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ASIA CLEAN BLUE SKIES PROGRAM | KNOWLEDGE SHARING EVENT
STRATEGIES FOR IMPLEMENTATION OF LOW EMISSION ZONES IN ASIA

Health Effects of Traffic-Related Air Pollution

Hanna Boogaard
Principal scientist
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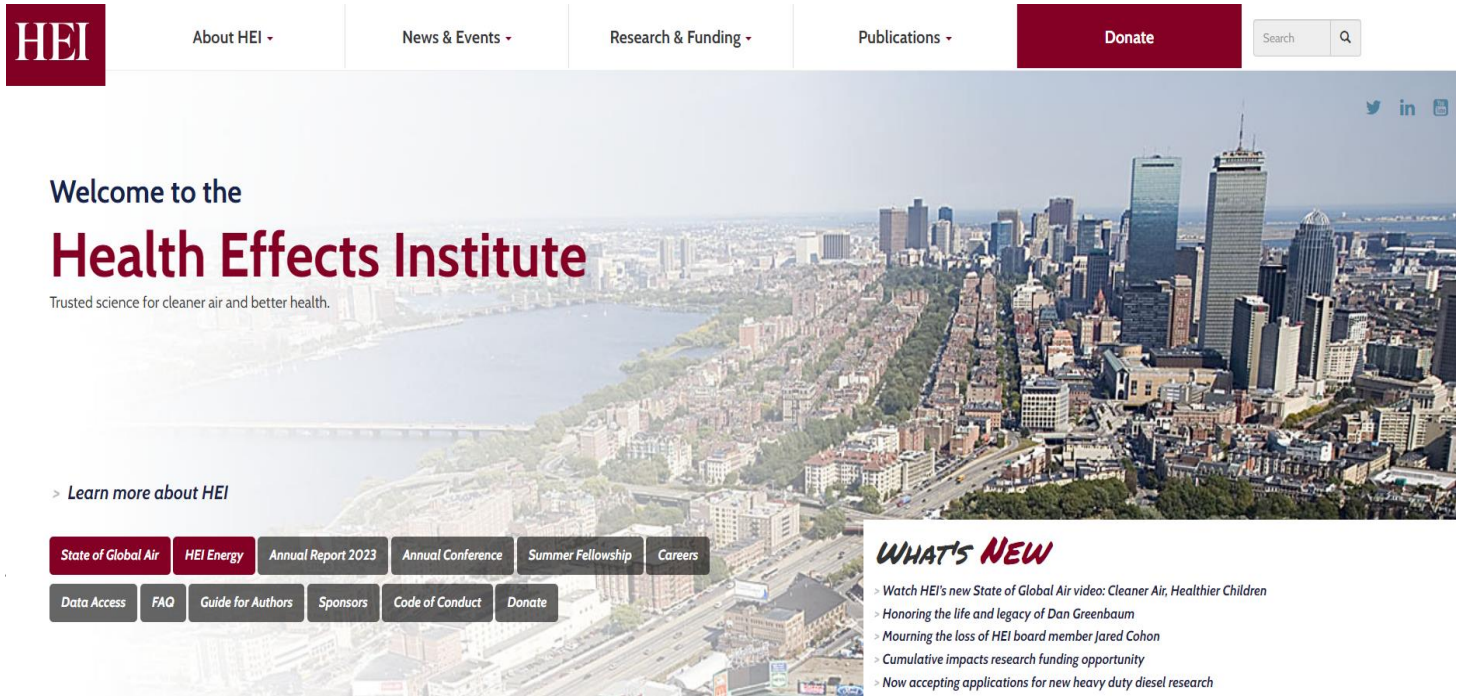
The Health Effects Institute

- An independent research organization providing policy-relevant, high-quality science on the health effects of air pollution
- Funded jointly by government and the worldwide motor vehicle industry and, occasionally, private foundations
- Funds research that is selected, conducted overseen, and reviewed independently of HEI's sponsors
- Does not take policy positions



We have published more than 400 studies so far
https://www.healtheffects.org/

Outline

- Health effects of traffic-related air pollution (TRAP)
  - HEI's Systematic review of epidemiological studies
- Health effects of traffic policy measures
  - Accountability studies or intervention studies
  - Intervention studies on LEZs

The full chain of events linking TRAP to health effects. Source: Center for Advancing Research in Transportation Emissions, Energy and Health (CARTEEH), available from: https://www.carteeh.org/.

The HEI Traffic Review has been Published in 2022

HEI

SPECIAL REPORT

HEALTH EFFECTS INSTITUTE

Number 23
June 2022

Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution

HEI Panel on the Health Effects of Long-Term Exposure to Traffic-Related Air Pollution

https://www.healtheffects.org/publication/systematic-review-and-meta-analysis-selected-health-effects-long-term-exposure-traffic

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Short communication

Long-term exposure to traffic-related air pollution and selected health outcomes: A systematic review and meta-analysis

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CONTENTS

HEI Panel on the Health Effects of Long-Term Exposure to Traffic-Related Air Pollution

- **Co-chairs:**
- Francesco Forastiere, *Imperial College London*
- Frederick Lurmann, *Sonoma Technology*

- **Members:**
- Richard Atkinson, *University of London*
- Jeffrey Brook, *University of Toronto*
- Howard Chang, *Emory University*
- Gerard Hoek, *Utrecht University*
- Barbara Hoffmann, *University of Düsseldorf*
- Sharon Sagiv, *University of California*
- Evi Samoli, *University of Athens*
- Audrey Smargiassi, *University of Montreal*
- Adam Szpiro, *University of Washington*
- Danielle Vienneau, *University of Basel*
- Jennifer Weuve, *Boston University*

- **Consultants to the Panel:**
- Julia Fussell, *Imperial College London*
- Frank Kelly, *Imperial College London*
- Tim Nawrot, *University of Hasselt*
- Gregory Wellenius, *Boston University*

- **Contractor:** Meltem Kutlar Joss and Ron Kappeler, *University of Basel*

- **HEI:** Hanna Boogaard, Dan Crouse, Dan Greenbaum, Robert O'Keefe, Martha Ondras, Allison Patton, Ellen Mantus, Rashid Shaikh, Eleanne van Vliet, Annemoon van Erp

