# Effects of low-level air pollution: A study in Europe, and a harmonized analysis with large studies in Canada and the United States

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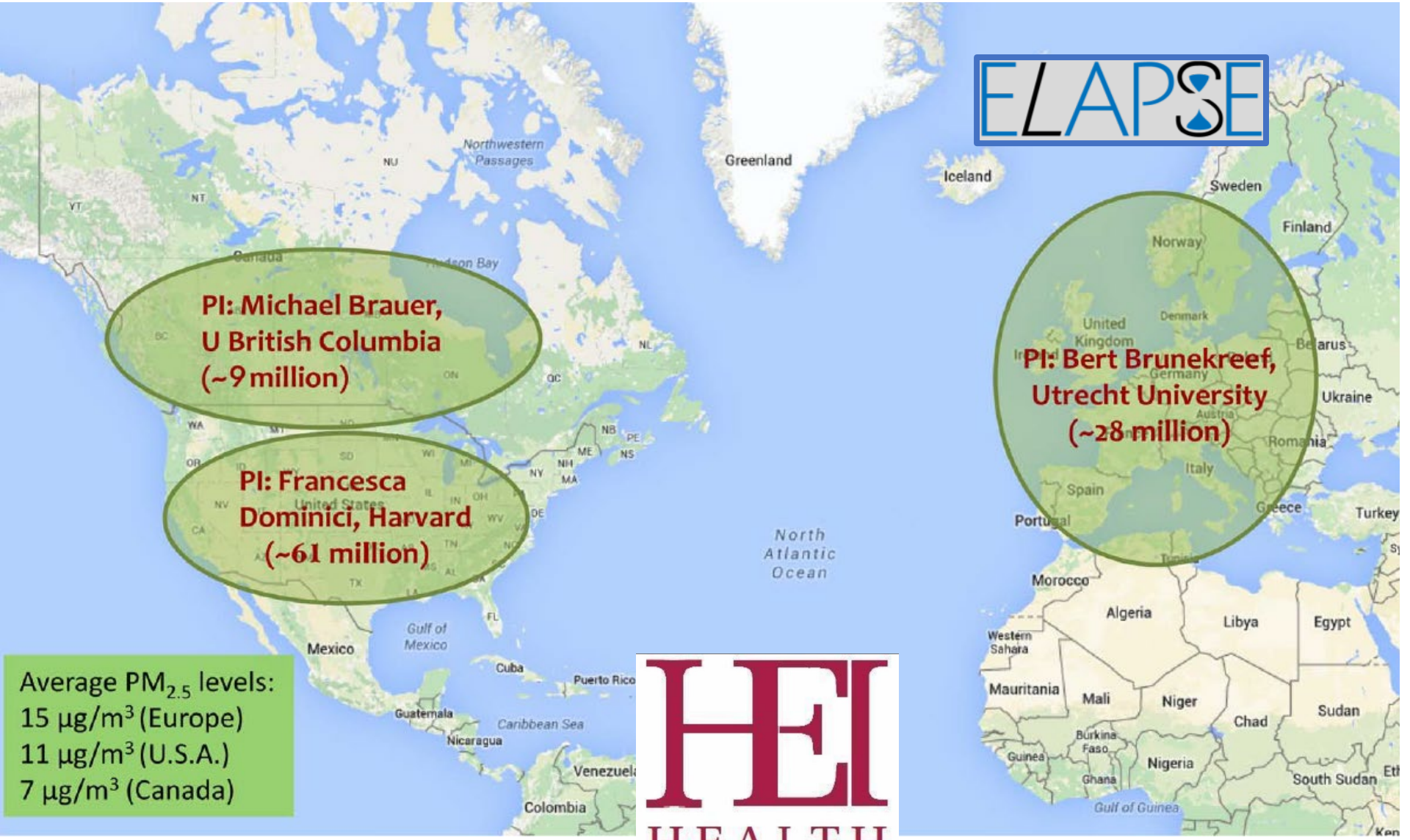
# The WHO AQGs and low-level studies

- The AQGs are defined as the lowest level at which adverse effects on health have been **demonstrated beyond reasonable doubt**
- Technically: the AQGs have been set at the mean of the 5th percentiles of the exposure distributions in a reasonable number of high-quality studies showing these adverse effects
- The 2021 AQG report does **not identify thresholds**
- Non-zero thresholds **may not exist** – we simply don't know, and we probably never will

