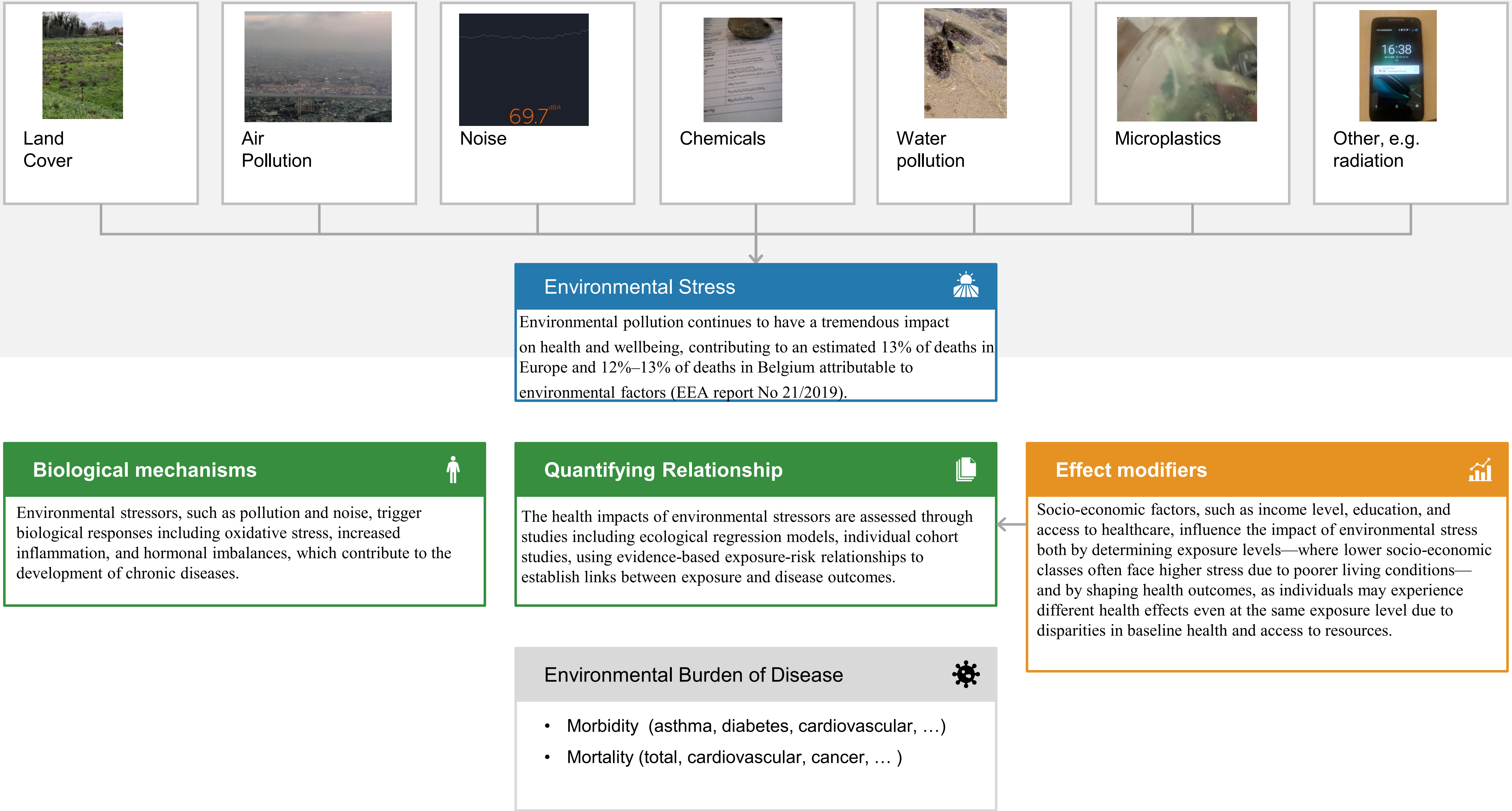
Health effects of urban and transport planning

Mitigating the environmental disease burden associated with transport and urban planning in Belgian cities

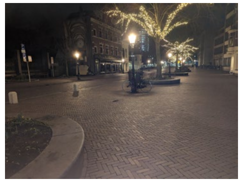
Case-study on reducing paediatric asthma through local traffic interventions



Land Cover
Air Pollution
69.7 dBA
Noise
Chemicals
Water pollution
Microplastics
16:38
Other, e.g. radiation
Environmental Stress
Environmental pollution continues to have a tremendous impact on health and wellbeing, contributing to an estimated 13% of deaths in Europe and 12%–13% of deaths in Belgium attributable to environmental factors (EEA report No 21/2019).
Biological mechanisms
Environmental stressors, such as pollution and noise, trigger biological responses including oxidative stress, increased inflammation, and hormonal imbalances, which contribute to the development of chronic diseases.
Quantifying Relationship
The health impacts of environmental stressors are assessed through studies including ecological regression models, individual cohort studies, using evidence-based exposure-risk relationships to establish links between exposure and disease outcomes.
Effect modifiers
Socio-economic factors, such as income level, education, and access to healthcare, influence the impact of environmental stress both by determining exposure levels—where lower socio-economic classes often face higher stress due to poorer living conditions—and by shaping health outcomes, as individuals may experience different health effects even at the same exposure level due to disparities in baseline health and access to resources.
Environmental Burden of Disease
• Morbidity (asthma, diabetes, cardiovascular, …)
• Mortality (total, cardiovascular, cancer, …)

Urban Design

Housing Quality



Street Design

Landcover/ green spaces/ recreation spaces

Transport infrastructure

Availability of services (15mC)

Other, e.g. speed controls

Urban and Transport Planning

Urban areas and transport systems are shaped by street design, housing, green spaces, land use, availability of services and public transport etc., impacting health positively (e.g., green spaces, mobility) and negatively (e.g., pollution, noise, heat islands, road injuries). These effects occur through environmental, behavioural, and social pathways. Interventions can reduce negative effects, and among other factors, socio-economic conditions may be relevant effect modifiers to account for. This research focuses on quantifying and reducing the disease burden linked to urban and transport planning through environmental factors.

Interventions

Local traffic interventions, congestion pricing, …

- Noise
- Air Pollution
- Green Spaces
- Urban Heat Islands

- Phyiscal Activity
- Social Contacts

Road travel injuries

Effect modifiers

such as socio-economic factors

Urban and transport planning associated disease burden through environmental factors

Urban and transport planning associated disease burden through behavioral factors

Urban and transport planning associated disease burden through other factors

Research Questions

- **Q1: How much of total mortality, cardiovascular mortality, diabetes incidence and asthma incidence/prevalence can be avoided in case of meeting the WHO guidelines for air pollution and green space?**
  - **Q1.2.: What if we only consider traffic-related air pollution and green space?**
- Q2: Case-study: In a hypothethised scenario where local traffic interventions resembling the effects of car-free Sundays are permanent, how much asthma incidence in children can be avoided in the European cities Brussels and Paris?

