Public Health England

Protecting and improving the nation's health

Attribution of all-cause mortality associated with long-term average concentrations of NO_2

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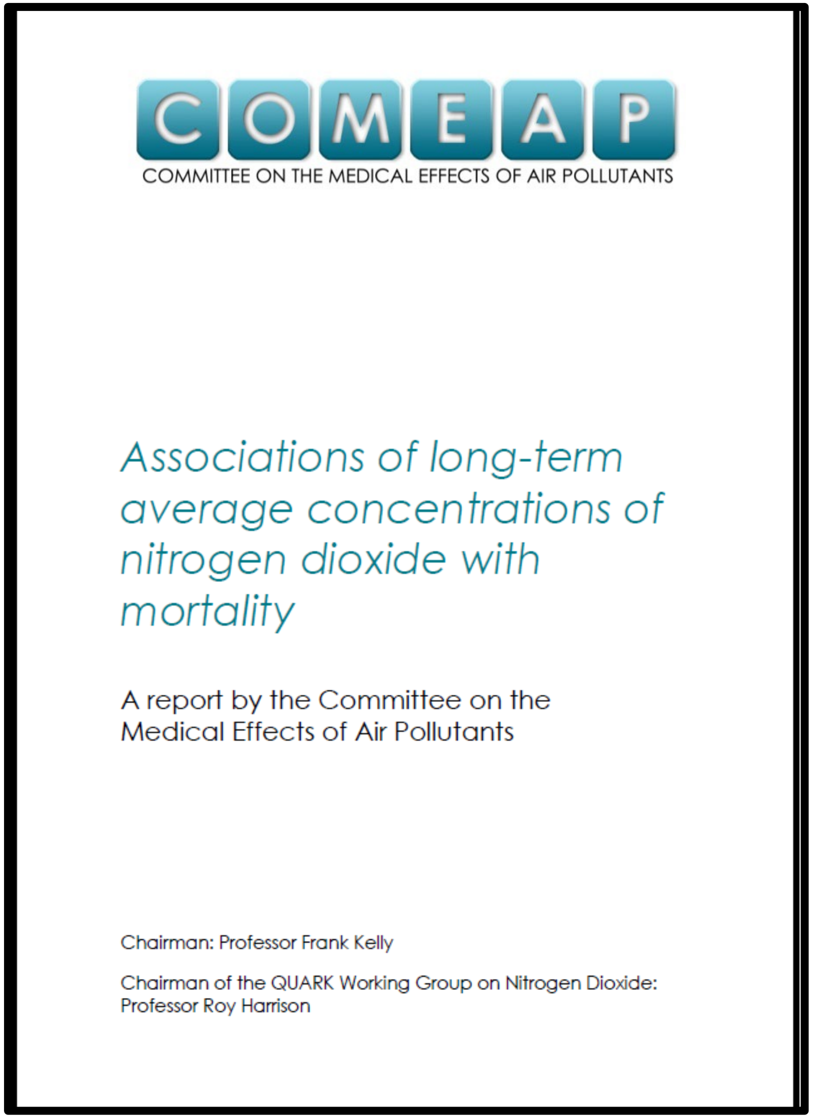
ERS, WHO, HEI, ISEE meeting, Brussels 21 and 22 January 2020



COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

Associations of long-term average concentrations of nitrogen dioxide with mortality

A report by the Committee on the Medical Effects of Air Pollutants

Chairman: Professor Frank Kelly

Chairman of the QUARK Working Group on Nitrogen Dioxide: Professor Roy Harrison

Request from Defra:

- How to quantify the benefits of reducing long-term average concentrations of NO_2.
- To support the development of Air Quality Plans to reduce NO_2 concentrations