Important Methodological Features of the Traffic Review

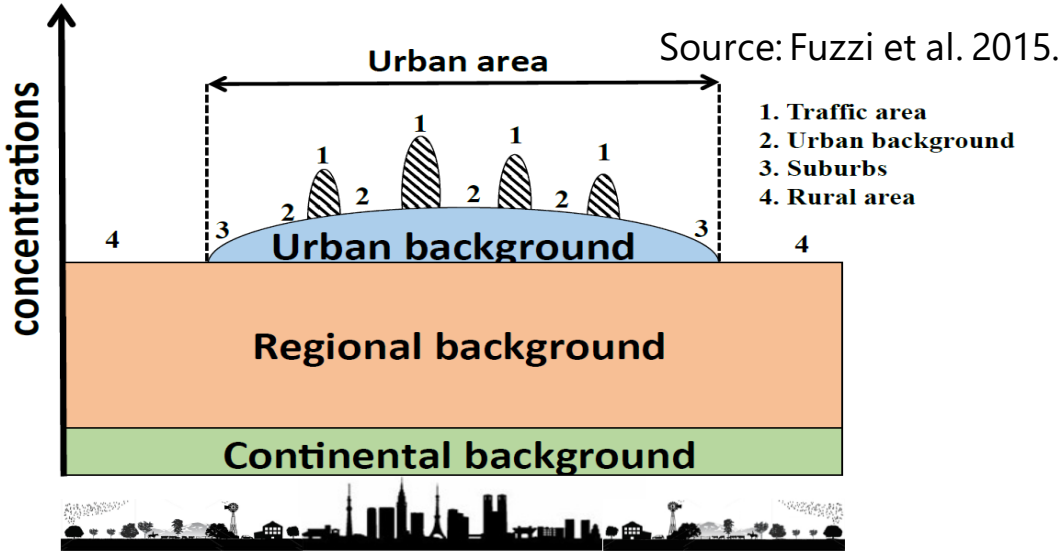
- Conducted largest effort of this type to date.
  - Evaluates the epidemiologic literature only.
  - Focuses on a selected set of health outcomes chosen *a priori*, including mortality, cardiovascular and respiratory morbidity and birth outcomes.
- Applies a new exposure framework.
  - Considers only long-term exposure to traffic-related air pollution.
  - Considers exposure contrasts in near-roadway and neighborhood environments.
- Assesses confidence in the evidence for an association.
  - 2 complementary methods with ratings of very low, low, moderate, or high for traffic-related air pollution mixture, not individual pollutants.

Traffic-Related Air Pollution is a Complex Mixture

Traffic is the main source of air pollution in many cities.

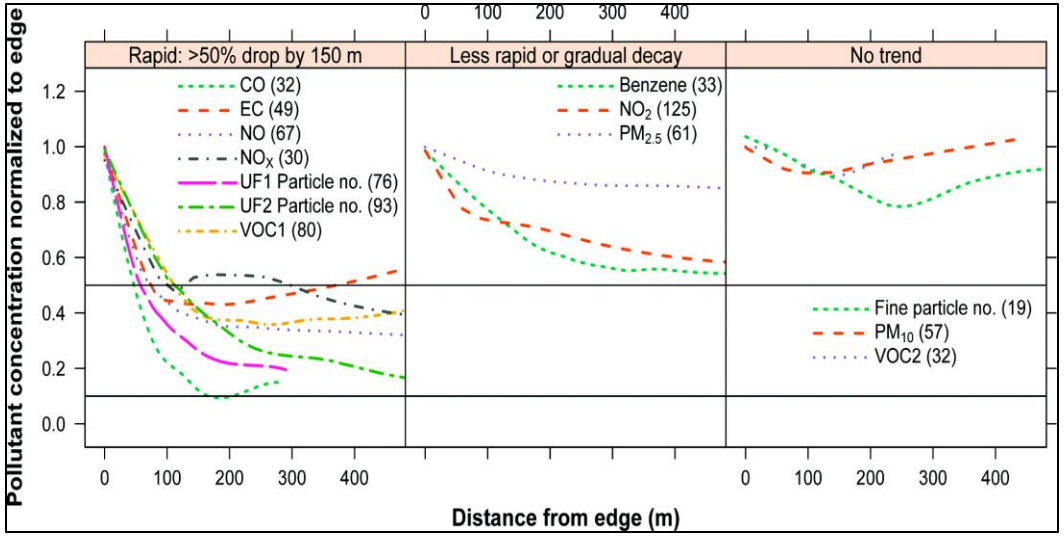
Exposure assessment of TRAP is challenging because it is a complex mixture and is characterized by high spatial and temporal variability.

- ✓ Still no pollutant specific for traffic sources
- ✓ TRAP impacts at different scales



Source: Fuzzi et al. 2015.

Source: Karner et al. 2010.