Mitigation Model: Example

$$PF = \frac{(1-RR)}{RR}$$

$$RRexposure = exp((ln(RR10)/10) * (CON))$$

(1) Recommended Exposure
WHO Guidelines Air Pollution exposure, Green Space availability

(2) Current Exposure
Air pollution, Green spaces

(3) Exposure Difference

(4) Exposure Response Function (ERF)

- **Air pollution** ELAPSE, 2021
- **Green spaces** Gascon et al. 2016

(5) Relative Risk (RR) Exposure Difference

BURDEN OF DISEASE

(6) Population Preventable Fraction (PF)

Preventable Mortality or morbidity

Relative Risks and PAF calculated from literature

- All-cause mortality
- Asthma incidence
- Diabetes incidence & mortality
- Cardiovascular mortality

Confounding & socio-economic factors correction

- Morbidity
- Mortality

Table 1: Dose-response relationships extracted from meta-analysis

- Individual Cohort studies
- Corrected for socioeconomic factors and confounding factors like smoking

Exposure-Response Functions (ERF's)	NO_2 per 10 µg/m³	$PM_{2.5}$ per 10 µg/m³	Source	NDVI per 0.1 unit increment	Source
Natural Mortality	1.050 [1.031 - 1.070]	1.083 [1.054 - 1.113]** Traffic-Specific: 1,212 [1,141 – 1,283]	(Brunekreef et al., 2021) (Chen et al., 2022)	0.96 [0.94 - 0.97]	(Rojas-Rueda et al., 2019)
Cardiovascular Mortality	1.043 [1.007 - 1.079]	1.100 [1.053 - 1.150]** Traffic-Specific: 1,212 [1,071 – 1,389]	(Brunekreef et al., 2021) (Chen et al., 2022)	0.97 [0.96 - 0.99]	(X.-X. Liu et al., 2022)
Diabetes Incidence	1.07 [1.04 - 1.11]	1.08 [1.04 - 1.12]	(Yang et al., 2020)	0.919 [0.862 - 0.982] per 0.09 NDVI (IQR)	(Ccami-Bernal et al., 2023)
Asthma Incidence – CHILDREN	1.125 [1.10 - 1.175]	*	(Khreis et al., 2017)	**	
Asthma Incidence - ADULTS	1.21 [1.11 - 1.32]	*	(S. Liu et al., 2021)	**	
Depression	**	**		0.931 (0.887, 0.977)).	(Z. Liu et al., 2023)

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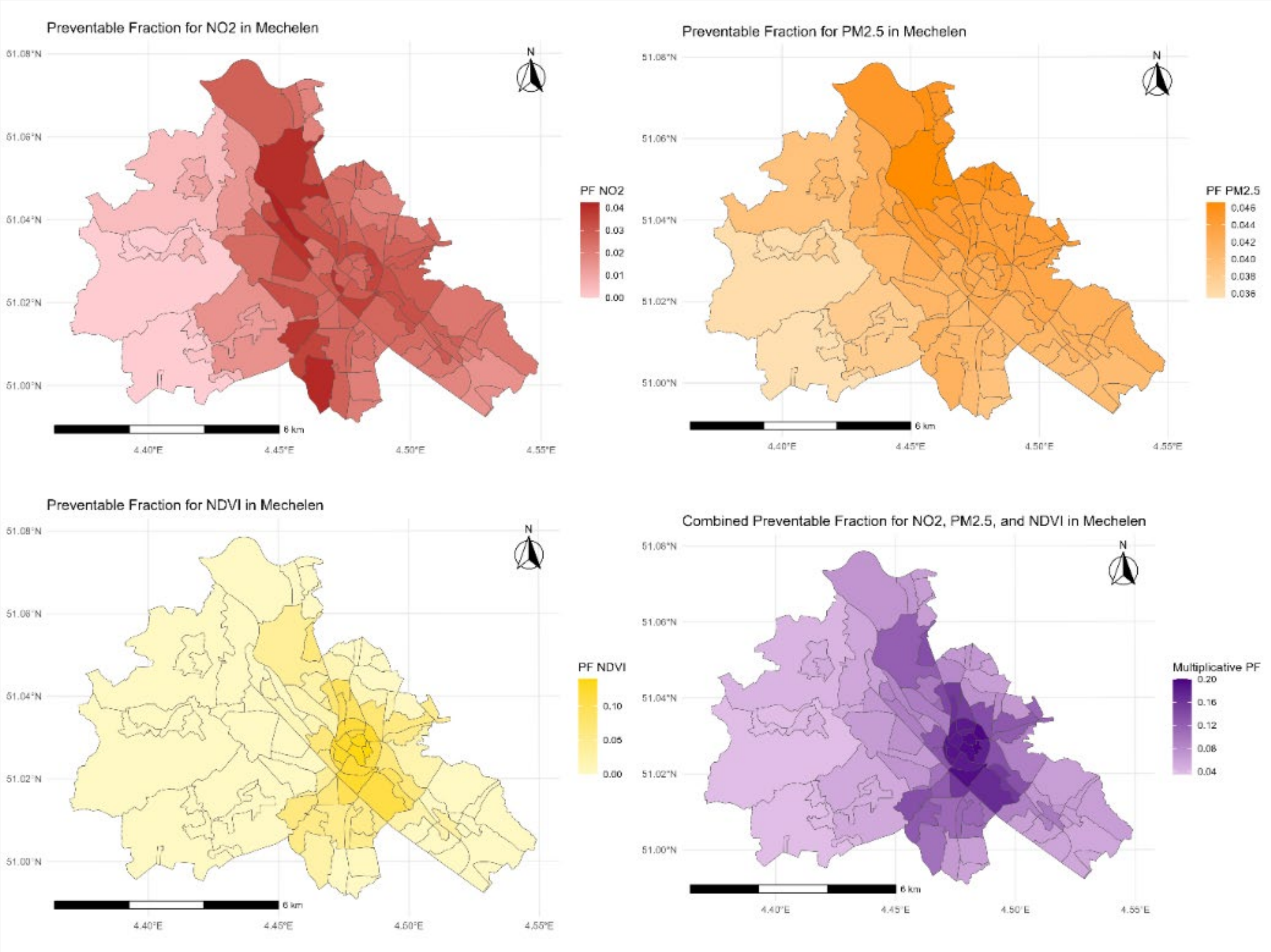
Preventable Fraction of Total Mortality if counterfactual target values (WHO) of NDVI, NO_2 and $PM_{2.5}$ are achieved



