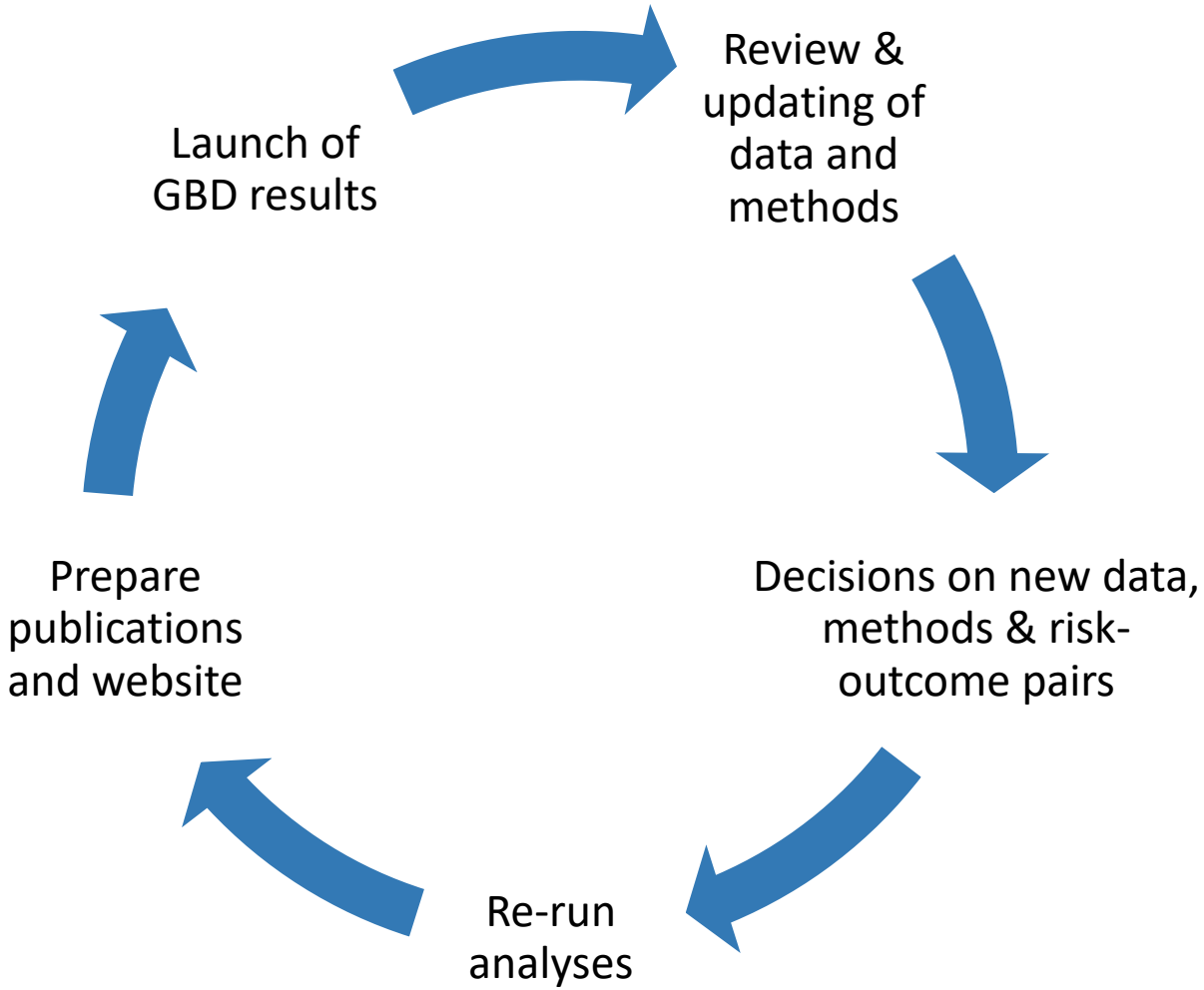
GBD 2021



88 risk factors

371 diseases and injuries

204 countries and territories

>12,000 researchers in 160+ countries

> 600 Billion estimates

Important!