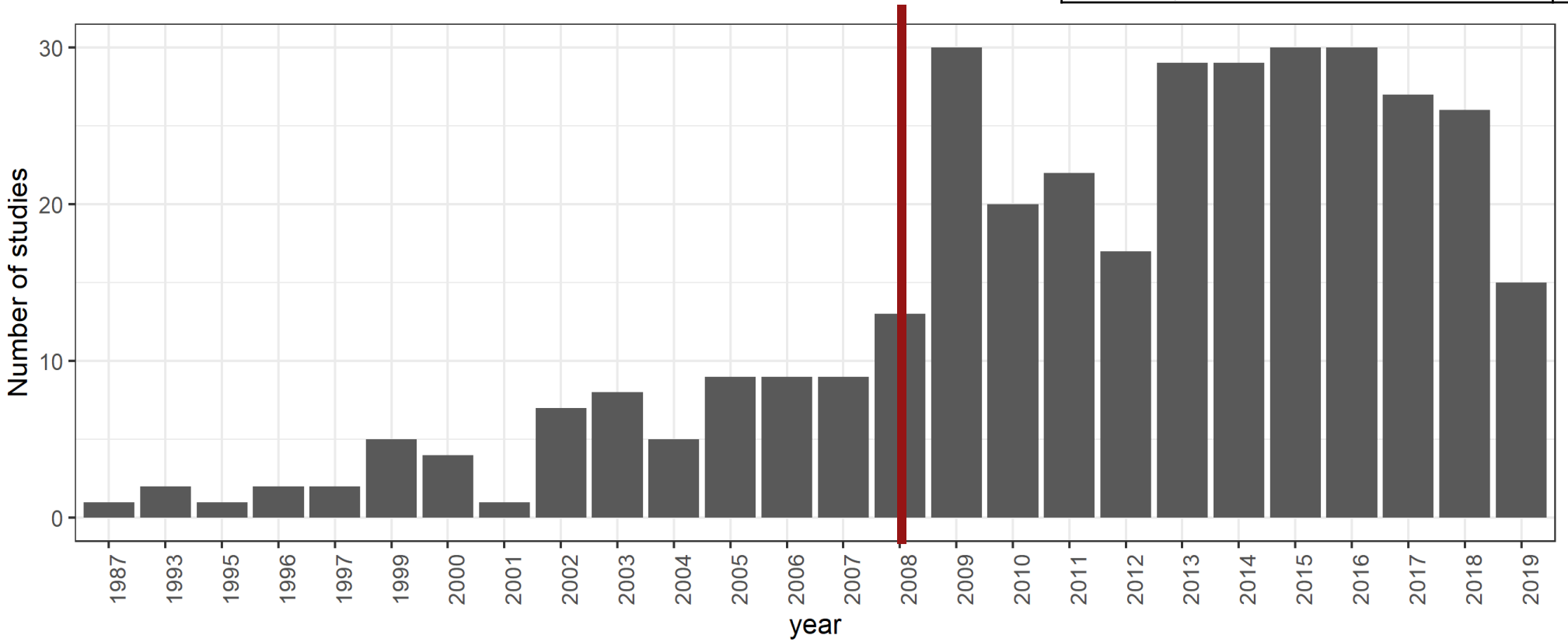


Literature Search Results

- 353 studies included

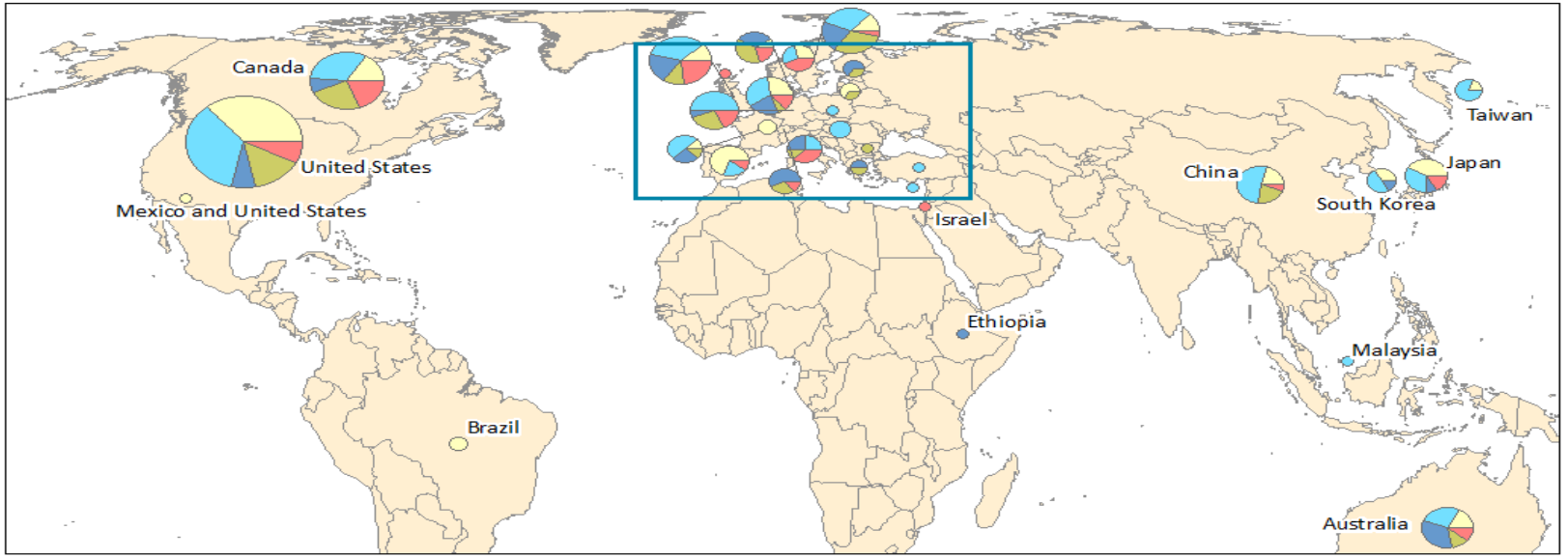
HEI 2010 report

Health outcome Category	Total number of studies
Birth outcomes	86
Respiratory outcomes - children	118
Respiratory outcomes - adults	50
Cardiometabolic outcomes	57
Mortality	48



Literature search from January 1980 - July 2019 in PubMed, LUDOK, and reviews

Geographical Location of the Studies



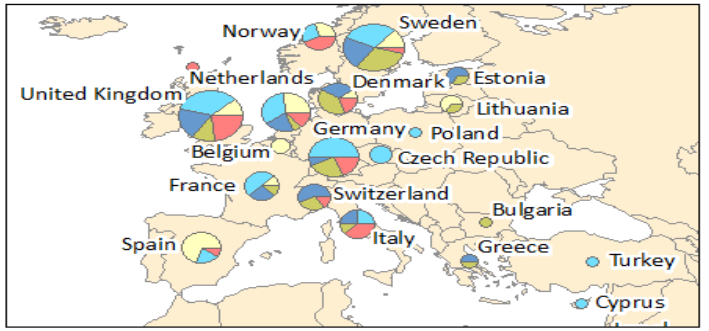
Studies in World Countries

Legend

28 Circle size indicates total studies for country
Range: 1 to 91

Health outcomes studied

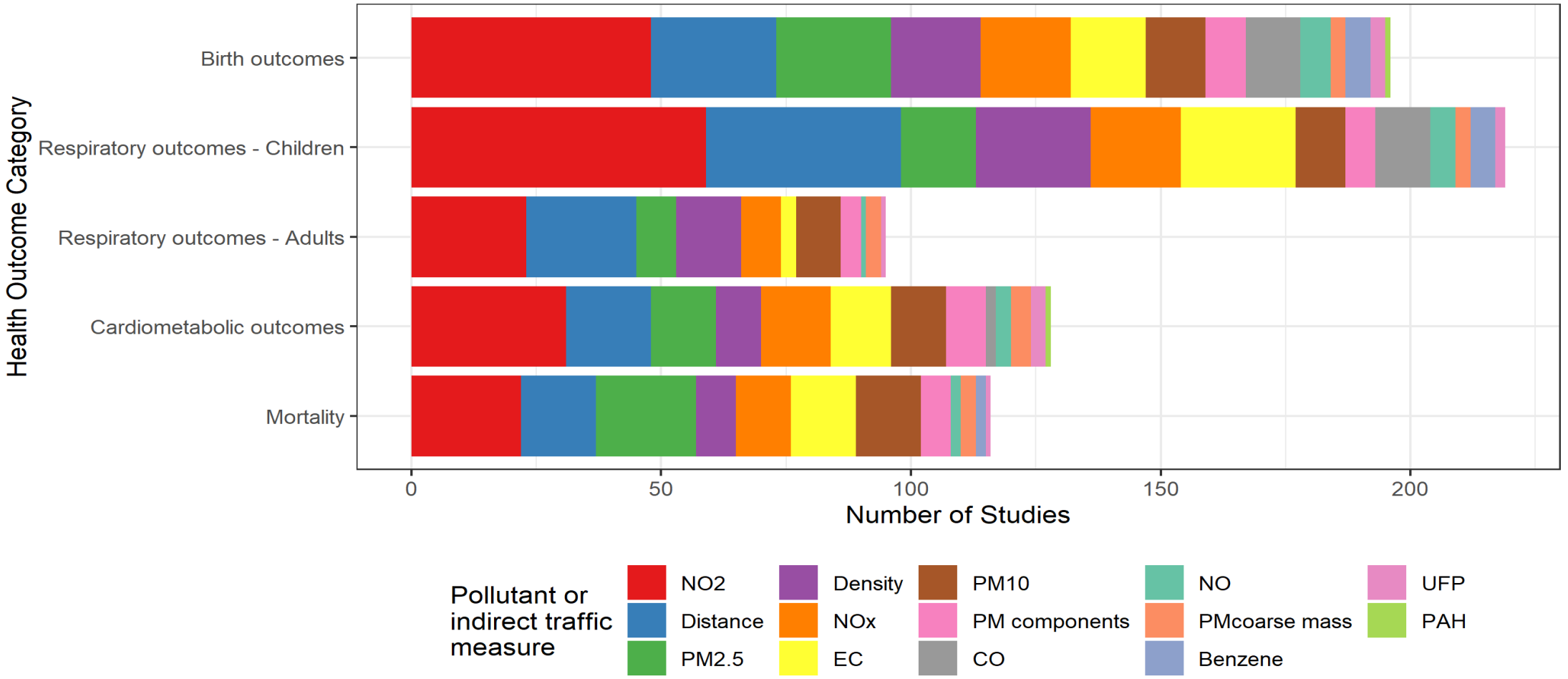
- Birth outcomes
- Respiratory outcomes - children
- Respiratory outcomes - adults
- Cardiometabolic outcomes
- Mortality