Preventable Fractions

Table 2: *Population-weighted PF values in the cities of Liège, Mechelen and Brussels for the selected diseases. Brackets contain the 95% CI. <2.50% = light green, 2.50-4.99% =yellow, 5.00-9.99% =orange; >=10.00%= Red*

Population-Weighted averages	Liège	Mechelen	Brussels
Total Mortality NDVI	0.060 [0.036- 0.085]	0.057 [0.034- 0.008]	0.067 [0.041- 0.095]
Total Mortality $PM_{2.5}$	0.019 [0.013- 0.026]	0.0436 [0.029- 0.058]	0.041 [0.027- 0.055]
Total Mortality NO_2	0.045 [0.028- 0.0615]	0.0253 [0.016- 0.035]	0.046 [0.0287- 0.10]
Total Mortality Multiplicative PF	0.117 [0.075 - 0.163]	0.1204 [0.077- 0.163]	0.147 [0.094- 0.198]
Cardiovascular Mortality NDVI	0.044 [0.02- 0.068]	0.040 [0.020- 0.062]	0.051 [0.025- 0.079]
Cardiovascular Mortality $PM_{2.5}$	0.023 [0.012- 0.033]	0.0519 [0.028- 0.075]	0.049 [0.027- 0.071]
Cardiovascular Mortality NO_2	0.039 [0.007- 0.070]	0.0218 [0.004- 0.039]	0.039[0.0073 0.071]
Card. Mor Multiplicative PF	0.103 [0.041- 0.16]	0.1098 [0.051- 0.166]	0.134 [0.058- 0.210]
Diabetes Incidence NDVI	0.148 [0.031- 0.288]	0.1334 [0.029- 0.257]	0.171 [0.036- 0.332]
Diabetes Incidence $PM_{2.5}$	0.019 [0.0097- 0.027]	0.0421 [0.022-0.062]	0.040 [0.021- 0.059]
Diabetes Incidence NO_2	0.062 [0.033- 0.0900]	0.035 [0.018- 0.051]	0.063 [0.019- 0.051]
Diabetes Multiplicative PF	0.216 [0.072- 0.370]	0.199 [0.067- 0.339]	0.254 [0.07- 0.403]
Asthma NO_2 Children	0.105 [0.077- 0.132]	0.060 [0.077 - 0.132]	0.107 [0.078- 0.134]
Asthma NO_2 Adults	0.164 [0.093- 0.228]	0.100 [0.053 - 0.135]	0.166 [0.095- 0.231]
Depression NDVI	0.109 [0.033- 0.194]	0.099 [0.030- 0.174]	0.126 [0.039- 0.224]

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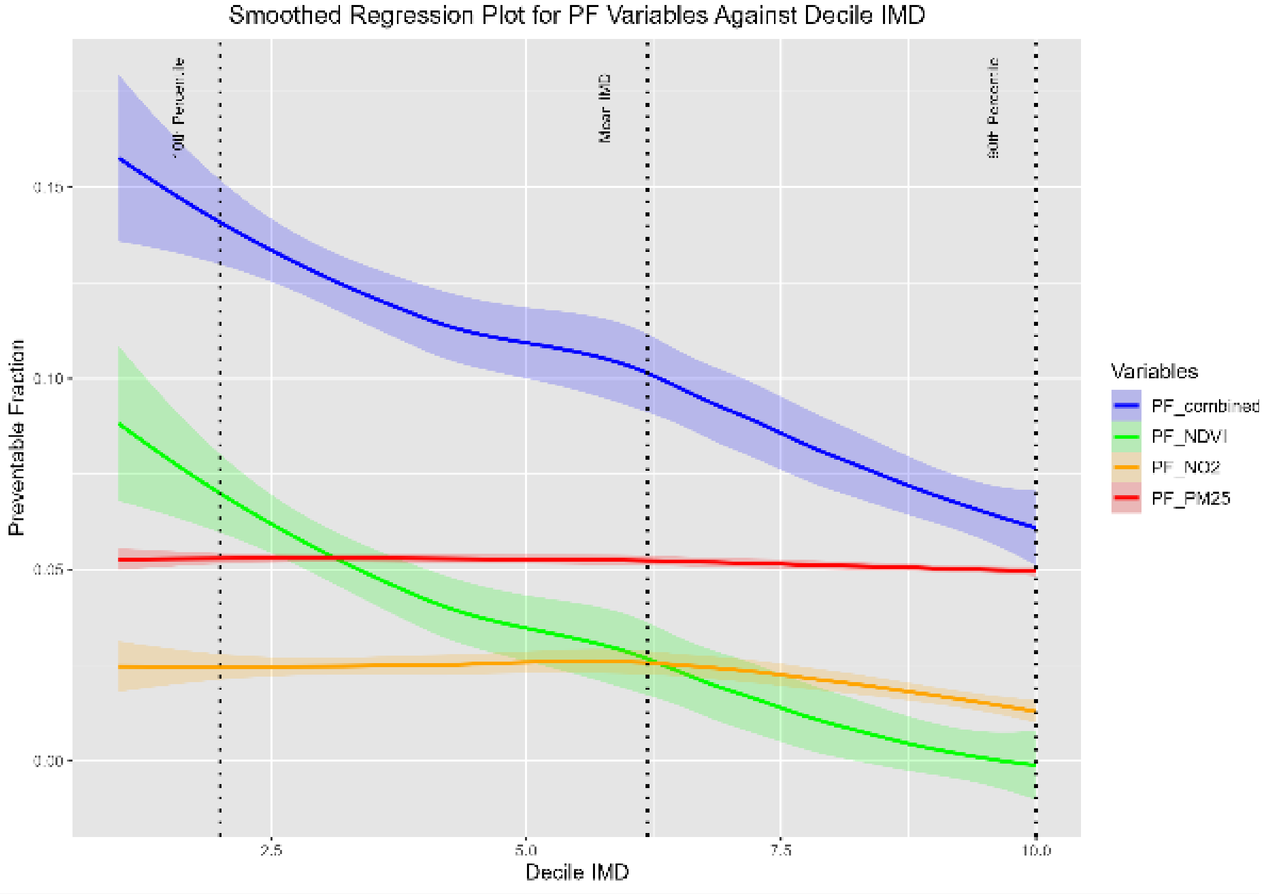
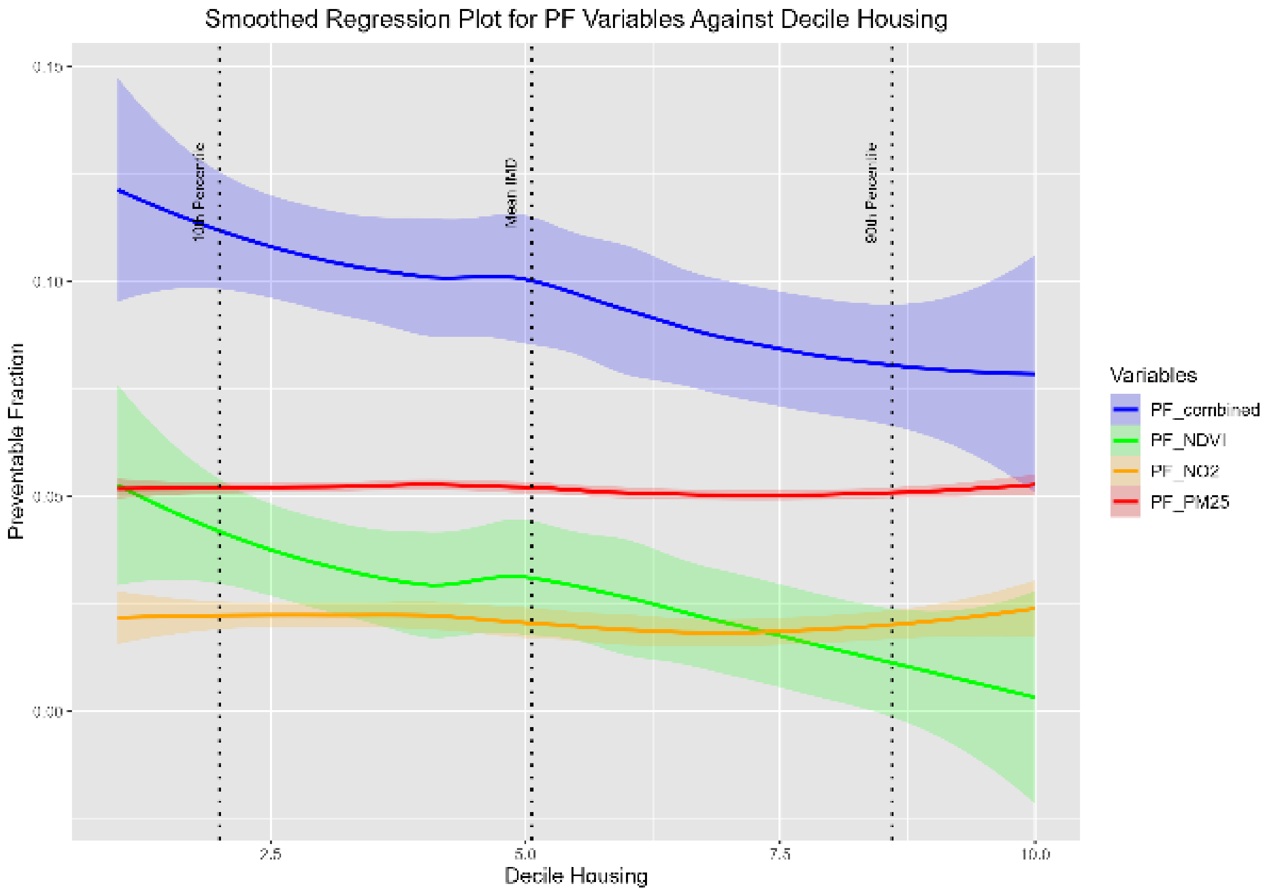
Socio-economic factors and health inequalities