Time trends from 1990 are re-calculated every year (1990 – 2021)

Risk Factor Capstone Publication

Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021

*GBD 2021 Risk Factors Collaborators**

Lancet 2024; 403: 2162–203

See **Comment** page 1960

*Collaborators listed at the end of the Article

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Summary

Background Understanding the health consequences associated with exposure to risk factors is necessary to inform public health policy and practice. To systematically quantify the contributions of risk factor exposures to specific health outcomes, the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2021 aims to provide comprehensive estimates of exposure levels, relative health risks, and attributable burden of disease for 88 risk factors in 204 countries and territories and 811 subnational locations, from 1990 to 2021.

Methods The GBD 2021 risk factor analysis used data from 54 561 total distinct sources to produce epidemiological estimates for 88 risk factors and their associated health outcomes for a total of 631 risk–outcome pairs. Pairs were included on the basis of data-driven determination of a risk–outcome association. Age-sex-location-year-specific estimates were generated at global, regional, and national levels. Our approach followed the comparative risk

2-page Risk Factor and Cause Summaries

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2-page Risk Factor and Cause Summaries

Household air pollution from solid fuels—Level 4 risk

Summary In 1990, household air pollution from solid fuels was the leading Level 4 risk factor for deaths among environmental and occupational risks, contributing to 4·82 million (95% UI 3·77–5·86) deaths. Deaths declined to 3·11 million (1·90–5·19) globally in 2021.

Abbreviated Definition Household air pollution includes exposure to particulate matter less than 2·5 micrometres in diameter ($PM_{2.5}$) due to the use of solid fuels for cooking, including coal, charcoal, wood, agricultural residue, and animal dung.

	Total sources
Exposure	1173
Relative risk	202

Table 1: Total sources used in GBD 2021 estimation

What is new in GBD 2021?