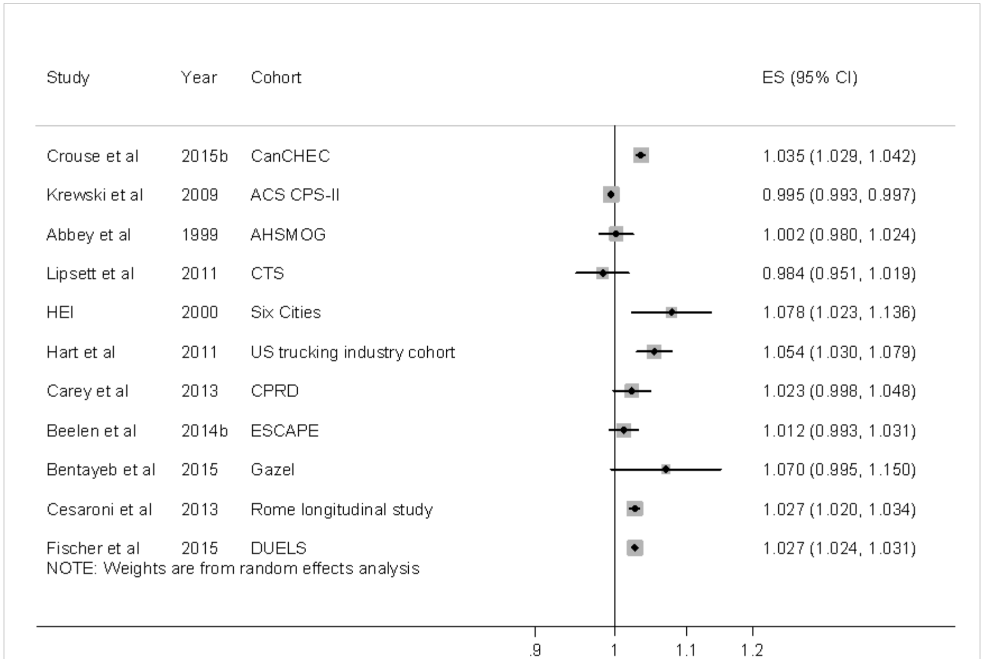
COMEAP 2018
www.comeap.org.uk

Mortality estimates for NO_2 - HRAPIE

Pollutant metric	Health outcome	Group	RR (95% CI) per 10 µg/m³	Range of concentration
NO_2, annual mean	Mortality, all (natural) causes, age 30+ years	B*	1.055 (1.031–1.080)	>20 µg/m³

Source of background health data	Source of CRF	Comments
MDB (WHO, 2013c), rates for deaths from all natural causes (ICD-10 chapters I–XVIII, codes A–R) in each of the 53 WHO Regional Office for Europe countries, latest available data	Meta-analysis of all (11) cohort studies published before January 2013 by Hoek et al. (2013); RR based on single-pollutant models	Some of the long-term NO_2 effects may overlap with effects from long-term $PM_{2.5}$ (up to 33%); this is therefore recommended for quantification under Group B to avoid double counting in Group A analysis

New meta-analysis



HRs (95% CI) per 10 µg/m^3 for cohort studies reporting associations between NO_2 and all-cause mortality

