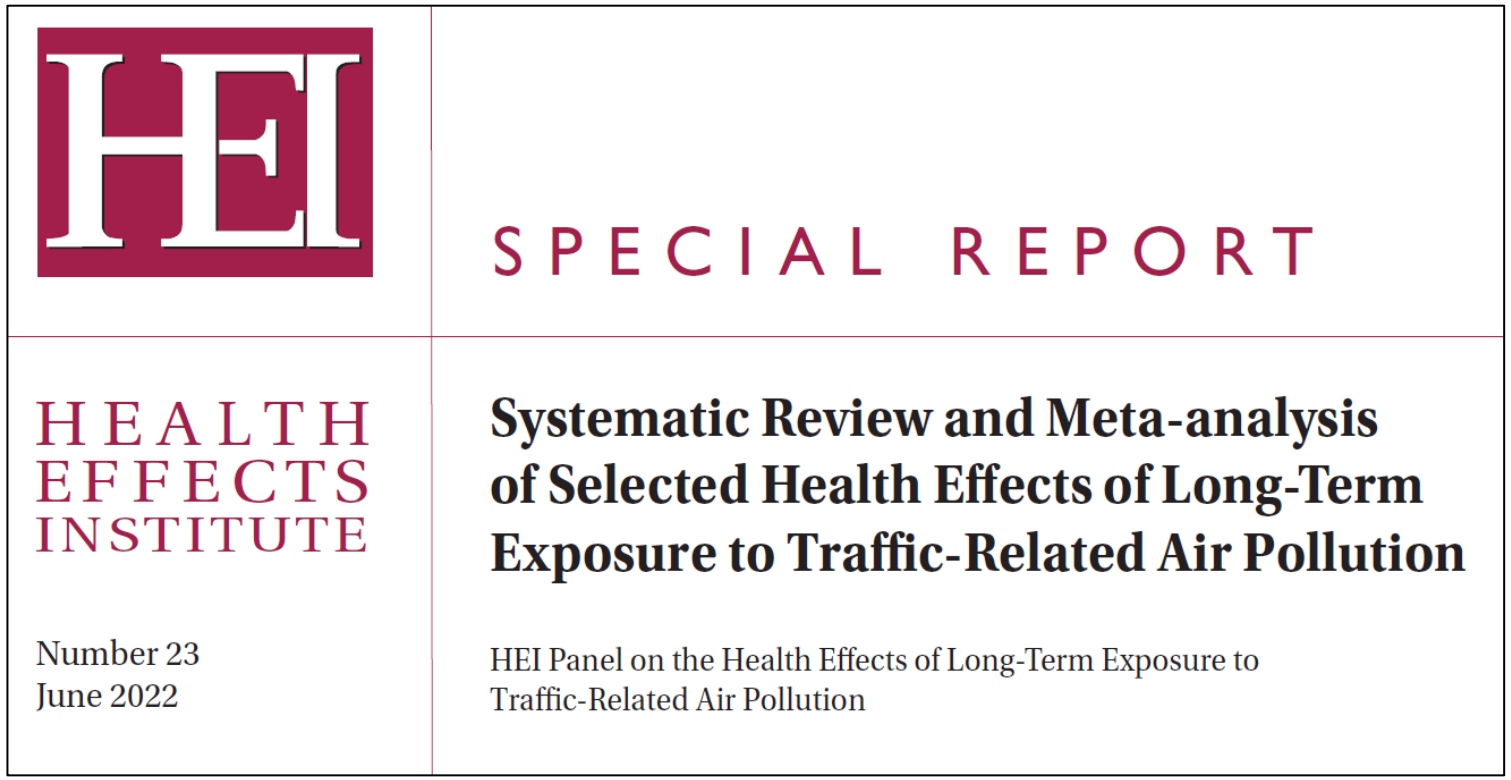
Systematic review of selected health effects of long-term exposure to traffic-related air pollution

Hanna Boogaard, HEI

HEI Annual Conference, June 2022

Trusted Science • Cleaner Air • Better Health

The New HEI Traffic Review has been published!



Join the webinar for a deep(er) dive into the evidence regarding traffic-related air pollution and the selected health outcomes on July 13, from 11 AM to 1 PM EDT

https://www.healtheffects.org/meeting/new-hei-review-webinar-health-effects-traffic-related-air-pollution

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HEI 2010 Traffic and Health Review

A Panel was convened to review the traffic and health literature **up to 2008**.

Detailed chapters on emissons, exposure, toxicology and epidemiology.

At that time, evidence was considered sufficient to support a causal relationship between traffic-related air pollution and exacerbation of **asthma** in children. Suggestive and/or limited evidence for other health outcomes.

https://www.healtheffects.org/

New Review of the Traffic and Health Literature

Strong interest in an update of the review:

- ✓ Substantial new research published
- ✓ Regulations and vehicular technology have advanced
- ✓ Interest in non-tailpipe emissions and traffic noise is increasing

HEI appointed a new panel to systematically review epidemiologic studies in 2018.

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/.

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; HEI Research Committee*
Howard Chang, *Emory University*
Gerard Hoek, *Utrecht University*
Barbara Hoffmann, *University of Düsseldorf; HEI Research Committee*
Sharon Sagiv, *University of California*
Evi Samoli, *University of Athens; HEI Research Committee*
Audrey Smargiassi, *University of Montreal*
Adam Szpiro, *University of Washington*
Danielle Vienneau, *Swiss Tropical and Public Health Institute*
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; HEI Research Committee*

Contractor: Meltem Kutlar Joss and Ron Kappeler, *Swiss Tropical and Public Health Institute*

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

The Special Report was subjected to detailed Peer Review

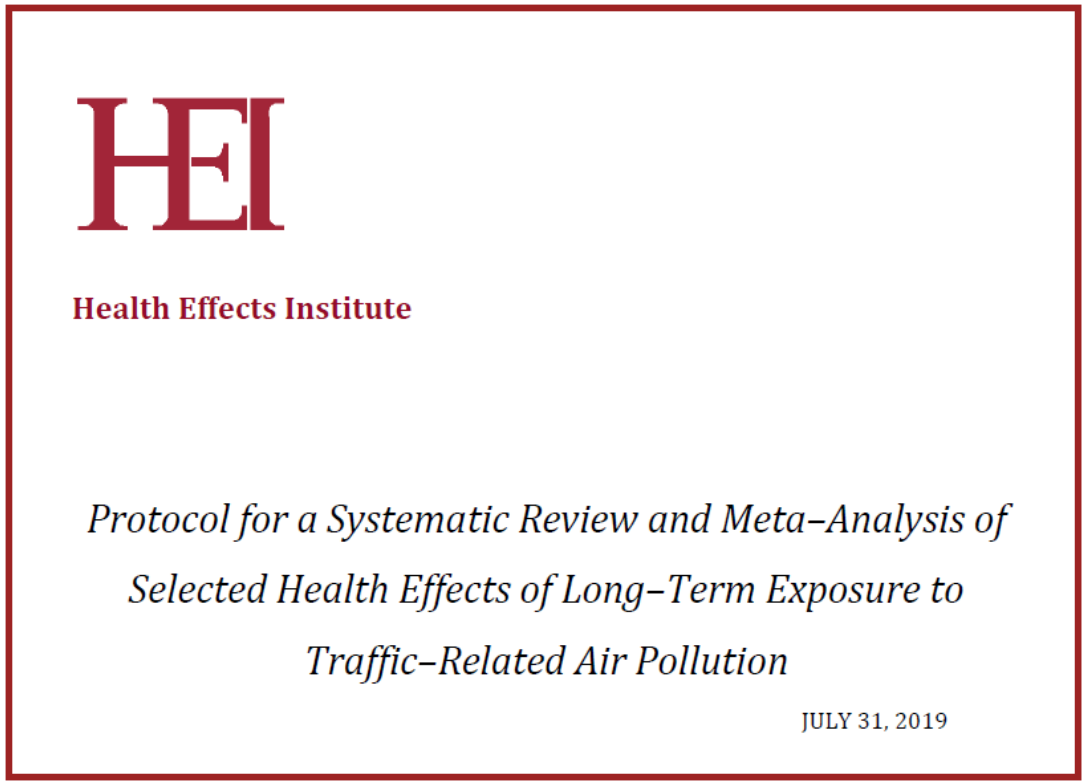
Chair:
Bert Brunekreef, *Professor Emeritus, Utrecht University*