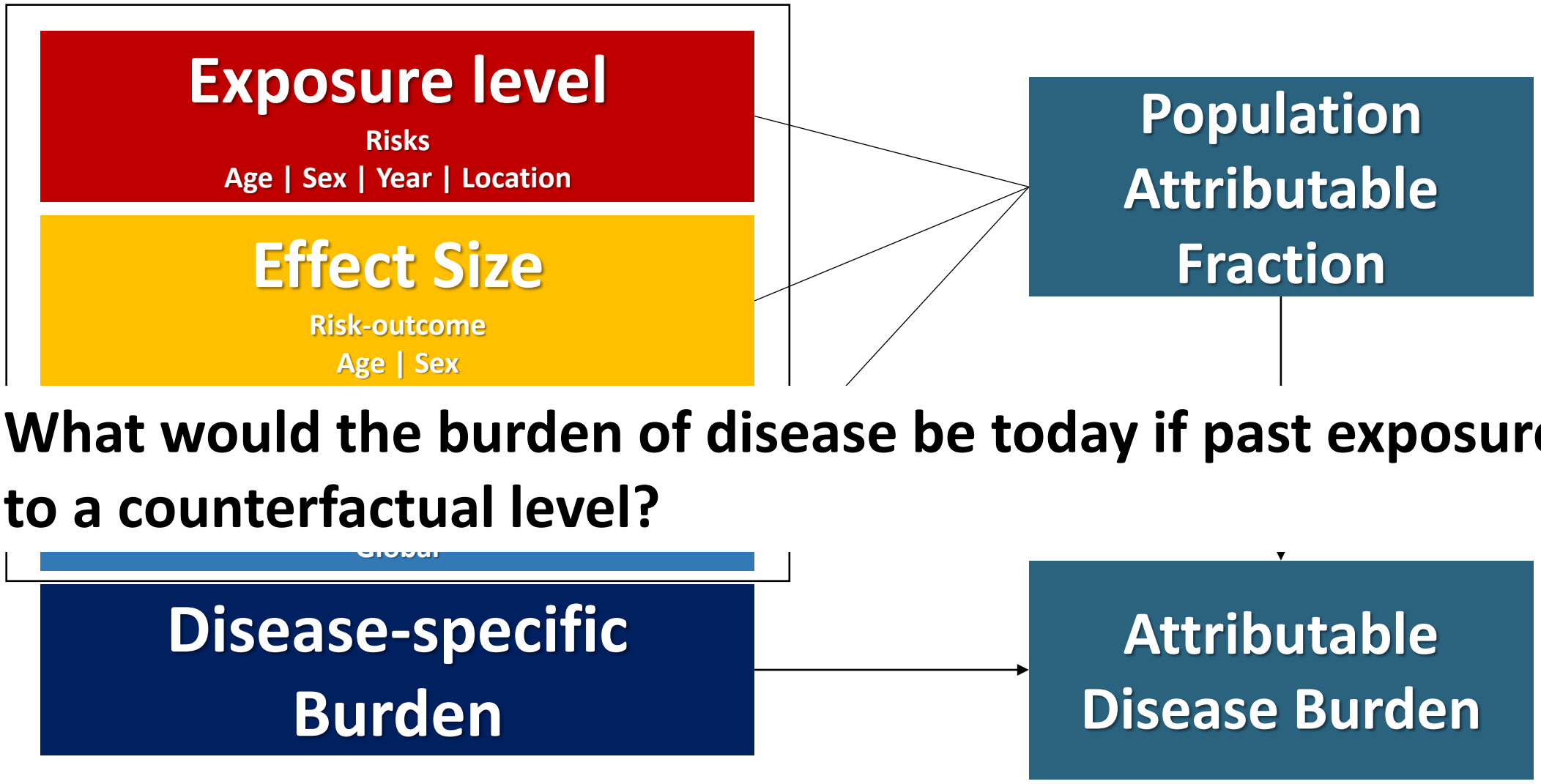
- Exposure estimates were updated to predict fuel-type-specific exposure estimates; these included estimates for the proportion of individuals using each fuel and the $PM_{2.5}$ exposure level associated with each fuel type.
- 182 new sources estimating the number of individuals using solid fuels for cooking and one new source estimating the $PM_{2.5}$ exposure level associated with solid fuels were added to the exposure model.
- The relative risk estimate for cataract was updated from 2·51 (95% UI 1·58–3·96) for those exposed to solid fuels for cooking to 2·52 (1·42–4·57) using the Burden of Proof approach.
- The relative risk curves for the eight outcomes of particulate matter pollution were updated using the Burden of Proof approach; these no longer include age-specific predictions for cardiovascular diseases or secondhand smoking data.

