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Oxidative potential as a complementary air quality metric

An AI-assisted systematic literature review

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What is the oxidative potential of particulate matter?

Oxidative potential is the capacity of particles to generate reactive oxygen species and deplete the antioxidants that defend lung tissue.

Volume-normalised

The concentration of the oxidative fraction in ambient air

Values in nmol/min/m^3

Intrinsic/mass-normalised

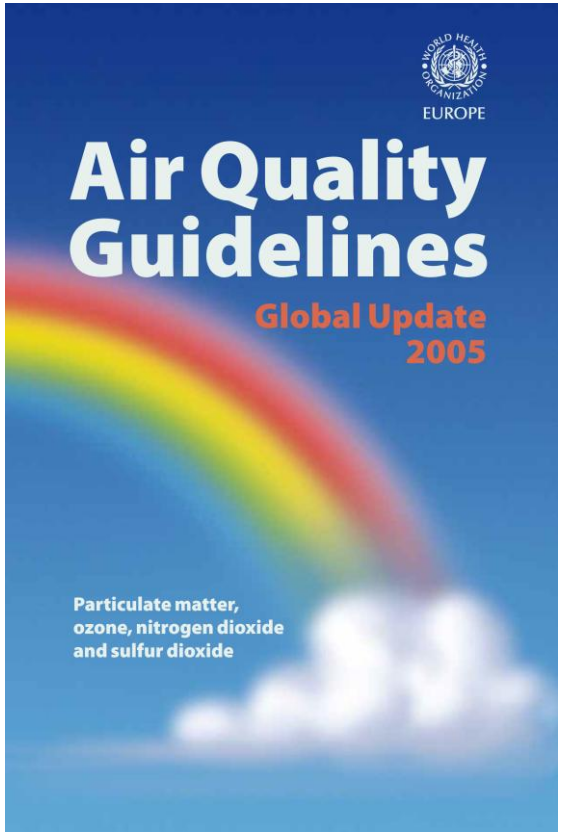
How reactive a given source's particles are

Values in nmol/min/µg

Mass tells us how much particulate a population breathes, not how harmful it is

A mass standard treats each particle of wood smoke, vehicle exhaust, and marine aerosol as having the same toxicity

Evidence indicates PM_{10} and $PM_{2.5}$ effects at lower concentrations than previously identified



PM_{10} annual average guideline reduced from 20 to 15 µg/m^3

$PM_{2.5}$ annual average guideline reduced from 10 to 5 µg/m^3

How do you measure oxidative potential?

We measure oxidative potential by acellular assay. Each measures different things

Assay	What it measures
Dithiothreitol (DTT)	Organic redox species (particularly quinones) and redox metal species (particularly copper, manganese and iron)
Glutathione (GSH)	Organic redox species (particularly quinones) and redox metal species (particularly copper, manganese and iron)
Ascorbic acid (AA)	Redox-active metals (particularly Cu and Fe)
Dichlorofluorescein (DCFH)	Total reactive oxygen species (non-specific)
Electron paramagnetic resonance (EPR)	Hydroxyl and other radicals

Oxidative potential is assay-specific

Oxidative potential from one assay cannot be applied to another

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AI-assisted systematic literature review workflow

Claude Haiku 4.5 for identification and title-abstract screening.

Claude Sonnet 4.6 for full-text eligibility, appraisal, verification, and synthesis.

