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The health effects of particulate air pollution – a Christchurch perspective

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Air quality in Christchurch has been debated widely over the last 30 years and at present there is a Draft Plan from the Canterbury Regional Council which has the main aim of improving air quality in the region. It has been shown in an inventory of emissions, that the main source of particulate pollution in the city is the use of solid fuel domestic heating appliances such as open fires and wood burners. Pollution from road traffic is considered a significant contributor to other contaminants but is less that 10% for particulate. There is local evidence that during the winter months, when atmospheric inversion conditions occur, levels of PM_{10} (particulate matter less than 10 μm in diameter) exceed local guidelines (50 mcg m^{-3} – 24 hr average) approximately 30 times each year. Research performed in Christchurch suggests that these levels of air pollution account for both premature mortality and an increase in symptoms and medication requirements in susceptible sub-groups such as those with chronic obstructive airways disease. Ongoing research is planned in Christchurch and a collaborative approach between public health physicians, biostatisticians, toxicologists and clinical researchers is likely to yield further useful information which will inform the decision-making process by the Canterbury Regional Council.

Keywords: air pollution, PM_{10}, particulate matter, emissions.

Abbreviation: PM_{10}, particulate matter less than 10 μm in diameter.

Introduction

World wide there is increasing interest in the problems of air pollution and the adverse health effects that may result from exposure of those living in polluted regions. Large numbers of our populations are exposed to ambient pollutants which have known adverse effects, particularly on the upper respiratory tract and the lung itself. In developing countries, the main source of pollution is solid fuel combustion for cooking and heating purposes. In western societies with industrial capacity, the main sources of air pollution are motor vehicle emissions, power plant emissions, waste incinerators and other industrial activities. More recently there has been increasing concern about ozone as a secondary pollutant, which is produced in the atmosphere during warm ambient conditions by photochemical reactions involving oxides of nitrogen and hydrocarbons.

The adverse health effects described as being associated with air pollution are focused on the cardio-respiratory system. There is evidence internationally from a large number of epidemiological studies of excess cardio-respiratory mortality, increased incidence of respiratory illnesses (particularly respiratory infections and asthma exacerbations), and adverse changes in lung function and airway reactivity (American Thoracic Society 1996a,b).

The Canterbury Regional Council has been monitoring ambient air pollution in Christchurch over the last 30 years and over the last 10 years has developed

increasingly sophisticated monitoring systems. Canterbury is subject to inversion atmospheric conditions during the winter months and this leads to trapping of air pollutants in the lower air atmosphere. The pollutant which most often exceeds local guidelines is particulate or PM_{10}, for which there are at least 30 excedences each winter. The mean level of PM_{10} during the winter months in Christchurch is around 45 mcg m^{-3} and peak levels may reach 80–170 mcg m^{-3} on some occasions (Canterbury Regional Council 1997). An emissions inventory undertaken in Christchurch has provided evidence that the main source of particulate air pollution during the winter months is the use of solid fuel domestic home heating appliances including open fires, coal burners and wood burners (Canterbury Regional Council 1998). There is significant contribution from road traffic emissions but these are not the dominant cause of particulates.

Adverse health effects of particulates

There is a large body of international research which describes the adverse health effects of particulate air pollution. The effects of air pollution on mortality have been described in large epidemiological studies across North America and Europe. This research has employed time series analyses to examine relationships between particulate pollution and a variety of cardio-respiratory events. Although such epidemiological research can only describe statistical associations, the remarkable consistency of findings across different continents and where the source of particles vary, provides convincing evidence that these associations are likely to be causal (American Thoracic Society 1996a,b).

Particulate matter in the atmosphere which is $<10\,\mu m$ in diameter has the potential to be inhaled beyond the upper respiratory tract into the lower airways and reach smaller airways and alveoli. Such particles have the capacity to irritate the lower airways and up-regulate inflammatory reactions. These responses are then manifest in individual subjects as an increase in respiratory symptoms such as cough and breathlessness, and in those with established disease there is an increase in medication requirements and health care utilization.

Particulate exposure is associated with an increase in all cause mortality with most studies showing an increase of around 1% for each increment of PM_{10} of 10 mcg m^{-3} (Canterbury Regional Council 1997). Most recent research shows no evidence of a 'no adverse effects' threshold and adverse effects appear to increase in a linear fashion as the level of pollution increases.

The mechanism by which exposure to particulates increases mortality has not been established with certainty. There are a number of plausible theories, but it does appear that those most likely to die are those with underlying severe cardio-respiratory illness. Exposure to particulates may aggravate airway inflammation and cause de-compensation in those with poor respiratory reserve and there is evidence of changes in cardiac rhythm and blood coagulation that may lead to ischaemic cardiac events or arrhythmias.

Local research in Christchurch

Despite the widespread interest and concern about adverse health effects of air pollution in Christchurch there has been surprisingly little local research undertaken. An early report from Dawson *et al*. (1983) examined the relationship

Table 1. Categorical analysis of ambient particulate and mortality in Christchurch, New Zealand.

Quartile of PM_{10}	Mortality from respiratory causes (relative to the first quartile of PM_{10})		
		SE	95% CI
1	1	–	–
2	1.105	0.093	0.937–1.304
3	1.130	0.098	0.953–1.340
4	1.281	0.114	1.076–1.525

Adapted with permission, Hales *et al*.

between particulate pollution and hospital admissions in children with asthma. This study did not show any convincing relationship between these variables, although there was a trend for reduced asthma admissions at times of high air pollution.

More recently the relationship between particulate air pollution and adverse outcomes for Canterbury residents has been examined in a more systematic fashion. The relationship between particulate pollution and mortality was examined by Hales *et al*. (1999). This study examined total and respiratory mortality for a 5-year period and found evidence of a 1.1% increase in total mortality and a 2.6% increase in respiratory mortality per 10 mcg m^{-3} (Canterbury Regional Council 1997) increase in PM_{10} (table 1). Extrapolating this information to provide an estimate of the number of premature deaths that may occur in Canterbury each year have indicated that up to 68 hastened deaths per year may be related to PM_{10} concentrations (Wilton 1999).

The respiratory effects of air pollution in a susceptible cohort of patients with chronic obstructive pulmonary disease (COPD) have been examined in the study by Harré *et al*. (1997). Forty subjects aged 45 years or older with doctor-diagnosed COPD completed twice-daily diaries for 3 months during the winter of 1994. They recorded respiratory symptoms, respiratory function as measured by peak expiratory flow rate, outdoor activity, hospital and doctor visits, and medication use. Daily and hourly mean pollutant levels including PM_{10}, NO_2, SO_2 and carbon monoxide (CO) were measured at the central city monitoring site. Although air pollution levels were relatively low during that year, there was clear evidence of an association between PM_{10} concentrations and an increase in night chest symptoms, but no change in lung function.

Ongoing research is planned in the Canterbury region with more detailed examination of the relationship between particulate air pollution and adverse health outcomes, and further work on the contribution of NO_2, SO_2 and carbon monoxide. A further project will examine the relationship between air pollution variables and the number of admissions to hospital or the Emergency Department with cardio-respiratory illnesses in adults and children. It is hoped that these additional projects will provide a more complete picture of the impact of air pollution on residents in the region.

Discussion

Air pollution continues to be a controversial topic. The Canterbury Regional Council is seeking further local research which will help inform the development of

policies designed to improve the quality of ambient air, particularly during the winter months. It is likely that these policies will need to include restrictions on the use of solid fuel appliances and through national policies more stringent regulations concerning motor vehicle emissions.

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