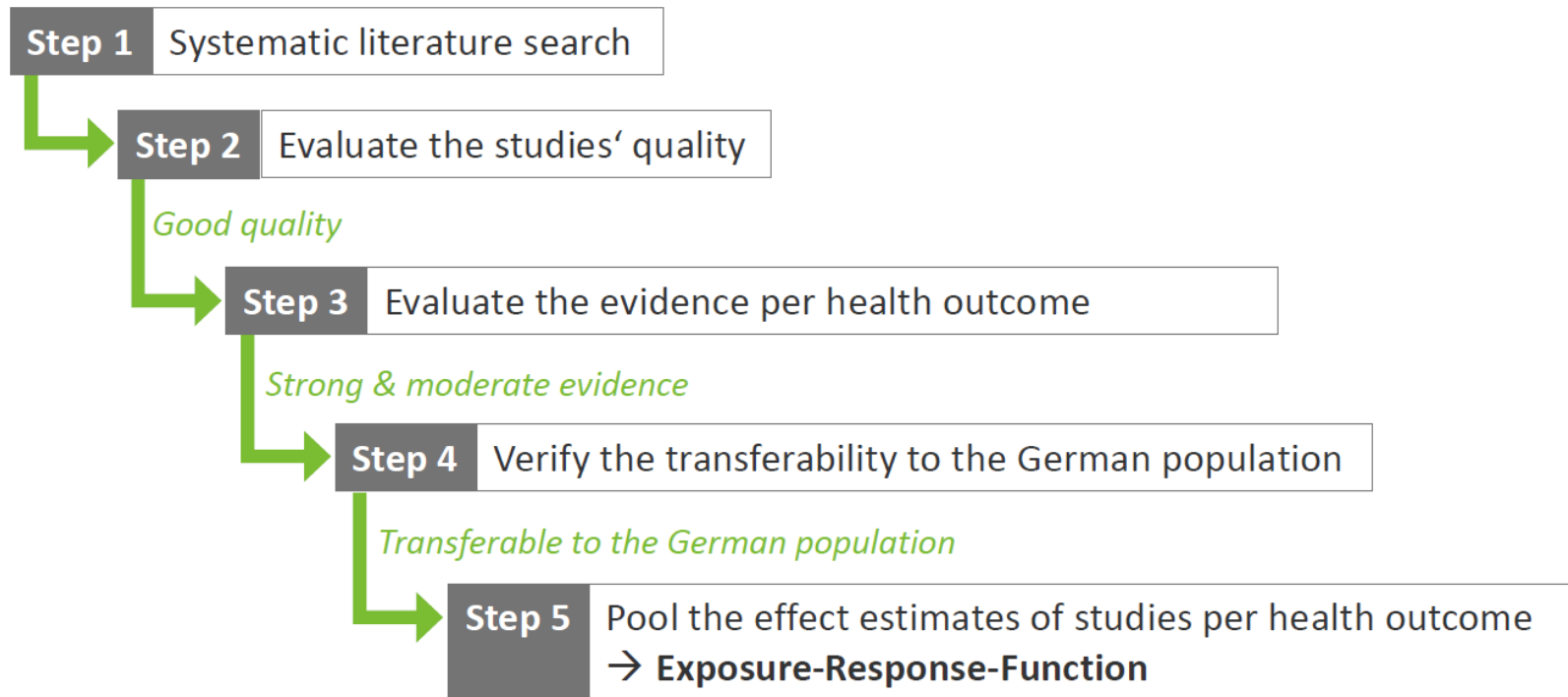*(based on Prüss-Ustün et al. 2003)*

Exposure Response Function in general

Integrated Response Function for $PM_{2.5}$ and ALRI

(Burnett et al. 2014)

Exposure-Response-Function for NO$_2$ (I) – literature review

Step 1	Systematic literature search

Step 2	Evaluate the studies' quality

Good quality

Step 3	Evaluate the evidence per health outcome

Strong & moderate evidence

Step 4	Verify the transferability to the German population

Transferable to the German population

Step 5	Pool the effect estimates of studies per health outcome → **Exposure-Response-Function**