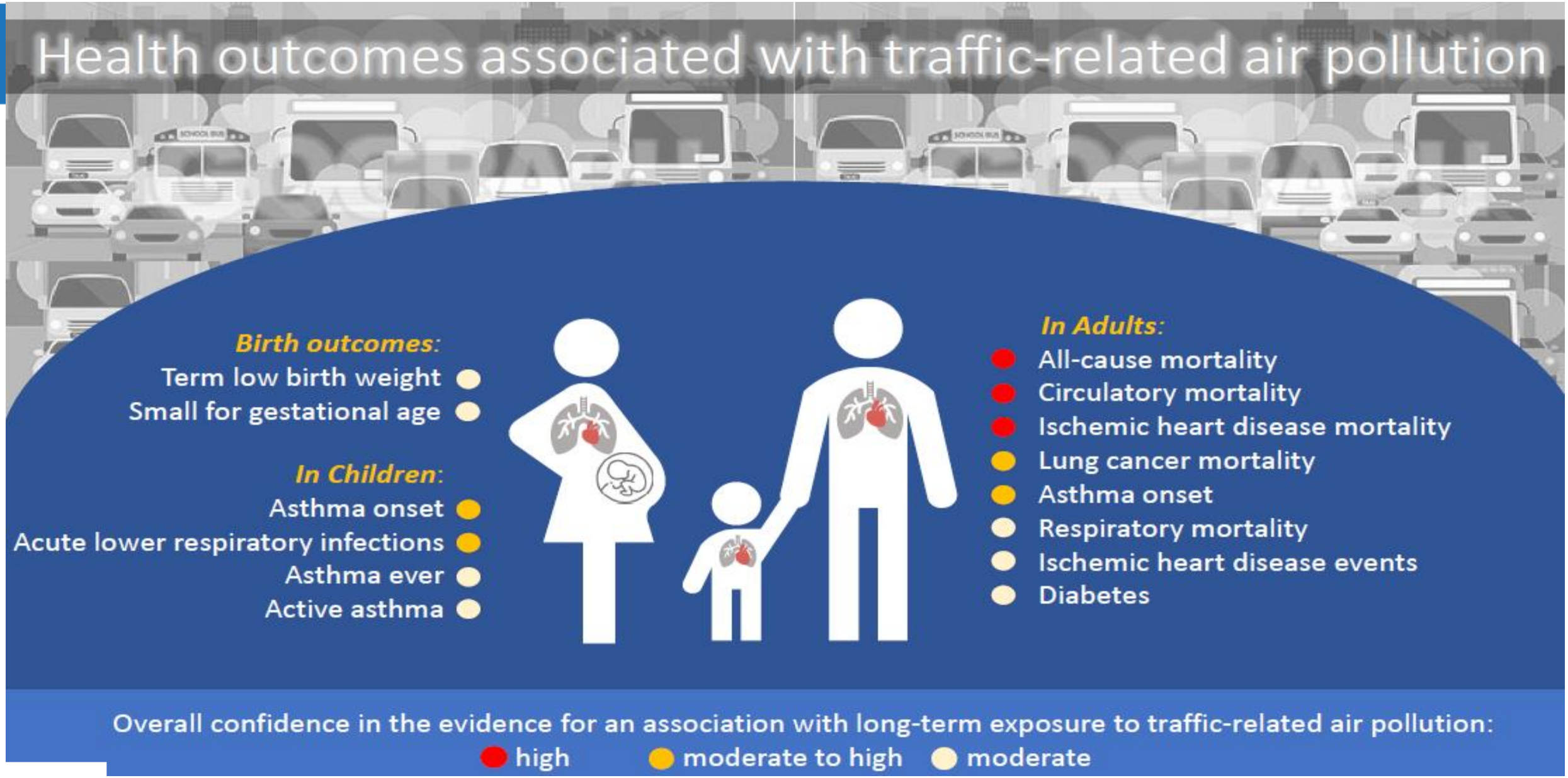
Studies in European countries

Region	Total number of studies
Europe	163
North America	130
Asia	41
Other regions	19

Number of Studies by Outcome and Pollutant



Health outcomes associated with traffic-related air pollution



Footnote: health outcomes for which the overall confidence in the evidence was low-to-moderate, low or very low are not in the picture.

Conclusions Traffic Review

- The health effects of TRAP continues to be a key health burden for people across the globe, with the highest exposures and impacts in urban settings and for those who live, work or play in close proximity to busy roadways.

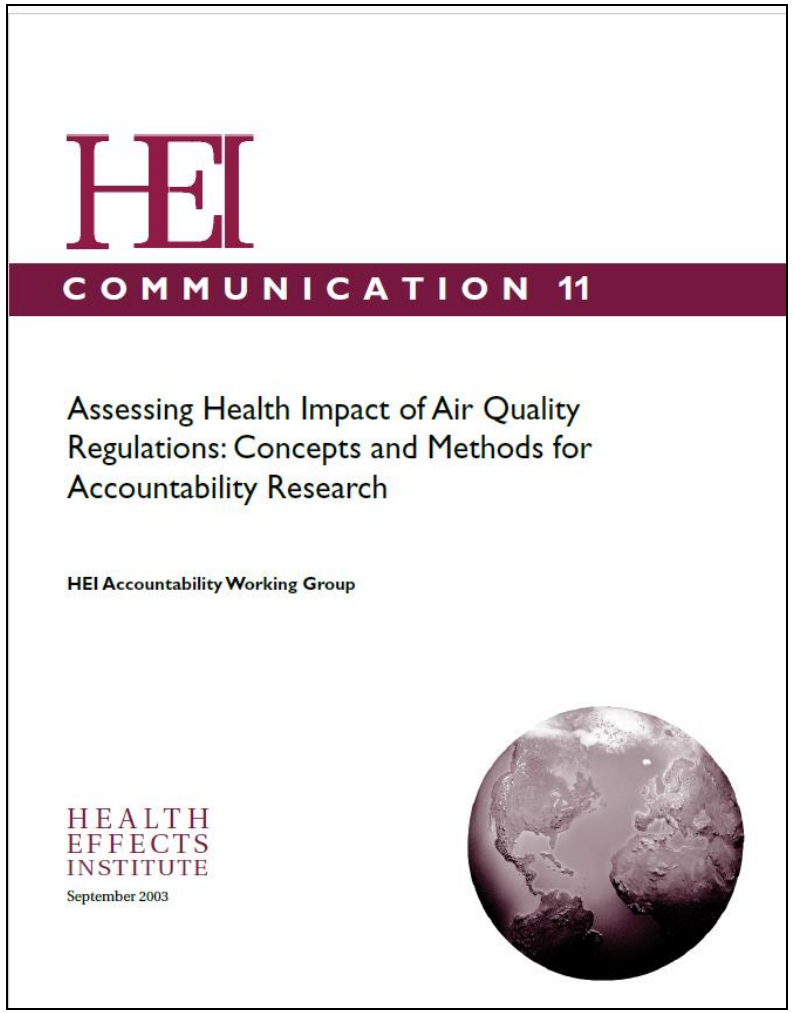
- Given the large number of people exposed to TRAP, and the overall strong links between long-term exposure to TRAP and several adverse health outcomes, TRAP remains an important public health concern and deserve greater attention from the public and from policymakers.

