The changing climate and its effect on mortality

do temperature and air pollution concentrations interact causing excess mortality?

Yuri Bruinen de Bruin - PhD
European Commission - Joint Research Centre
Institute for Health and Consumer Protection
Physical and Chemical Exposure Unit
yuri.bruinen-de-bruin@jrc.it

Investigated associations

3. Do ambient temperature and air pollution have a synergistic effect on mortality?

1. Are air pollution and mortality associated?

2. Are ambient temperature and mortality associated?

Common air pollutants and sources

Table 1. Categorized sources of outdoor air pollutants

Sources of outdoor pollutants	PM10	BS	SO_4^{2-}	NO_3^-	O_3	SO_2	NO_2	CO
	 							
								

 Long range transport

 Traffic

Other combustion

 Soil re-suspension

Part 1. Are air pollution and mortality associated?

Air pollution and mortality associations

Table 2. References of studies that found associations between air pollution and mortality

References	PM	BS	SO_4^{2-}	NO_3^-	O_3	SO_2	NO_2	CO	Country
Anderson H.R. et al., 1996, 1997									6 EU cities
Ballester F. et al., 1996									Spain
Hoek G. et al., 2000									Netherlands
Katsouyanni K. et al., 1997, 2000									Greece/US
Michelozzi P. et al., 1998									Italy
Samet J.M. et al., 1999									US
Schwartz J. 1994, 1996									US
Spix C. et al., 1998									6 EU cities
Touloumi G. et al., 1997									Greece
Vigotti M.A. et al., 1995									Italy

Some air pollution-mortality associations found in Europe-1

- APHEA study (Air Pollution and Health: A European Approach).
  - Goal: to study the short-term effect of ambient particles on mortality
  - 29 European cities

The estimated increase in the daily number of deaths for all ages for a 10 ug/m^3 increase in daily PM_{10} or Black Smoke concentrations was 0.6%. For the elderly it was slightly higher (Katsouyanni K. et al., 2001).

The increase was highest in cities with high concentrations of NO2 (0.80%) and a warm climate (0.82%).