(Schneider et al. 2018)

Exposure Response Function for NO_2 (II) – health outcomes

Strong Evidence:

- Cardiovascular mortality

Moderate Evidence:

- Asthma
- COPD
- Hypertension
- Ischemic heart disease
- Heart failure
- Stroke
- Diabetes

Weak Evidence or missing health data:

- Mortality (total, respiratory)
- Hospital admissions
- Myocardial infarction
- Lung cancer
- Chronic bronchitis
- Lung function / Lung growth
- Premature birth (< 37th week)
- Low birth weight (< 2,500 g)

Cardiovascular mortality:

- Estimates of 6 studies were pooled to a Hazard Ratio of 1.03 (95% CI: 1.01 – 1.05)
- Sources: Turner et al. (2016), Beelen et al. (2014b), Carey et al. (2013), Cesaroni et al. (2013), Jerrett et al. (2011) and Brunekreef et al. (2009)

Exposure Response Function for NO_2 (III) – counterfactual value

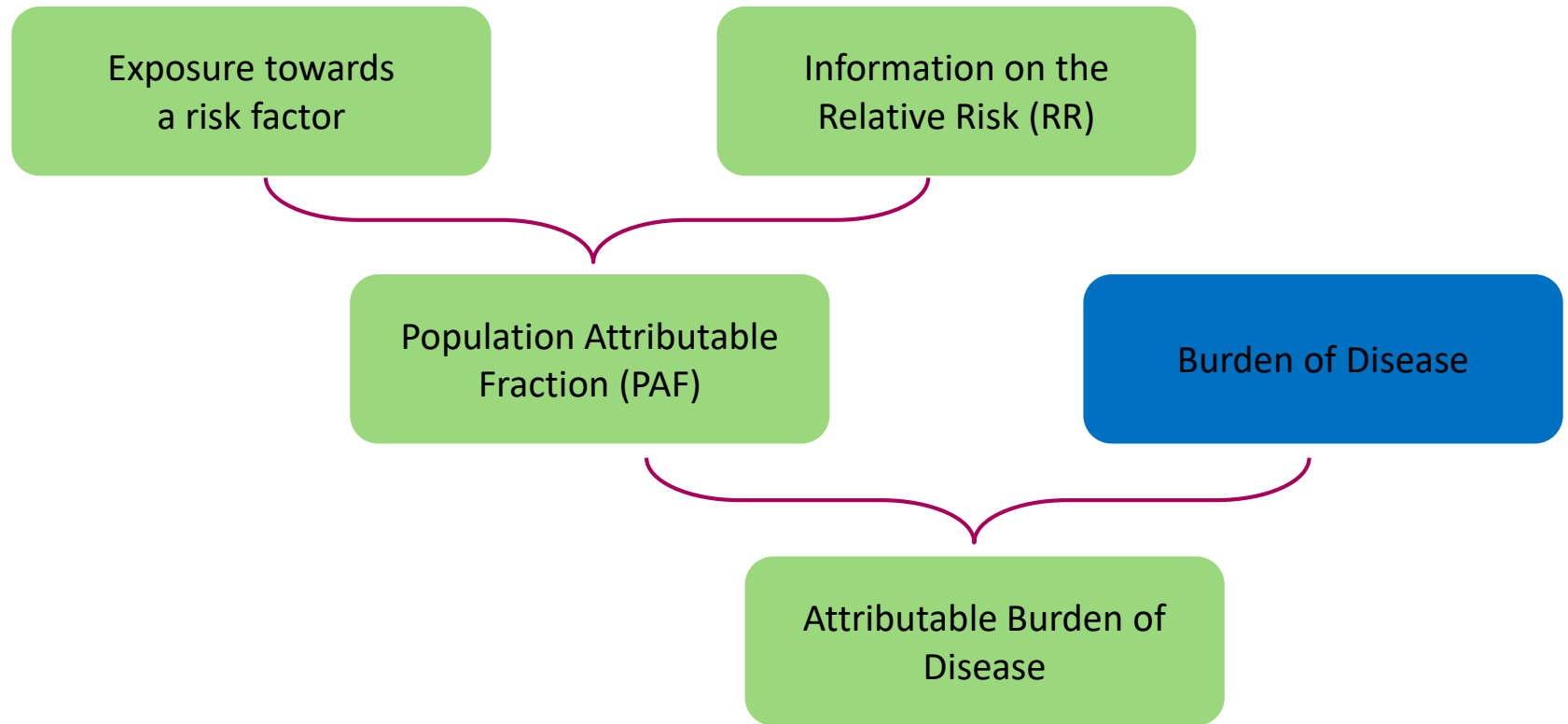• Current studies do not show a safe level for NO_2-exposure