Eight Principles of the GBD

Aim:
Make estimates:
(i) comprehensive,
(ii) comparable, &
(iii) as accurate as possible.

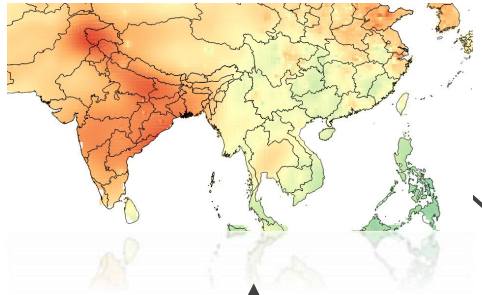
1. **Comprehensive** comparisons, a.k.a leave no blanks
2. Communicate the **strength** of the evidence (uncertainty)
3. Ensure internal **consistency**
4. **Iterative** approach to estimation
5. Identify **all relevant data** sources
6. Compare like with like, a.k.a crosswalk different measurements
7. **Correct** for data errors
8. Pick the best model based on **performance**

Risk factor attributable burden



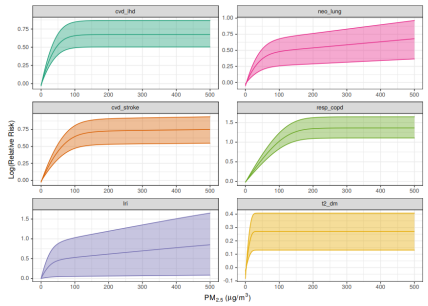
What would the burden of disease be today if past exposure was set to a counterfactual level?