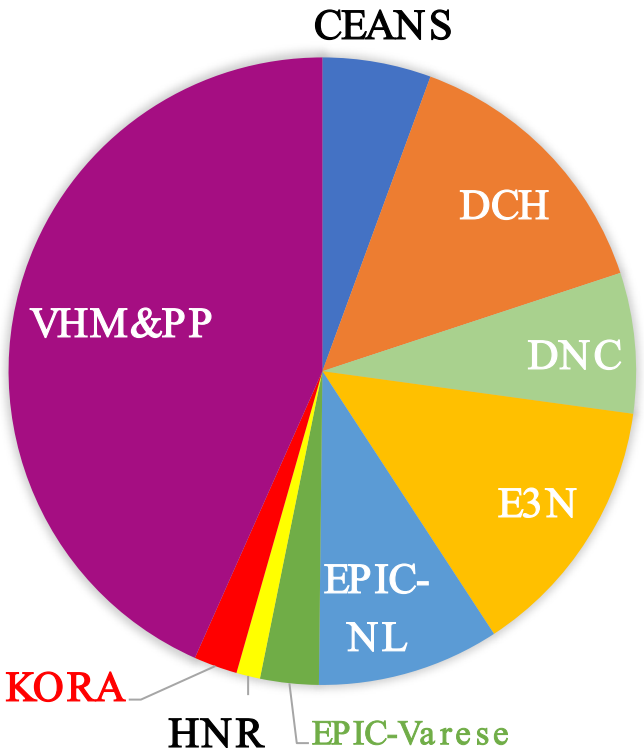
# 2021 WHO Air Quality Guidelines

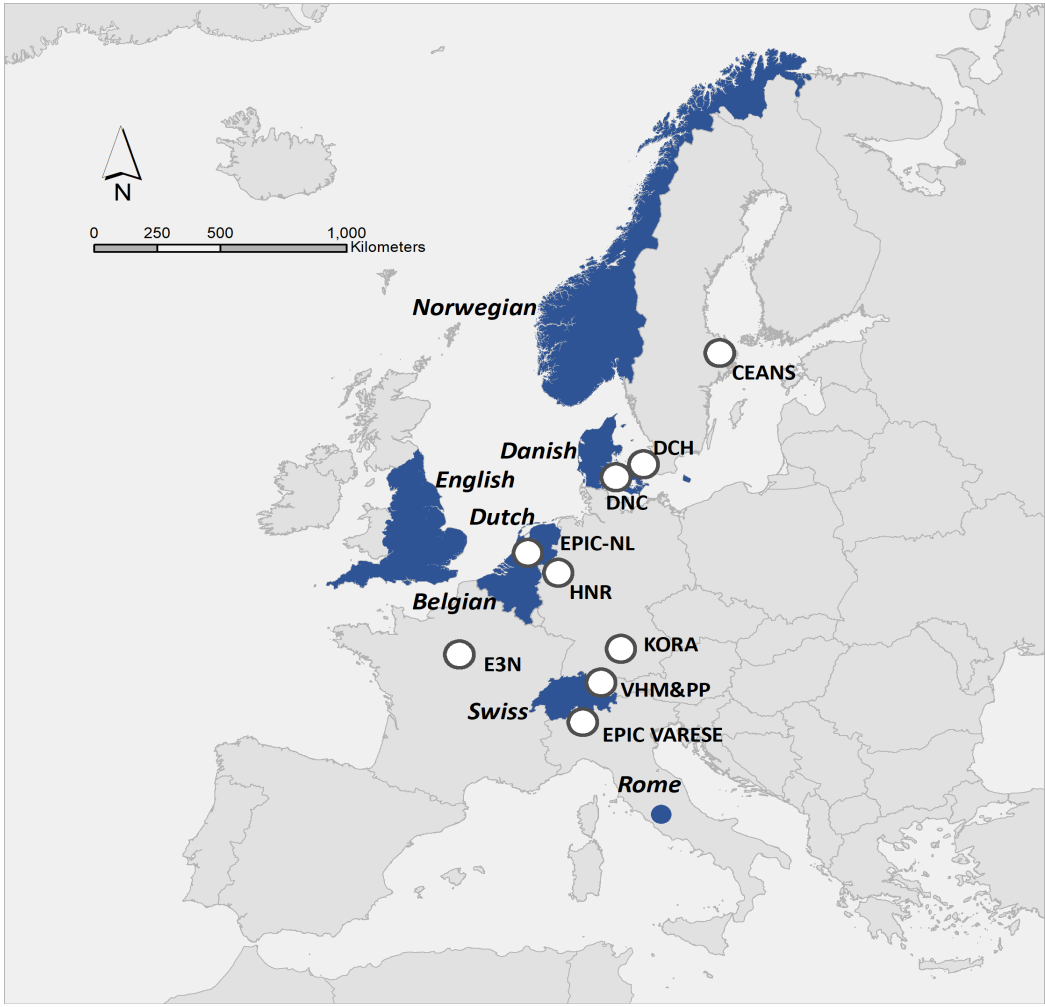
| Pollutant | AQG 2005 | AQG 2021 |
|---|---|---|
| $PM_{2.5}$ year | 10 µg/m$^3$ | 5 µg/m$^3$ |
| $PM_{2.5}$ 24 hrs | 25 µg/m$^3$ | 15 µg/m$^3$ |
| $PM_{10}$ year | 20 µg/m$^3$ | 15 µg/m$^3$ |
| $PM_{10}$ 24 hrs | 50 µg/m$^3$ | 45 µg/m$^3$ |
| $O_3$ warm | -- | 60 µg/m$^3$ |
| $O_3$ 8 hrs | 100 µg/m$^3$ | 100 µg/m$^3$ |
| $NO_2$ year | 40 µg/m$^3$ | 10 µg/m$^3$ |
| $NO_2$ 24 hrs | -- | 25 µg/m$^3$ |
| $SO_2$ 24 hrs | 20 µg/m$^3$ | 40 µg/m$^3$ |
| CO 24 hrs | -- | 4 mg/m$^3$ |