Main Analysis:
• 10 µg/m³ annual mean

• Epi-studies show considerable uncertainties below 10 µg/m³

• In rural areas of Germany, i. e. away from the typical NO_2 sources, the annual average concentrations for the years 2007 to 2014 were about 10 µg/m³

Scenario analyses:
  • 0 µg/m³ NO_2
  • 5 µg/m³ NO_2
  • 20 µg/m³ NO_2

Pathway of an EBD-Assessment

Exposure towards
a risk factor

Information on the
Relative Risk (RR)

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Burden of Disease

Attributable Burden of
Disease

(based on Prüss-Ustün et al. 2003)

Health data

Mortality

- Deaths statistics from German Vital Registration System
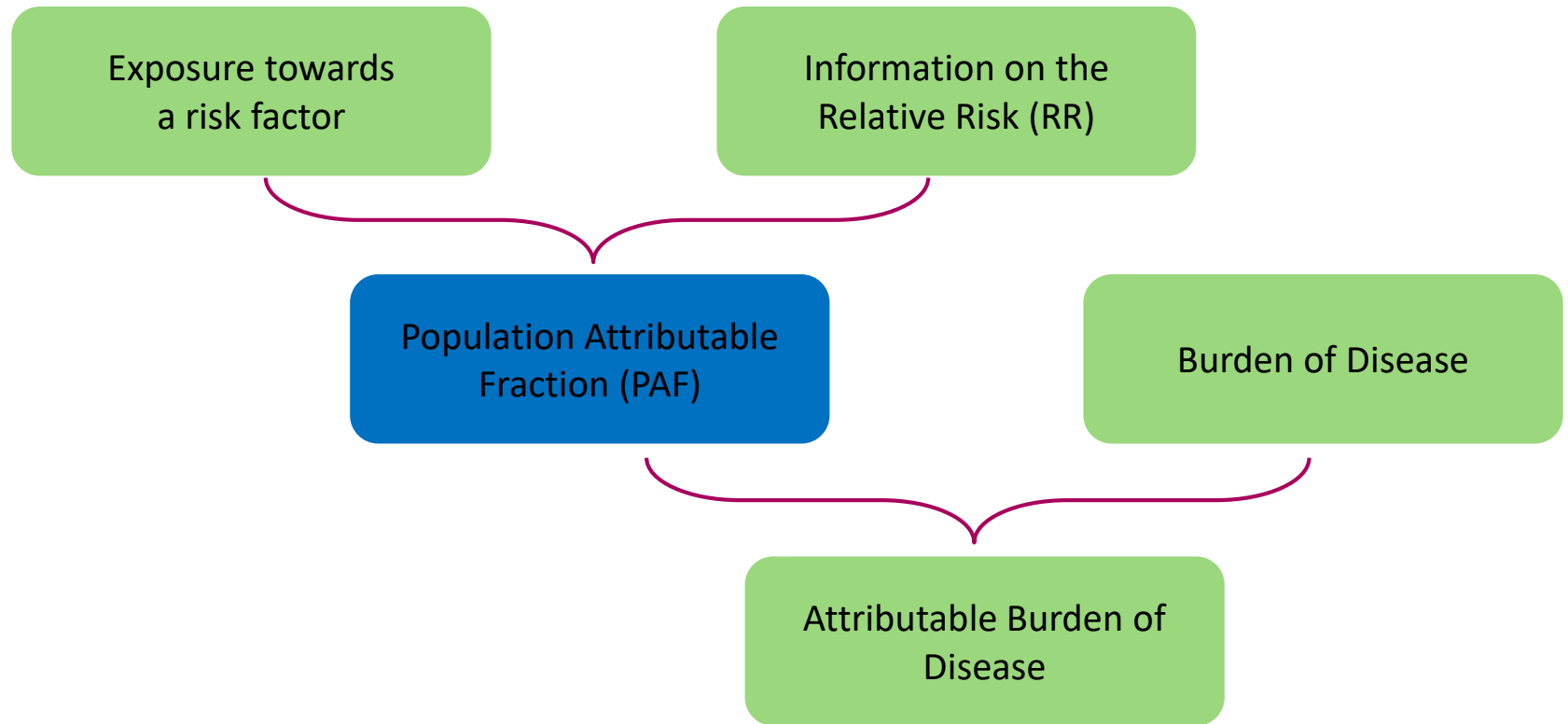 - By age group, sex, and cause