PRISMA 2020 systematic literature review

Stream 1 588 records

Eight open-access databases

Stream 2 312 records

Consensus platform, plus citation chasing

127 studies critically appraised

Mixed Methods Appraisal Tool for quality assessment

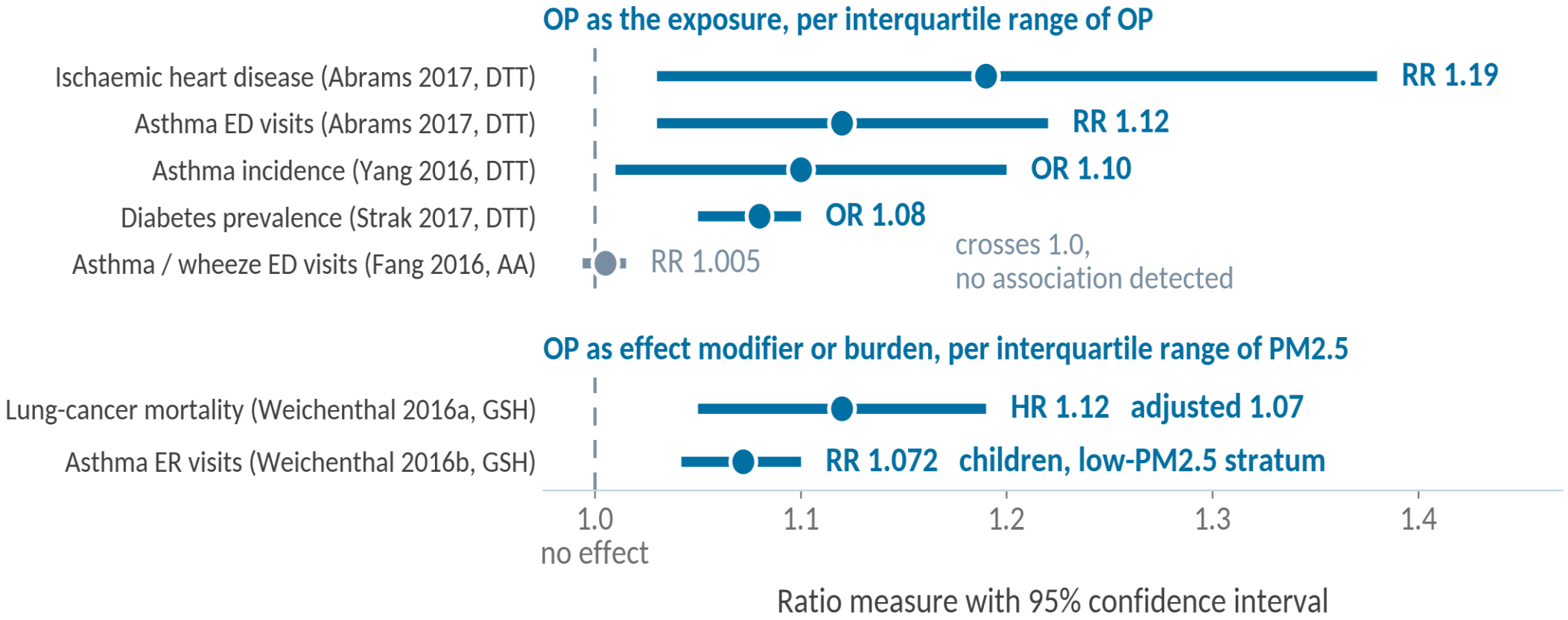
118 studies in synthesis

50	40	27	1
Assay methodology	Source apportionment	Epidemiology	Applied health impact

What the evidence says

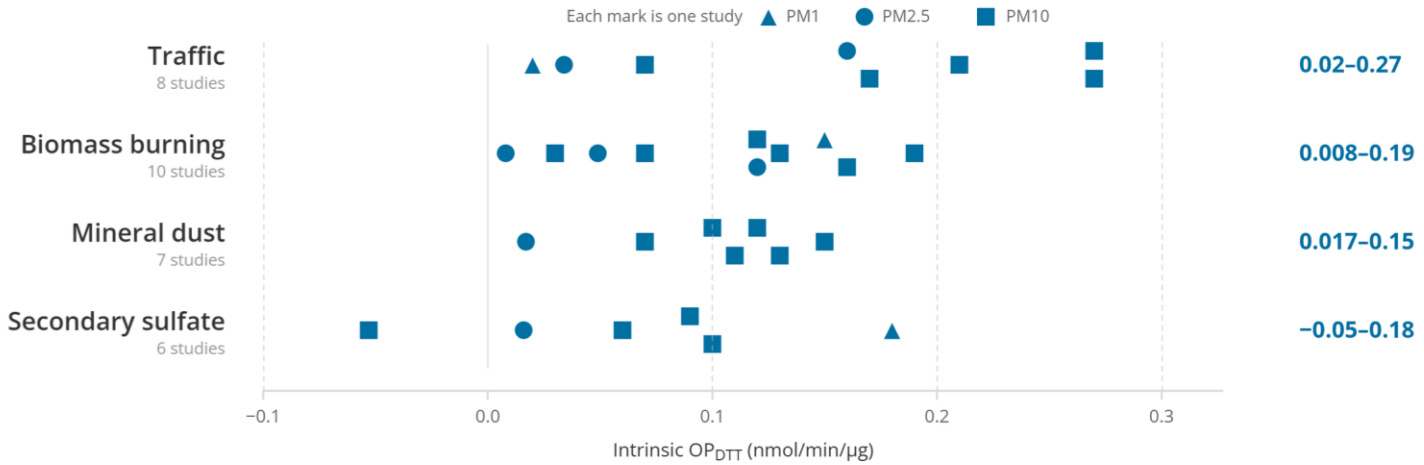
Health associations, assay agreement, and source attribution.

