

Joint Meeting of the Extended Bureau of EMEP Steering Body and the Extended Bureau of the WGE



Updates on Ozone and Health

16 September 2020, virtual meeting

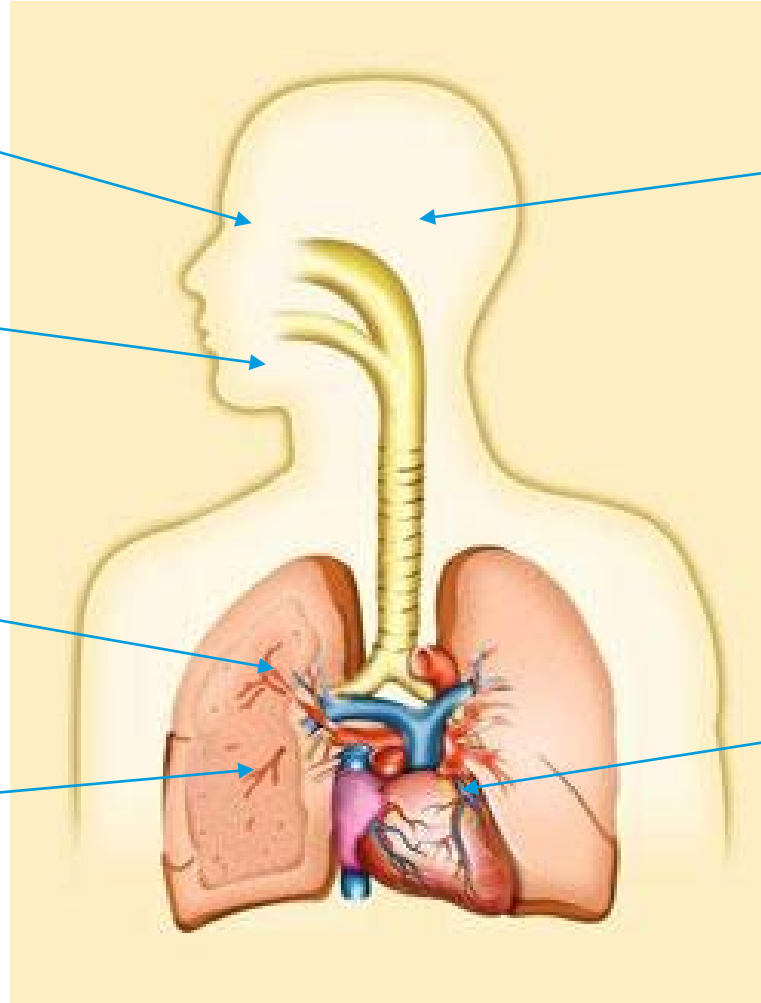
Multiple effects of exposure to ozone

Burning eyes & throat;
mucous irritation

Shortness of breath,
wheezing, coughing

Pulmonary inflammation

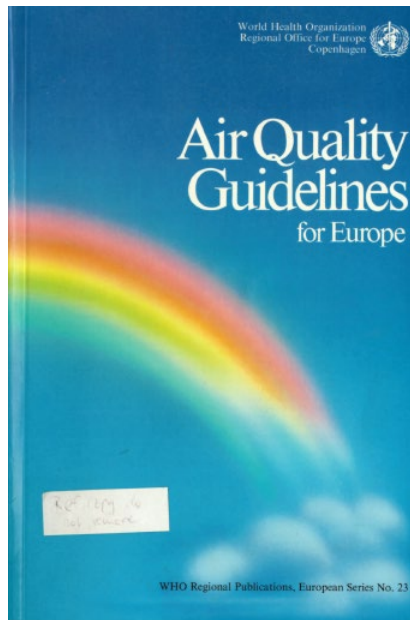
Asthma attacks, chest pain,
increased risk of respiratory
diseases