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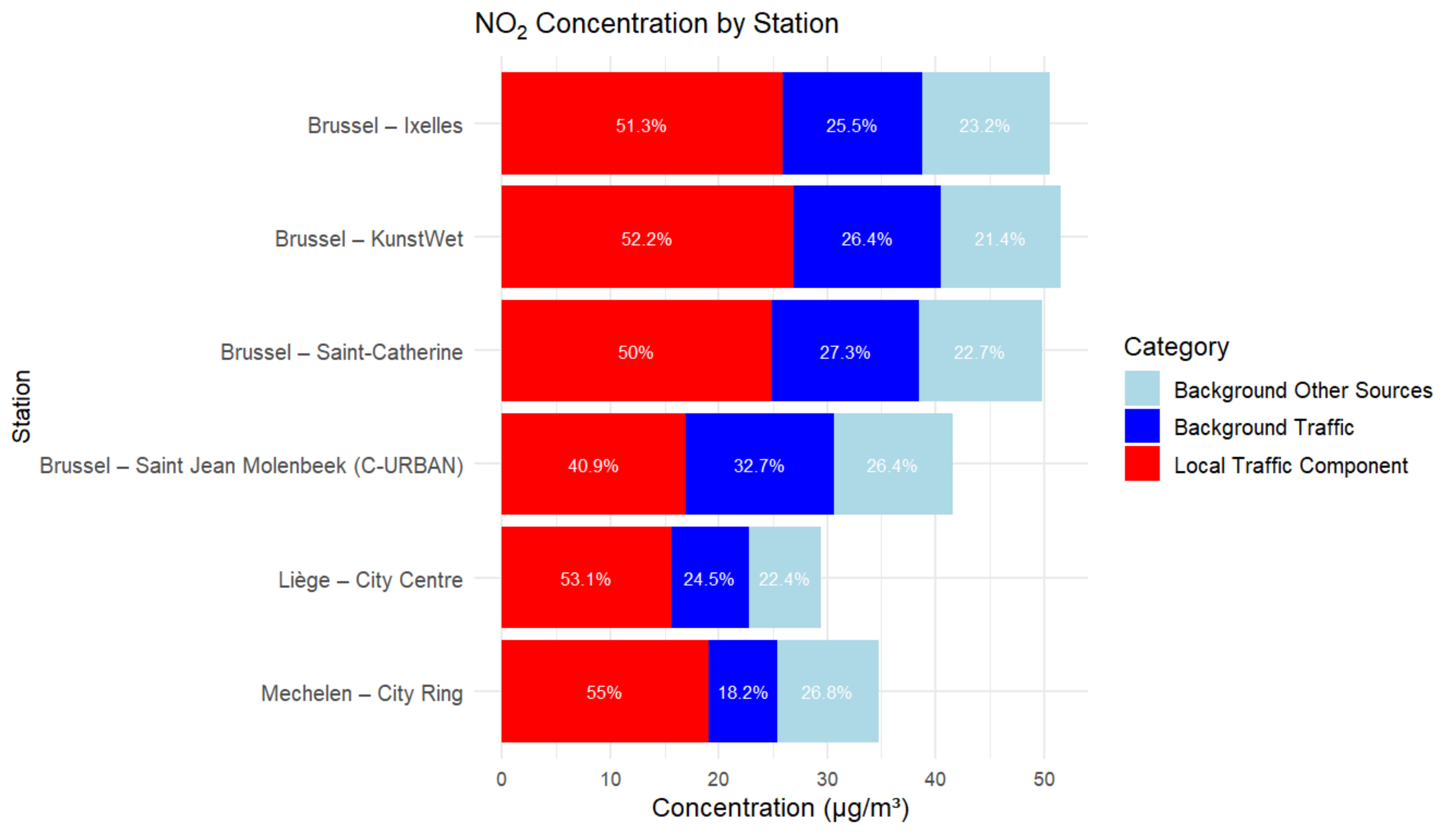
Methodological considerations: source allocation