→ **deaths and YLL**

Morbidity

- Representative population based surveys
  - GEDA – a German health examination survey
  - 12-month prevalence
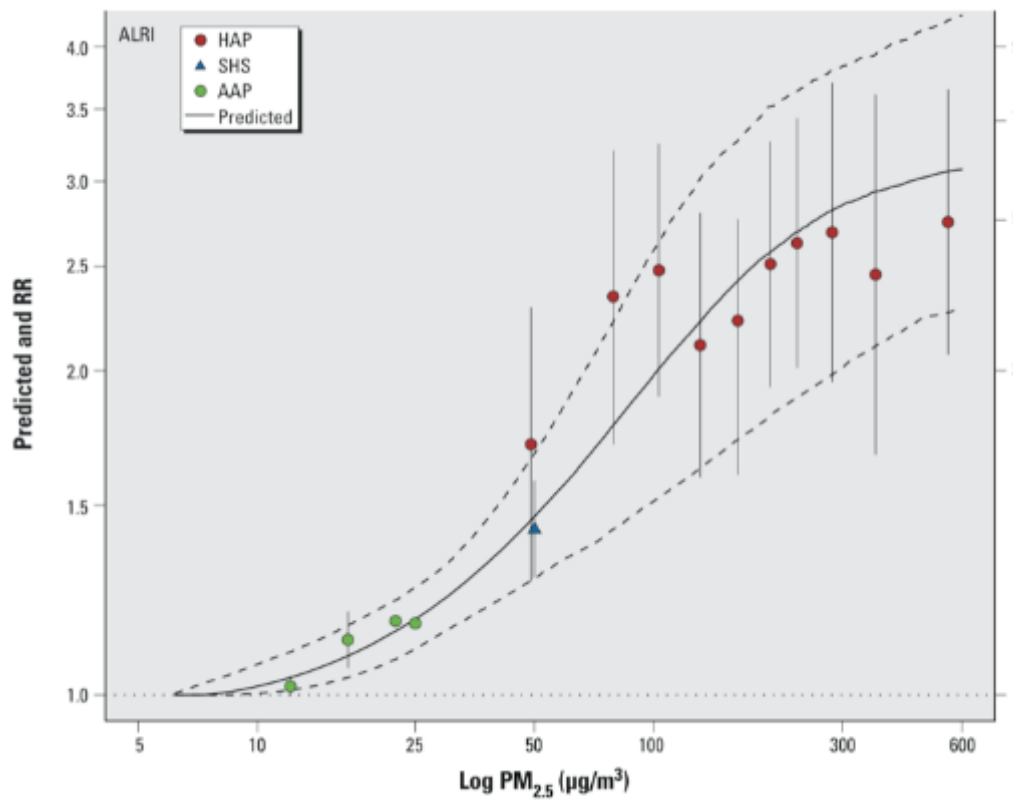 - Extrapolation of data for missing years

