Task Force on Hemispheric Transport of Air Pollution

HTAP 2010 Chapter 5: Impacts Focus on Health

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http://www.htap.org

Evidence for effects of O_3 and PM on health

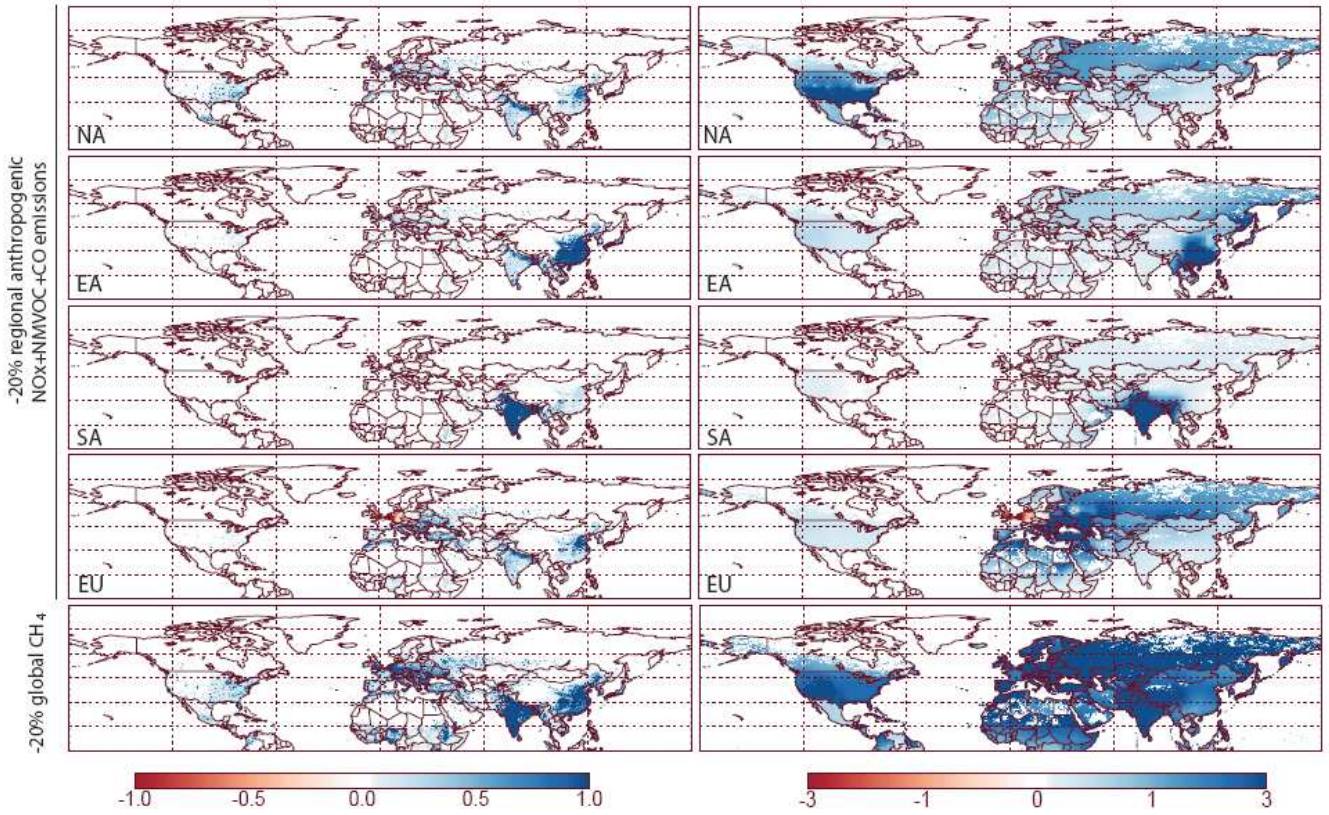
- **Key finding:** There is broad consensus that exposure to ambient PM and O_3 causes adverse health effects ranging from minor sensory irritation to death.
- **Key finding:** Short-term and long-term exposure to PM are associated with increased mortality and morbidity.
- **Key finding:** Short-term exposure to O_3 is associated with increased daily mortality and morbidity. Unlike PM, the evidence linking O_3 with long-term mortality is limited.
- Current evidence suggests that PM is most important air pollutant for health:
  - Previously, urban $PM_{2.5}$ estimated to cause 800,000 annual deaths worldwide (WHO 2004)
  - New analysis suggests the total burden of $PM_{2.5}$ and O_3 could be much larger – 3.7 million for $PM_{2.5}$ and 700,000 for ozone (Anenberg et al. 2010)
  - Global Burden of Disease Study 2010 ongoing

Health impacts of ozone long-range transport

Key finding: Emissions from one continent affect human health on other continents, by affecting O_3 and PM concentrations through long-range transport.