A Key Question

How do we know that actions taken for clean air have actually reduced air pollution – and benefitted public health?

Los Angeles Then and Now
Source: New York Times

Intervention research

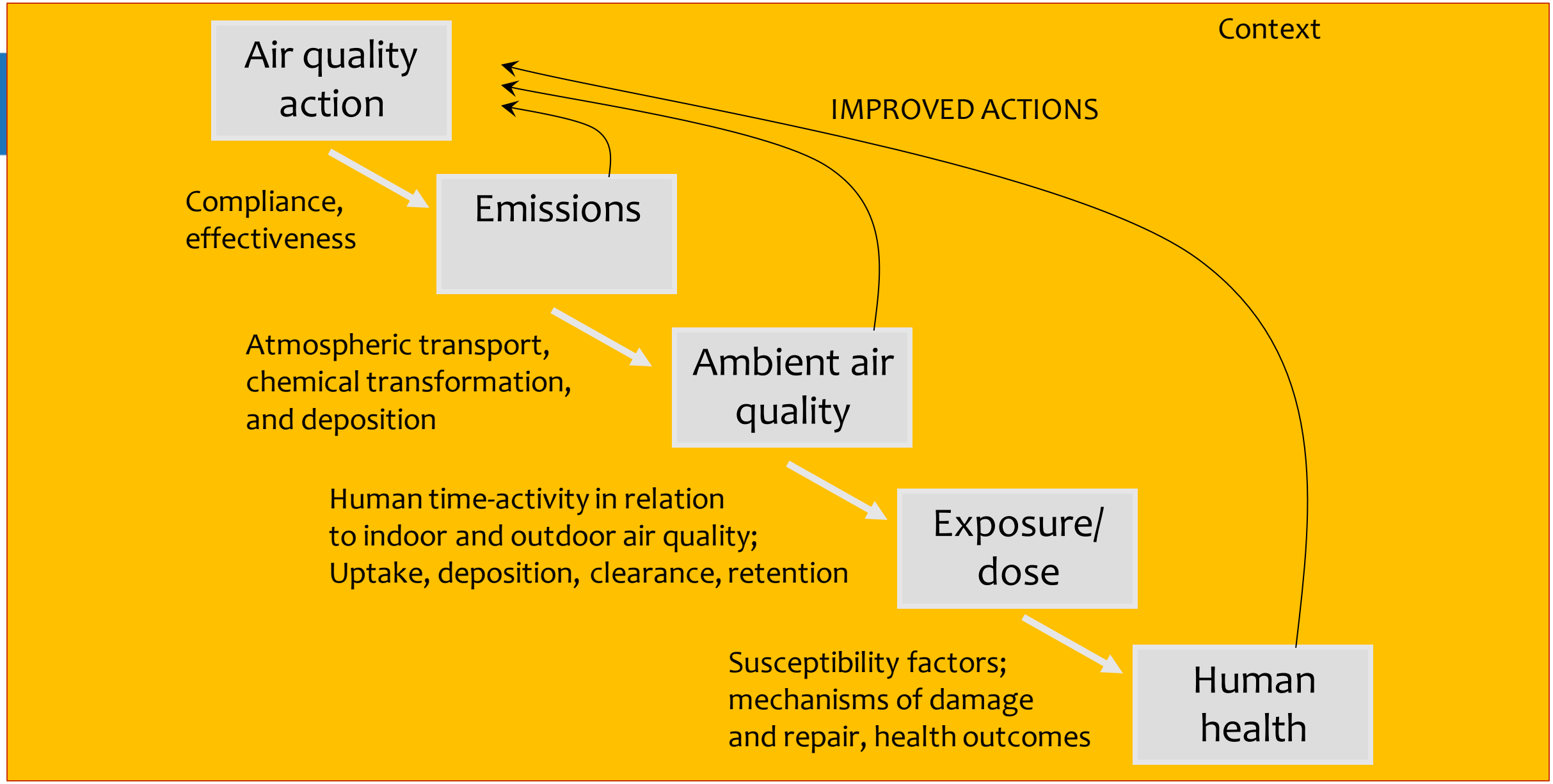


- **How do we know that air quality regulations and actions "work"?**

✓ Testing the extent to which air quality actions improve public health.

✓ Assessments of past environmental policies—termed accountability studies—contribute important information to the decision-making process used to review the efficacy of past policies, and subsequently aid in the development of effective new policies.

✓ HEI has a long track-record of comprehensive research and reviews.



The Chain of Accountability

Showing relationship of air quality action to health effects of air pollution

Overview of intervention studies funded by HEI

Traffic measures
- Sara Adar: School bus retrofit and replacement US wide (under review)
- Perry Hystad: Traffic and congestion measures in Texas (under review)
- Frank Kelly: Congestion charging scheme in London
- Frank Kelly: London low emission zone baseline study
- Jennifer Peel: Traffic measures during the 1996 Olympic Games in Atlanta

Fuel changes
- Doug Dockery: Coal bans in Irish cities
- Sam Harper, Jill Baumgartner: Coal ban and heat pump subsidy in Beijing, China (under review)
- Curtis Noonan: Wood stove change-out program in Montana
- Chit-Ming Wong: Reducing sulfur in fuel in Hong Kong

Multiple sources
- Frank Gilliland: Policy-driven air quality improvements on children's health
- Patrick Kinney: Major national regulatory policies in China (under review)
- Dick Morgenstern: Air quality improvement 1990 Clean Air Act Amendments
- Annette Peters: Air quality improvement after German reunification
- Ted Russell: Impacts of air quality regulations in Atlanta
- Jim Zhang: Air quality improvements 2008 Olympic Games in Beijing

Ports
- Ying-Ying Meng: Goods Movement Actions in Los Angeles

All available at www.healtheffects.org

Statistical Methods
- Cory Zigler: Causal inference methods for estimating long-term health effects of air quality regulations

Various reviews on intervention studies

- Cochrane systematic review (Burns 2020)

https://pubmed.ncbi.nlm.nih.gov/31855800/

- Systematic evidence map (Khreis 2023)

https://pubmed.ncbi.nlm.nih.gov/36780750/. The evidence recorded for each unique policy scenario is hosted in an open-access Excel database, and an interactive visualization tool.

- Summarizing the HEI experience (Boogaard 2017)

https://pubmed.ncbi.nlm.nih.gov/28988407/

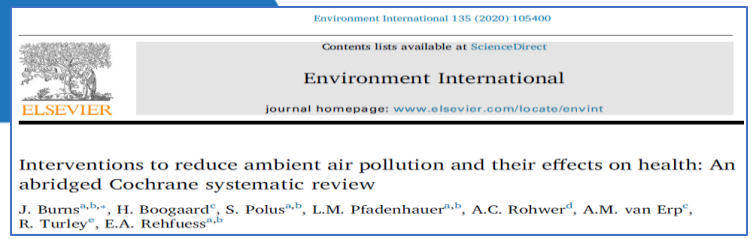
- Two other reviews (Rich 2017, Henneman 2017)

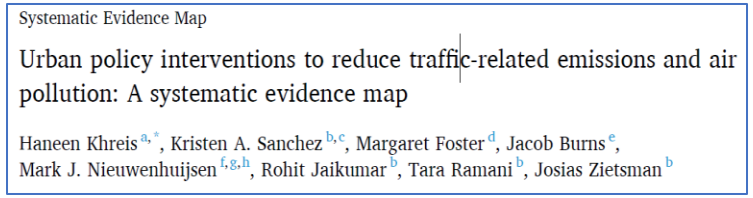
https://pubmed.ncbi.nlm.nih.gov/28089581/

https://pubmed.ncbi.nlm.nih.gov/27715473/

- A review by Public Health England in 2019

https://www.gov.uk/government/publications/improving-outdoor-air-quality-and-health-review-of-interventions





Key observations

- Most intervention studies to date have focused on effects of relatively short-term, local-scale, and sometimes temporary interventions.
- Only a few recent intervention studies have sought to investigate large-scale, multiyear regulatory programs.
- Most intervention studies come from Western Europe and North America.
- Wide range of interventions, contexts, outcomes and study methods, making any overall conclusions difficult.
- Intervention research provide weak evidence that air quality and health improvements over last few decades can be assigned to individual air quality policies.