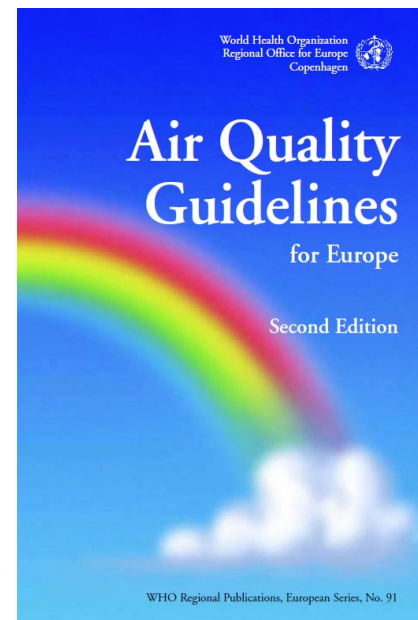
Headache

Increased risk of
heart attacks

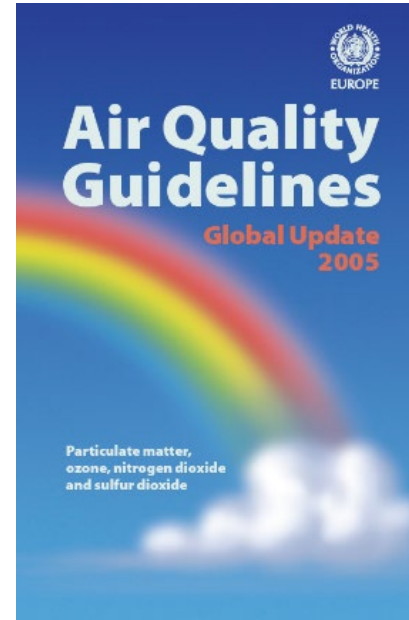
Ozone in WHO air quality guidelines (WHO AQGs)



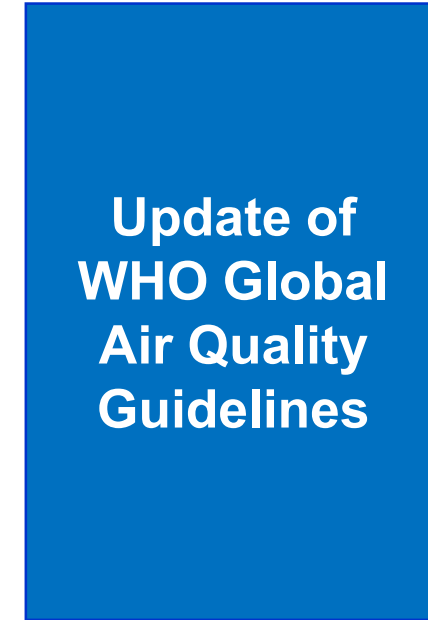
1987



2000



2006



Ongoing update

since 2016 ...

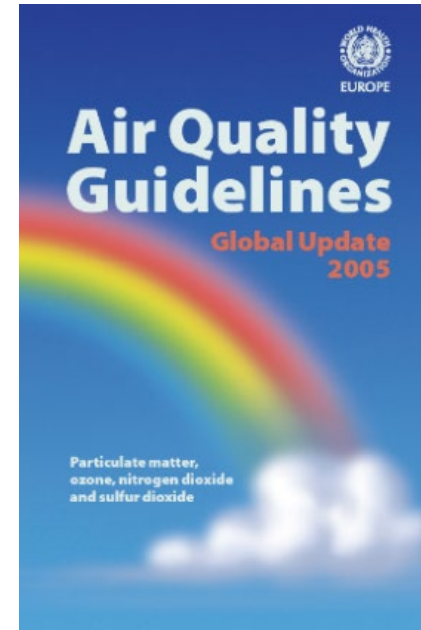
Acute and chronic effects of ozone

Acute responses

- pulmonary system effects
- cardiovascular system effects
- time series morbidity and mortality effects

Chronic effects

- reduced lung function
- development of asthma
- development of atherosclerosis
- reduction in life expectancy