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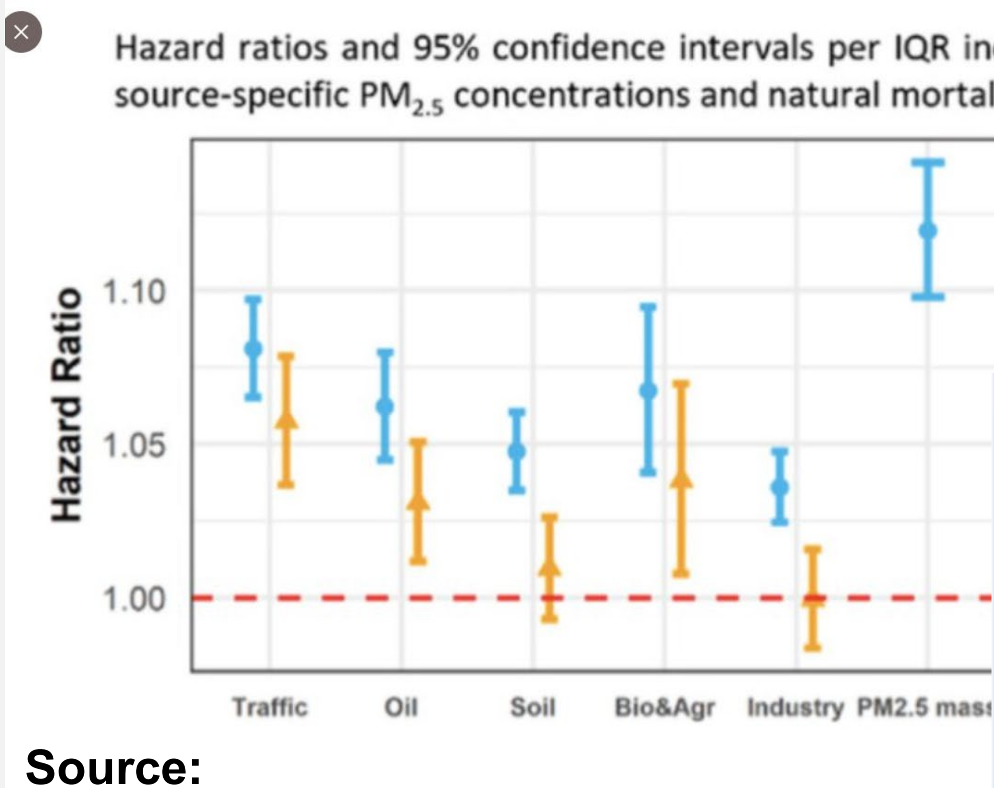
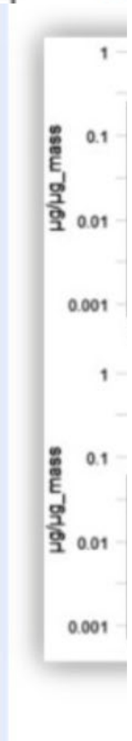
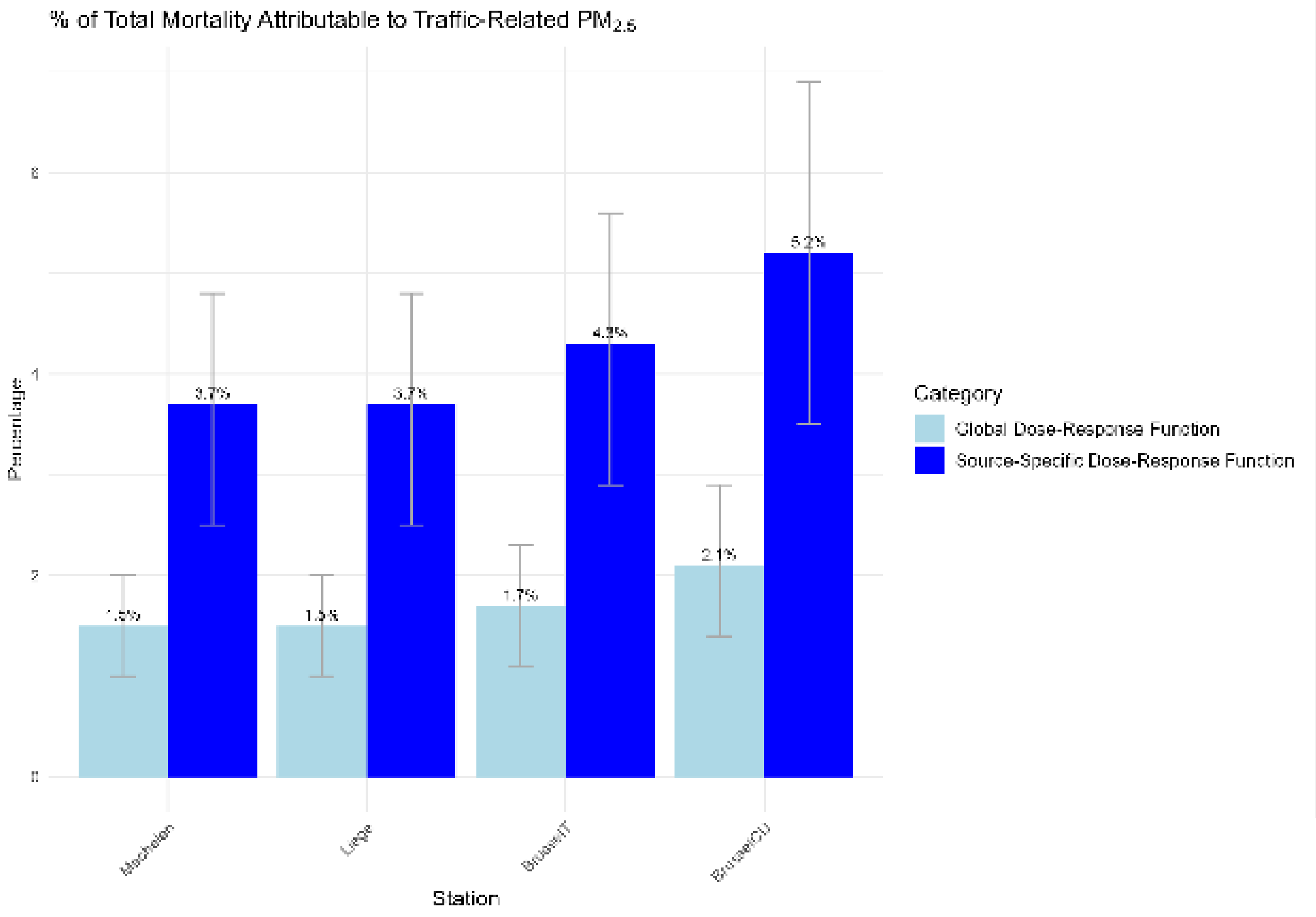
ERF $PM_{2.5}$ depends on chemical composition







Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC9261290/#!po=30.1020

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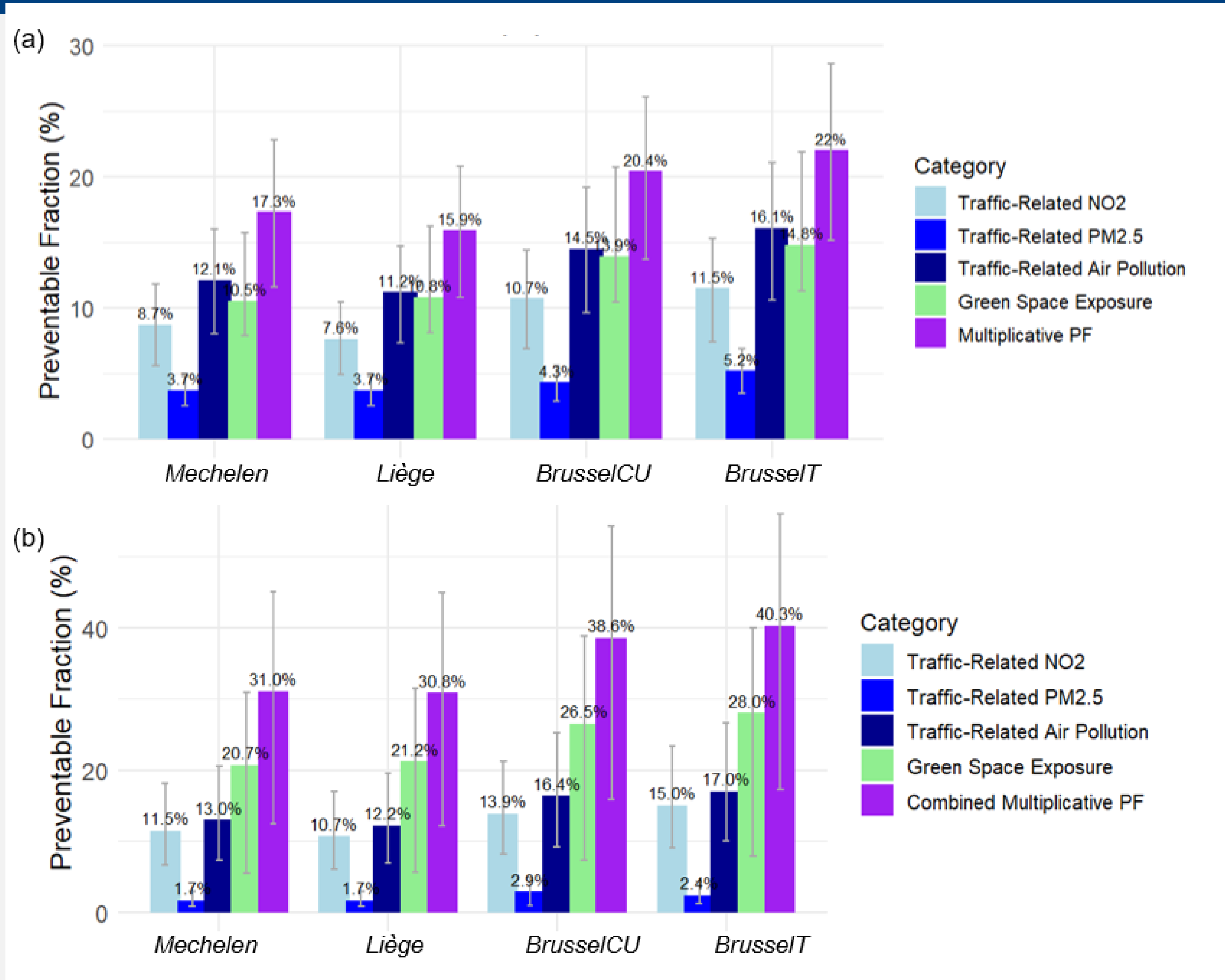
Multiplicative preventable mortality traffic-related air pollution + green space



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Research Questions

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Case-study: Paediatric asthma and local traffic interventions