Attributable burden estimation framework



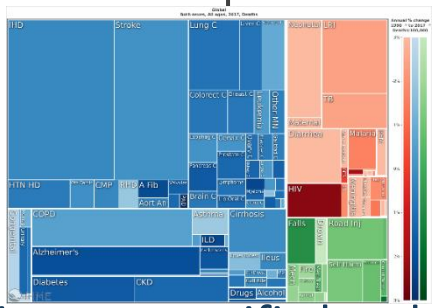
Minimum risk exposure level

Exposure-response relationships



Population-attributable fraction due to air pollution

Burden of Disease attributable to Air Pollution



Disease-specific burden

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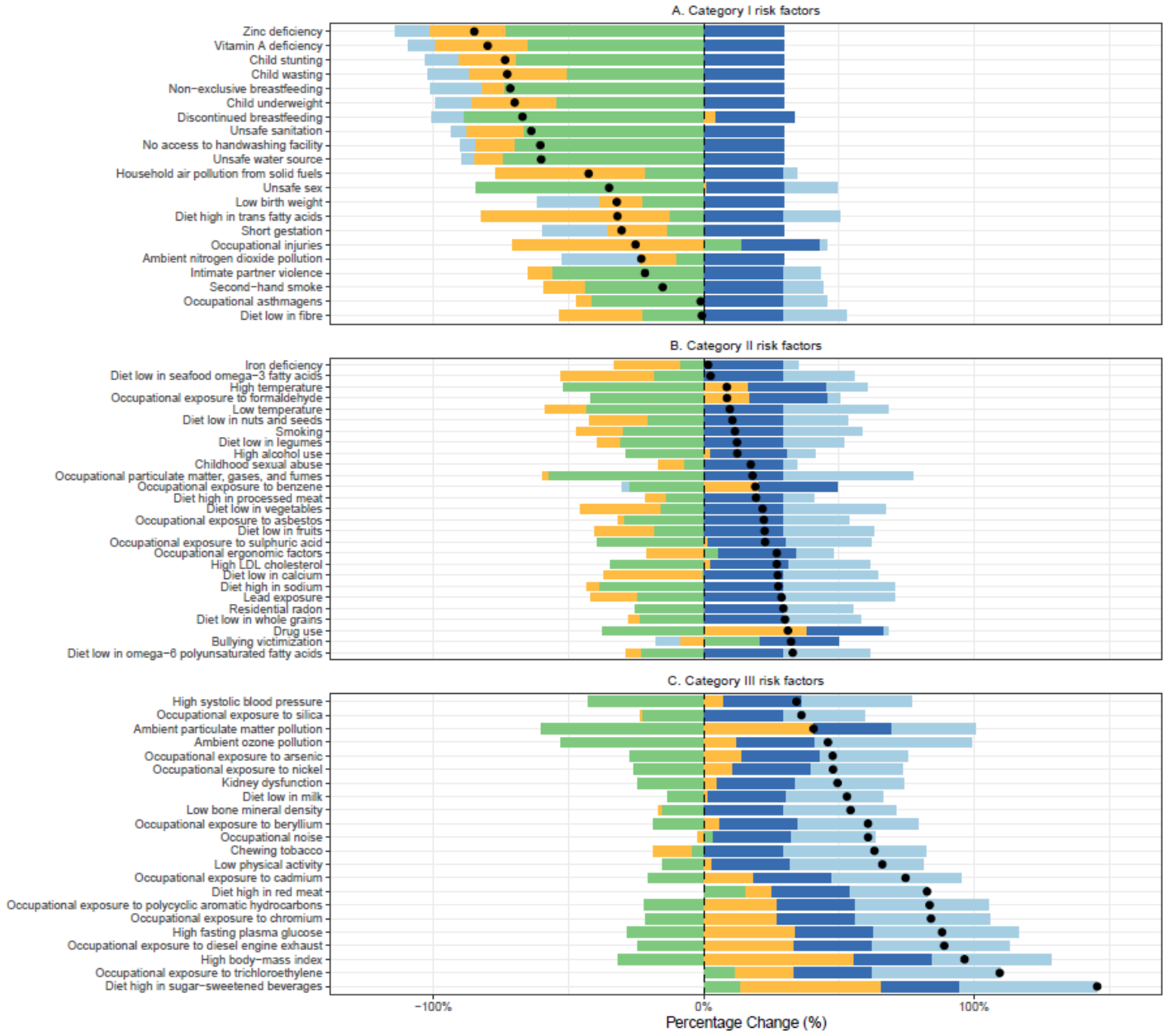
Figure 5. Percentage change in number of global DALY attributable to Level 4 risk factors, from 2000–2021, due to the following drivers: population growth, population ageing, changes in risk factor exposure, and changes in risk-deleted DALY rates.