Peer Reviewers Full Report:
Haneen Khreis, *University of Cambridge*
Michael Jerrett, *University of California – LA; HEI Review Commitee*
Susan Norris, *Oregon Health & Science University*
Annette Peters, *Helmholtz Zentrum München*
Neil Pearce, *London School of Hygiene and Tropical Medicine; HEI Research Commitee*
Marie Pedersen, *University of Copenhagen*
David Savitz, *Brown University; Chair HEI Research Commitee*
Jay Turner, *Washington University in St. Louis*

Peer reviewers Specific Chapters:
Chad Bailey, *United States Environmental Protection Agency*
David Carslaw, *University of York*
Flemming Cassee, *National Institute for Public Health and the Environment, Netherlands*
David Foster, *University of Wisconsin–Madison*
Mark Frampton, Professor Emeritus, *University of Rochester Medical Center*
Monica Guxens, *Barcelona Institute for Global Health*
Michael Kleeman, *University of California–Davis*
Nick Molden, *Emissions Analytics, UK*
Marc Weisskopf, *Harvard T.H. Chan School of Public Health*

A Systematic Review

- ✓ Use methods largely based on standards set by Cochrane Collaboration, World Health Organization, and the National Institute of Environmental Health Sciences
- ✓ Summarize epidemiological results quantitatively, where possible
- ✓ Include an evaluation of the risk of bias in individual studies
- ✓ Reach conclusions about the confidence in the quality of the body of evidence and with assessing the level of confidence in the presence of an association.



The review protocol was published in July 2019 on the HEI website* and registered with Prospero**

* https://www.healtheffects.org/announcements/panel-publishes-protocol-review-traffic-related-air-pollution
** https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=150642

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.

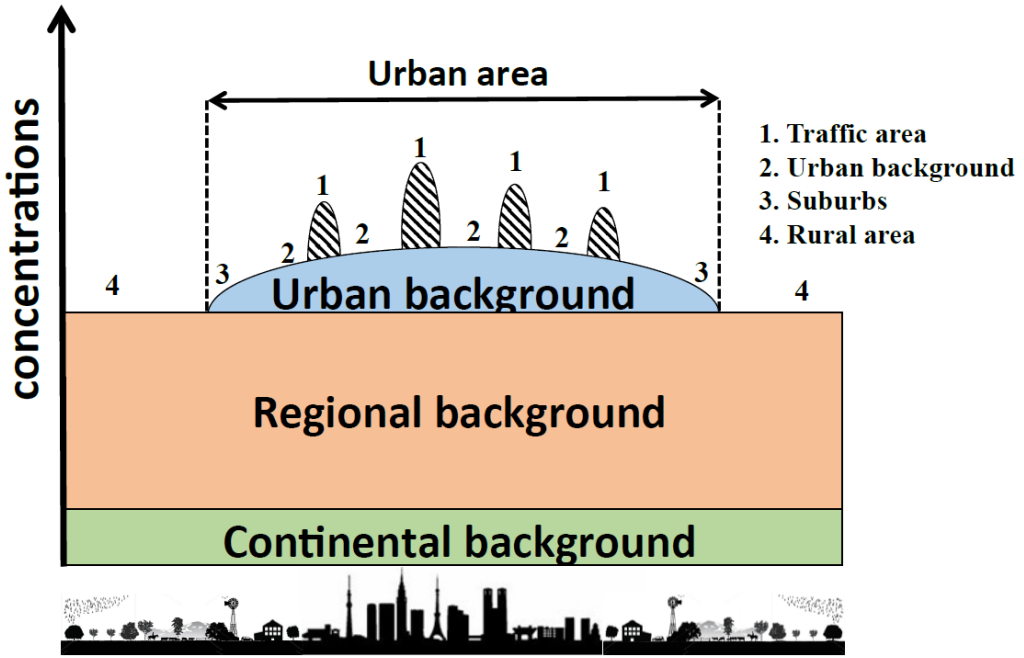
HEI

Exposure Framework

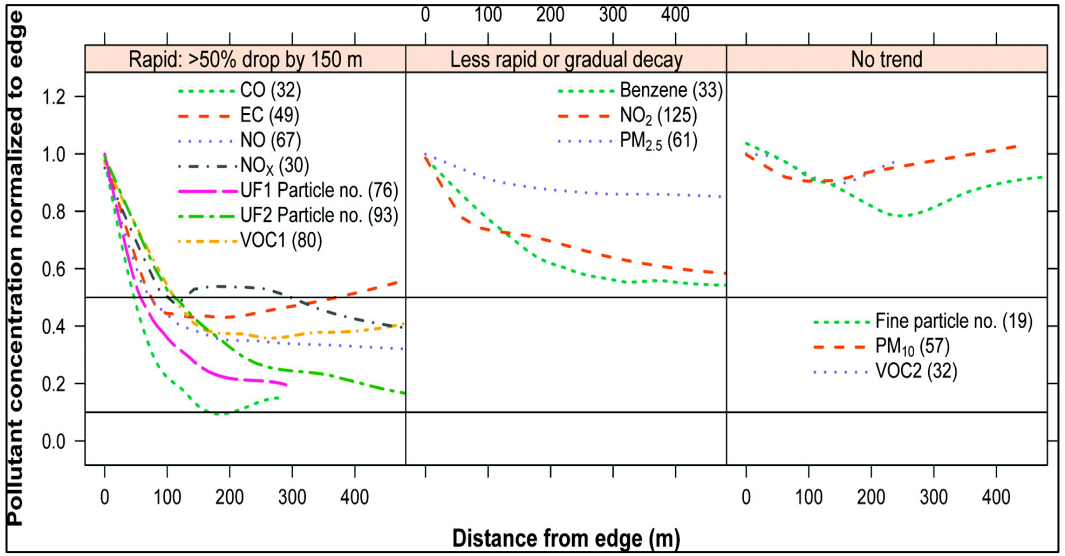
Exposure assessment of TRAP is challenging because it is a complex mixture and is characterized by high spatial and temporal variability.

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

Three strategies were developed to select 'traffic-related' studies, namely the selection of traffic-related pollutants, the exposure assessment method and its spatial resolution.



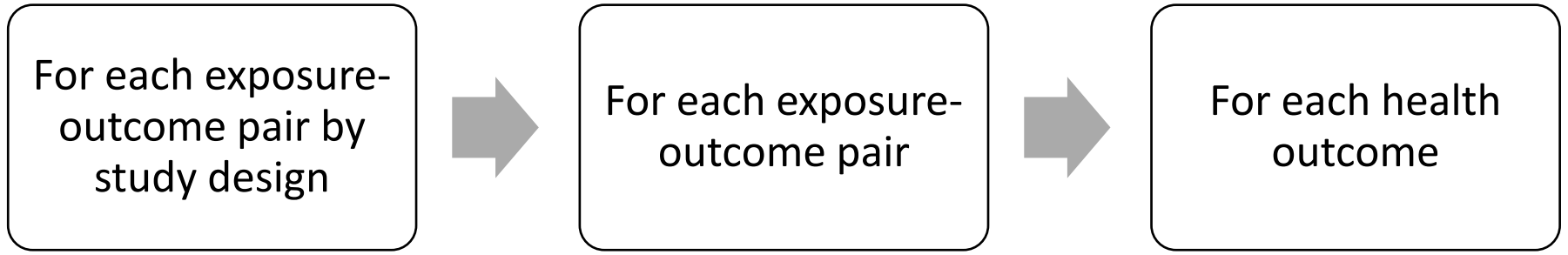
Source: Fuzzi et al. 2015.