DTT- and GSH-based oxidative potential associate with disease

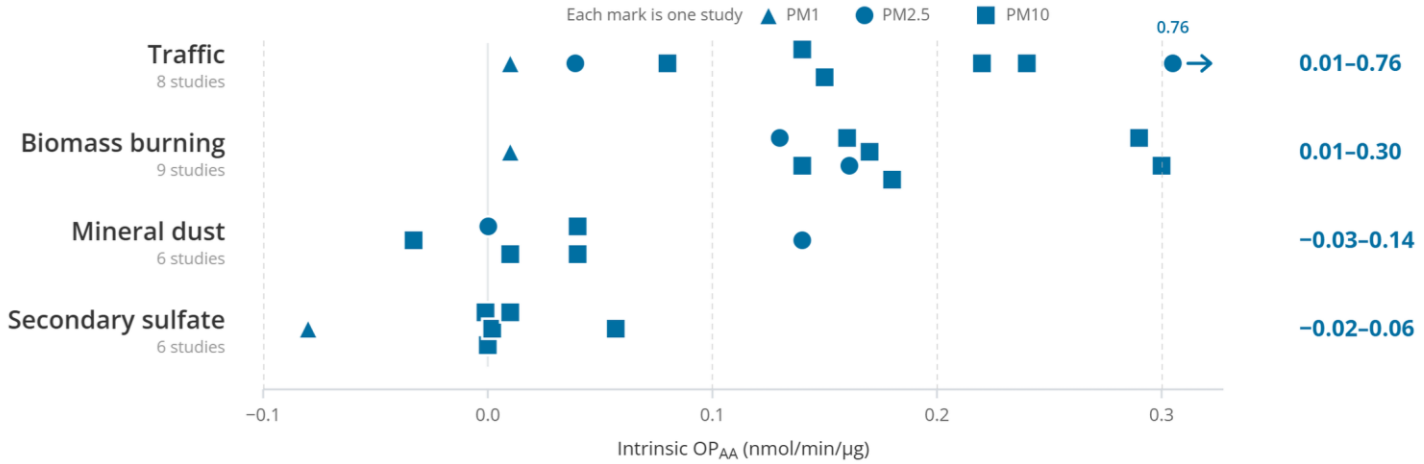


OR odds ratio, RR relative risk, HR hazard ratio.

Which source looks most oxidative?



All four ranges overlap: no source ranks consistently above another. Traffic leads in four studies, biomass in one, and each is near-lowest in another.



Same scale as the DTT panel. Ordering is less stable, not more: mineral dust is the most potent source in one study and the least in another.

It’s hard to tell…

Standardisation between laboratories is a challenge

A comparison between 20 laboratories found:

- 10% to >40% variation between repeat samples across labs
- Between -35% and +135% variation from the assigned (consensus) value across labs
- Only 10 out of 0 labs met acceptance criteria based on standard deviation of repeat samples.

Dominutti 2024. 20 laboratories, identical liquid samples, one shared analysis protocol

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The evidence is concentrated in the Northern Hemisphere

North America
Epidemiology and source apportionment
Canada, United States

Europe
Epidemiology and source apportionment
Netherlands, France, Italy

Asia
Source apportionment
China, East Mediterranean

equator

South America
No published OP study

Southern Africa
Source apportionment
South Africa, one study

Oceania
No published OP study
New Zealand, Australia

No published oxidative potential studies surfaced from New Zealand, Australia, or elsewhere in Oceania.

The EU now recommends measuring OP at monitoring supersites (European Union Directive 2024/2881)

The “AI-assisted” part of the literature review

Limitations and learnings

A number of failures along the way, and many were silent

- Silently failing early in the screening process but reporting that all text had been screened
- Values being quoted accurately, but with the wrong surrounding context (e.g., a different exposure, outcome, or population)
- Fabricated or incorrect DOIs/citations
- Paraphrasing of source quotes or bibliographic values

What verification checks helped

- Mapping papers and their claims in an evidence table
- Validating that the papers have corresponding real DOIs, titles and authors against official registries
- Checking for papers with similar titles but differing contents
- Minimum documentation requirements and success criteria

Future improvements might include checkpoints between stages

Newer models may also provide better results

Research-ready, not regulation-ready

Oxidative potential shows promise as a complementary air quality metric to PM mass.

But…

Inter-laboratory agreement is poor

Epidemiological and applied health studies are limited

What is needed

Better standardisation of laboratory analysis protocols

More oxidative potential measurements, paired with source apportionment

More epidemiological studies

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