Effective air quality management from a broad range of policies has resulted in significant reductions in levels of air pollution in many countries. Challenges remain around methodological difficulties in linking specific interventions causally to the effect.

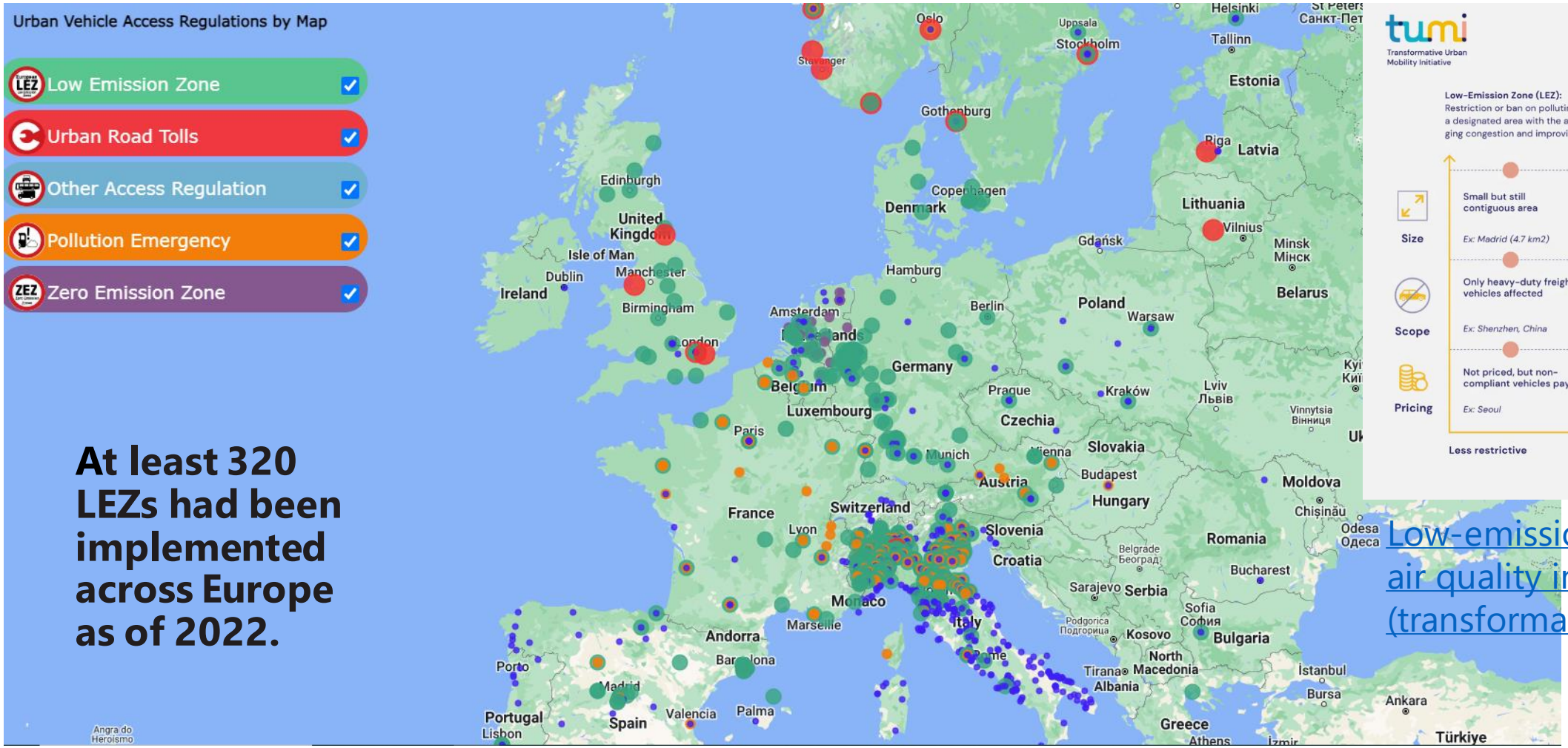
Lessons learned

- Accountability chain remains useful
- Importance of exposure contrast: establish size of air quality improvement before starting a health study
- Control groups: select appropriate time windows and geographic areas for comparison
- Need quality data collected continuously (health tracking, air quality monitoring)
- Controlling for time-varying confounders
- May need advanced statistics
- Teasing apart actions and regulations that happen simultaneously remains challenging
- Built in an evaluation component from the start

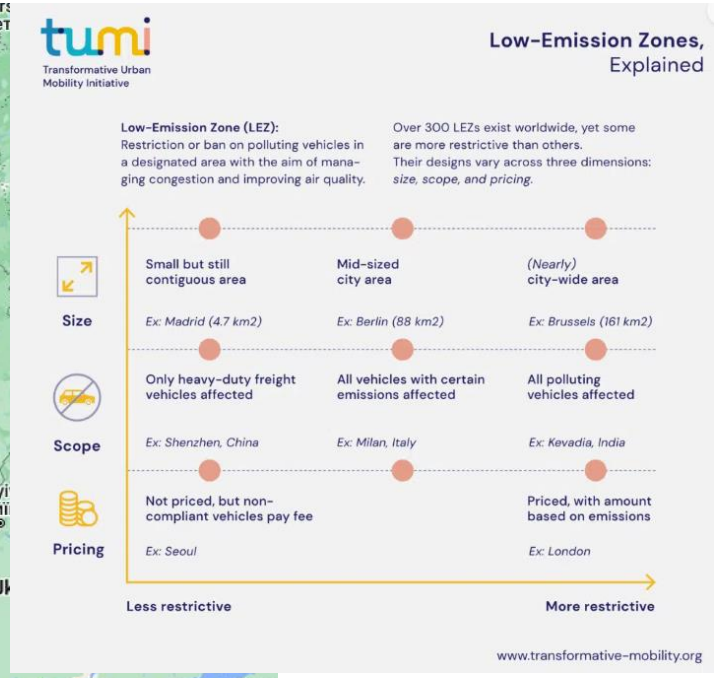
Some general health principles to guide local action

- Take a whole system approach; address air and climate pollutants together and work at all levels and across all sectors;
- Prioritize interventions that prevent or reduce emissions over those that address traffic-related air pollution once it has been emitted (concentration reductions) or relying on avoidance (individual exposure reductions).
- Focus on reducing people's long-term exposure to traffic-related air pollution but consider short-term exposures and additional actions during episodes of poor air quality.
- Seek to lower population-level exposure and reduce everyone's exposure to air pollution, as well as targeting 'hotspots' (the most polluted areas).
- Lowering exposures below national standards and WHO (Interim) Air Quality Guidelines will improve people's health because there is no evidence of a threshold for health effects.
- Some interventions improve air quality and have 'co-benefits' for people's wider health and wellbeing, such as measures that increase walking and cycling, improve housing, or enhance local greening. These potential co-benefits are opportunities to increase the overall benefits to public health.
- As action is taken, exposure reductions in some population groups may need to be prioritized including marginalized communities.