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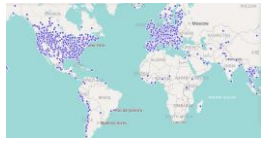
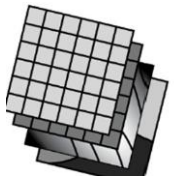
Quantifying exposure to air pollution



Ground monitoring of air quality

Satellite data

Chemical transport models



Geospatial data

Fuel use and other surveys

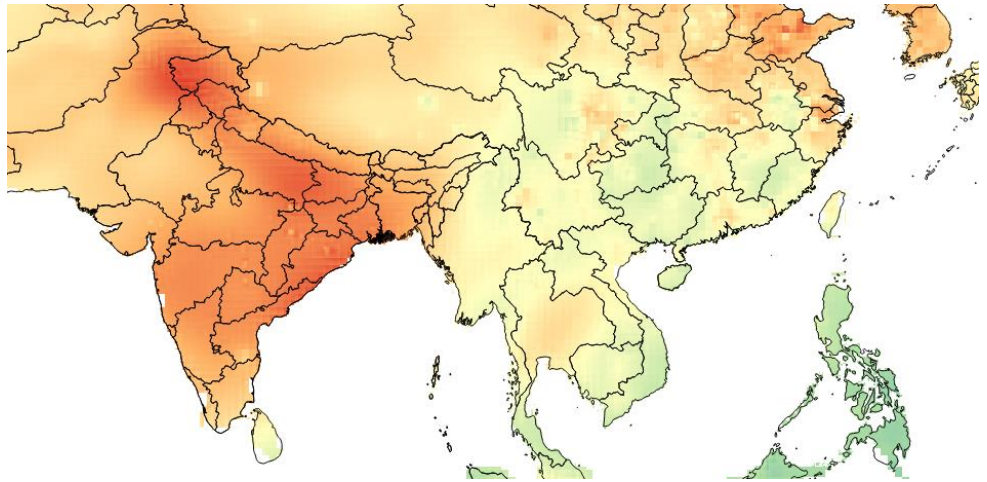
$PM_{2.5}$

Ozone

Nitrogen Dioxide

Household Air Pollution

Population-weighted exposures for every country*



*Based on aggregation from pixel estimates at 1km - 11 km grid scales

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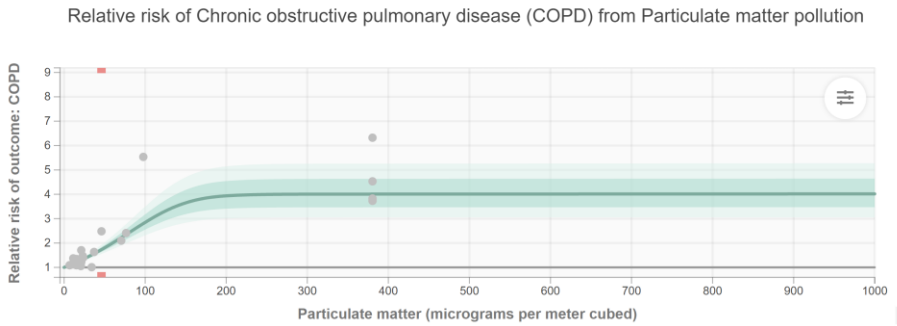
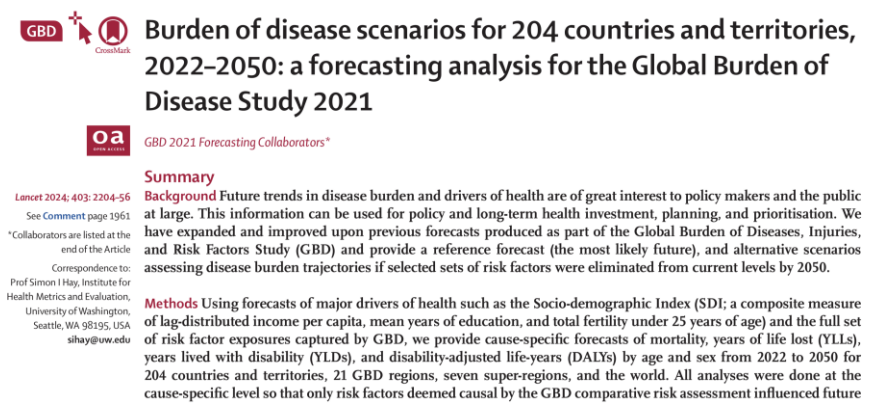
Key updates for GBD 2021

- Additional ground monitoring data
- HAP: fuel-specific exposure estimates
- New Risk Factor
  - NO_2
- Burden of Proof Risk Function
  - $PM_{2.5}$ – all-ages risk curves
  - Ambient and HAP data only
- Attributable Burden forecasting




Burden of disease scenarios for 204 countries and territories, 2022–2050: a forecasting analysis for the Global Burden of Disease Study 2021

GBD 2021 Forecasting Collaborators*

Summary

Lancet 2024; 403: 2204-56

See Comment page 1961

*Collaborators are listed at the end of the Article

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Background Future trends in disease burden and drivers of health are of great interest to policy makers and the public at large. This information can be used for policy and long-term health investment, planning, and prioritisation. We have expanded and improved upon previous forecasts produced as part of the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) and provide a reference forecast (the most likely future), and alternative scenarios assessing disease burden trajectories if selected sets of risk factors were eliminated from current levels by 2050.

Methods Using forecasts of major drivers of health such as the Socio-demographic Index (SDI; a composite measure of lag-distributed income per capita, mean years of education, and total fertility under 25 years of age) and the full set of risk factor exposures captured by GBD, we provide cause-specific forecasts of mortality, years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life-years (DALYs) by age and sex from 2022 to 2050 for 204 countries and territories, 21 GBD regions, seven super-regions, and the world. All analyses were done at the cause-specific level so that only risk factors deemed causal by the GBD comparative risk assessment influenced future