Random effects summary HR: 1.023 (95% CI 1.008, 1.037) per 10 µg/m^3 NO_2

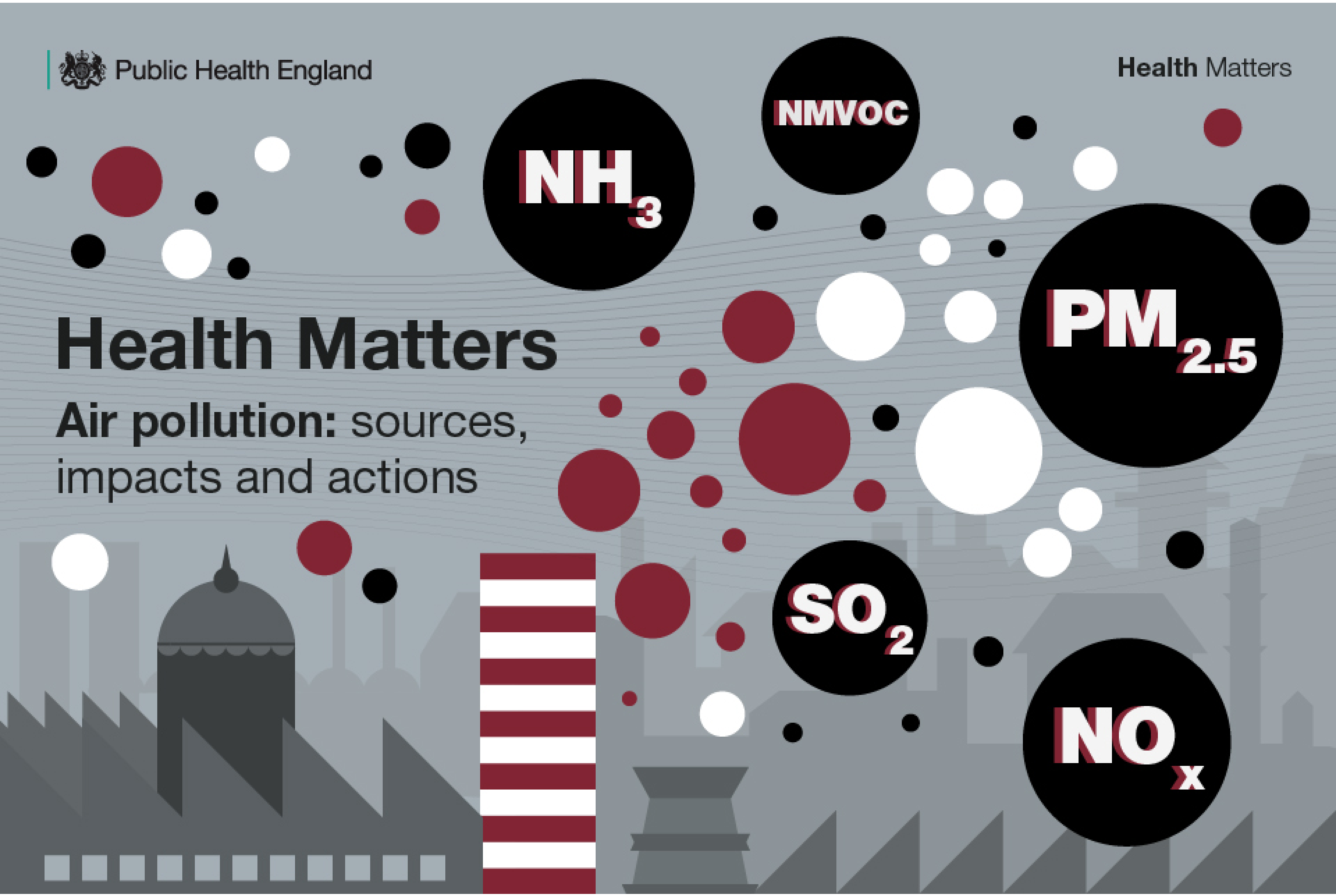
To note:

All-cause mortality only considered (not cause-specific mortality)