Source: Karner et al. 2010.

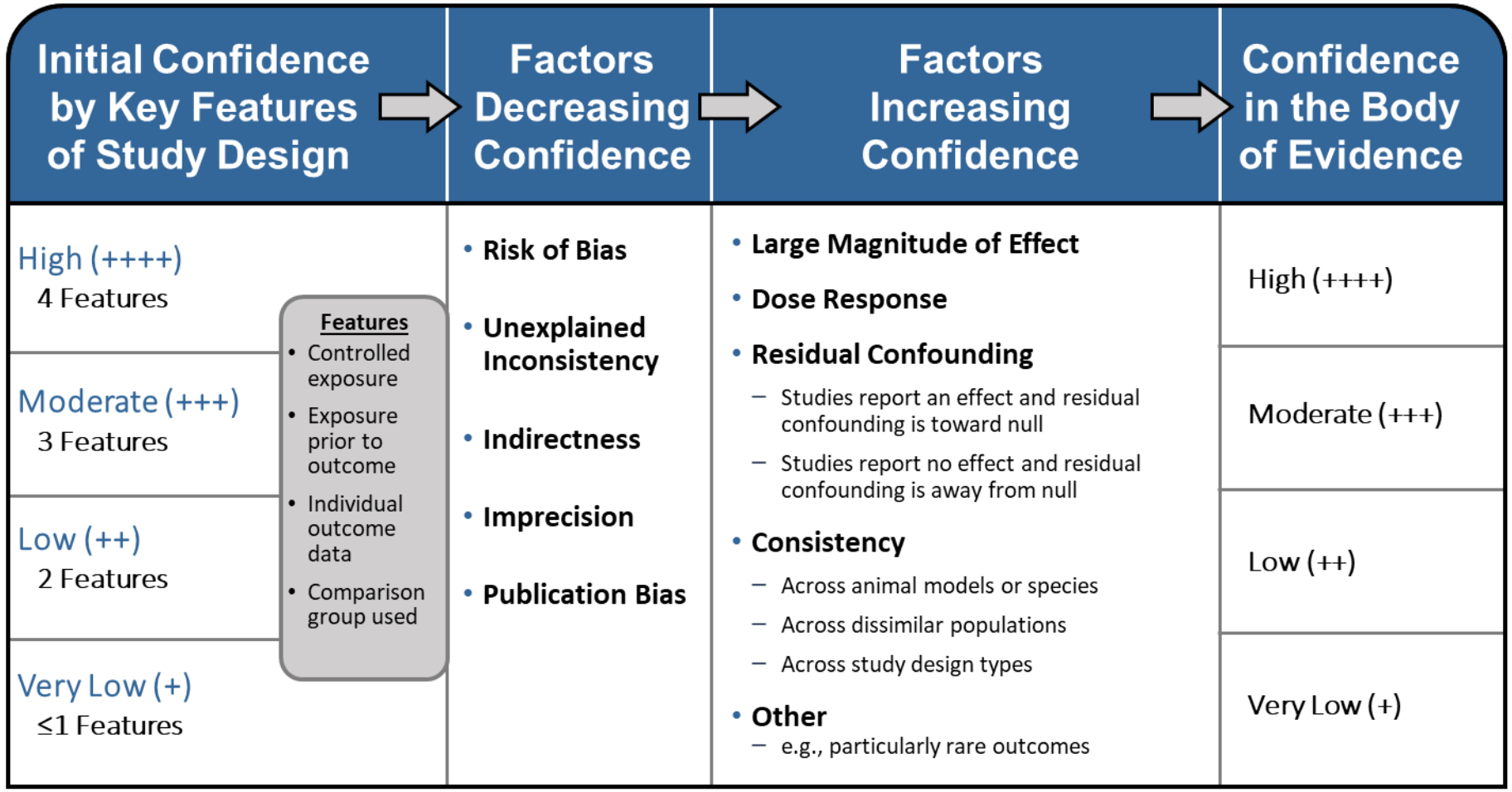
Confidence Assessments

Separate assessments for confidence
in the quality of the body of evidence (modified OHAT) and
in the presence of an association (narrative)
(high, moderate, low, and very low)



Overall confidence

Methods for Confidence in the Quality of the Body of Evidence (Modified OHAT* – or GRADE**-type approach)



- ✓ Initial rating based on study design features
- ✓ Upgrade or downgrade based on certain factors
- ✓ The Panel did not apply the methods in a "mechanistic" way

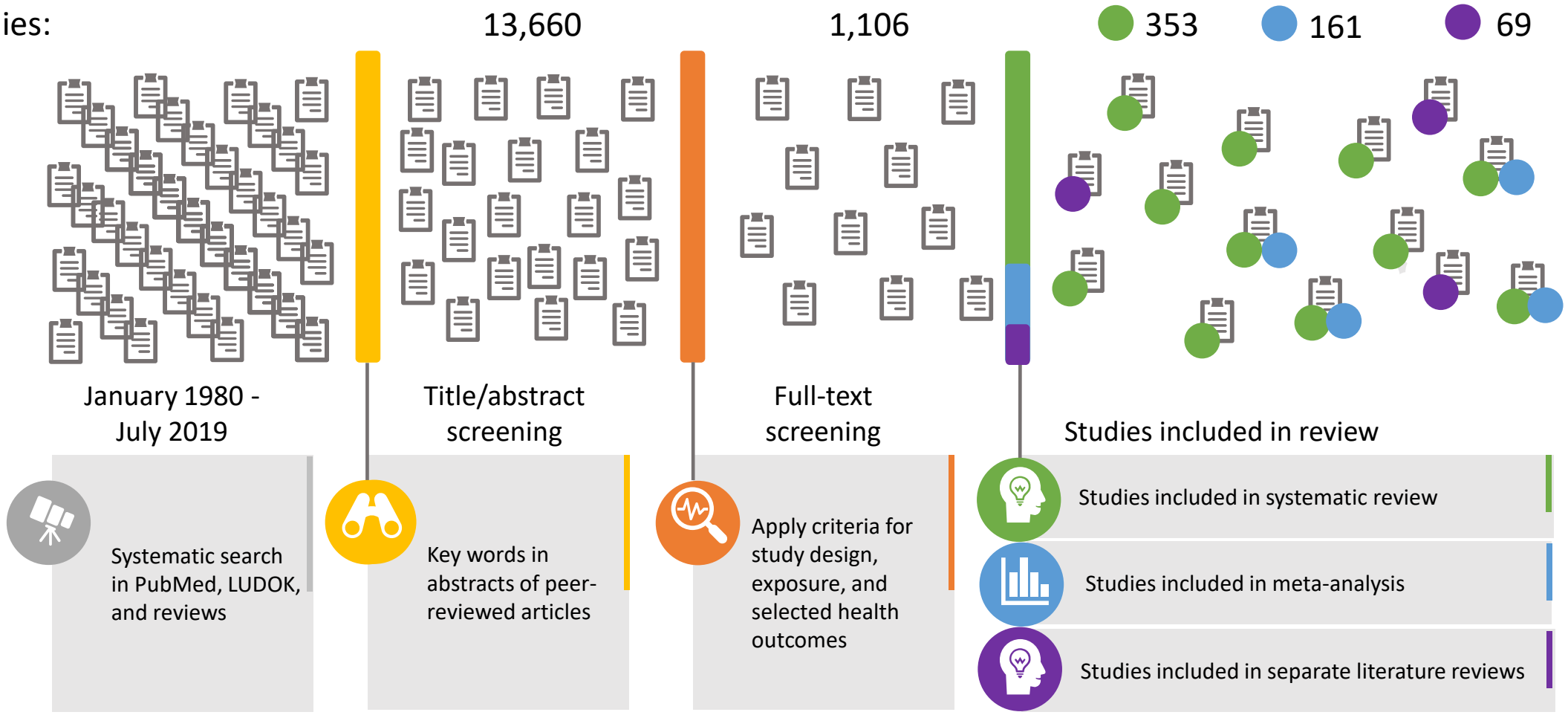
*Office of Health Assessment and Translation (OHAT), 2019. Handbook. National Toxicology Program, National Institute of Environmental Health Sciences, U.S. Dept of Health and Human Services.