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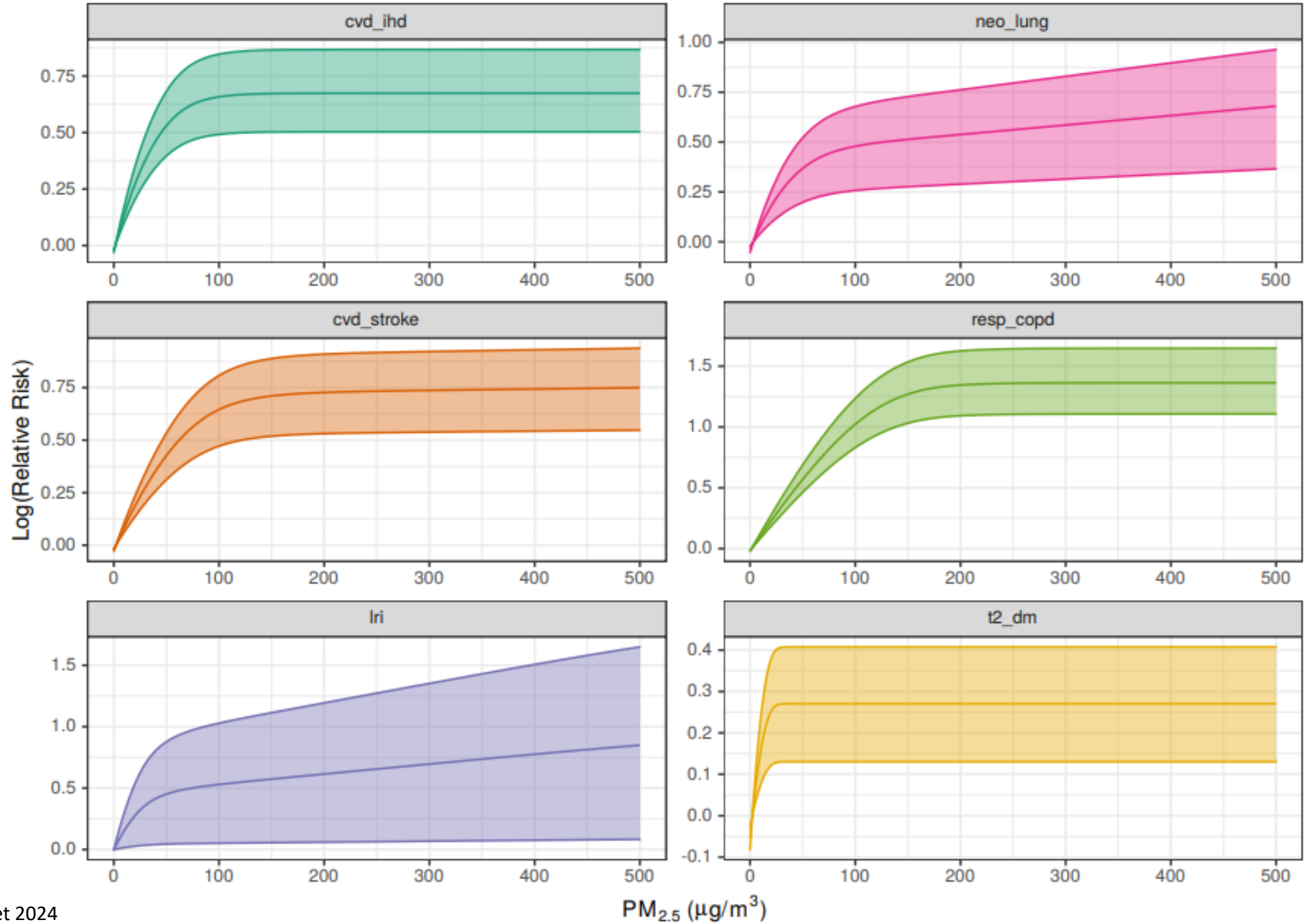

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Robust assessment of the risk-outcome relationship