# New studies into effects of low air pollution concentrations



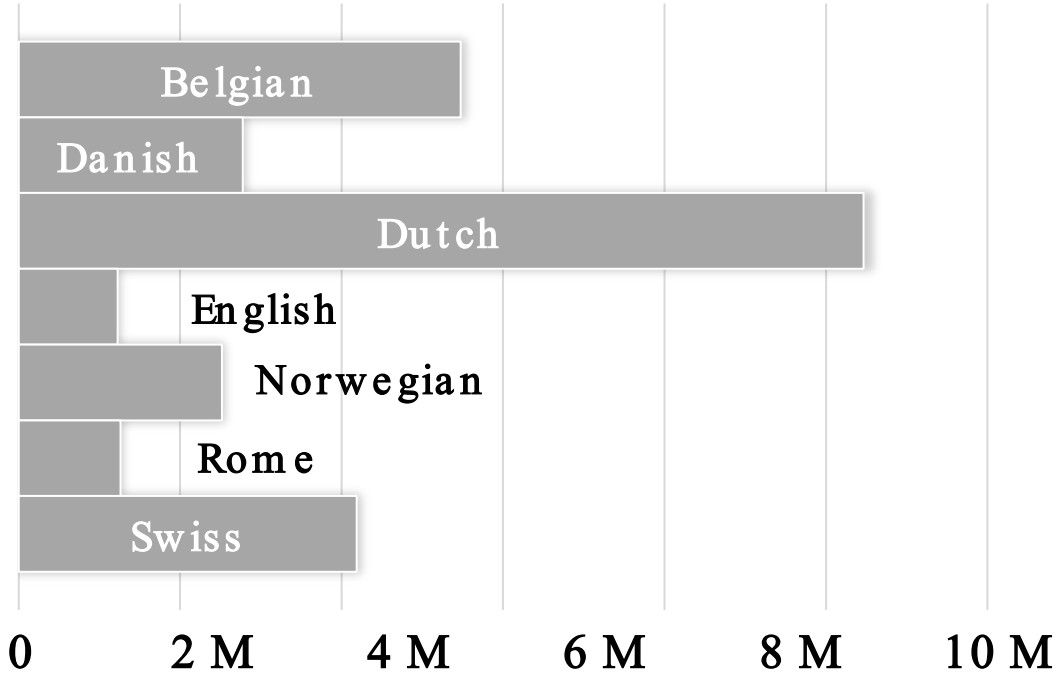
# Pooled cohort

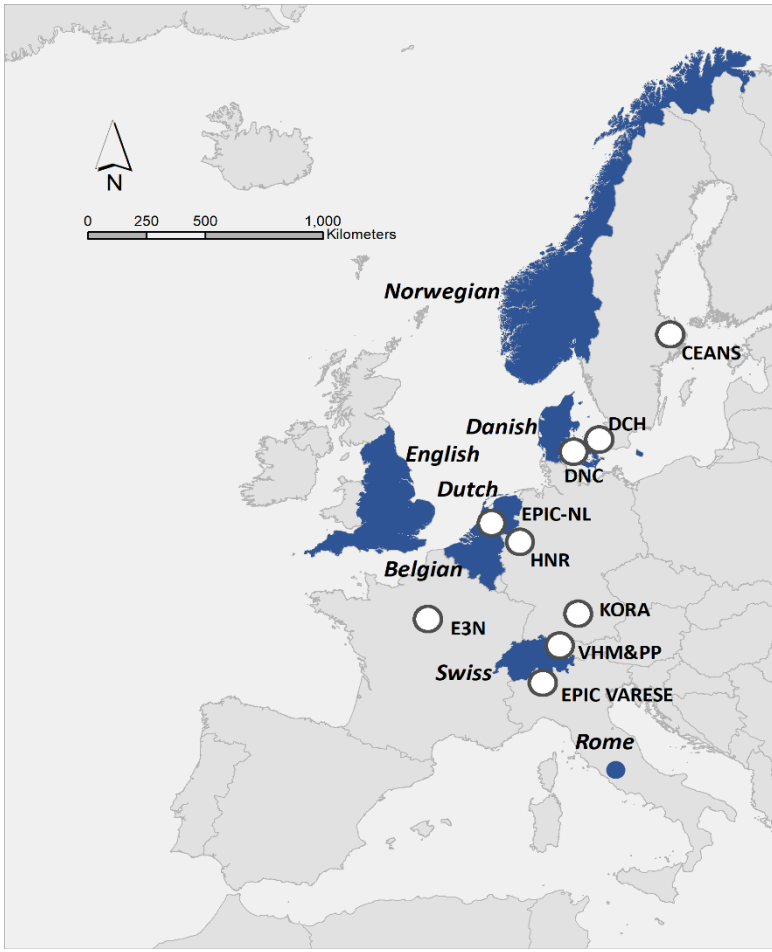



- **N = 392,826**
- Extensive covariate information

# Administrative cohorts

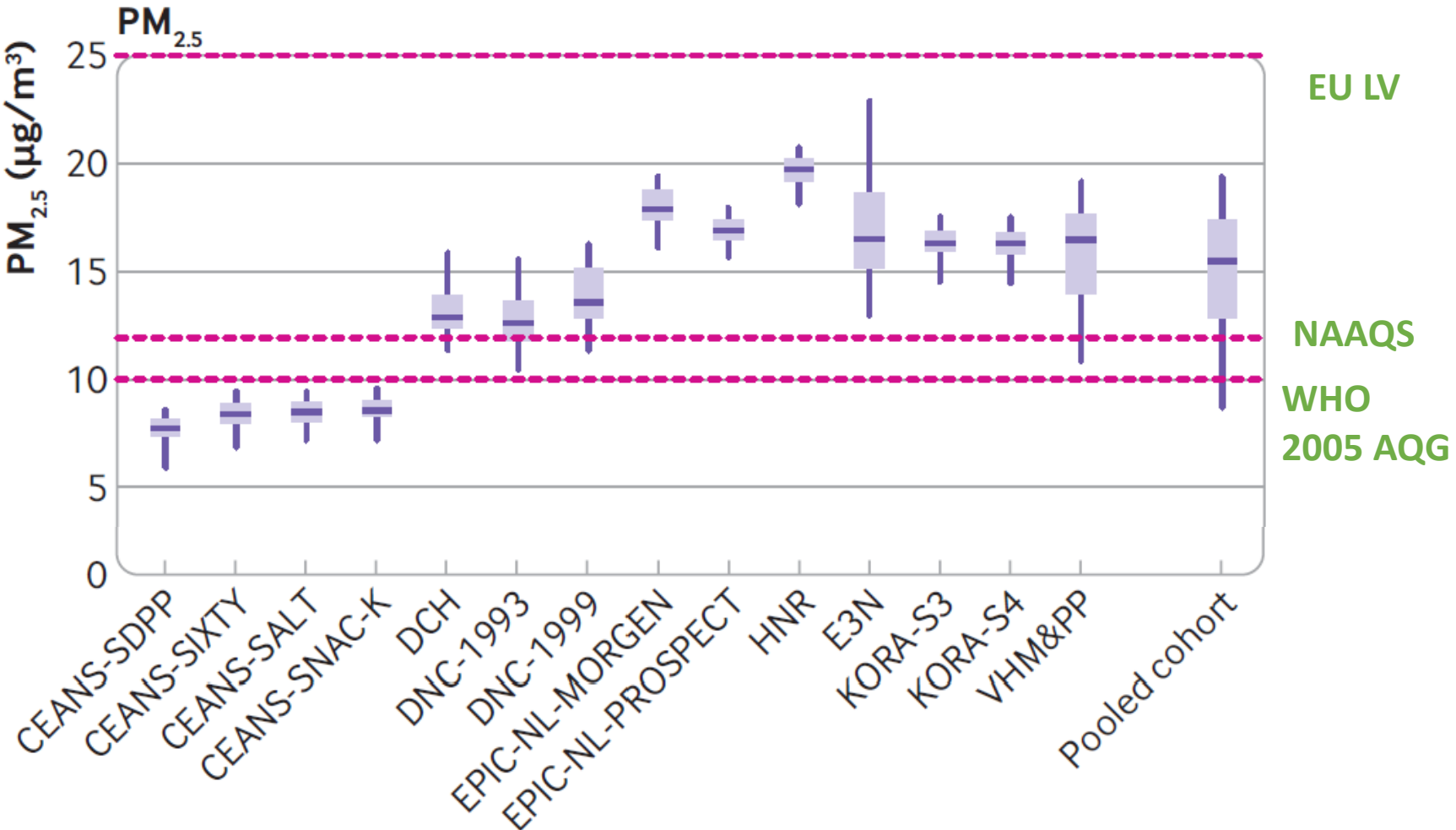



- **N = 27,910,693**
- Limited covariate info (except English)
- Analyzed individually -> Meta-analysis

# Long term exposure to low level air pollution and mortality in eight European cohorts within the ELAPSE project: pooled analysis