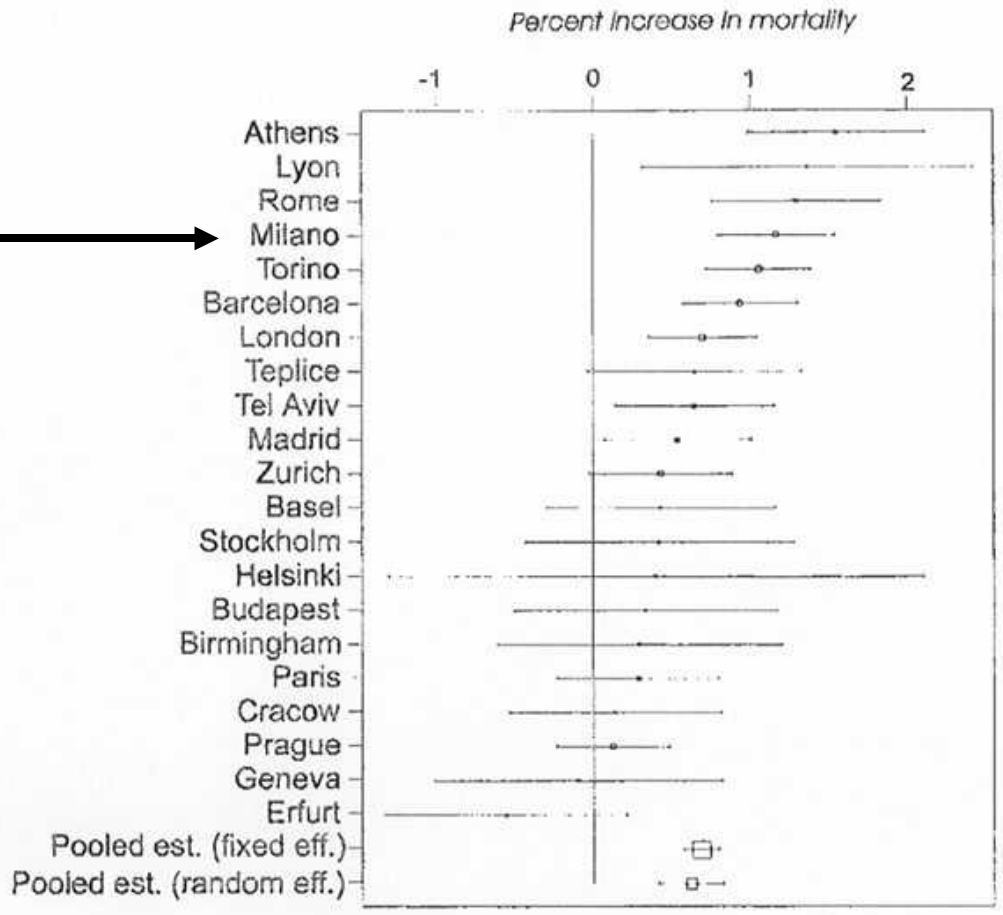


FIGURE 1. Percentage increase in the total daily number of deaths (excluding deaths from external causes) and their 95% confidence intervals associated with an increase of 10 $\mu g/m^3$ in the levels of particulate matter less than 10 μm in aerodynamic diameter in each city. The size of the point representing each increase is inversely proportional to its variance.

Some air pollution-mortality associations found in Europe-2

(WHO, Air Quality Guidelines for Europe, 2000).

Table 3. Estimated number of deaths (in a population of 1 million) over a period of 3 days characterized by a mean PM_{10} concentration of 50 or 100 ug/m3

Health effect indicator	No. of people affected by a three-day episode of PM10 at:	
	50 ug/m^3	100 ug/m^3
No. of deaths	4	8

Some air pollution-mortality associations found in Europe-3

- Hoek G. et al., 2000
  - The Netherlands
  - Population study

Pollutan	Lag	Season	RR
PM10	0-6	Winter	1.022
		Summer	**1.090**
BS	0-6	Winter	1.025
		Summer	**1.111**
SO_4^{2-}	1	Winter	1.027
		Summer	**1.057**
NO_3^-	1	Winter	1.054
		Summer	**1.072**
O_3	1	Winter	0.988
		Summer	**1.074**
SO_2	0-6	Winter	1.033
		Summer	**1.068**
NO_2	0-6	Winter	1.025
		Summer	**1.042**
CO	0-6	Winter	1.038
		Summer	**1.199**

Note: Lag 1 is previous day concentration; lag 0-6 is weekly average concentration (average of lag 0-6

Some air pollution-mortality associations found in Europe-4

Table 4. Estimated number of O_3 and PM_{10} related deaths in the summers of 2000, 2002 and 2003 (heatwave) in the Netherlands (population around 16 million) (Fisher et al., 2003)

Period	Estimated number of deaths related to O3	Estimated number of deaths related to PM10
June-August 2000	990	1290
June-August 2002	1140	1380
June-August 2003	1400	1460
Excess 2003 vs. 2000	410	160
Excess 2003 vs. 2002	250	80

Part 2. Are ambient temperature and mortality associated?

Some of the strongest temperature-mortality associations-1

(Katsouyanni et al., 1993)

- Athens, Greece
  - Goal: Do air pollution and air temperature have synergistic effects
  - Greek air pollution and temperature data
    - 1987 heat wave
    - 6 previous years

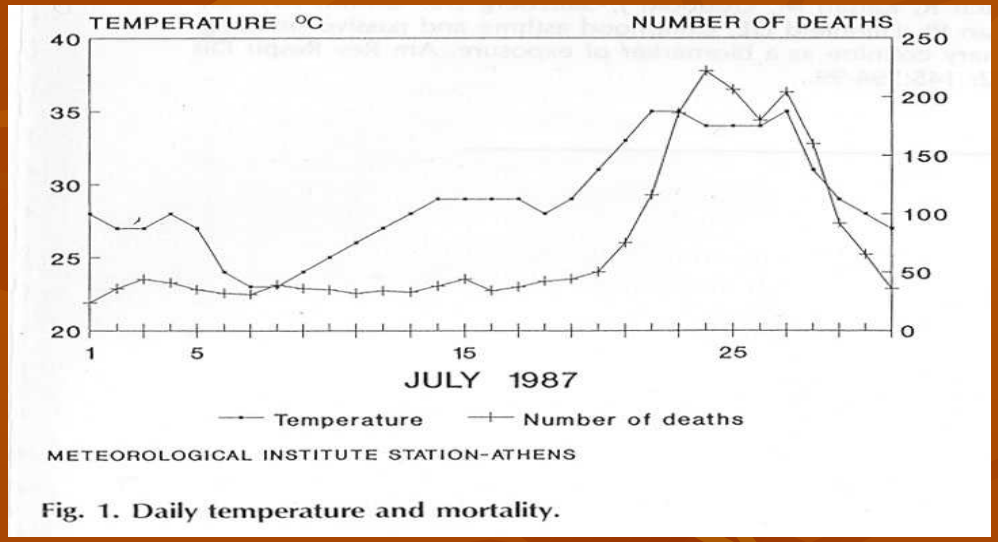


Fig. 1. Daily temperature and mortality.

