The relationship between Ambient Measurements of Particulate Matter ($PM_{2.5}$) and GP Presentations for Respiratory Complaints

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Abstract

Numerous studies have found a relationship between poor air quality and respiratory disease. Most previous research has focused on hospital presentations, however, many people with respiratory symptoms may to present to their general practitioner (GP) rather than to a hospital. Anecdotal evidence suggests that GPs in regional Australia have observed an increased frequency of respiratory presentations during periods of elevated wood heater use. This study aimed to explore whether any association exists between the frequency of GP visits for respiratory complaints and fine particulate matter ($PM_{2.5}$) levels, an air pollutant associated with wood fire smoke. Data on respiratory symptoms were collected from a large general practice in Bunbury, Western Australia. Records of 1285 patients who presented to this GP clinic during selected periods of high and low $PM_{2.5}$ concentrations in 2004 were studied. Average $PM_{2.5}$ concentrations per hour from 6:00pm to 12:00am were used as a measure of pollution from wood fire smoke. Patients' symptoms were compared to the corresponding $PM_{2.5}$ concentration data for 0-7 days prior to presentation. No relationship was found between $PM_{2.5}$ concentrations and respiratory presentations to the GP clinic, even when accounting for a lag of 1-7 days. The results of this initial investigation suggest that $PM_{2.5}$ measurements, at levels recorded in this study at this specific location, did not affect respiratory presentations to the GPs.

1.0 Background

This project was commissioned by the Air Quality Management Branch of WA Department of Environment and Conservation (DEC). This was an inquiry into one aspect of the health implications of smoke from wood fired heaters in Bunbury, regional Western Australia. National Environment Protection Measures (NEPMs) set by the National Environment Protection Council govern acceptable levels of pollutants in Australia. Bunbury recorded only four excedances of the acceptable $PM_{2.5}$ concentration limit in 2004 (the year of interest in our study). (NEPM, 2005). For the great majority of records, Bunbury's air quality is very acceptable by the NEPM standards. Despite this, the DEC had received complaints of high pollution levels and there have been anecdotal reports of increased general practitioner (GP) workload due to respiratory complaints.

In 2003, the Ambient Air Quality NEPM was varied to consider particles as $PM_{2.5}$. (NEPM, 2003). Particles were formerly measured as PM_{10} concentrations only. Under this variation, $PM_{2.5}$ concentrations should not exceed a 24 hour average of 25_g/m^3 or a yearly average of 8_g/m^3. Shorter term peaks of particulate matter (PM) concentrations may not be detected when using these guidelines. There has been some concern over possible health impacts of these peak PM concentrations (within the NEPM standards) in Bunbury.

1.1 Health effects of particulate matter air pollution

PM is most often measured as PM_{10}, (particles with a diameter < 10_m) or $PM_{2.5}$ (diameter < 2.5_m). Increased hospital admissions resulting from respiratory complaints have been attributed to both high levels of PM_{10} (Schwartz, 1996, McGowan et al., 2002, SKM, 2003, Alexis et al., 2004) and $PM_{2.5}$. (Alexis et al., 2004, Dominici et al., 2006). The latter is a more accurate measure of particulates that are most likely to exacerbate respiratory conditions, and hence were selected for analysis in this study.

Both gaseous and particulate substances contribute to air pollution from wood smoke. Purvis *et al.* (2000) analysed the composition of wood smoke particles and estimated $PM_{2.5}$ to constitute 74 to 84 percent of the smoke, depending on temperature. Sources of PM air pollution other than wood smoke include vehicle exhaust, paved road dust, emissions from food cooking and to a smaller extent, tire dust, plant fragments, natural gas, combustion, aerosol, and cigarette smoke. (Schauer et al., 1996). In this study, the source of $PM_{2.5}$ was dependent on the airshed where data were collected. The time period for data analysis was selected to give a maximum in the wood fire smoke contribution and minimum in traffic contribution.

1.2 $PM_{2.5}$ concentration a predictor of GP presentations

The majority of studies in this field use hospital admissions as the outcome variable in analysis. However, only those with more severe respiratory health conditions would be admitted to hospital. Primary healthcare contacts are likely to provide a better estimation of moderate to severe respiratory exacerbations occurring in the study population. One study which has used primary healthcare to measure the effects of air pollution on respiratory health in Hong Kong has shown a significant association between first visits for respiratory diseases and infections and an increase in the concentration of $PM_{2.5}$. (Wong et al., 2006). Traffic is the most likely source of the high $PM_{2.5}$ levels in this particular airshed. To date, health impacts of increased $PM_{2.5}$ from the use of wood heaters have not been explicitly examined.