REVIHAAP/HRAPIE – new evidence on ozone

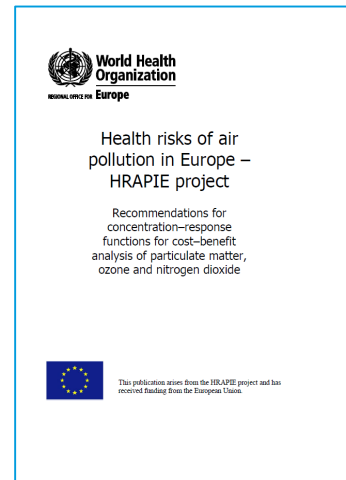
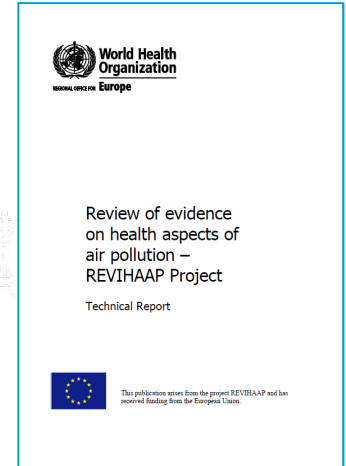
Reinforced evidence on short-term exposure and all-cause, cardiovascular and respiratory mortality, respiratory and cardiovascular hospital admissions (adjusted for co-pollutants)

Evidence for effects of long-term exposure to ozone on respiratory and cardiorespiratory (less conclusive) mortality (based on large cohort studies)

In new follow-up long-term exposure studies evidence on asthma incidence and severity, hospital care for asthma, and lung function growth

New experimental evidence of chronic injury and long-term structural changes in the airways due to prolonged exposure to O₃, and to O₃ and allergens combined

New epidemiological and experimental data suggestive of an effect of O₃ on cognitive development and reproductive health, including preterm birth



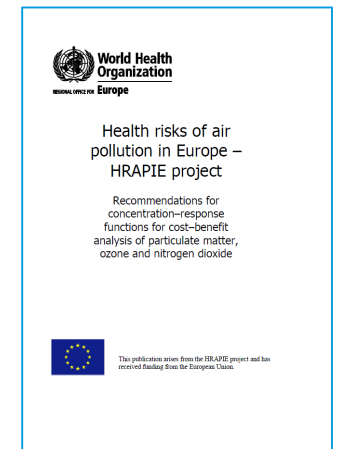
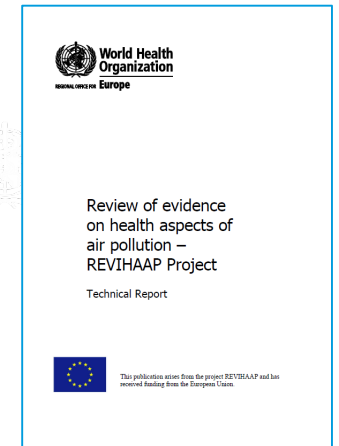
REVIHAAP /HRAPIE - ozone metrics, health outcomes and CRFs suitable for HIA

Adverse health outcomes with known baseline rates, such as mortality and hospital admissions, most suited for health impact assessments (HIA)

For short-term exposure, HIA calculations feasible for all-age, all-cause, cardiovascular and respiratory mortality, and for the age group 65 +, for respiratory and cardiovascular hospital admissions

HIA calculations for short-term exposures to assume linear CRF for the outcomes considered, with the recommended cut-off points

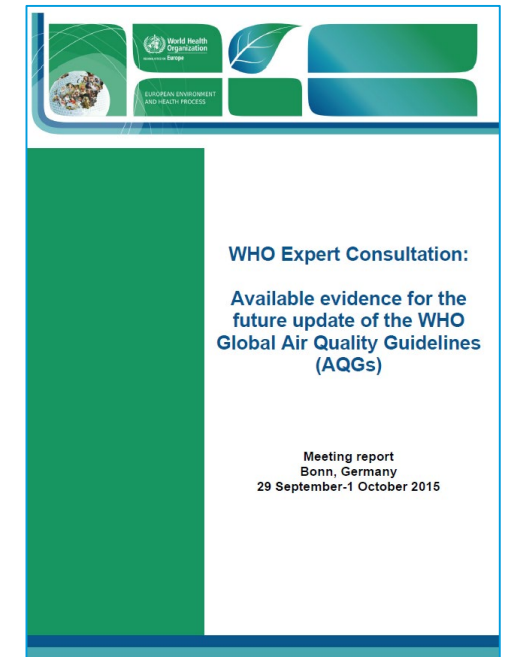
Due to uncertainties about the effects of long-term exposure, a sensitivity scenario recommended for HIA for respiratory and cardiopulmonary mortality



Expert consultation on the evidence for the update of the WHO Global AQG

General agreement with the REVIHAAP conclusions on a need to revisit the current guidelines for PM, O₃, NO₂, and SO₂

The evidence base for the association between short- and long-term exposure to these pollutants and health effects has become much larger and broader since 2006