**Grading of Recommendations Assessment, Development and Evaluation (GRADE). 2013. Handbook.

Addition of a Broader "Narrative" Approach to Maximize What can be Learned from Observational Studies

- ✓ GRADE-type assessments focus on the quality of the body of evidence rather than the presence of an association.
- ✓ Those assessments are heavily geared towards studies entering a meta-analysis.
- ✓ Hence, the Panel deemed it necessary to accompany the GRADE-type assessment with a broader ''narrative'' assessment.

Number of studies identified

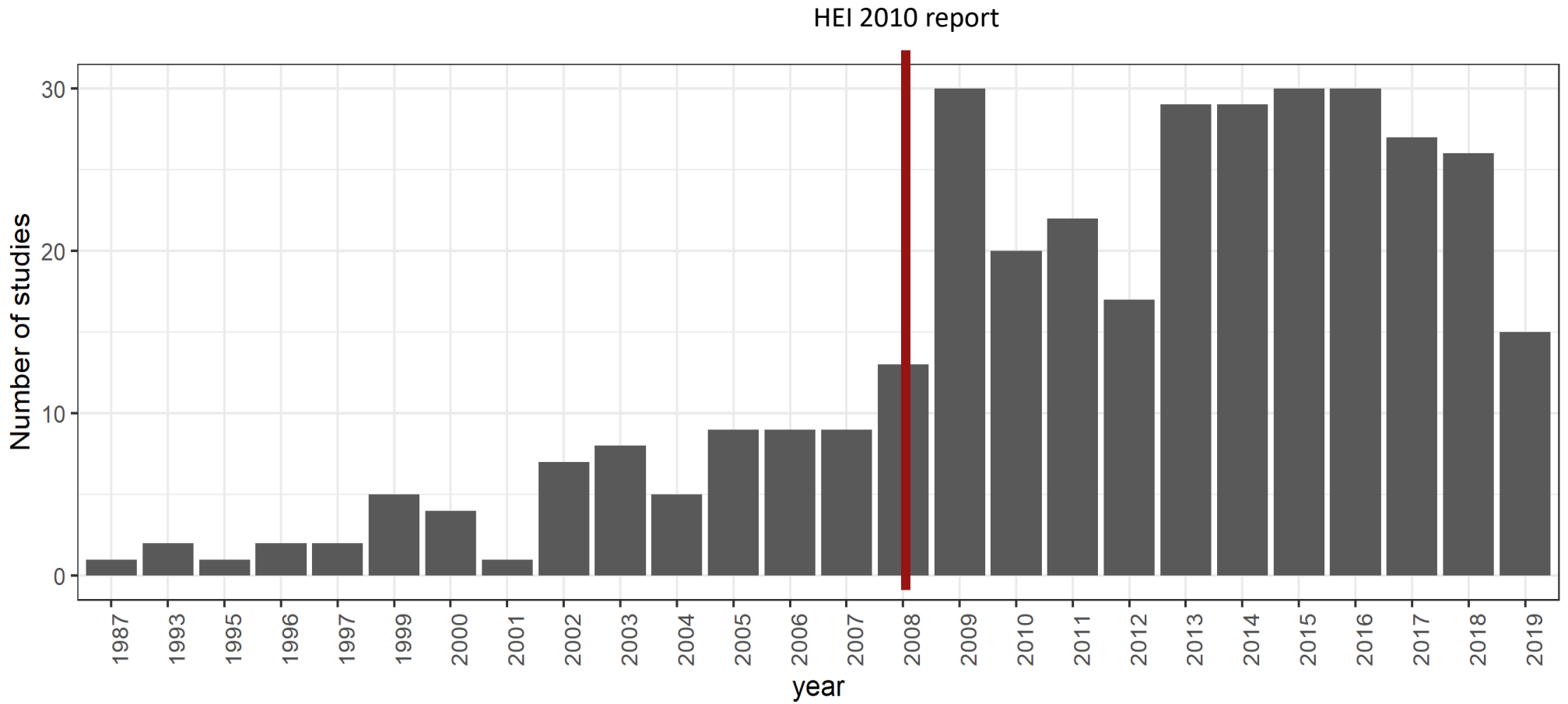


Systematic review on the health effects of long-term exposure to traffic-related air pollution