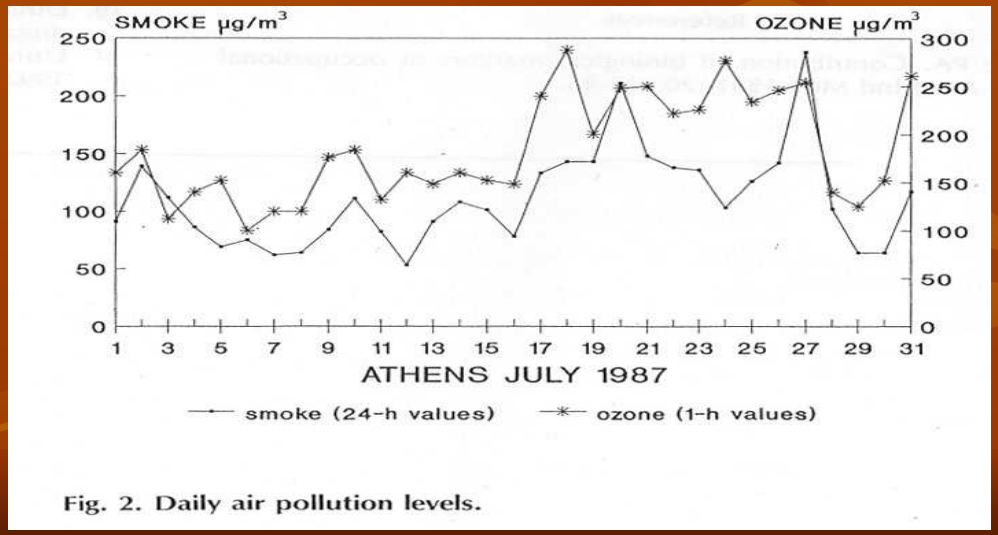


Fig. 2. Daily air pollution levels.

Some of the strongest temperature-mortality associations-2

Table 5. Mean daily Number of Deaths During Days with Different Levels of 24-h Temperature (Katsouyanni et al., 1993).

Temperature	No. days	No. deaths	
		Avg.	STD
<25	445	35.6	6.7
<=25 and <30	348	36.0	9.1
>=30	26	85.7	63.8

Some of the strongest temperature-mortality associations-3

Table 6. Mean daily Number of Deaths During Days with Different Levels of 24-h Temperature and Air Pollution Indices (Katsouyanni et al., 1993).

Air pollution index	Temperature								
	<25			<=25-<30			>=30		
	No. days	**No. deaths**		No. days	**No. deaths**		No. days	**No. deaths**	
		Avg	SD		**Avg**	SD		**Avg**	SD
Smoke < 125 ug/m^3	256	**35.3**	6.7	209	**36.1**	9.8	8	**80.3**	70.7
Smoke >= 125 ug/m^3	166	**36.1**	6.3	109	**36.1**	8.7	17	**90.0**	63.3
SO2 <80 ug/m^3	415	**35.5**	6.7	329	**35.9**	9.3	24	**82.4**	61.2
SO2 >= 80 ug/m^3	25	**38.6**	5.9	12	**38.5**	7.3	2	**126.0**	110.3
O3 <150 ug/m^3	19	**31.8**	7.4	27	**38.6**	14.7	2	**100.0**	84.9
O3 >= 150 ug/m^3	10	**33.4**	6.5	45	**36.1**	7.9	10	**131.0**	76.6

Some of the strongest temperature-mortality associations-4

Findings:

Daily number of deaths increased by more than 40 when the mean 24-h air temperature exceeded 30 degrees Celsius.

The interaction between high levels of air pollution and high temperature (>=30 degrees C) are statistically significant (P<.05) for SO2 and are suggestive (P<.20) for O_3 and smoke.

However,
To prove the cause of mortality in relation to temperature and air pollution is difficult, because a high proportion of deaths during days with extremely high temperatures is attributed to 'heatstroke'.

The fact that high temperature days are mostly also days with relatively high air pollution levels (especially photochemical), questions the conditional variability of both temperature and air pollution.

Part 3. Do ambient temperature and air pollution have a synergistic effect on mortality?