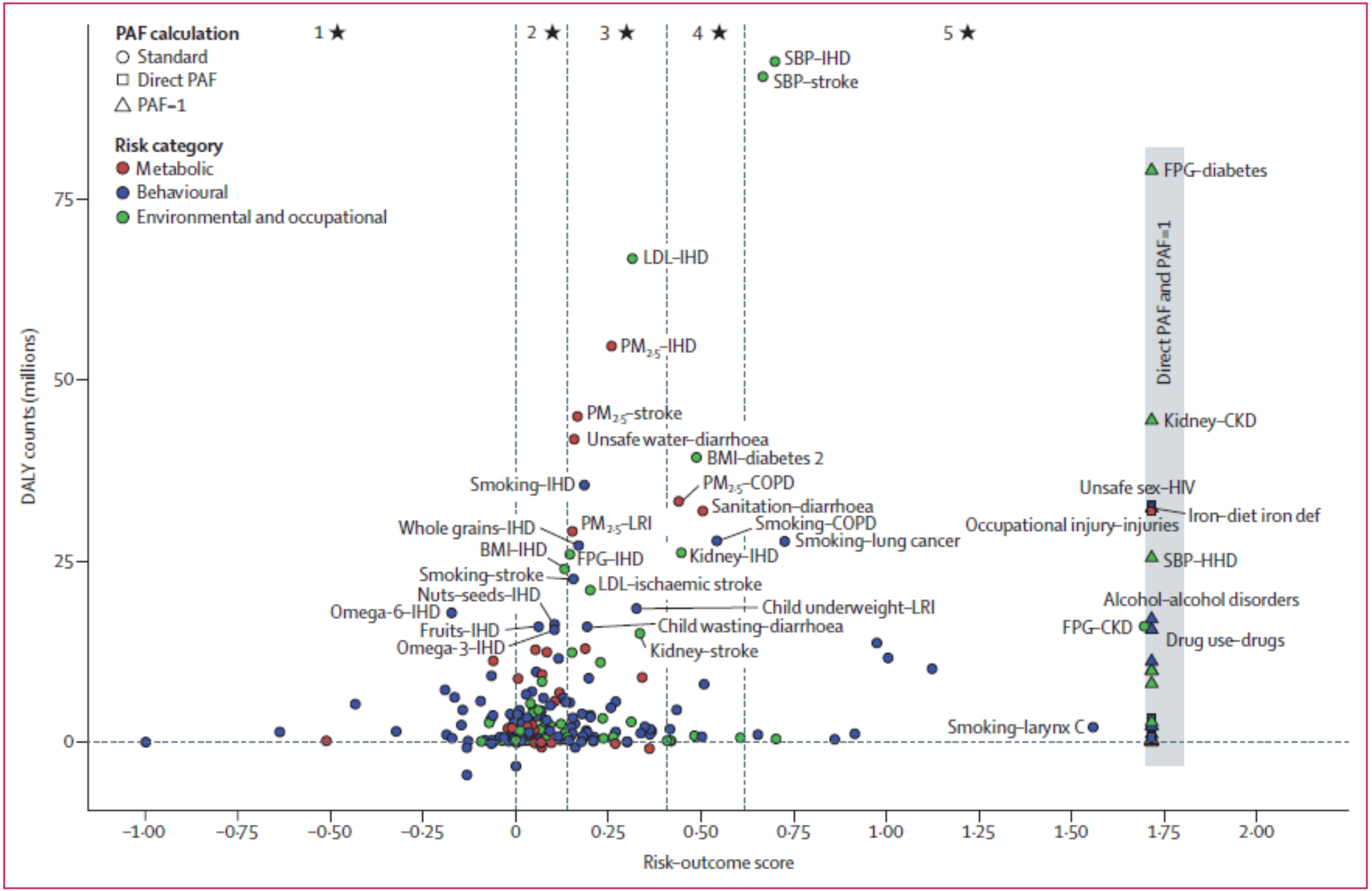
- **Meta-analysis or meta-regression** often used as an input.
- Many methods assume the relationship between exposure and risk is **log-linear**
- National or international guidelines typically come from **expert committees**
  - can consider nuances hard to capture in quantitative methods
  - different expert groups can and do arrive at different conclusions
- **GRADE** proposed to standardize issues that are considered. But GRADE is also subjective.

- Risk-outcome relationships with **small increases in risk** are more likely due to residual confounding or other biases.
- **Unexplained between-study heterogeneity** suggests uncaptured uncertainty

Burden of Proof Risk Function

- Smallest level of excess risk that is consistent with data.
- Incorporates:
  - **mean** relationship between risk and exposure in the available data
  - **unexplained* between study heterogeneity** adjusted for **number of studies**
    - *study design covariates (confounding, selection bias, exposure measurement, etc.)

Data Visualization



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Air Pollution Evidence Scores

Outcome	Risk Score	Star rating
$PM_{2.5}$ – COPD	0.441	4
$PM_{2.5}$ - Lung cancer	0.342	3
$PM_{2.5}$ - Ischemic heart disease	0.259	3
$PM_{2.5}$ – Stroke	0.167	3
$PM_{2.5}$ - Type-2 diabetes	0.188	3
$PM_{2.5}$ – LRI	0.126	2
Dementia (GBD 2023)	0.085	2
Ozone - COPD	0.011	2
NO_2 – (pediatric) Asthma	-.349	1
$PM_{2.5}$ – Birthweight	Mediation	-
$PM_{2.5}$ - Gestational age	Mediation	-

Brauer et al. Lancet 2024