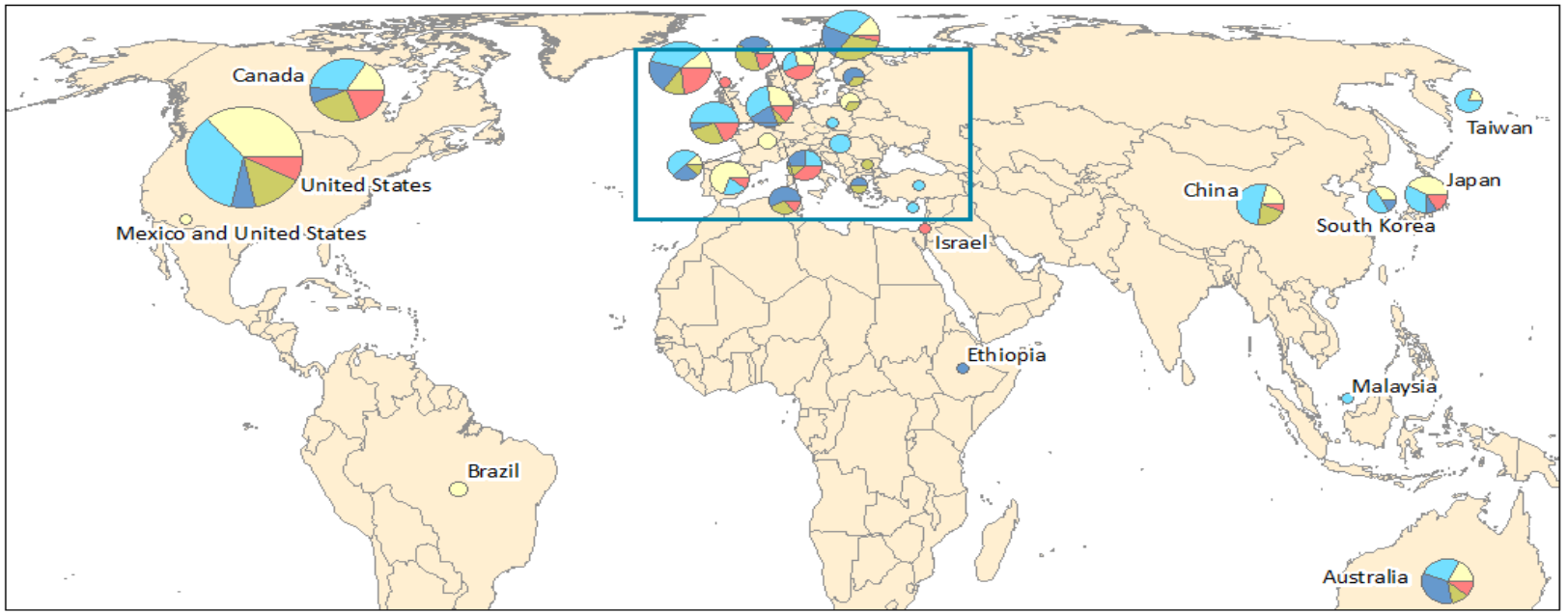
Literature Search Results

353 studies included

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



Geographical Location of the Studies



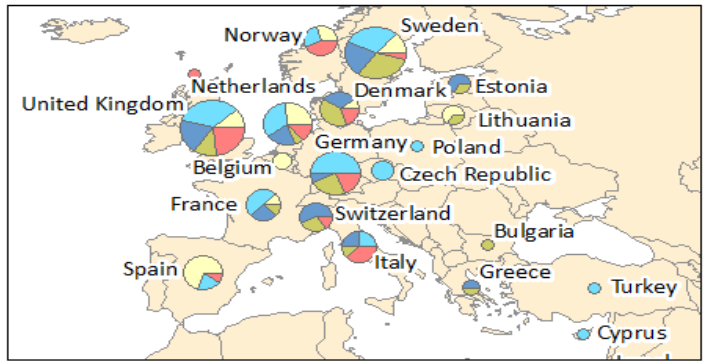
Studies in World Countries

Legend

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

Health outcomes studied

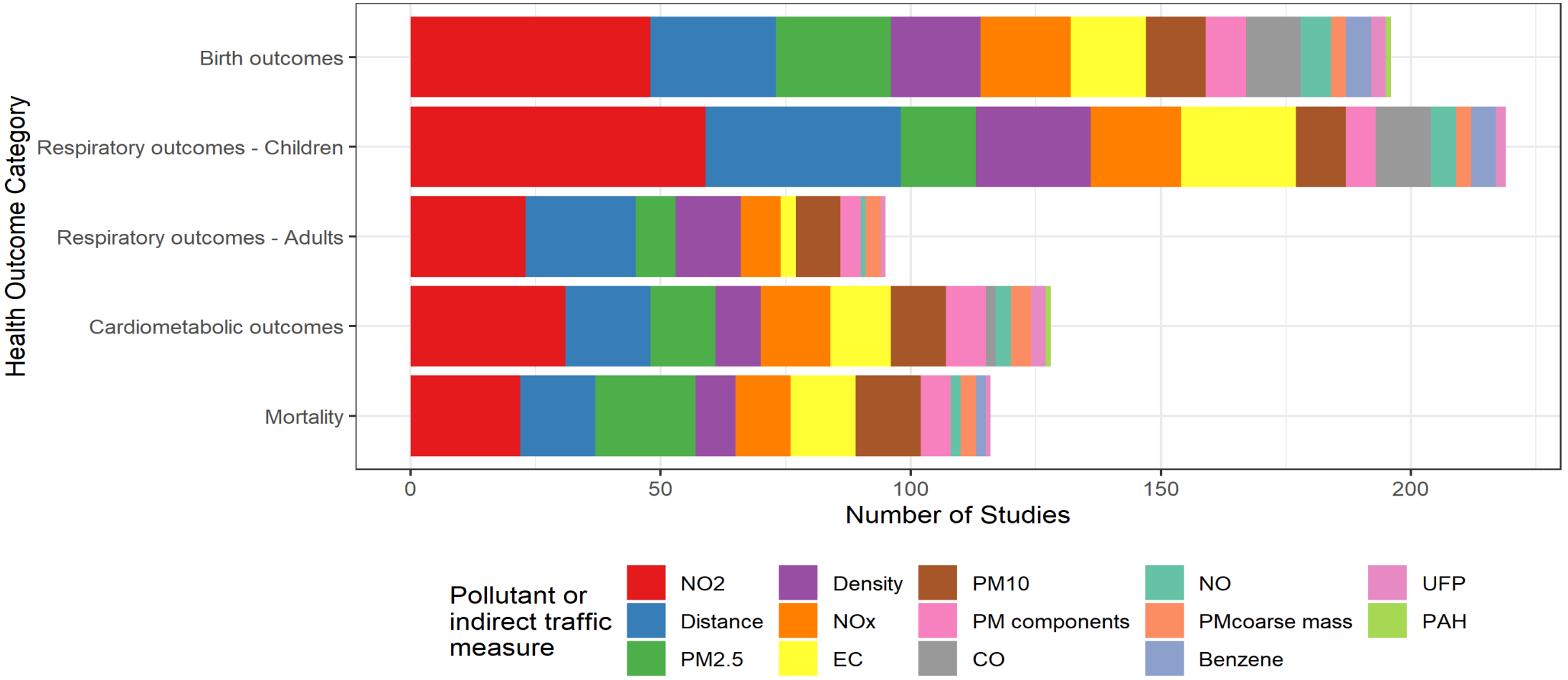
- Birth outcomes
- Respiratory outcomes - children
- Respiratory outcomes - adults
- Cardiometabolic outcomes
- Mortality