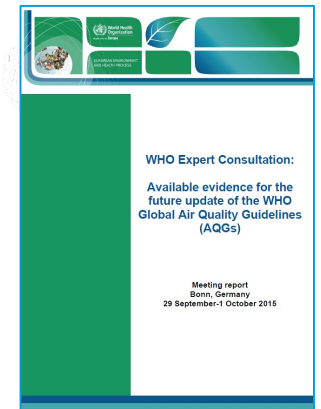
Expert consultation – short-term effects of O₃

New mixed evidence of effects at levels below 100 µg/m³ for an average 8-h mean exposure

Consideration of additional short-term averaging times

Consideration of multipollutant models

The use of the SOMO35 indicator in the context of management issues rather than in the development of the guidelines



Expert consultation – long-term effects of O₃

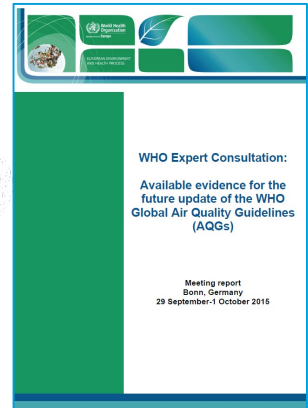
Consideration of the new evidence on health effects of long-term exposure in the revision of the guidelines

Consideration of US EPA ISA for O₃ and Related Photochemical Oxidants (2013):

- *likely to be a causal relationship between long-term exposure and respiratory effects*
- *the evidence suggestive of a causal relationship for long-term exposure and cardiovascular effects, reproductive and developmental effects, cancer, and total mortality*

Strong support to review the evidence to consider the development of AQG level for long-term exposure

- *potential major policy implications, including the need to address global emissions of ozone precursors, and impacts on other areas, such as CC mitigation*
- *need to address confounding due to multipollutant exposure, consideration of seasonality, and effects due to repeated peaks of exposure versus chronic exposure*



Update of the WHO Global AQGs: systematic reviews



Short-term exposure to O₃, NO₂ and SO₂ and asthma

Long-term exposure to O₃ and NO₂ and all-cause and cause-specific mortality

Short-term exposure to PM, NO₂ and O₃ and all-cause and cause-specific mortality

Short-term exposure to SO₂ and all-cause and cause-specific mortality

Short-term exposure to CO and ischaemic heart disease

Long-term exposure to PM and all-cause and cause-specific mortality

Update of the WHO Global Air Quality Guidelines: Systematic Reviews

Edited by Paul Whaley, Mark Nieuwenhuijsen, Jake Burns
Last update 3 August 2020

The World Health Organization is in the process of updating its Global Air Quality Guidelines. To this end, a series of systematic reviews investigating associations between a range of air pollutants and human health outcomes are being conducted. This Special Issue aggregates these systematic reviews and other supporting evidence, presents the context of the work, and summarises important methodological information about the approaches taken.

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Short-term exposure to particulate matter (PM₁₀ and PM_{2.5}), nitrogen dioxide (NO₂), and ozone (O₃) and all-cause and cause-specific mortality: Systematic review and meta-analysis
Pablo Orellano, Julieta Reynoso, Nancy Quaranta, Ariel Bardach, Agustín Ciapponi
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Systematic reviews AQGs – short-term effects (I)

Health outcomes: all-cause mortality

67 eligible papers, most studies from Europe, North America and Asia

24-h average: pooled effect size 1.0043 (1.0034 -1.0052) per $10\mu\text{g}/\text{m}^3$

CRF: some evidence of non-linearity in half of the papers

Multipollutant models: associations attenuated upon adjustment

for co-pollutants, but analysed in few studies

Certainty in the evidence: judged as high for all-cause mortality



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Review article

Short-term exposure to particulate matter (PM₁₀ and PM_{2.5}), nitrogen dioxide (NO₂), and ozone (O₃) and all-cause and cause-specific mortality: Systematic review and meta-analysis

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ABSTRACT

Background: Air pollution is a leading cause of mortality and morbidity worldwide. Short-term exposure (from one hour to days) to selected air pollutants has been associated with human mortality. This systematic review was conducted to analyse the evidence on the effects of short-term exposure to particulate matter with aerodynamic diameters less or equal than 10 and 2.5 µm (PM₁₀, PM_{2.5}), nitrogen dioxide (NO₂), and ozone (O₃), on all cause mortality, and PM₁₀ and PM_{2.5} on cardiovascular, respiratory, and cerebrovascular mortality.

