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J. Epidemiol. Community Health 1999;53;580-581

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*Short reports***Does ozone have any effect on daily hospital admissions for circulatory diseases?**

Chit-Ming Wong, Stefan Ma, Anthony Johnson Hedley, Tai-Hing Lam

Ozone is a known toxin to human health. However, studies using daily hospital admission data have shown that it is related to respiratory diseases but not to circulatory diseases, with one exception that showed an effect on ischaemic heart disease.¹

In Hong Kong, concentrations of ozone have increased more than 80% in the past seven years and are high, with the hourly air quality objective of 240 g/m³ being violated more than three times in 1996. We examined the short-term effect of ozone on 87 538 daily hospital admissions (January 1995 to June 1997) attributable to circulatory diseases for the 65 or older age group (population 629 196) in Hong Kong.

Methods

Daily hospital admissions through emergency departments, air pollutant concentrations and weather conditions were obtained from the Hospital Authority, the Government Environmental Protection Department and the Observatory.

Poisson regression with adjustment for overdispersion and auto-correlation (when necessary) was used to model daily hospital admissions, based on International Classification of Diseases version 9, for ischaemic heart disease (410–414), cardiac arrhythmias (427), heart failure (428), cerebrovascular disease (430–438), as well as all causes of circulatory diseases (390–459). The core model included mean daily temperature and relative humidity, day of the week, holidays and day after holidays, and days with number of influenza admissions over 75 percentile, day ($t=1$ to 912), t^2 , year, and seasonality variables

$\sin(2\pi kt/365.25)$ and $\cos(2\pi kt/365.25)$, where k are positive values to be determined by spectral analysis.

Average concentration, cumulated from current day up to the previous five days of ozone and up to three days of nitrogen dioxide, sulphur dioxide and respirable suspended particulates were entered into each core model. The relative risk with the minimum Akaike's Information Criterion (AIC) defined as residual deviance plus number of parameters in model, was obtained for each pollutant. The analyses were also stratified into warm (May–October) and cool (November–April) seasons.

Findings

CORE MODELS

The variables for seasonality, day of the week (Monday to Friday), holiday, day after holiday, and either or both temperature and humidity showed significant ($p<0.05$) effects on each of the admission categories. Residual plots did not show any pattern nor any auto-correlations.

LAG EFFECTS OF OZONE

The number of lag days to reach the minimum AIC value were five for all causes of circulatory and heart failure, three for ischaemic heart disease and arrhythmias, and two for cerebrovascular diseases.

EFFECTS ADJUSTED FOR POLLUTANTS

There was significant interaction between ozone and season for all causes of circulatory diseases, arrhythmias and heart failure ($p<0.05$) with the relative risks markedly increased in the cool season (table 1).

Table 1 Relative risk for admissions from circulatory diseases per 50 µg/m³ ozone in all, warm and cool seasons for 65 or older age group

| Diseases | All* | | Warm | | Cool | |
|-----------------|--------------------|---------|--------------------|---------|--------------------|---------|
| | RR (95% CI) | p value | RR (95% CI) | p value | RR (95% CI) | p value |
| Circulatory all | 1.03 (1.00, 1.07)† | 0.076 | 1.01 (0.95, 1.07)† | 0.772 | 1.08 (1.02, 1.14)† | 0.005 |
| Ischaemic heart | 1.01 (0.93, 1.07)† | 0.886 | 1.03 (0.93, 1.14)† | 0.518 | 1.03 (0.94, 1.12)† | 0.564 |
| Arrhythmias | 1.07 (0.99, 1.16)‡ | 0.079 | 1.13 (0.95, 1.34)‡ | 0.177 | 1.14 (1.01, 1.29)‡ | 0.038 |
| Heart failure | 1.14 (1.05, 1.23)† | 0.001 | 1.11 (0.95, 1.30)† | 0.194 | 1.20 (1.07, 1.35)† | 0.001 |
| Cerebrovascular | 0.99 (0.94, 1.05)‡ | 0.773 | 0.98 (0.88, 1.10)‡ | 0.751 | 1.03 (0.95, 1.13)‡ | 0.465 |

†‡All relative risks were adjusted for a pollutant, nitrogen dioxide† or respirable suspended particulate‡, which produced the least significant result (that is, largest p value) per 50 µg/m³ ozone concentration measured by average of current up to a previous day with minimum Akaike's Information Criteria of hospital admission as well as adjustment for temperature, humidity, day of the week, holidays, day after holidays, influenza, time trend and seasonality. Sulphur dioxide had no significant effect on the model and was not included in the adjustment.

*Also adjusted for auto-correlation.

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Accepted for publication
9 March 1999

Discussion

This is the first study to show that ozone has an effect on daily hospital admissions attributable to all causes of circulatory diseases with the strongest effects on arrhythmias and heart failure in the elderly population. Other studies have attributed these effects to carbon monoxide, nitrogen dioxide and respirable suspended particulates.²⁻⁵

Hong Kong has a sub-tropical climate with mild weather most of the year (daily temperature mostly between 10°C and 30°C). The effects of ozone were stronger in the cool season when concentrations of ozone are higher than in the warm season (mean 34.8 g/m³ v 31.2 g/m³). During this period the weather is less humid (mean 74.9% v 80.5%), less cloudy (66.5% v 72.1%), and drier (rainfall 17.4 mm v 129.9 mm) so that people are more likely to open windows or stay outdoors and be exposed to the risk of air pollution.

This is the first study of short-term effect of air pollution on hospital admissions attributable to circulatory disease in the Asia Pacific Region. As the economies are growing fast in the region, air pollution becomes an important issue. The information generated from the study will contribute to the setting of air quality objectives based on locally derived data.

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