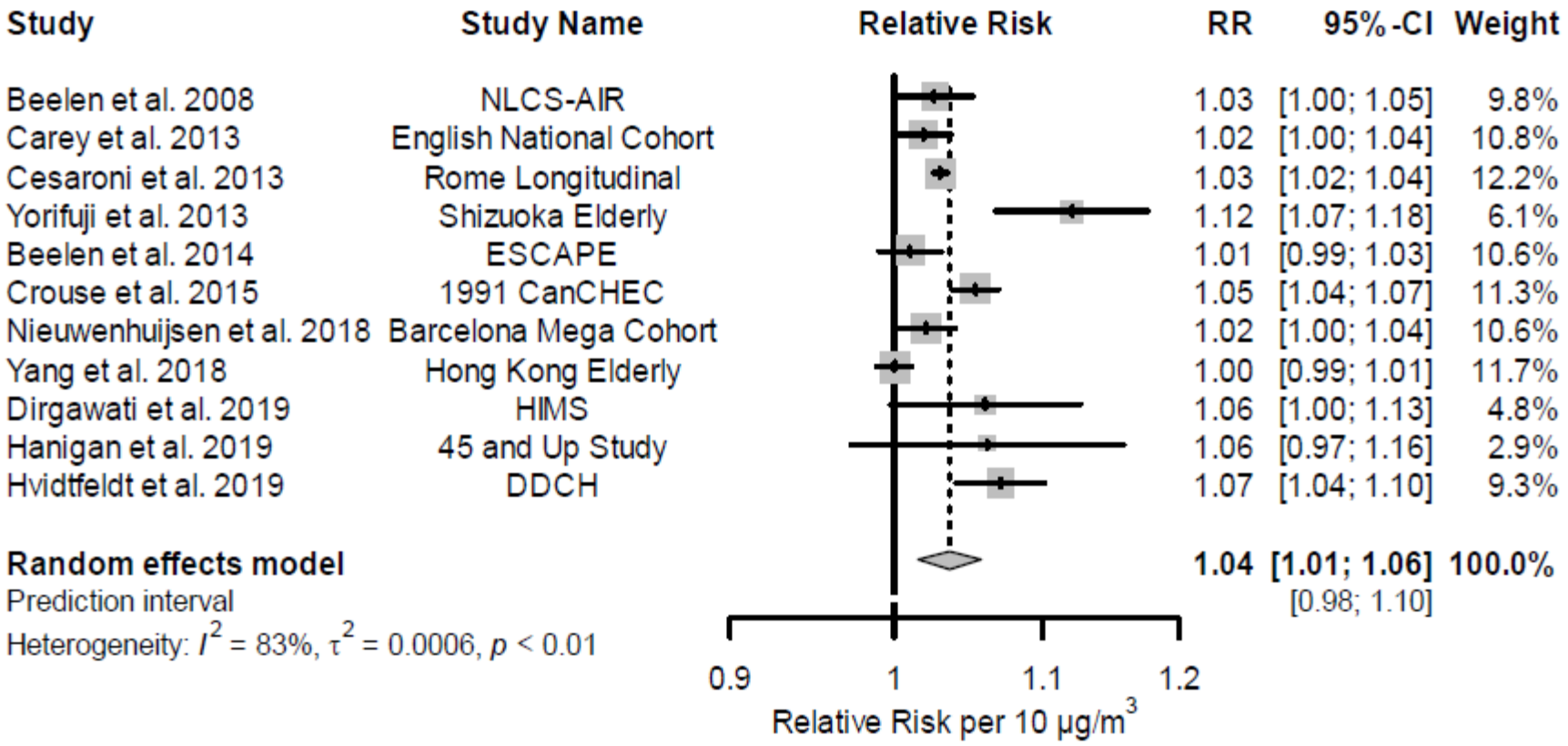
Studies in European countries

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

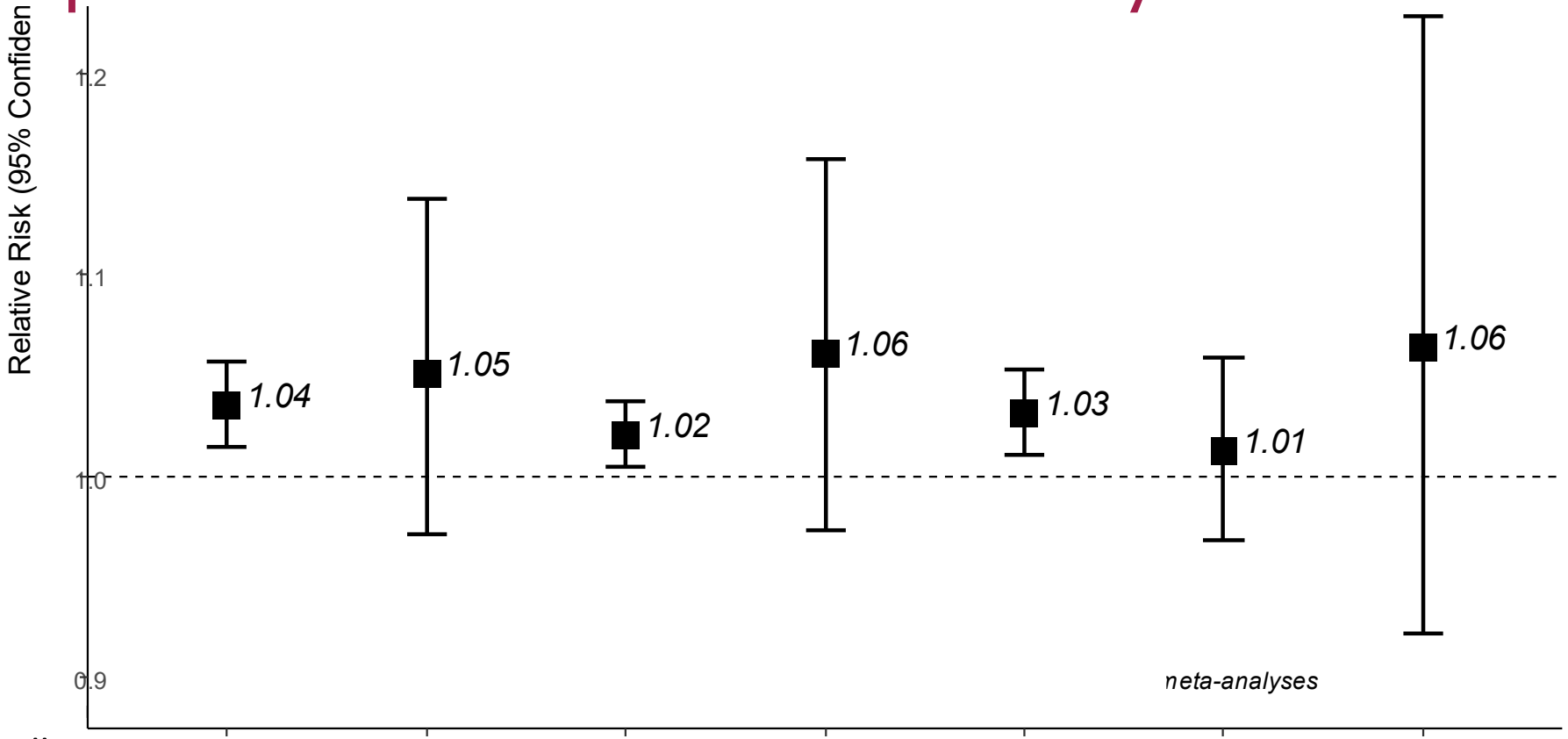
Number of Studies by Outcome and Pollutant



Meta-analysis NO_2 – All cause mortality



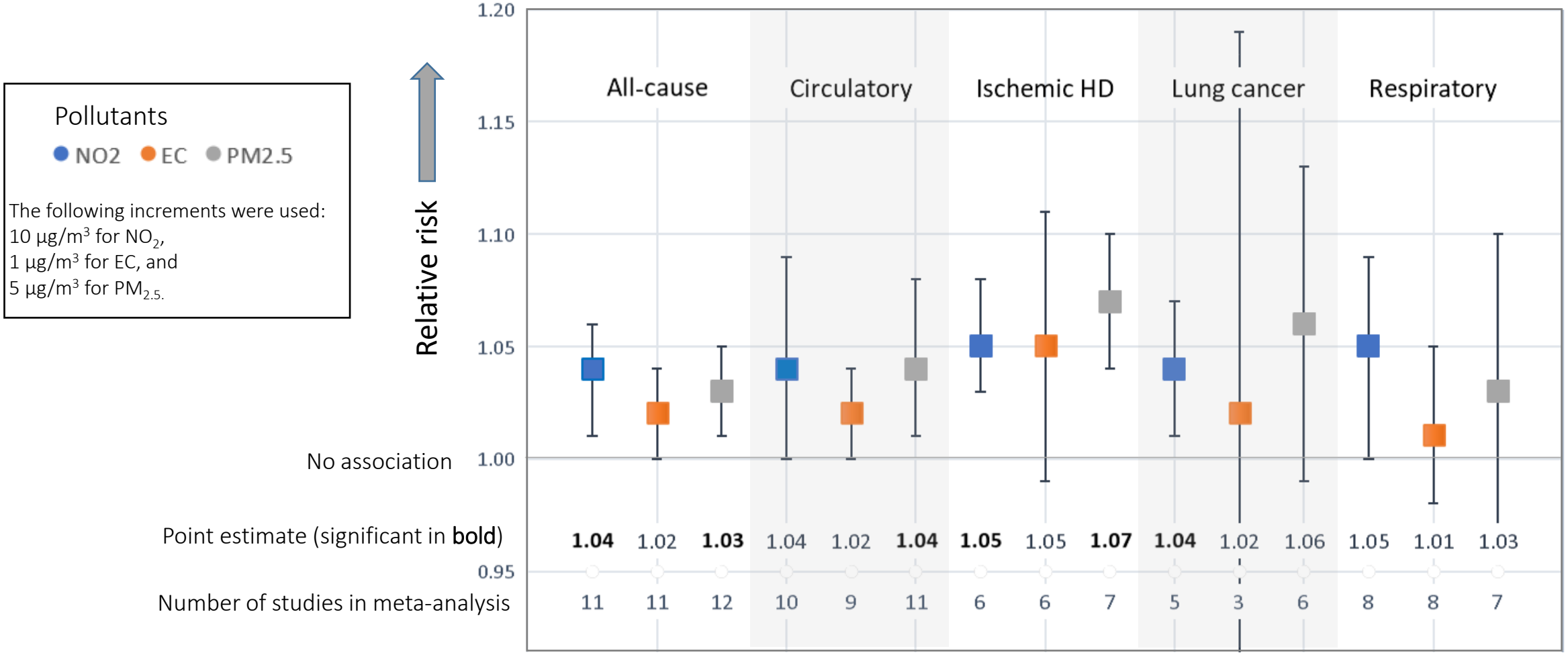
Meta-analysis of associations between traffic-related air pollutants and all-cause mortality



Pollutant:	NO_2	NO_x	EC	PM_{10}	$PM_{2.5}$	Cu□$PM_{2.5}$	Fe□$PM_{2.5}$
No. studies in meta-analysis:	11	5	11	6	12	3	3
Increments:	10 µg/m³	20 µg/m³	1 µg/m³	10 µg/m³	5 µg/m³	5 ng/m³	500 ng/m³

Effect estimates cannot be directly compared across the different traffic-related pollutants because the selected increments do not necessarily represent the same contrast in exposure. The individual pollutants are considered as indicators of the TRAP mixture.