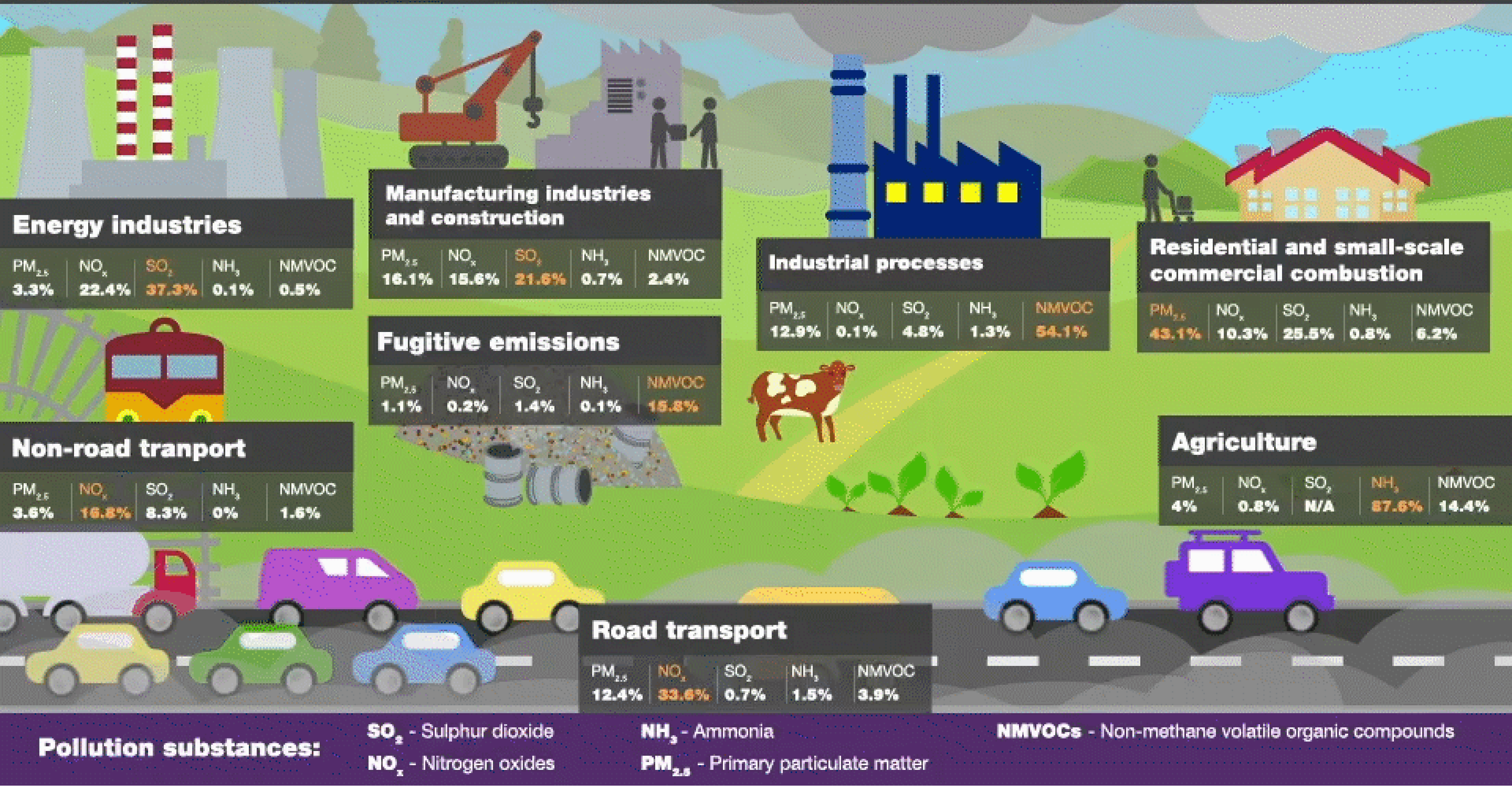
Cut-off date for literature review – **October 2015** (new studies now available)

Health Matters

Air pollution: sources, impacts and actions



Sources of air pollution



Report of a Workshop to Identify Needs for Research on the Health Effects of Nitrogen Dioxide - London, 2-3 March 2011

Workshop convened by the Air Pollution Group, Health Protection Agency. Commissioned by the Department of Health's Policy Research Programme

ABSTRACT

It is clear from epidemiological and laboratory studies that air pollution has adverse effects on health. However, understanding whether ambient concentrations of nitrogen dioxide (NO_2) have direct adverse effects on health has proved to be difficult, because levels in ambient air correlate closely with those of other pollutants, notably particles. This difficulty arises because NO_2 and particles have similar sources, such as traffic.

COMEAP (2015) Statement on NO_2

- Strengthening evidence for associations with NO_2
- Associations robust to adjustment for other pollutants incl PM
- May act as a marker for TRAP to some extent, but evidence suggests that it would be sensible to regard NO_2 as causing some of the health impact reported in epidemiological studies

Other assessments:

WHO REVIHAAP (2013): NO_2 might represent TRAP but

- Reasonable to infer that NO_2 has some direct effects following short-term exposure (associations robust to adjustment, some mechanistic support for causality - particularly for respiratory outcomes)
- Harder to judge independent effects of NO_2 in studies of long-term exposure. Short-term associations and mechanistic evidence, particularly on respiratory effects, suggest a causal relationship

USEPA ISA (2016)

Health Canada (2016)

Unadjusted coefficient for NO_2

Reflects:

- any causal effect of NO_2
- and also, to some extent, the effects of other pollutants correlated with NO_2

Correlated pollutants:

- $PM_{2.5}$
- other components of the air pollution mixture eg
  - Ultrafine particles
  - Black Carbon
  - Volatile Organic Compounds etc

Independence from PM mass

Using HRs (per IQR) from studies reporting results from single and two/multi-pollutant models for NO_2 and PM:

Compared:

- HRs from single-pollutant models with
- Combined adj HRs (NO_2 adj for PM; PM adj for NO_2)

➢ The combined effect using coefficients each adjusted for the effects of the other, is either similar to or only little higher than what would be estimated for either $PM_{2.5}$ or NO_2 alone