Low emission zones



At least 320 LEZs had been implemented across Europe as of 2022.



[Low-emission zones: Managing air quality in cities » TUMI (transformative-mobility.org)]

https://urbanaccessregulations.eu/

Health effects of low emission and congestion charging zones: a systematic review

Lancet Public Health 2023; 8: e559–74

Rosemary C Chamberlain, Daniela Fecht, Bethan Davies, Anthony A Laverty

https://pubmed.ncbi.nlm.nih.gov/37393094/

- Included studies that evaluated the effect of implementation of a LEZ or CCZ on air pollution-related health outcomes (cardiovascular and respiratory diseases, birth outcomes, dementia, lung cancer, diabetes, and all-cause) or road traffic injuries (RTIs) using longitudinal study designs and empirical health data.
- Literature was included up to January 2023 searching six electronic databases, without start date or language restrictions.
- Of 2.279 studies screened, 16 were included, of which 8 assessed LEZs and 8 assessed CCZs.

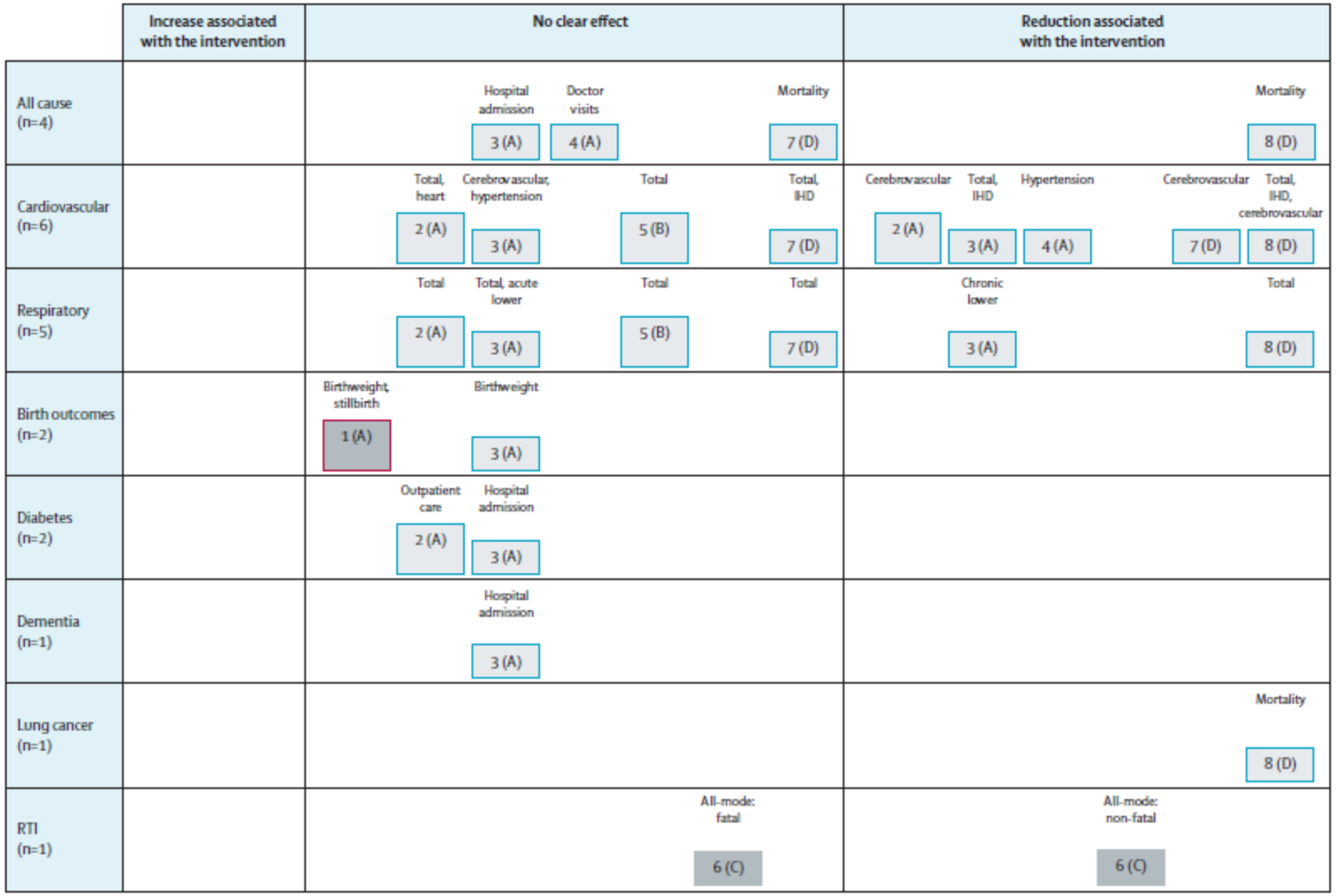
8 Empirical Health Studies on LEZ identified

Health effects of low emission and congestion charging zones: a systematic review

Rosemary C Chamberlain, Daniela Fecht, Bethan Davies, Anthony A Lavarty

Reference	Location	Health outcome	Period	Sample size	Intervention area/population	Control area/population
Gehrsitz 2017	Germany	Birth outcomes	2005-2012	1.85 million births	Cities > 100.000 population, with LEZ active in city during gestation period	Cities >100.000 population, without LEZ active in city during gestation period
Margaryan 2021		Outpatient and hospital admission data for cardiovascular diseases	2004-2017	954 area-year observations for outpatient data	Cities > 100.000 population with LEZ in place	Cities > 100.000 population without LEZ in place
Pestel and Wozny 2021		Hospital admission data for all-cause, cardiovascular, respiratory and other causes	2006-2016	2736 hospital - year observations (342 hospitals per year)	Hospitals in cities >100.000 population, where the hospital is located inside an active LEZ	Hospitals in cities >100.000 population, where the hospital is not located inside an active LEZ
Samiento 2021		Hypertension; doctor visits (all-cause)	2009-2018	9218 year-individual observations	Participants living in a LEZ at time of measurements	Participants living in areas that never had a LEZ within the study period, and are not within 25 km of a LEZ
Beshir and Fichera 2022	London, UK	Specific respiratory and heart-related health problems lasting ≥12 months	2003-2015	1.2 million individual-quarter observations	Participants living in Greater London	Participants living in other major towns or cities in England
Percoco 2016	Milan, Italy	Total incidents; injuries from road traffic incidents (all vehicles); deaths from road traffic incidents (all-vehicles)	2001-2011	?	Eco-Pass area (Central Milan)	Milan, outside the Eco-Pass area
Yorifuji 2011	Tokyo, Japan	All-cause and cause-specific mortality	2003-2008	8.310.572	23 urban wards of Tokyo Metropolitan Government area	Rest of Japan
Yorifuji 2016			2000-2013	8.489.653	23 urban wards of Tokyo Metropolitan Government area	Osaka, Japan