**Strak, BMJ 2021**



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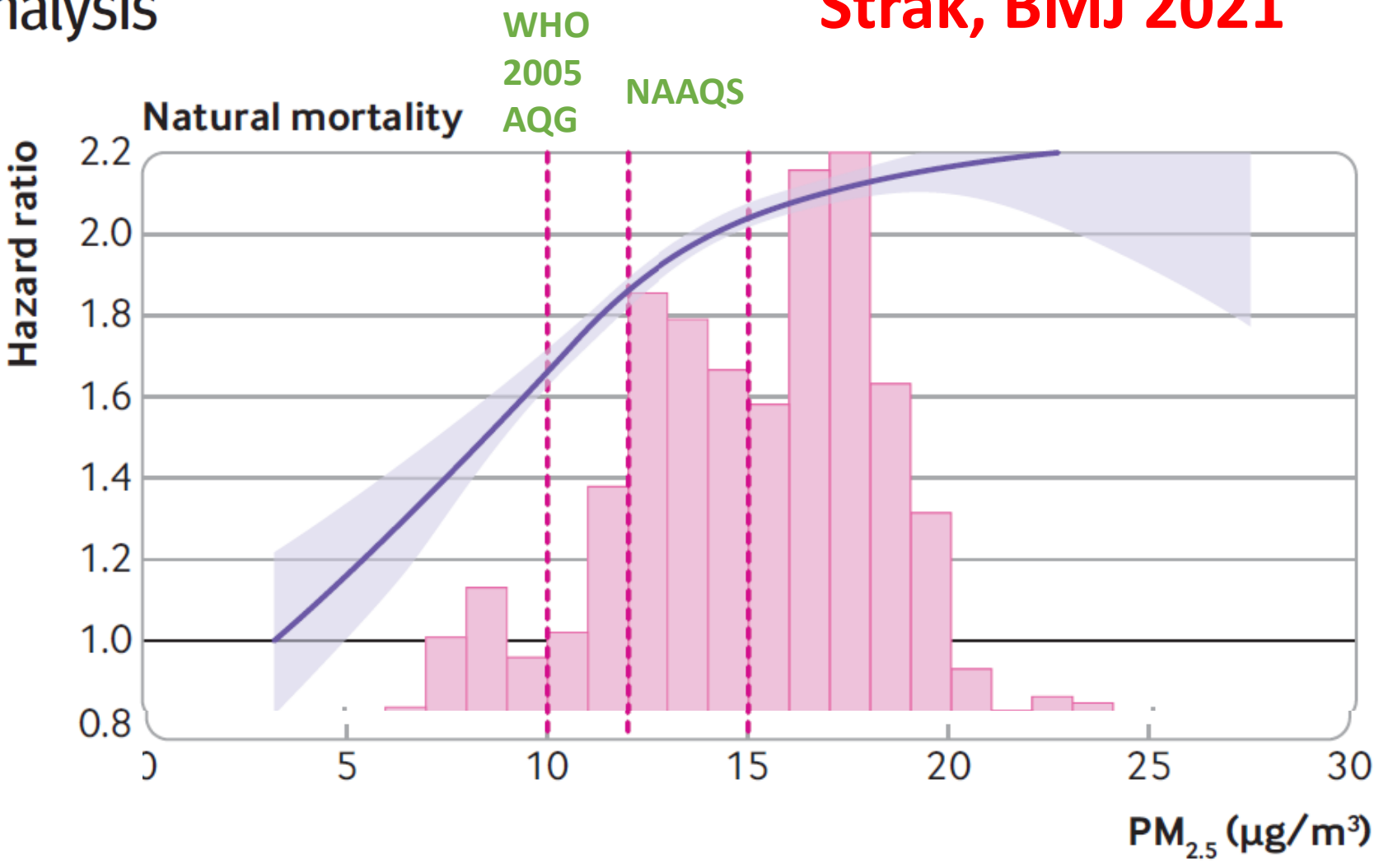
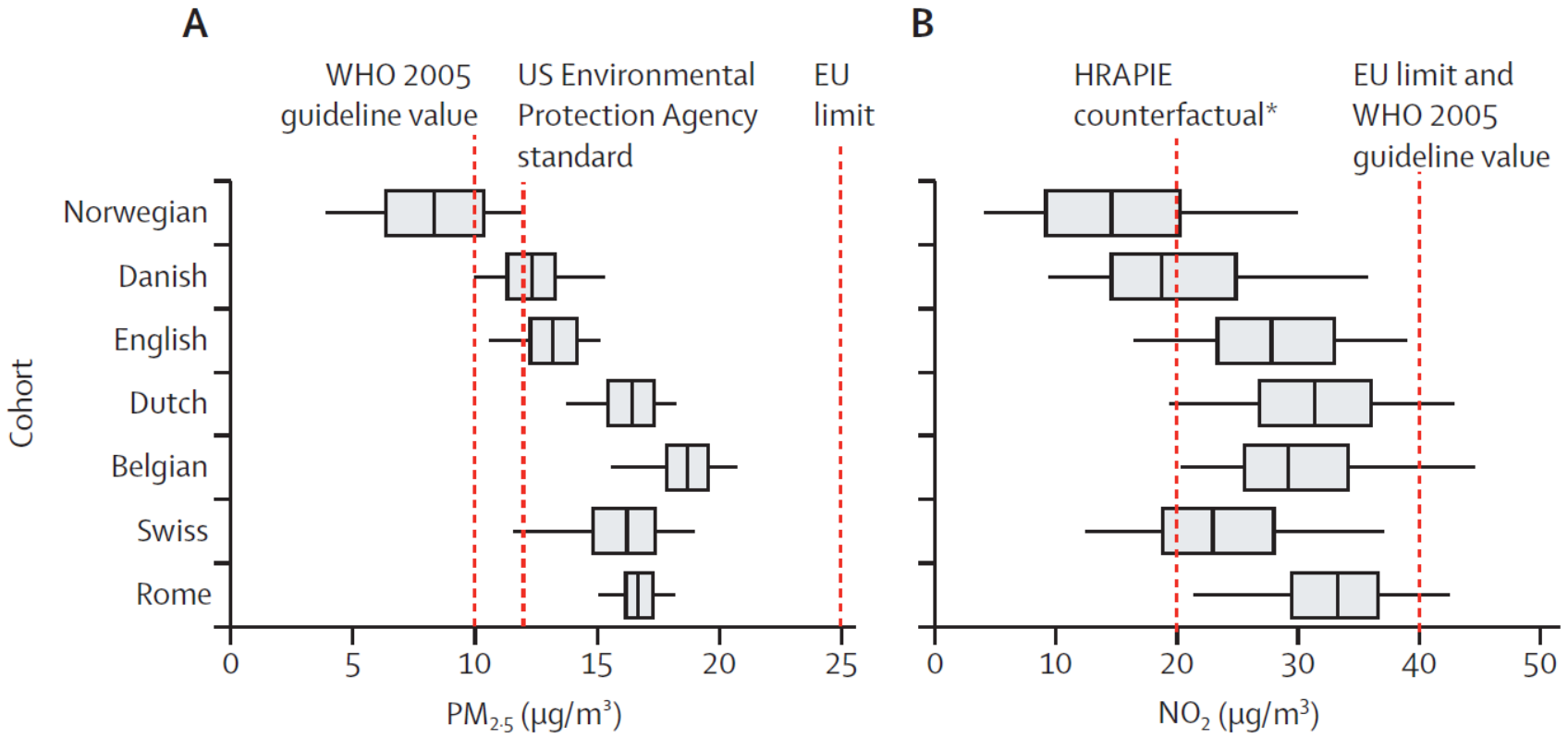


# Long-term exposure to low ambient air pollution concentrations and mortality among 28 million people: results from seven large European cohorts within the ELAPSE project

**Stafoggia, Lancet Plan Health 2022**



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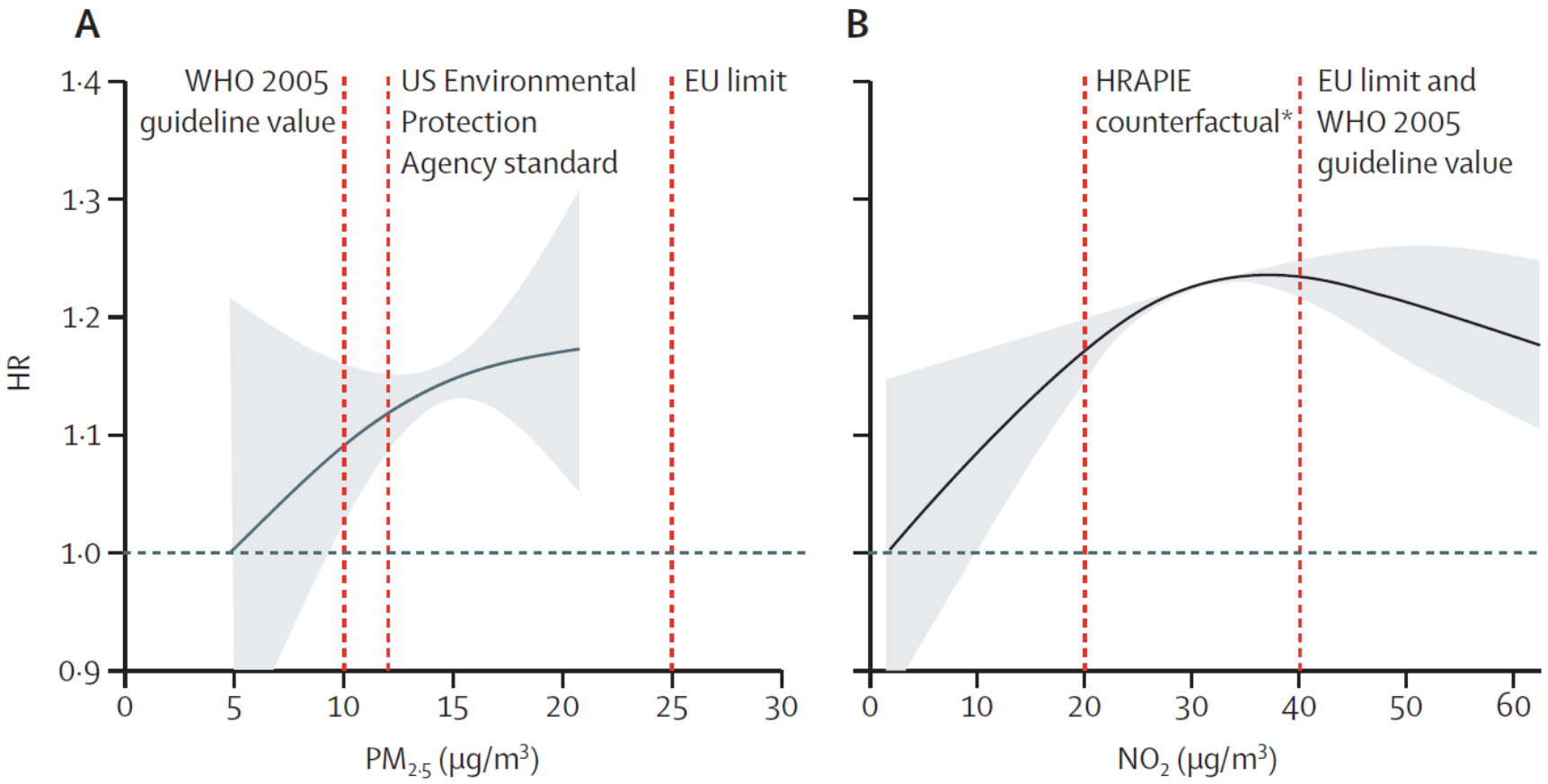