Methods: We included studies on human populations exposed to outdoor air pollution from any source, including occupational exposures. Relative risks (RRs) per 10 µg/m³ increase in air pollutant concentrations were used as the effect estimates. Heterogeneity between studies was assessed using 95% prediction intervals. Risk of bias (RoB) in individual studies was analysed using a new domain-based assessment tool, developed by a working group convened by the World Health Organization and designed specifically to evaluate RoB within eligible air pollution studies included in systematic reviews. We conducted subgroup and sensitivity analyses by age, sex, continent, study design, single or multiple studies, time lag, and RoB. The certainty of evidence was assessed for each exposure-outcome combination. The protocol for this review was registered with PROSPERO (CRD42019067749).

Results: We included 196 articles in quantitative analysis. All combinations of pollutant and all cause and cause-specific mortality were positively associated in the main analysis, and in a wide range of sensitivity analyses. The only exception was NO₂, but when considering a 1-hour maximum exposure. We found positive associations between pollutants and all-cause mortality for PM₁₀ (RR: 1.0043; 95% CI: 1.0038–1.0049), PM_{2.5} (RR: 1.0045; 95% CI: 1.0044–1.0046), NO₂ (24-hour average) (RR: 1.0072; 95% CI: 1.0058–1.0088), and O₃ (RR: 1.0012; 95% CI: 1.0011–1.0013). PM₁₀ and PM_{2.5} were also positively associated with cardiovascular, respiratory, and cerebrovascular mortality. We found some degree of heterogeneity between studies in three exposure-outcome combinations, and this heterogeneity could not be explained after subgroup analysis. Both was low or moderate in the majority of articles. The certainty of evidence was judged as high in 10 out of 11 combinations, and moderate in one combination.

Conclusions: This study found evidence of a positive association between short-term exposure to PM₁₀, PM_{2.5}, NO₂, and O₃ and all-cause mortality, and between PM₁₀ and PM_{2.5} and cardiovascular, respiratory and cerebrovascular mortality. These results were robust through several sensitivity analyses. In general, the level of evidence was high, meaning that we can be confident in the associations found in this study.

1. Introduction

A high proportion of ambient air pollution is generated from combustion processes (Goldberg et al., 2003). Particularly for the most studied and widespread air pollutants, i.e. particles with aerodynamic diameters under 10 and 2.5 µm (PM₁₀ and PM_{2.5}), ozone (O₃), sulphur

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0160-6120/© 2020 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Systematic reviews AQGs – short-term effects (II)

Health outcomes: emergency room visits / hospital admissions due to asthma

Eligible: 50 studies, mostly from Europe, North America and Asia **(forthcoming)**

Max 8-h daily or average 24-h concentration: pooled effect size 1.008 (1.005–1.011) per 10 $\mu\text{g}/\text{m}^3$

Max 1-h daily concentration: pooled effect size 1.017 (0.973–1.063) per 10 $\mu\text{g}/\text{m}^3$

CRF: some evidence of non-linearity (8-h or 24-h)

Certainty in the evidence:

- judged as high for O_3 (8-h or 24-h)
- not analysed for O_3 (1-h), because the associations were non-significant

Systematic reviews AQGs – long-term effects

Health outcomes: all-cause mortality, respiratory mortality, COPD mortality, ALRI mortality

Eligible: 20 articles, majority from North America and Europe **(forthcoming)**

Annual metrics: associations with all-cause and respiratory mortality 0.97 (0.93, 1.02) and 0.99 (0.89, 1.11) per $10\mu\text{g}/\text{m}^3$, respectively

Peak metrics: associations with all-cause and respiratory mortality 1.01 (1.00, 1.02) and 1.02 (0.99, 1.05) per $10\mu\text{g}/\text{m}^3$, respectively

CRF: limited evidence to reject the assumption of linearity

Multipollutant models: associations attenuated upon adjustment for co-pollutants in some studies

Certainty in the evidence: judged as moderate for O_3 peak exposure and all-cause mortality, and low for other exposure-outcome pairs assessed