Fig. A

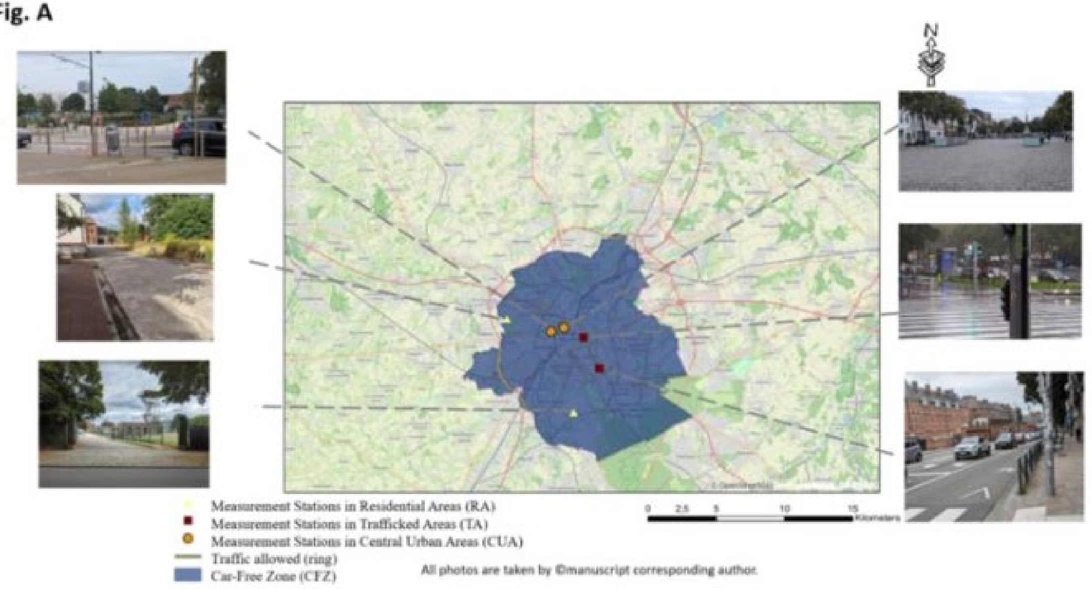
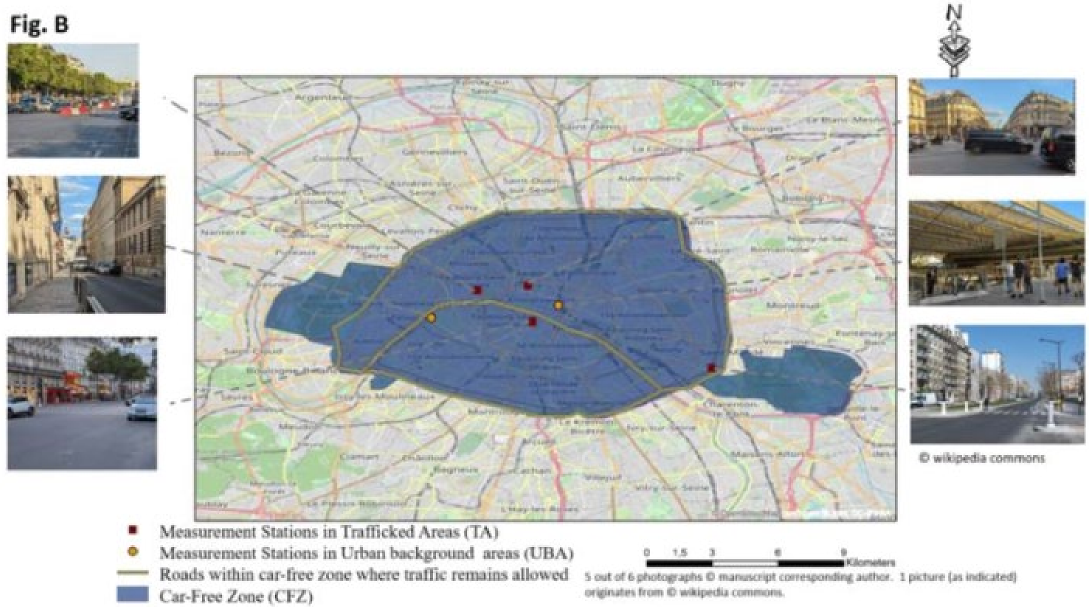


Fig. B



Concentrations on car-free days

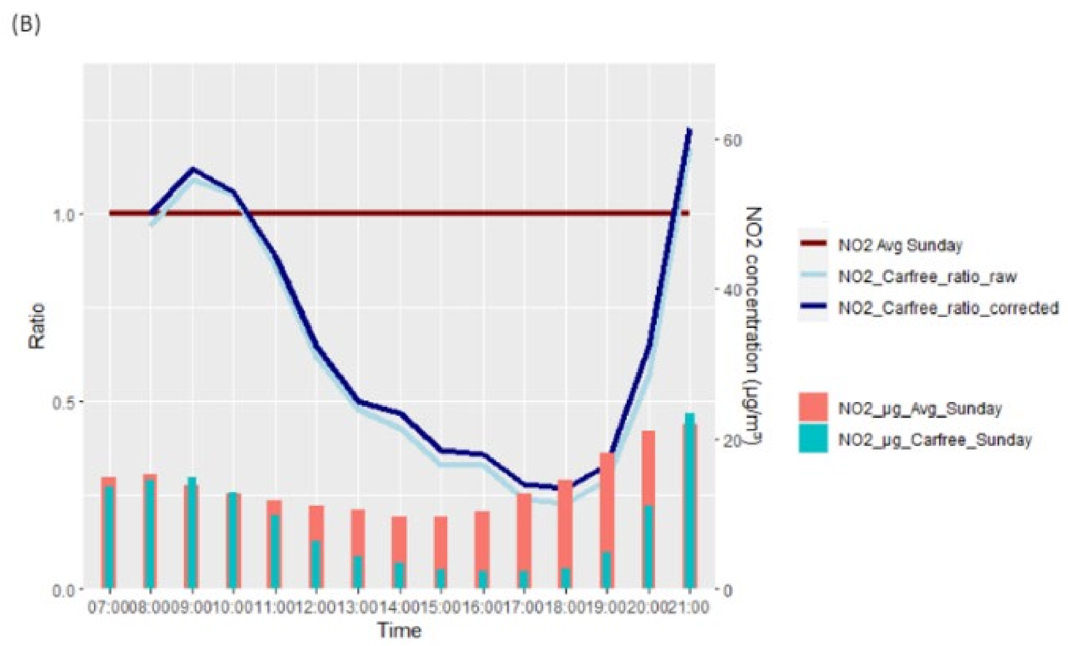


***Table 2:** Comparison of reduction in NO_2 concentrations in the European cities Brussels and Paris on car-free Sundays (13-18h) versus regular Sundays (13-18h), for different types of locations, using four different methods to calculate the reduction percentages.*

	% Reduction, method 1: direct calculation without correction	% Reduction, method 2: direct calculation, corrected	% Reduction, method 3: Random Forest (RF)	% Reduction; method 4: Boosted Regression Trees (BRT)
Brussels Traffic Stations	69% [64 – 74%]	71% [66 – 77%]	81% [80 - 83%]	80% [78 - 82%]
Brussels central urban stations	72% [67 – 77%]	77% [72 – 82%]	77% [73 – 79%]	81% [76– 82%]
Brussels residential	66% [61 – 71%]	63% [58 – 68%]	80% [75 – 83%]	79% [73 – 82%]