→ **YLD**

Pathway of an EBD-Assessment

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┌─────────────────────┐        ┌─────────────────────┐
│  Exposure towards   │        │  Information on the  │
│    a risk factor    │        │  Relative Risk (RR)  │
└─────────────────────┘        └─────────────────────┘
              ┌─────────────────────┐        ┌─────────────────────┐
              │ Population Attributable│       │  Burden of Disease  │
              │    Fraction (PAF)    │        └─────────────────────┘
              └─────────────────────┘
                      ┌─────────────────────┐
                      │ Attributable Burden of│
                      │       Disease        │
                      └─────────────────────┘
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(based on Prüss-Ustün et al. 2003)

Population Attributable Fraction (PAF)

Integrated Response Function for ALRI

$$PAF = \frac{\sum P_i\, RR_i - \sum P_i'\, RR_i}{\sum P_i\, RR_i}$$

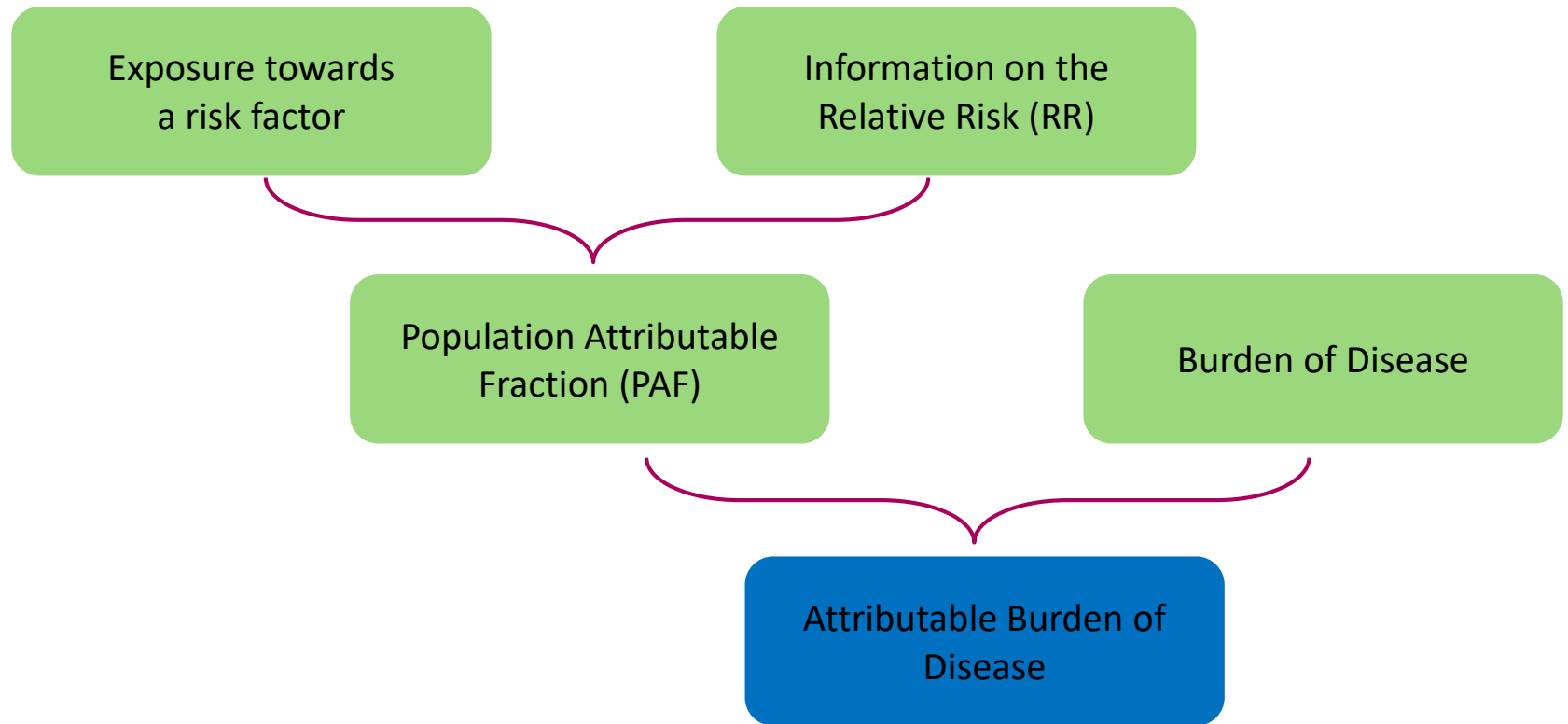Exposure — Alternative

$$PAF = \frac{\sum P_i\, RR_i - 1}{\sum P_i\, RR_i}$$

Exposure — Alternative

(Burnett et al. 2014, Prüss-Ustün et al. 2016)

Pathway of an EBD-Assessment

Exposure towards a risk factor

Information on the Relative Risk (RR)

Population Attributable Fraction (PAF)

Burden of Disease

Attributable Burden of Disease

(based on Prüss-Ustün et al. 2003)

Results –
cardiovascular mortality attributable to NO$_2$ in 2014

Parameter	Value (95% Confidence Interval)
Attributable fraction in %	1.8 (0.6 – 2.9)
Attributable number of deaths	5,966 (2,031 – 9,893)
Years of Life Lost due to premature mortality (YLLs)	49,726 (16,929 – 82,456)
YLLs per 100.000	87.96 (29.95 – 145.85)