Meta-analysis of associations between traffic-related air pollutants and selected mortality outcomes*



*Outcomes selected where the confidence in the evidence for an association with TRAP was judged high (all-cause, circulatory and ischemic HD; moderate to high (lung cancer), or moderate (respiratory).

Meta-analysis of associations between traffic-related air pollutants and selected morbidity outcomes

Pollutants

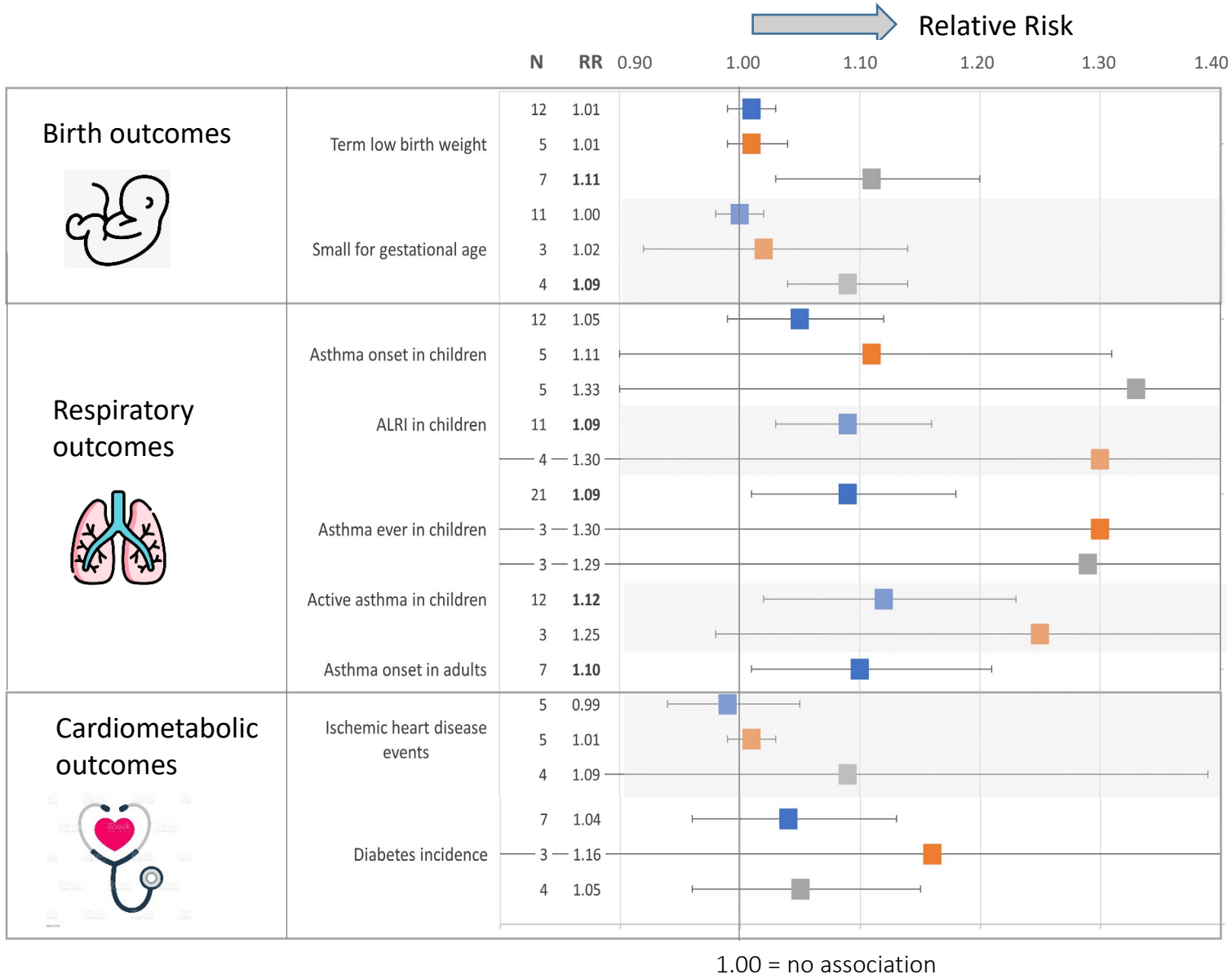
● NO2 ● EC ● PM2.5

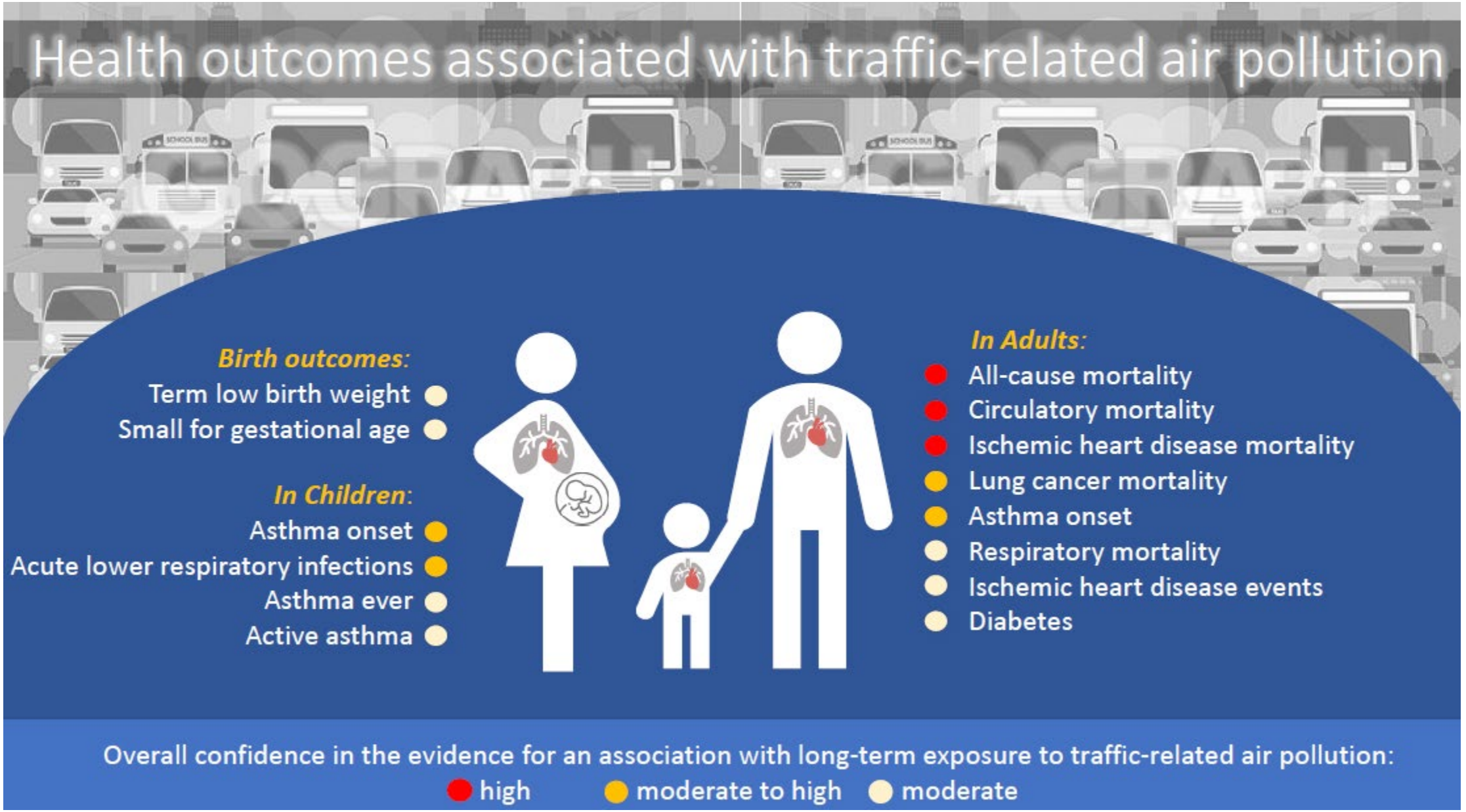
The following increments were used:
10 µg/m^3 for NO_2
1 µg/m^3 for EC
5 µg/m^3 for $PM_{2.5}$