**Table 7.** Hazard Ratios for Associations Between Air Pollution and Natural-Cause Mortality in Subset Analysis[a]

| Pollutant | Subset | N | HR (95% CI) |
|---|---|---|---|
| **$PM_{2.5}$** | | | |
| | Full dataset | 325,367 | 1.130 (1.106, 1.155) |
| | <25 μg/m$^3$ | 325,339 | 1.131 (1.107, 1.156) |
| | < 20 μg/m$^3$ | 316,540 | 1.138 (1.113, 1.164) |
| | <15 μg/m$^3$ | 151,250 | 1.257 (1.193, 1.324) |
| | <12 μg/m$^3$ | 52,528 | 1.296 (1.140, 1.474) |
| | <10 μg/m$^3$ | 25,422 | 1.146 (0.931, 1.410) |
| **$NO_2$** | | | |
| | Full dataset | 325,367 | 1.086 (1.070, 1.102) |
| | <40 μg/m$^3$ | 310,643 | 1.101 (1.083, 1.119) |
| | <30 μg/m$^3$ | 247,039 | 1.114 (1.088, 1.140) |
| | <20 μg/m$^3$ | 88,510 | 1.099 (1.033, 1.170) |

**HEI RR 208**

https://www.healtheffects.org/publication/mortality-and-morbidity-effects-long-term-exposure-low-level-pm25-bc-no2-and-o3-analysis

# The data cloud…

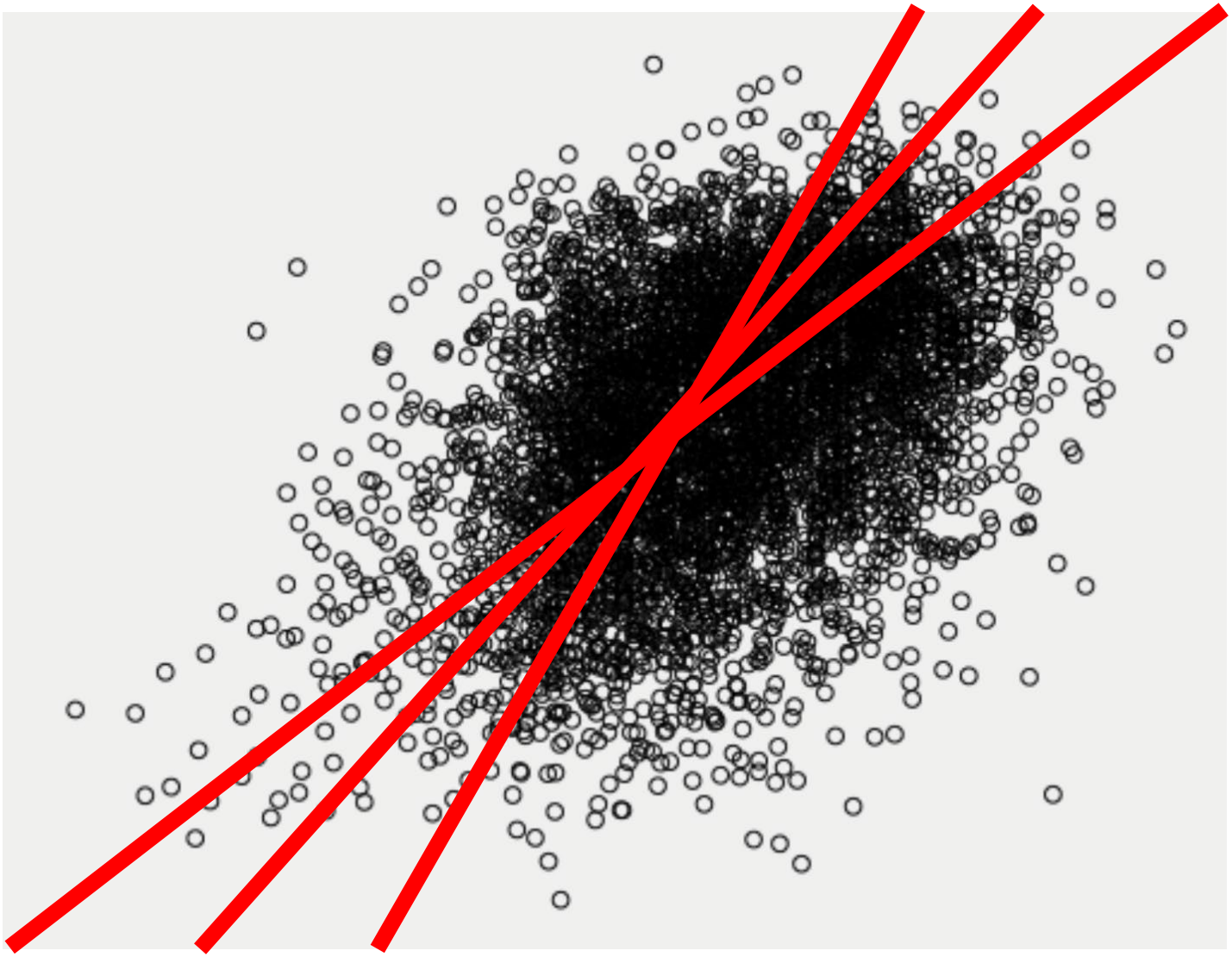
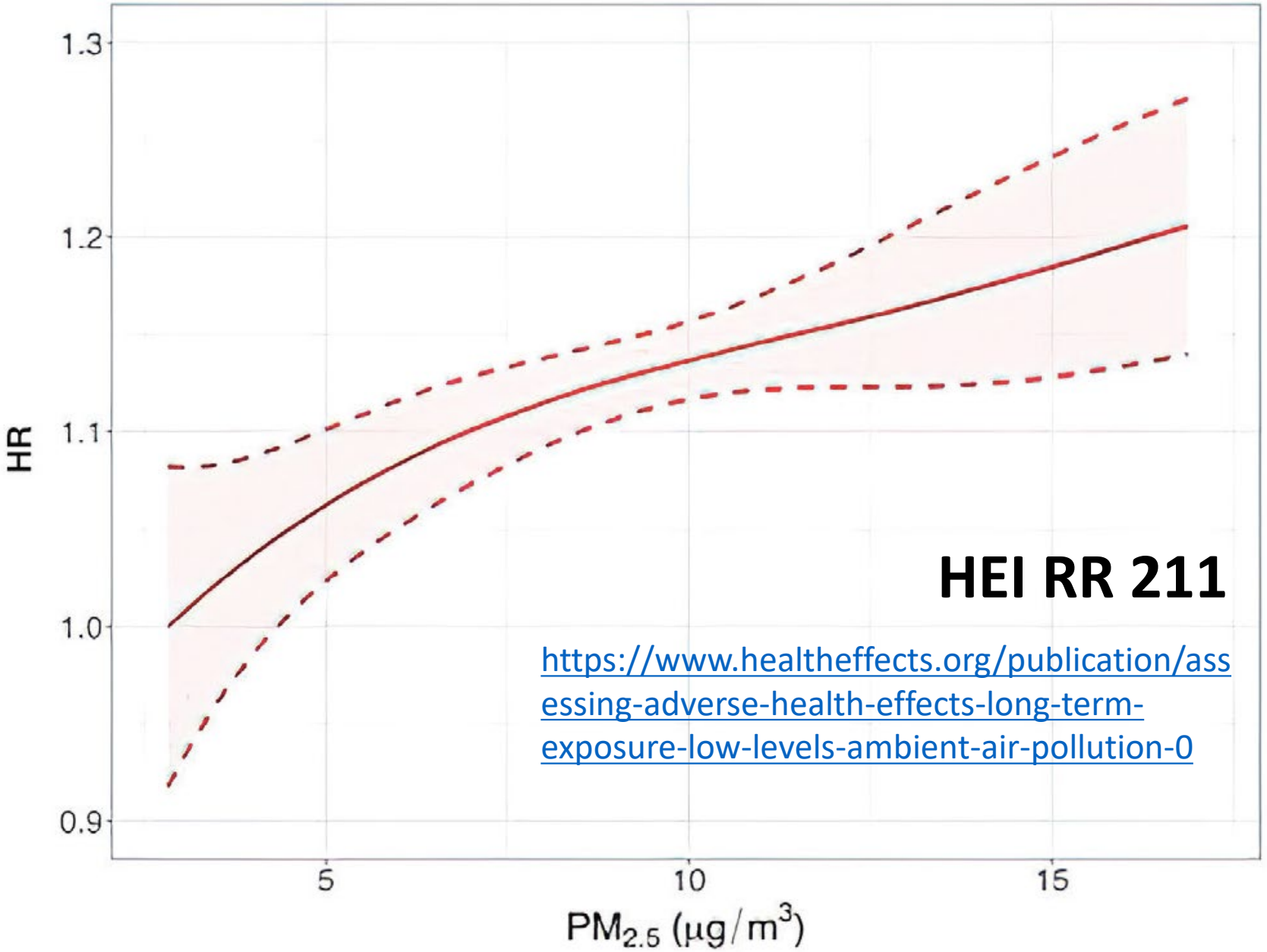