Air pollution- temperature associations

- Change of temperature might cause
  - Dryer conditions

    → more re-suspension of dust/particles

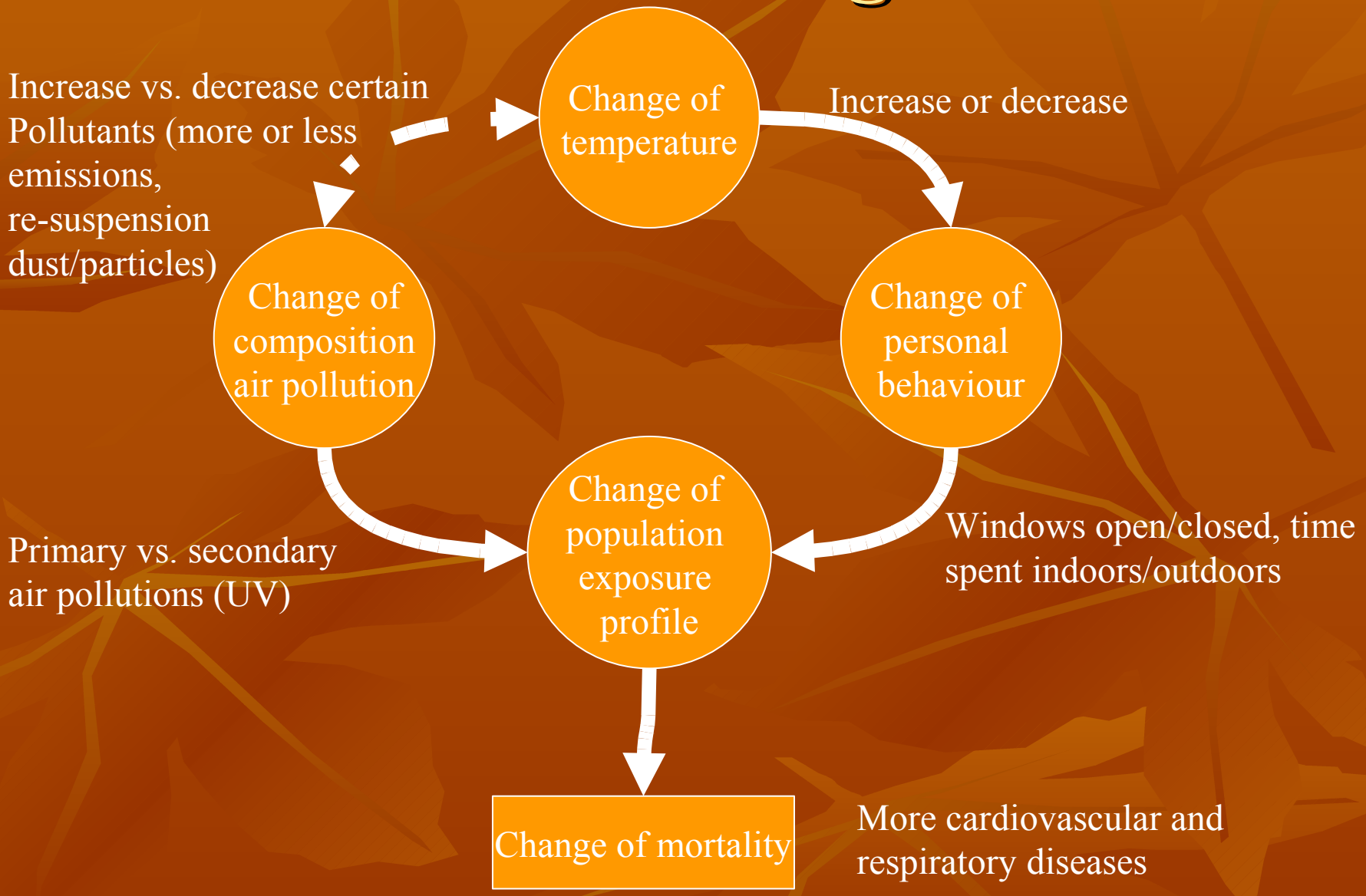
    → more biogenic emissions

  - Speed of atmospheric chemical reactions

    → formation of secondary particles

    → ozone

Relational diagram



Conclusions

1. There is a proven association between
   - air pollution and mortality
   - temperature and mortality
2. The synergistic effects of air pollution and ambient temperature on excess mortality remain suggestive.

Climate change…

….affects the daily temperature and consequently some human behaviour characteristics (open/closed windows, time spent outdoors) changing the personal exposure to air pollution.

….is expected to rise the mean global temperature affecting the state of health of the world's population.

Because of its important public health implication this topic deserves more attention.

Research option

- Gather more insight to impact on public health during urban traffic blocks.

Acknowledgements

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