Hazard ratios (HRs) expressed per interquartile range (IQR) from single and two pollutant models for NO_2 and $PM_{2.5}$

Study (additional sig figs for HRs obtained from the authors)	Corr NO_2/ $PM_{2.5}$	NO_2 IQR (µg/m3)	$PM_{2.5}$ IQR (µg/m^3)	NO_2 adj $PM_{2.5}$	$PM_{2.5}$ adj NO_2	Combined NO_2 adj / PM adj	$PM_{2.5}$ Single	NO_2 Single
Cesaroni et al 2013	0.79	10.7	5.7	1.026	1.004	**1.030**	1.023	**1.029**
Carey et al 2013 pers comm	0.85	10.7	1.9	1.001	1.023	**1.024**	**1.023**	1.022
Beelen et al 2014 14 cohorts	0.2-<0.7	10.0	5.0	1.007	1.060	**1.067**	**1.070**	1.015
Fischer et al 2015 PM_{10}	0.58 (with PM_{10})	10.0	2.4	1.019	1.010	**1.029**	1.019	**1.027**
HEI 2000 41 cities	-0.08	81.4 (min,max)	24.5 (min,max)	0.90	1.22	**1.09**	1.15	0.95
Jerrett et al 2013	0.55	7.7	5.3	1.025	1.015	**1.040**	**1.032**	**1.031**

Coefficient for NO_2 adjusted for $PM_{2.5}$

Excludes, as far as possible:

- effects associated with $PM_{2.5}$ concentrations, and other components of the air pollution mixture that are more closely correlated with $PM_{2.5}$ concentrations than with NO_2 concentrations

Reflects:

- any causal effect of NO_2 and also, to some extent, of other pollutants closely correlated with NO_2

➢ The extent to which the effect is likely to be causally related to NO_2 is unclear

Uncertainty related to causality

A key point of COMEAP's discussions:

Uncertainty in the extent to which the effects associated with NO_2 in epidemiological studies are caused by NO_2 itself

- How to take the uncertainty into account quantitatively when predicting the benefits that would be expected from interventions (eg in cost-benefit assessments)

- Some Members doubtful that the evidence is sufficient to allow a robust recommendation for quantification
- The majority thought it important to attempt to estimate the possible mortality benefit from reducing NO_2 concentrations

COMEAP – HIA Recommendations

HIA of reductions in all traffic-related pollutants:

- Use summary unadjusted NO_2 coefficient:
  - ➢ 1.023 (95% CI 1.008, 1.037) per 10 μg/m^3
- (Alternatively, could assess based on $PM_{2.5}$ reductions)

HIA of interventions which target NO_x emissions

- Use 25 – 55% of summary unadjusted coefficient
  - ➢ 1.006 – 1.013 per 10 μg/m^3 – "central range"

Informal expert judgement approach equivalent to:

- ○ Reduction of approx 20% on adjustment for PM
- ○ 30 - 70% of adjusted coefficient may be causal

Advised: assessment on the basis of reductions of both NO_2 and PM (unadjusted) is likely to result in an overestimate

Implementation in CBA

In practice:
Modelling combines predicted changes in pollutant concentrations arising from a range of proposed interventions

- CBA guidance includes mortality benefits associated with reductions in both
  - NO_2 (reduced coefficient)
  - $PM_{2.5}$ (unadjusted)

- Analysts should
  - Acknowledge this limitation
  - Undertake sensitivity analyses

COMEAP: Research recommendations

- Studies to reduce uncertainties in understanding the effects of long-term exposure to NO_2 on health
  - Toxicological, epidemiological, exposure errors
- Studies to improve quantification of effects associated with air pollution mixtures
  - Develop multi-pollutant and statistical methods
- Investigation of reasons for between-study variability in reported associations

Summary and discussion points

Science-policy interface:

- NO_2 has been less-studied than $PM_{2.5}$
- But evidence for independent effects of NO_2 grows
- Nonetheless, there is more certainty about the health benefits of interventions that reduce both $PM_{2.5}$ and NO_2 (and other co-pollutants)
- Communicating uncertainty is important
  - to allow informed policy decisions to be taken
- New studies and method developments will continue to inform scientific thinking and policy development

Acknowledgements

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Thank you !