**Table P7** Comparison of performance of models with and without a threshold: **natural-cause mortality**

| Pollutant | Threshold | AIC | BIC |
|---|---|---|---|
| $PM_{2.5}$ | None | 831671.6 | 831803.0 |
| | 5 µg/m³ | 831671.6 | 831803.0 |
| | 7.5 µg/m³ | 831672.7 | 831804.1 |
| | 10 µg/m³ | 831677.4 | 831808.8 |
| $NO_2$ | None | 831678.6 | 831810.0 |
| | 10 µg/m³ | 831680.1 | 831811.6 |
| | 15 µg/m³ | 831685.4 | 831816.9 |
| | 20 µg/m³ | 831709.6 | |

HEI RR 208

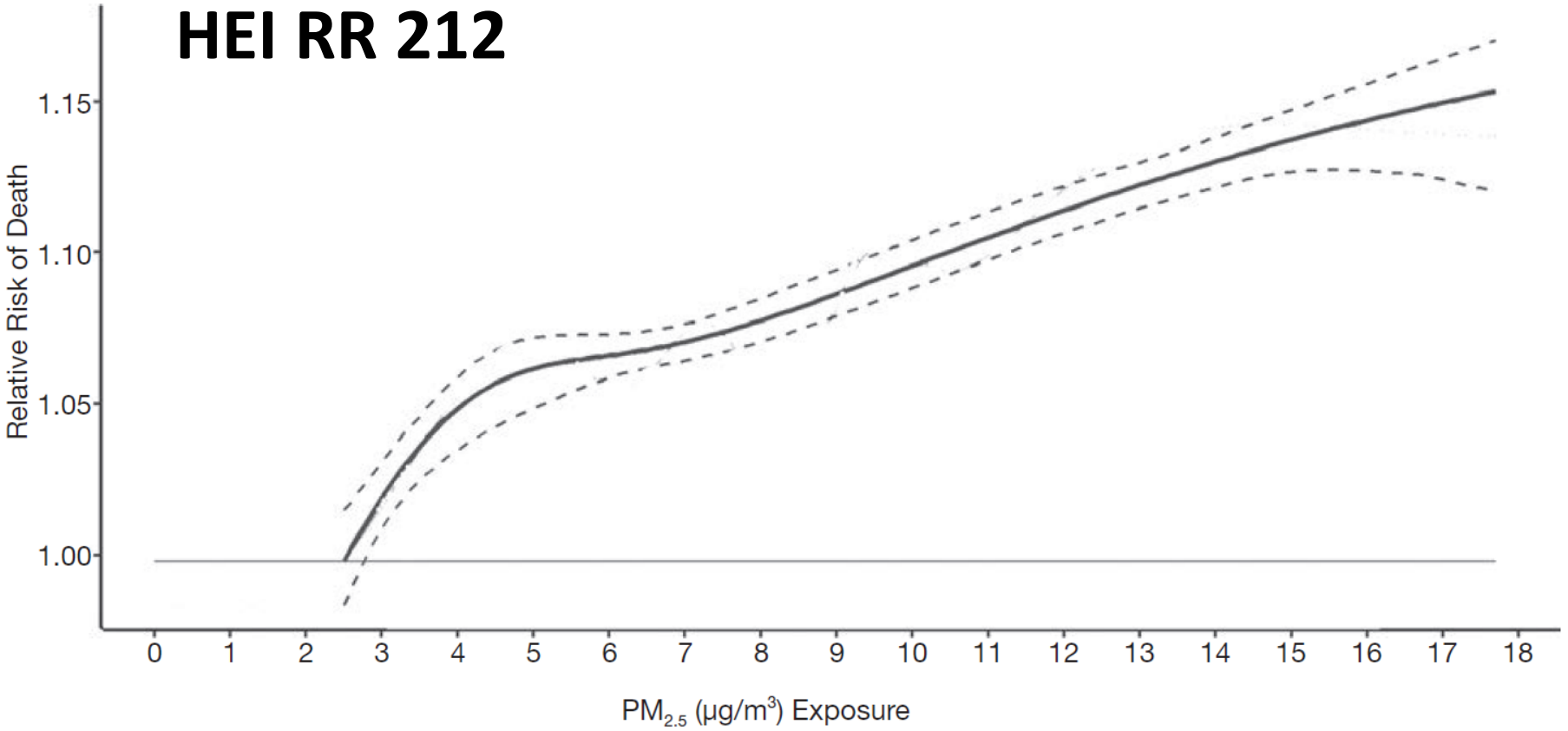
# Medicare, USA, all-cause mortality




**HEI RR 211**

https://www.healtheffects.org/publication/assessing-adverse-health-effects-long-term-exposure-low-levels-ambient-air-pollution-0

