Is there a threshold for associations between ozone concentrations and health outcomes?? A review.

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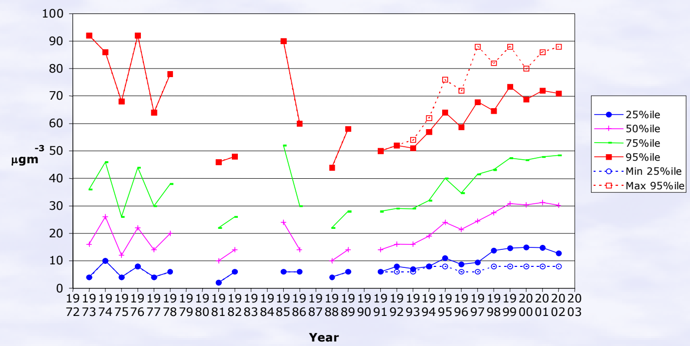
Introduction

Background mean concentrations of ozone are rising in urban areas of the UK (Figure 1), although peaks are declining. This trend is predicted to continue as a result of global warming and reductions in nitric oxide emissions from vehicles. To what degree is this a matter for public health concern? If levels are increasing but are always below a threshold for health effects, then no health impact would be expected. Is there sufficient evidence for a threshold to depart from a precautionary assumption of linearity? Thresholds could be indicated by a lack of an association in seasons or places with low ozone concentrations or on days with low ozone concentrations within individual studies. The literature was assessed for information on this, looking in particular for good contrasts in ozone levels and clear separation of effects from other pollutants.

Figure 1 Running 8-hour mean ozone concentrations in London



Methods

Studies on the St George's Air Pollution Epidemiology Database for 8 hour, 1 hour and 24 hour average ozone were obtained and searched for information on seasonal differences, maximum ozone concentrations and descriptions of the shape of the dose-response relationships. The use of multi-pollutant models when addressing these aspects was also checked. Outcomes covered were all cause, respiratory and cardiovascular mortality and respiratory and cardiovascular admissions, concentrating mainly on all ages associations. Panel studies on lung function and respiratory symptoms were also covered except for seasonal differences as most were summer only.

Results

Season Many studies show greater associations in the summer but only 12 studies gave coefficients by season and specified seasonal ozone concentrations. Several of these divided the year into just two 6 month periods which limited the contrast in ozone concentrations. In the example below (Table 1), there is extensive overlap in the ozone concentrations yet there is still a marked difference in coefficient by season. This might be due to different patterns of confounding by other pollutants in summer and winter. Only 3 studies[1-3] adjusted for other pollutants and only one of these[1] included seasonal maximum ozone levels. This study found no association in winter when levels were below 33 ppb 24 hour average.

Table 1 Seasonal differences in Brisbane, Australia

Season	Mean ozone (8 hour) (range)	Outcome	Estimate % per 5ppb (95% CI)
Summer Oct - Mar	20 ppb (3-63)	All-cause mortality	1.48 (0.49-2.48)
		Respiratory mortality	1.14 (-2.65-5.07)
		Cardiovascular mortality	1.19 (-0.58-2.99)
Winter Apr-Sep	16 ppb (2-57)	All-cause mortality	0.65 (-0.72-2.04)
		Respiratory mortality	0.51 (-2.41-3.51)
		Cardiovascular mortality	0.73 (-1.81-3.33)

Source: Simpson *et al*; 1997 Arch. Env. Health 52:442-454

Geographical differences There are several studies[4-9] which have found positive and statistically significant associations stable to adjustment for other pollutants in places where maximum ozone levels were only 60 to 80 ppb 8 hour average. Positive significant adjusted associations with asthma symptoms have been found in Paris[10] with a maximum ozone level of 40 ppb 8 hour average. Ozone was not associated with respiratory symptoms in non-asthmatics in studies with Northern European ozone levels[11-14] except during vigorous exercise[15]. Plotting of study coefficients against maximum ozone concentration in the study was not pursued. Interpretation is difficult as linear coefficients may be imposed on data with thresholds in the individual studies.

Results (cont.)

Shapes of relationships There were apparent thresholds in 13 studies of mortality or hospital admissions but only 1 of these studies[16] adjusted for other pollutants. 7 studies suggested linear associations of which two[1-2] adjusted for other pollutants. Adjustment for other pollutants is important as it may affect the shape of the relationship. For example in the figure below[17], days to the left are more likely to be winter days and days to the right are more likely to be summer days. Ozone may be correlated with particles negatively in winter and positively in summer. This makes interpretation of the shape difficult. There were also very few panel studies[18-20] that examined the shape of relationships with adjustment for other pollutants.

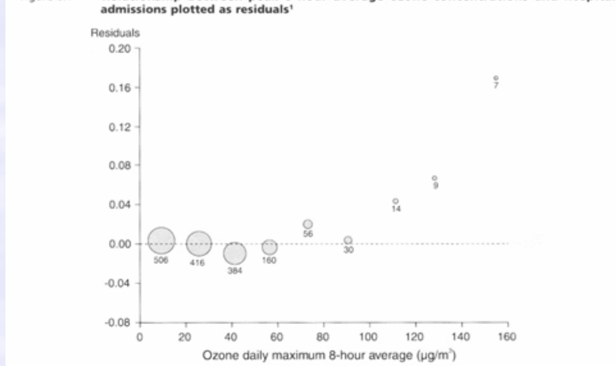


Figure 6.1 Relationship between peak 8 hour average ozone concentrations and hospital admissions plotted as residuals[1]

[1] In this figure the area of the circles is proportional to the data available at the given concentrations. The number of 8 hour periods of given concentration is shown by the figures adjacent to the circles

Messages for policy makers

- Seasonal differences and shapes of relationships may appear to suggest thresholds but may be due to different patterns of confounding by other pollutants.
- Only a small number of studies have adjusted for other pollutants when addressing these aspects and some of these suggest linear relationships.
- Positive significant associations have been found below 40 - 80 ppb 8 hour average
- There is insufficient evidence at present to depart from an assumption of linearity
- Linear associations can be used to estimate the health impact of policies to alleviate the rise in ozone

The opinions expressed represent those of the author and not the Department of Health. References 1. Moolgavkar et al (1995) 2. Hoek et al (1997) 3. Wong et al (1999) 4. Simpson et al (1997) 5. Anderson et al (1996) 6. Wong et al (2002) 7. Bremner et al (1999) 8. Petroeschevsky et al (2001) 9. Ponce de Leon et al (1996) 10. Desqueyroux et al (2002) 11. Hoek et al (1999) 12. Declercq et al (2000) 13. Hoek et al (1995) 14. Ward et al (2002) 15. Brunekreef et al (1994) 16. Fairley et al (2003) 17. COMEAP (1998) 18. Higgins et al (1990) 19. Higgins et al (1995) 20. Schwartz et al (1994) Full references available on request. Further details www.doh.gov.uk/comeap/index.htm under Current Issues. Acknowledgements Tony Bush NETCEN (Fig 1); Professor Ross Anderson's team; COMEAP.