(Schneider et al. 2018)

Results – cardiovascular mortality attributable to NO_2 from 2007 to 2014

	2007	2008	2009	2010	2011	2012	2013	2014
Attributable proportion in % (95% CI)	2.19 (0.75-3.62)	2.29 (0.78-3.79)	2.26 (0.77-3.74)	2.26 (0.77-3.74)	1.86 (0.63-3.08)	1.87 (0.64-3.10)	1.58 (0.54-2.63)	1.77 (0.60-2.93)
Attributable deaths (95% CI)	7,832 (2,669-12,973)	8,157 (2,780-13,510)	8,035 (2,735-13,309)	7,960 (2,715-13,172)	6,343 (2,161-10,514)	6,531 (2,225-10,822)	5,605 (1,907-9,299)	5,966 (2,031-9,893)
Years of Life Lost (YLLs) (95% CI)	69,244 (23,601-114,690)	71,396 (24,334-118,251)	69,526 (23,696-115,157)	68,428 (23,343-113,235)	53,489 (18,218-88,653)	54,536 (18,579-90,369)	46,795 (15,924-77,631)	49,726 (16,929-82,456)
YLLs per 100.000 inhabitants (95% CI)	122.78 (41.85-203.36)	126.40 (43.08-209.35)	123.04 (41.94-203.80)	120.85 (41.23-199.98)	94.10 (32.05-155.97)	95.48 (32.53-158.22)	83.13 (28.29-137.91)	87.96 (29.95-145.85)

CI, Confidence interval

(Schneider et al. 2018)

Discussion

- The results show a considerable burden of disease attributable to the NO_2 exposure in Germany
- Relative impact of NO_2 (ca. 6,000) lower as compared to particulate matter (ca. 41,000 attributable deaths)
- Underestimation likely because:
  - Not considered concentrations of traffic hot spots
  - Only estimated for health outcomes with strong evidence
- Combined effects not considered in the main analysis
  - Scenario analysis indicate a decrease of NO_2-burden by about 46%
  - Combined effects in scenario only based on estimates from one study
- Considerable impact of parameter choices
  - E. g. counterfactual value

Merci beaucoup pour votre aimable attention

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