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Health Impact Assessment

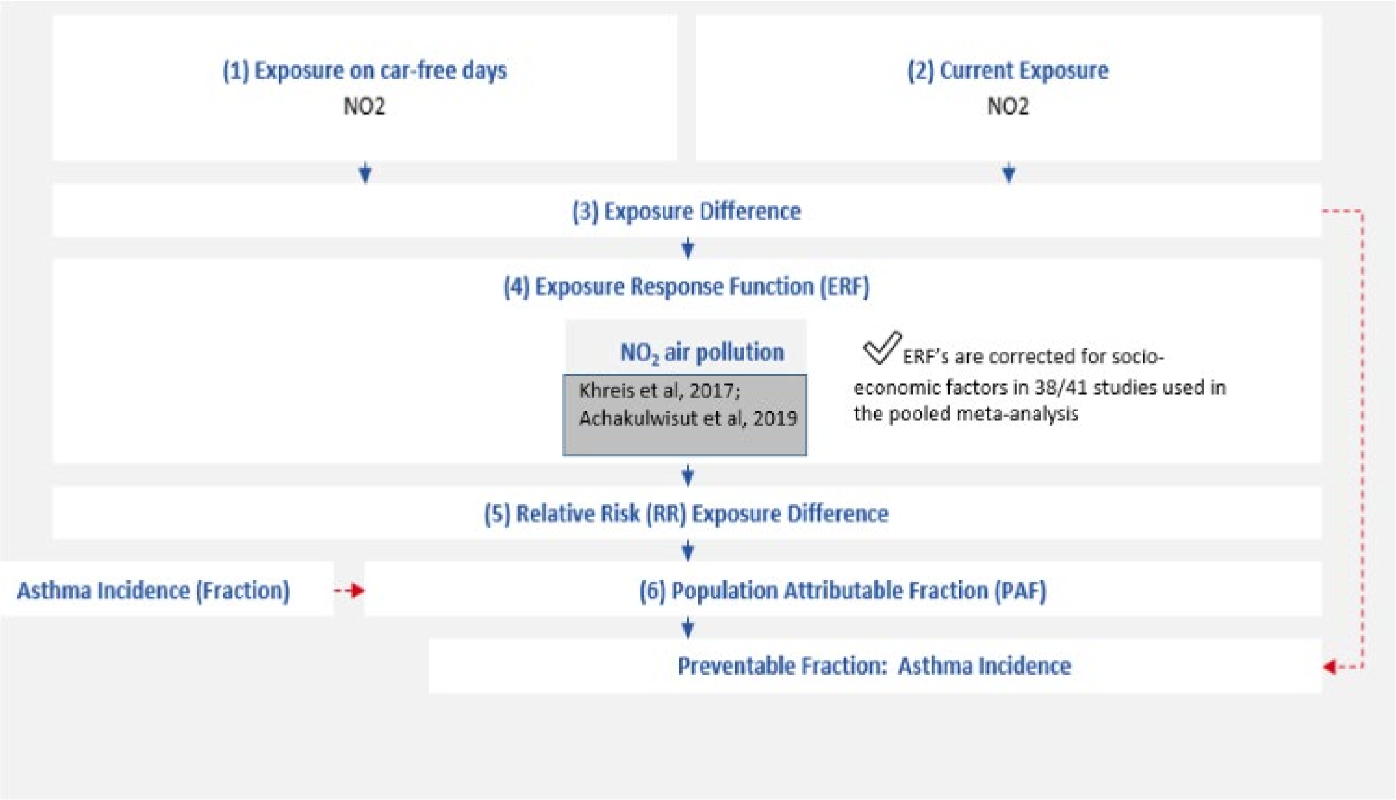

Figure 2: Procedural steps to conduct a Health Impact Assessment, adapted from Mueller et al (2017).

Ref: https://ehp.niehs.nih.gov/doi/10.1289/EHP220

Preventable Paediatric Asthma (%)

Read the publication:https://www.sciencedirect.com/science/article/pii/S2214140524001993

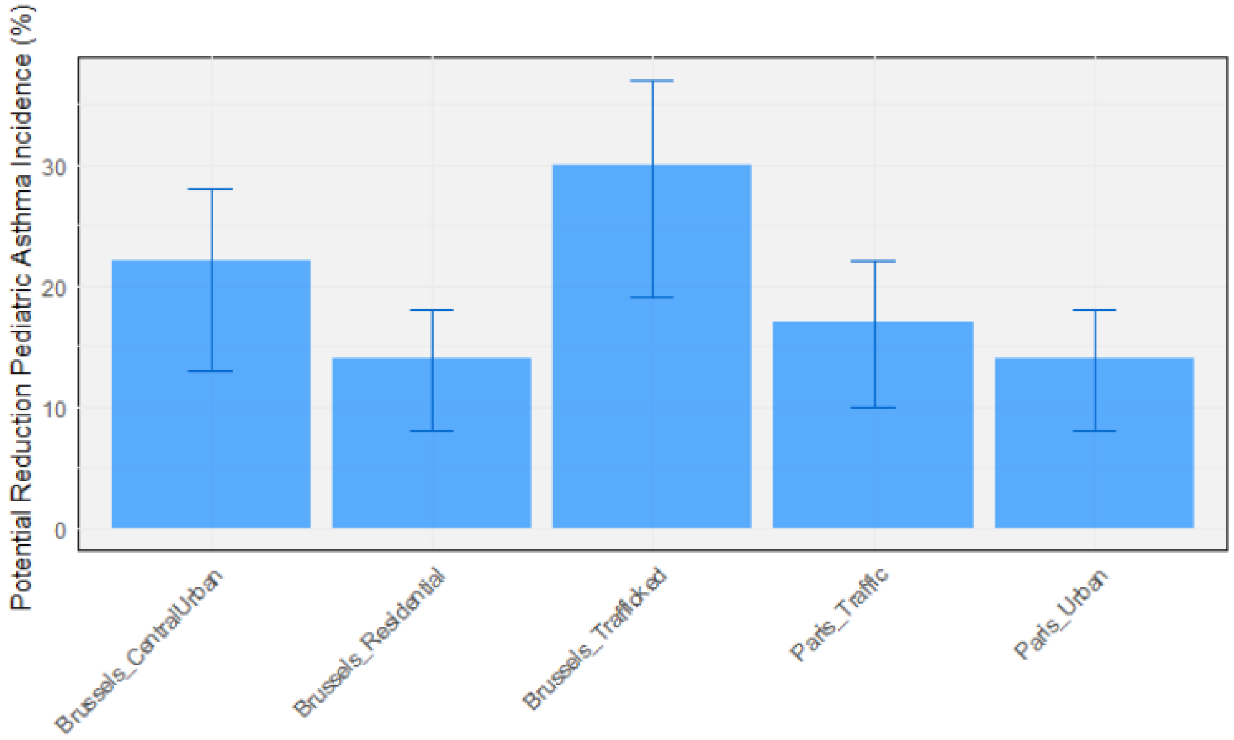

Figure 5: Percentage of paediatric asthma incidence that could be avoided by local interventions in traffic volume in different areas of Brussels and Paris.

Figure 3.

Percentage of pediatric asthma incidence that could be prevented in trafficked, central urban and residential areas in Brussels as local traffic was permanently reduced to the levels of car-free Sunday.

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Implications for real life

- E.g. 24 children in classroom
- 3 have asthma
- Ca. 1/3 could be prevented in large cities by local traffic interventions
- Ca. 250K children Brussels
- 25K with asthma
- 6K cases could be prevented

Thanks for your attention!

Health effects of transport and urban planning

ELLIS final conference

31/01/2025 – Bram Vandeninden

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