Pollutant	Effects on health	Assessment
Particulate Matter (<2.5µm)	Death	causal
	Cardiovascular diseases	causal
	Lung cancer	causal
	Respiratory diseases	probably causal
Ozone	Short-term effects on respiratory diseases	causal
	Short-term effects on cardiovascular diseases	probably causal
	Respiratory diseases	probably causal
Nitrogen dioxide	Short-term effects on respiratory diseases	causal
	Respiratory diseases	probably causal

US EPA ISA for O₃ and Related Photochemical Oxidants (2013)



The US EPA ISA for Ozone and Related Photochemical Oxidants (2020)

Main conclusions presented at 23rd meeting of the TFH

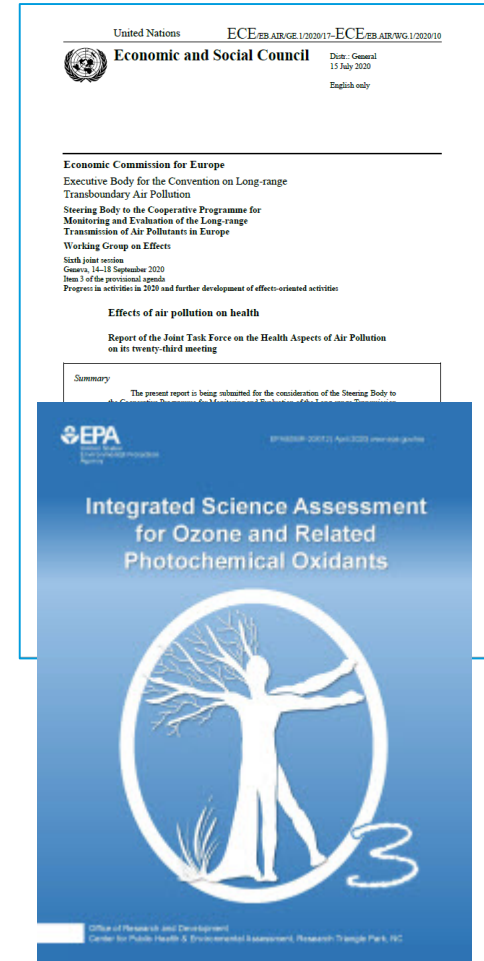
For short-term exposure and respiratory effects the evidence continues to suggest a *'causal'* relationship (as in 2013)

For short-term exposure and metabolic effects emerging evidence suggests a *'likely to be causal'* relationship

For short-term exposure and cardiovascular effects and mortality, revision of causality assessment from *'likely to be causal'* to *'suggestive of, but not sufficient to infer, a causal relationship'*

For long-term exposure, metabolic and reproductive effects, the evidence *'suggestive of, but not sufficient to infer, a causal relationship'*

Continued support to a linear CRF, with less certainty at lower concentrations below 30–40 ppb



Causality Determinations for Health Effects of Ozone



US EPA ISA for Ozone and Related Photochemical Oxidants (2020)



			2020 Ozone ISA
Health Outcome	Respiratory	Short-term exposure	
		Long-term exposure	
	Metabolic	Short-term exposure	+
		Long-term exposure	+
	Cardiovascular	Short-term exposure	↓
		Long-term exposure	
	Nervous System	Short-term exposure	
		Long-term exposure	
	Reproductive	Male/Female Reproduction and Fertility	*
		Pregnancy and Birth Outcomes	
	Cancer	Long-term exposure	
	Mortality	Short-term exposure	↓
		Long-term exposure	

Causal
Likely causal
Suggestive
Inadequate

+ new causality determination; ↓ causality determination changed from likely causal to suggestive; * change in scope of health outcome category from 2013 Ozone ISA

<https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=348522>

Final comments

- The relationship between short-term exposure to ozone and increased respiratory-related mortality and increases in respiratory-related emergency room visits and hospital admissions considered causal
- The relationship between short-term ozone exposure and the increase in cardiovascular mortality with less evidence on causality of the association
- Long-term exposure to ozone correlated with increased all-cause and respiratory-related mortality, with less evidence on causality of the association; moderate certainty in the evidence for peak exposure and all cause mortality
- The evidence on the association between short- and long-term exposure to ozone and health effects has been growing, but methodological challenges remain due to complex relationships between ozone and other pollutants

Thank you



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