# CanCHEC, non-accidental mortality



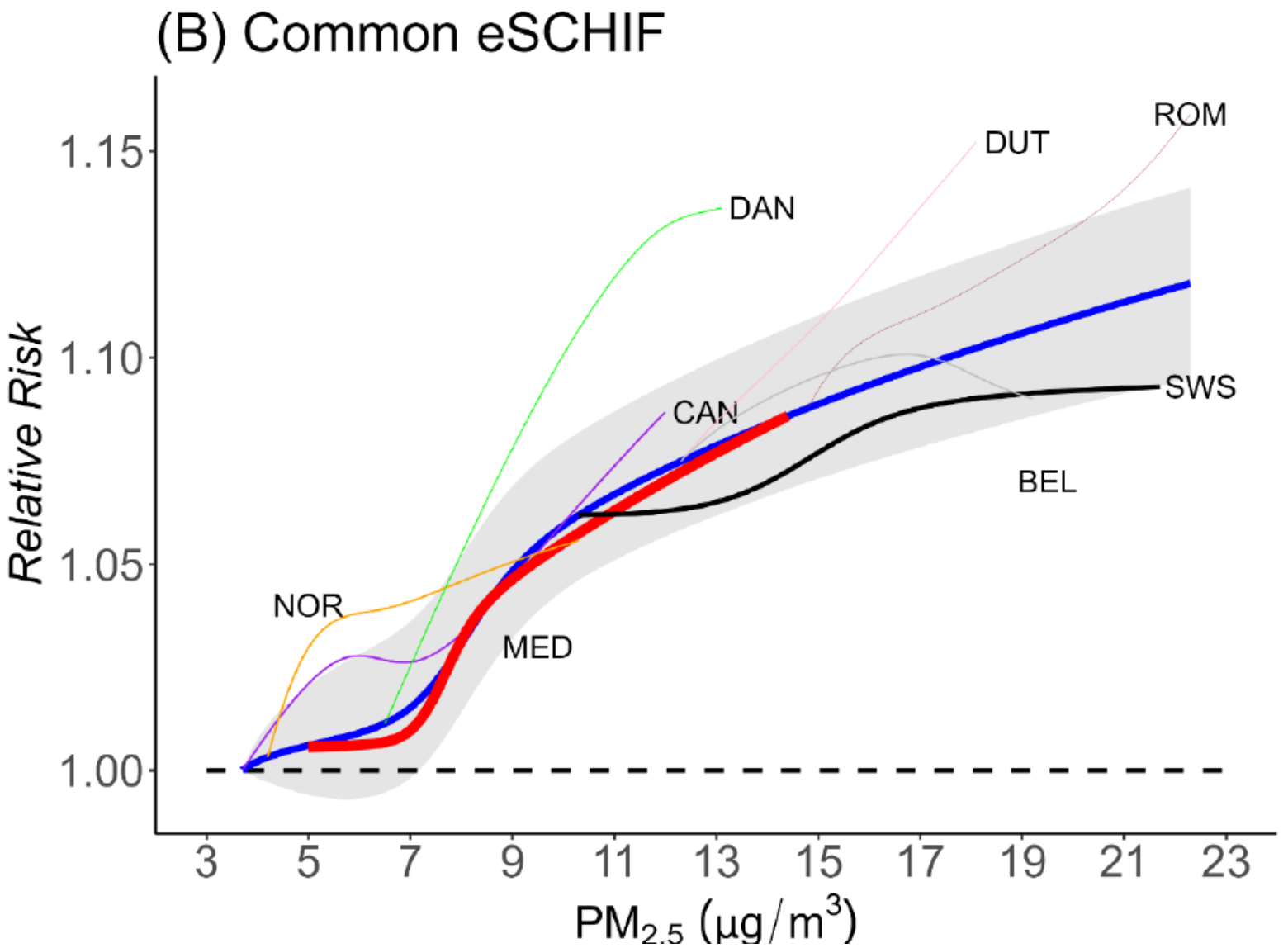

**Statement Figure. Shape of the association between outdoor $PM_{2.5}$ exposure and nonaccidental death**. This plot shows how the risk of death changes over different $PM_{2.5}$ exposure concentrations. The relative risk of death compares the lowest observed $PM_{2.5}$ concentration (2.5 µg/m³) to all higher concentrations. (Adapted from Investigators' Report Figure 29.)

https://www.healtheffects.org/announcements/new-canadian-study-reports-health-effects-very-low-air-pollution-levels.

# Harmonized analysis of Canadian, US and European studies

- We harmonized the study populations to individuals age 65+, applied the same satellite-derived PM2.5 exposure estimates, selected the same sets of potential confounders and the same outcome.
- Hazard ratios for all-cause mortality associated with a 5 $\mu g/m^3$ increase in PM2.5 were:
- 1.039 (1.032, 1.046) in CanCHEC - Canada,
- 1.025 (1.021, 1.029) in Medicare- USA, and
- 1.041 (1.014, 1.069) in ELAPSE - Europe.