RR = point estimate (significant in **bold**)

N = number of studies in meta-analysis

*Outcomes selected where the confidence in the evidence for an association with TRAP was judged moderate to high (asthma onset, acute lower respiratory infections), or moderate (remainder)





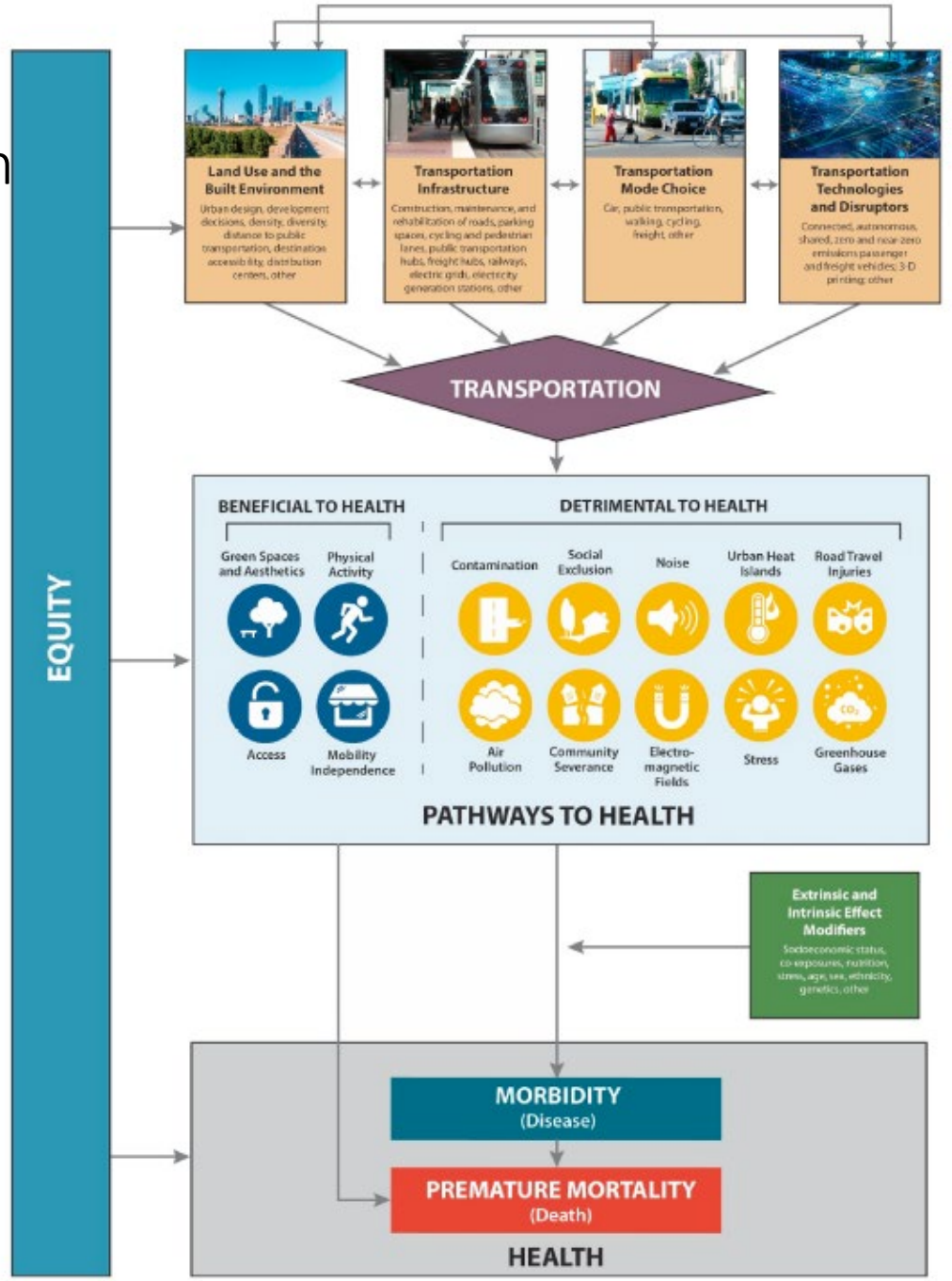
Footnote: health outcomes for which the overall confidence in the evidence was low-to-moderate, low or very low are not in the picture.

Some Key Observations

- ✓ This review has 3 times more studies than the 2010 report, though a direct comparison is difficult because of the difference in scope.
- ✓ Only half of the total number of identified studies entered a meta-analysis.
- ✓ The most common reason for a lower confidence judgement was "*imprecision*", most often for cardiometabolic outcomes.
- ✓ The most common reason for a higher confidence judgement was evidence for a "*monotonic exposure-response relationship*".
- ✓ Most of the studies were rated as low to moderate "risk of bias" for all but the "confounder" domain, for which about one third of the meta-analyzed studies were rated as high "risk of bias".
- ✓ Several future research opportunities emerged from this report.

Several Future Research Opportunities

- ✓ Evaluate the mechanisms behind the association of TRAP with the selected outcomes by studying biomarkers and subclinical outcomes (e.g., lung function, blood pressure, atherosclerosis, structure and function of the brain….)
- ✓ Evaluate the role of spatially correlated factors that may either confound and/or modify the health effects of TRAP, most notably socioeconomic status, traffic noise, and factors related to the built environment, such as presence of green space
- ✓ Evaluate the fuller range of potential impacts of transportation and (new) mobility on public health.
- ✓ Improve methods in systematic reviews and evidence synthesis of observational studies in environmental health



And many more…

Glazener et al. 2021. Fourteen pathways between urban transportation and health: A conceptual model and literature review. Journal of Transport & Health

Overall Conclusions

The findings have provided an overall high or moderate-to-high level of confidence in an association between long-term exposure to traffic-related air pollution and the adverse health outcomes

all-cause, circulatory and ischemic heart disease mortality, lung cancer mortality, asthma onset in children and adults, and acute lower respiratory infections in children.

The Panel's confidence in the evidence was considered moderate, low or very low for the other selected outcomes.

In light of the large number of people exposed, the findings indicate that traffic-related air pollution remain an important public health concern and deserve greater attention from the public and from policymakers.

THANK YOU!

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