Analysis of O_3 LRT impacts on mortality:

- HTAP SR6: -20% regional NO_x, NMVOC, CO
- HTAP SR2: -20% global CH_4
- Bell et al. (2004) short-term O_3-mortality relationship



Anenberg et al. (2009)

Health impacts of ozone long-range transport

Key finding: One study based on the HTAP multi-model comparison estimated that O_3 resulting from emissions from foreign regions contributes 20% to >50% of O_3 mortalities, subject to large uncertainty.

Hundreds of annual avoided mortalities, threshold=35ppb in *italics*

Source Region	Receptor Region				
	NA	**EA**	**SA**	**EU**	**NH**
NA	9 (4 - 13) *9 (4 - 14)*	7 (3 - 10) *4 (2 - 6)*	6 (3 - 9) *5 (3 - 8)*	11 (5 - 17) *6 (3 - 9)*	36 (18 - 55) *27 (13 - 41)*
EA	2 (1 - 3) *1 (1 - 2)*	43 (21 - 66) *40 (19 - 61)*	6 (3 - 9) *5 (2 - 8)*	5 (3 - 8) *3 (1 - 4)*	59 (29 - 91) *49 (24 - 76)*
SA	1 (0 - 1) *0 (0 - 1)*	4 (2 - 6) *3 (1 - 4)*	76 (37 - 117) *66 (32 - 101)*	2 (1 - 3) *1 (0 - 2)*	85 (41 - 130) *71 (34 - 108)*
EU	2 (1 - 3) *1 (0 - 1)*	8 (4 - 12) *6 (3 - 8)*	6 (3 - 10) *6 (3 - 9)*	17 (8 - 26) *25 (12 - 38)*	38 (18 - 58) *40 (19 - 61)*

Relative Intercontinental Response: ↑ 30% ↑ 30% ↑ 20% ↑ >50%

Anenberg et al. (2009)

Health impacts of ozone long-range transport

Key finding: Three studies estimate that reductions in O_3 precursor emissions may avoid more premature mortalities outside of some source regions than within, mainly because of larger populations outside of the source regions.

Hundreds of annual avoided mortalities, threshold=35ppb in *italics*

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Impact on foreign receptor regions:

← 75%

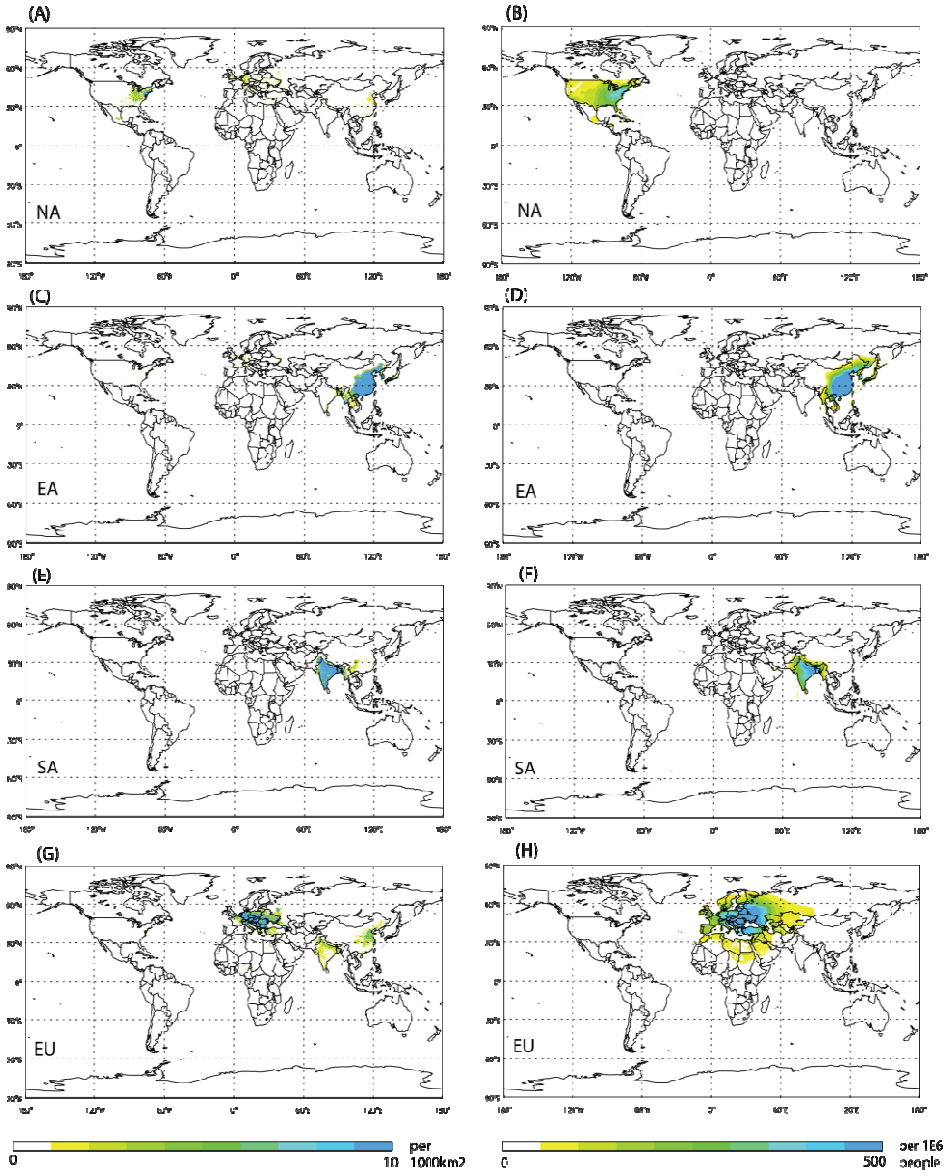
← 30%

← 10%

← 55%

Anenberg et al. (2009)

Health impacts of PM long-range transport



Mortalities per 1000 km^2 Mortalities per million people

- PM has a shorter atmospheric lifetime and may not travel as far as O_3
- PM has a stronger relationship with mortality than does O_3
- New health analysis of HTAP SR6 experiments:
  - -20% regional emission of primary PM (BC, OC) and PM precursors (SO_2, NO_x, NH_3)
  - Krewski et al. (2009) long-term $PM_{2.5}$-mortality relationship

Health impacts of PM long-range transport

Key Finding: Contributions to PM from emissions within a region are much more important for health than emissions from foreign continents.

Key Finding: Intercontinental transport of PM can cause more mortalities than intercontinental transport of O_3, due to the stronger PM-mortality relationship.

Hundreds of annual avoided mortalities, threshold=5.8 μg/m^3 in *italics*

Source Region	Receptor Region				
	NA	EA	SA	EU	World
NA	502 *125*	20 *19*	9 *8*	49 *38*	590 *190*
EA	10 *5*	4348 *3330*	25 *23*	18 *14*	4433 *3376*
SA	2 *1*	42 *39*	2105 *1099*	5 *3*	2168 *1142*
EU	8 *4*	82 *78*	70 *57*	1769 *573*	2010 *71600*

Relative Intercontinental Response: 3.7% 3.2% 4.7% 3.9%

$PM_{2.5}$ = BC+POM+SO_4

Health impacts of PM long-range transport

Emissions from North America and Europe have much greater impacts on foreign regions than do emissions from East Asia and South Asia

Hundreds of annual avoided mortalities, threshold=5.8 μg/m^3 in *italics*

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EU	8 *4*	82 *78*	70 *57*	1769 *573*	2010 *71600*

Impact on foreign receptor regions:

← 14.9%

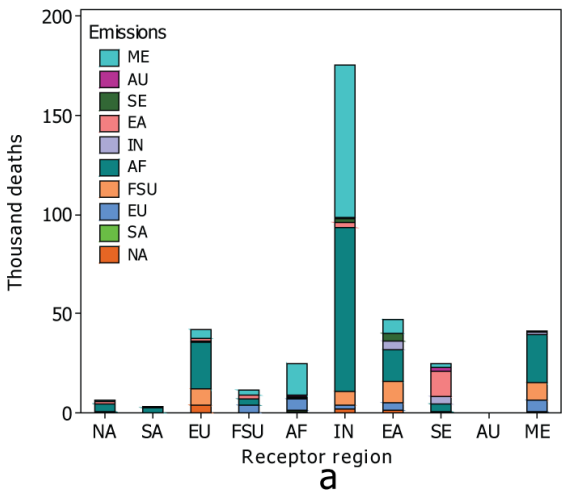
← 1.9%

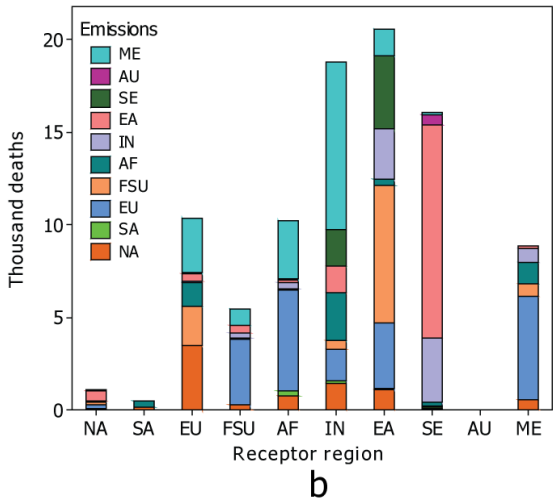
← 2.9%

← 12.0%

$PM_{2.5}$ = BC+POM+SO_4

Health impacts of PM long-range transport





Liu et al. (2009)

Another study that included all global emissions found many more mortalities due to long-range transport, mostly attributable to dust; those attributed to anthropogenic PM are estimated to be ~25% of the total.

All $PM_{2.5}$:

Annual premature deaths due to LRT = 380,000

~ 290,000 due to dust

>50% in India due to transport from Africa and Middle East

Non-dust $PM_{2.5}$:

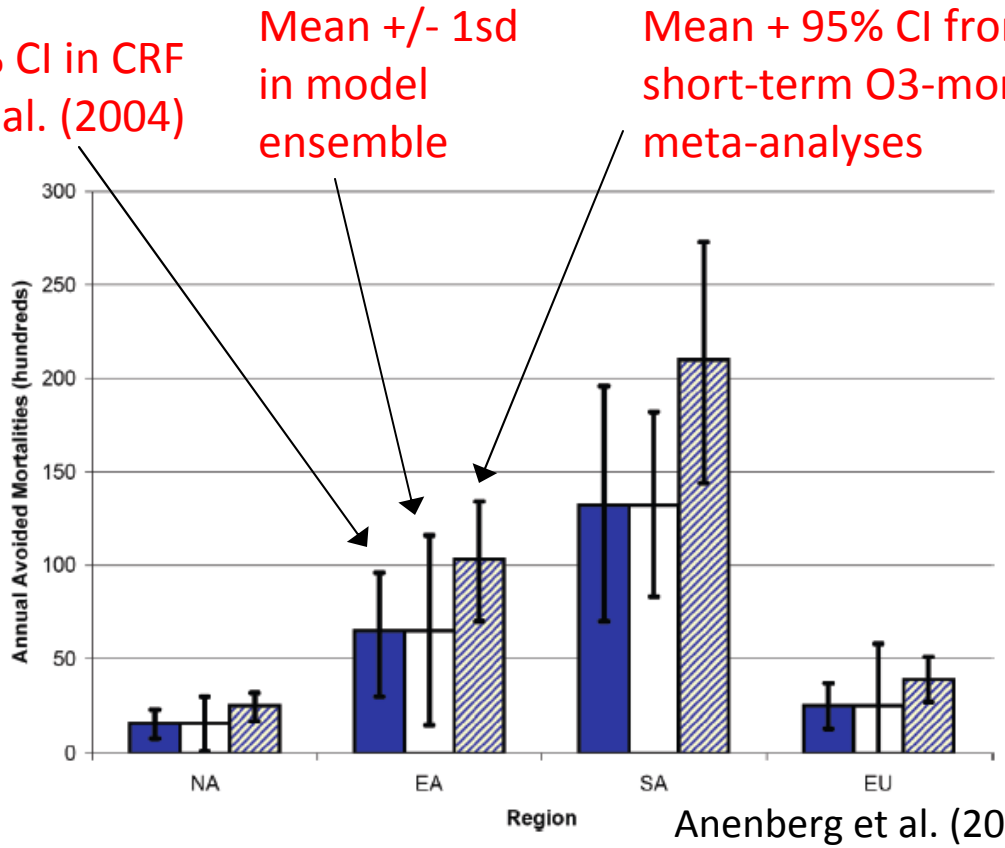
Annual premature deaths due to LRT = 90,000

>50% from Europe, Middle East, and East Asia

~60% occur in East Asia, India, and Southeast Asia

Uncertainties and Research Needs

Large range among models of simulated O_3 responses to within-region emissions changes :



Anenberg et al. (2009)

- Concentration-response relationships in less industrialized nations and over a range of concentrations
- Resolution of global atmospheric models and improving nested models
- Differential toxicity of PM components, sizes, and age