A LEZ



Studies
1) Gehrsitz (2017)
2) Margaryan (2021)
3) Pestel and Wozny (2021)
4) Sarmiento et al (2021)
5) Beshir and Fichera (2022)
6) Percoco (2016)
7) Yorifuji et al (2011)
8) Yorifuji et al (2016)
9) Green et al (2016)
10) Li et al (2012)
11) Li and Gao (2019)
12) Noland et al (2008)
13) Quddus (2008)
14) Tang and van Ommeren (2022)
15) Transport for London (2005)
16) Simeonova et al (2021)

Location
A) Germany
B) London, UK
C) Milan, Italy
D) Tokyo, Japan
E) Stockholm, Sweden

Overall internal validity
++
+
–

Intermediate factor
Reduction
No clear effect
Increase
NR

Health effects of low emission and congestion charging zones: a systematic review

Rosemary C Chamberlain, Daniela Fecht, Bethan Davies, Anthony A Laverty

Several LEZ studies identified positive effects on air pollution-related outcomes, with reductions in some cardiovascular disease subcategories found in five of six studies investigating this outcome, although results for other health outcomes were less consistent.

Evidence on CCZs is mainly limited to London and confined to road traffic injuries.

Conclusions – what do intervention studies add?

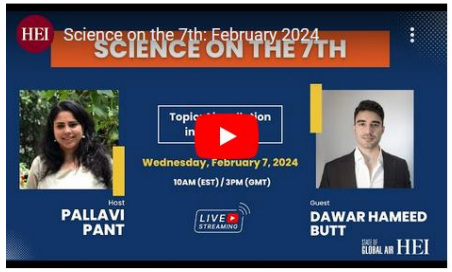
- They offer real world opportunities to test whether changes in air pollution result in changes in health.
- If well-designed – control populations, well-defined health outcomes, etc. – they can offer significant insight on cause and effect.
- You need to find the “sweet spot” where an action has caused a significant change in air quality; coincident with a good health data set.
- More to be done!

STATE OF GLOBAL AIR

Track and communicate long-term trends in air quality levels and health impacts for cities and countries around the world. https://www.stateofglobalair.org/ | https://www.healtheffects.org/science-on-the-7th

Updated website

Livestream series



Resources in multiple languages

NEW: Video on air pollution and children's health

STATE OF GLOBAL AIR /2024

UPCOMING: State of Global Air 2024, in partnership with IHME and UNICEF

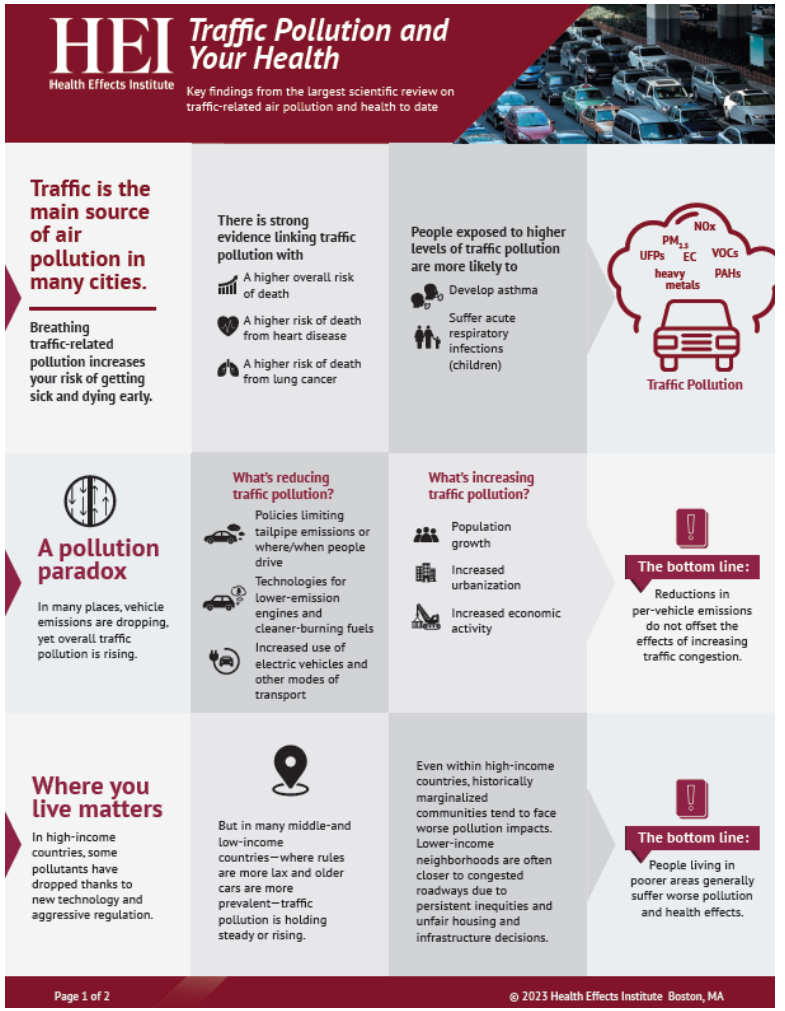
ADB IER RICARDO Logika Noise Air Quality Consultants CLEAN AIR ASIA **Strategies for Implementation of Low Emission Zones in Asia**

STATE OF GLOBAL AIR HEI

THANK YOU!

Hanna Boogaard
jboogaard@healtheffects.org

https://bit.ly/HEI-traffic-review-factsheet



HEI Health Effects Institute

Traffic Pollution and Your Health

Key findings from the largest scientific review on traffic-related air pollution and health to date

Traffic is the main source of air pollution in many cities.

Breathing traffic-related pollution increases your risk of getting sick and dying early.

There is strong evidence linking traffic pollution with
- A higher overall risk of death
- A higher risk of death from heart disease
- A higher risk of death from lung cancer

People exposed to higher levels of traffic pollution are more likely to
- Develop asthma
- Suffer acute respiratory infections (children)

NOx, $PM_{2.5}$, UFPs, EC, VOCs, heavy metals, PAHs

Traffic Pollution

A pollution paradox

In many places, vehicle emissions are dropping, yet overall traffic pollution is rising.

What's reducing traffic pollution?
- Policies limiting tailpipe emissions or where/when people drive
- Technologies for lower-emission engines and cleaner-burning fuels
- Increased use of electric vehicles and other modes of transport

What's increasing traffic pollution?
- Population growth
- Increased urbanization
- Increased economic activity

The bottom line:

Reductions in per-vehicle emissions do not offset the effects of increasing traffic congestion.

Where you live matters

In high-income countries, some pollutants have dropped thanks to new technology and aggressive regulation.

But in many middle-and low-income countries—where rules are more lax and older cars are more prevalent—traffic pollution is holding steady or rising.

Even within high-income countries, historically marginalized communities tend to face worse pollution impacts. Lower-income neighborhoods are often closer to congested roadways due to persistent inequities and unfair housing and infrastructure decisions.

The bottom line:

People living in poorer areas generally suffer worse pollution and health effects.

Page 1 of 2

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