# Chen, EHP 2023 (under review)



Commentary

ENVIRONMENTAL EPIDEMIOLOGY

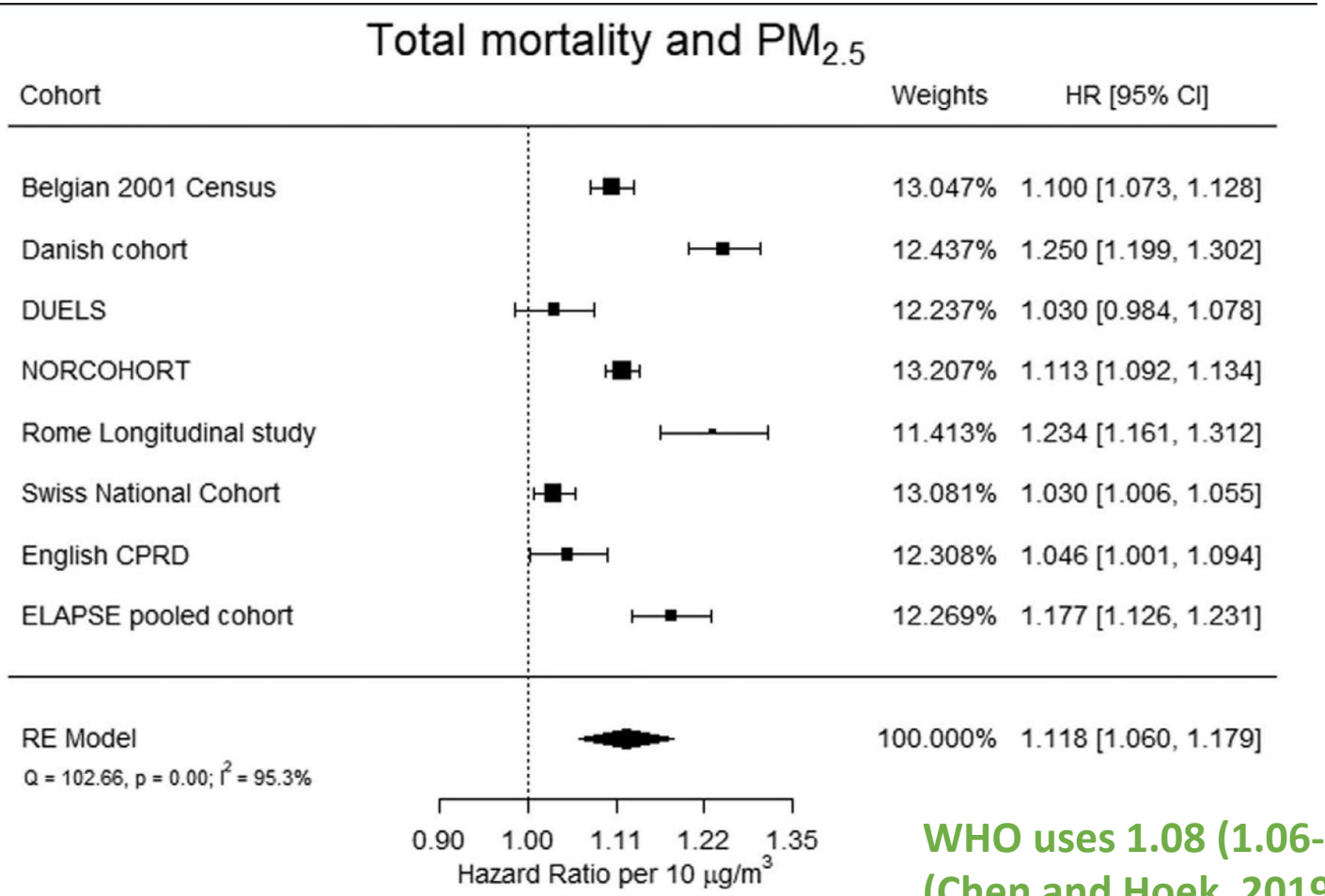
OPEN

# Benefits of future clean air policies in Europe

2022

***Proposed analyses of the mortality impacts of $PM_{2.5}$ and $NO_2$***

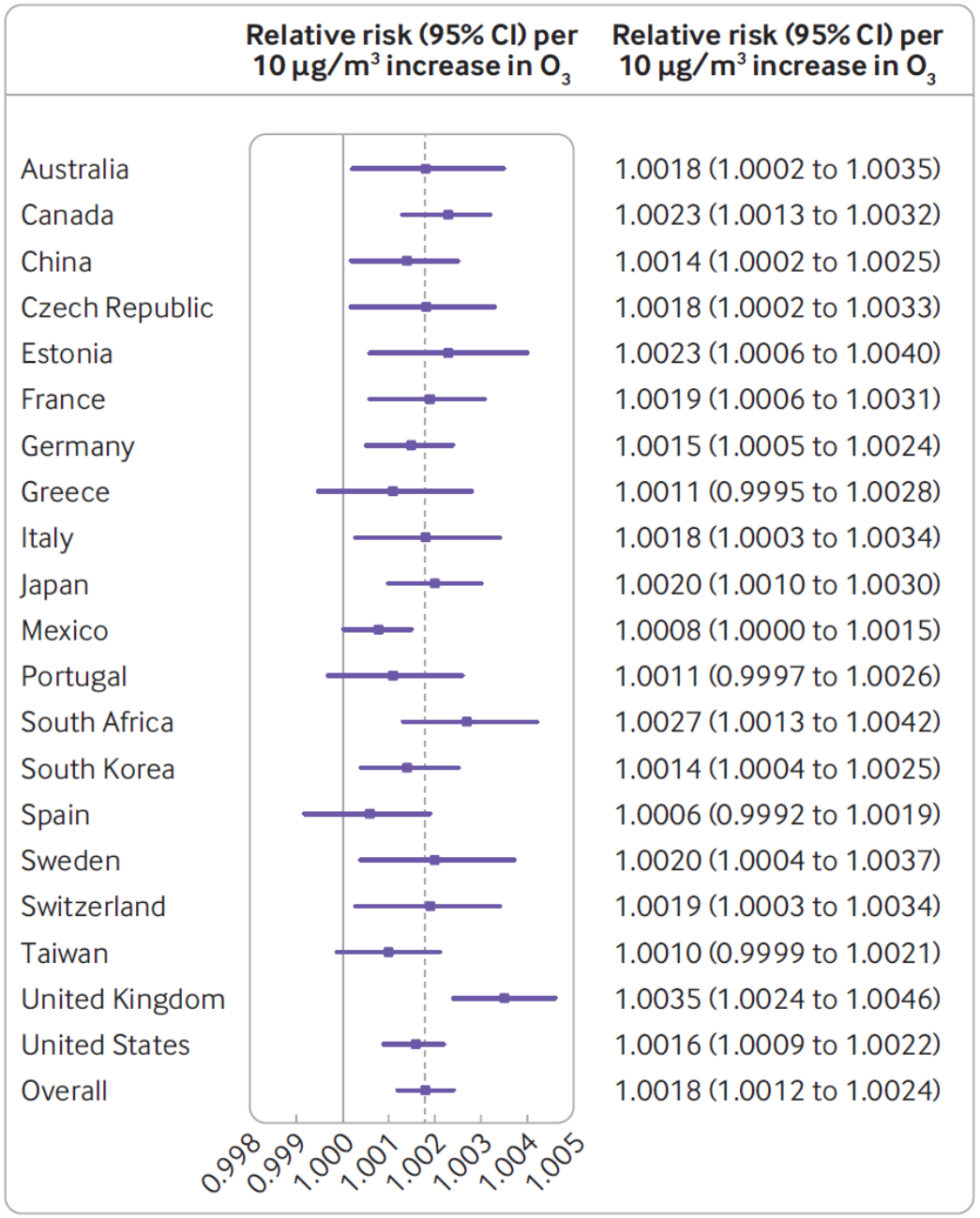
Barbara Hoffmann[a], Bert Brunekreef[b], Zorana J. Andersen[c], Francesco Forastiere[d], Hanna Boogaard[e*]




**WHO uses 1.08 (1.06-1.09) (Chen and Hoek, 2019)**

# What about ozone?

- No association between long-term O3 and mortality in ELAPSE
- Associations with PM2.5, NO2 in ELAPSE robust against adjustment for O3
- Positive association in Medicare and CanCHEC even after adjustment for PM2.5 and NO2
- O3 ***positively*** correlated with PM2.5 and NO2 in Medicare and CanCHEC
- O3 ***negatively*** correlated with PM2.5 and NO2 in ELAPSE
- O3 modeled on different spatial scales, and concentration ranges small in ELAPSE cohorts




**Short-term O3 is associated with mortality in all parts of the world Vicedo-Cabrera, BMJ 2020**

Fig 2 | Overall and country specific short term ozone-mortality association, expressed as relative risk per 10 µg/m$^3$ increase in ozone ($O_3$, maximum eight hour average) (lag 01)

# Concluding remarks

- WHO 2021 Air Quality Guidelines much lower than in 2005 for long-term PM2.5 and NO2
- Mostly because we know better what happens at low concentrations >> role of science has been crucial in documenting effects at low levels in great detail
- AAQD needs to specify how and when Limit Values will be aligned with new WHO AQGs

# THANK YOU FOR LISTENING!