2.0 Methods

A retrospective experimental time series study was identified as the most appropriate methodology for this project. Examining past PM data allowed us to select time periods most suitable for analysis and collect data on corresponding GP presentations.

2.1 Data from GP clinics

In March 2006, GPs in Bunbury were invited to participate in the study. One of the largest practices in the region was used to examine symptom presentations. Given that respiratory symptoms and infections are known to increase in winter months, it was decided that three periods over the same season (winter) with different $PM_{2.5}$ concentrations and some difference in temperature that may affect wood fire usage should be compared. A preliminary analysis of the $PM_{2.5}$ data series for 2004 enabled the identification of suitable time periods to compare with the available $PM_{2.5}$ records. Patient records were retrieved for these time periods. The records of 1285 patients who presented to this GP clinic with respiratory symptoms on 25-28th and 31st of May, 25-30th of July and 21st-25th September 2004 were examined.

The following presenting complaints / existing conditions were collected from patient records: episodes of wheeze, cough, sputum production, nasopharyngeal symptoms, shortness of breath, asthma, chronic bronchitis/ COPD, eye irritation, chest pain, sore throat and allergic symptoms. Other information collected included stratified age strata, gender, smoking status and the number of prescriptions issued. No personally identifying information was collected. The numbers of non-

respiratory presentations were tallied on each day of collection within the data periods to determine the proportion of respiratory complaints.

2.2 $PM_{2.5}$ data collection

Data on $PM_{2.5}$ levels were provided by the Western Australian DEC – Air Quality Management Branch. The air monitoring station in Bunbury collected data continuously, with output recorded in 10 minute intervals. These values were averaged 6-hourly. The 6:00pm to 12:00am time period was chosen because wood fire heaters were most likely to be used at this time of day. Traffic density in Bunbury is low, particularly during the chosen time period. This period (6:00pm to 12:00am) was identified as having the highest $PM_{2.5}$ concentrations during winter. The average $PM_{2.5}$ concentration from 6:00pm to 12:00am for the selected period in May is 23.3_g/m^3, compared to a 24-hour average of 14.9_g/m^3. For the period in July, a 19.2_g/m^3 average was recorded from 6:00pm to 12:00am, compared to a 24-hour average of 11.5_g/m^3. The difference in average $PM_{2.5}$ was not so marked in September (6:00pm to 12:00am average: 6.4_g/m^3, 24-hour average: 6.3_g/m^3). This is probably due to the higher temperatures correlating with a decrease in wood fire heater usage in September. Averaged hourly $PM_{2.5}$ levels within this time period were evaluated against frequency of respiratory presentations. Three periods of time spanning 5-6 days were selected for comparison based on $PM_{2.5}$ concentrations between 6:00pm and 12:00am, as well as 24-hour average temperature.

Three data periods were chosen from the months of May, July and September in 2004. The mean $PM_{2.5}$ value for 2004 based on monthly averages is 9.1_g/m^3 (range: 7.4_g/m^3 to 15.3_g/m^3). May and July represented periods of average to high $PM_{2.5}$ (with monthly averages of 11.8_g/m^3 and 9.0_g/m^3 respectively) while September represented a period of low $PM_{2.5}$ (7.6_g/m^3). To minimize the confounding effect of temperature, two periods of high $PM_{2.5}$ were chosen, one with lower average temperature (July, 12.5°C) and one with a relatively high average temperature (May, 15.3°C).

2.3 Statistical analysis

Poisson regression using Stata V.9.0™ was used to compare the frequency of patients presenting with respiratory tract symptoms on days with differing $PM_{2.5}$ air pollution levels. Upper respiratory symptoms and lower respiratory complaints were analysed separately. Sub-analyses were conducted by gender and three broad age groups. Smokers were excluded from the final analysis.

3.0 Results

Summary statistics for the percentage of respiratory cases, $PM_{2.5}$ concentrations per hour obtained from 6:00pm to 12:00am and temperature between 6:00pm to 12:00am per day for selected periods are provided in *Table 1*. This table indicates that the lowest percentage of respiratory presentations per day occurred in May. The highest percentage of respiratory cases per day of all three months was observed in July.

	Month	Mean	Min	Max
Percentage (%) of respiratory cases per day	May	17	11	27
	July	23	9	63
	Sept	21	15	27
$PM_{2.5}$ 6:00pm to 12:00am per day (_g/m3)	May	23.3	10.8	30.5
	July	19.2	3.9	28.0
	Sept	6.4	5.5	8.1
Temperature 6:00pm to 12:00am per day (°C)	May	11.2	9.3	12.8
	July	11.3	7.8	15.5
	Sept	12.7	9.5	14.2

Table 1- Summary statistics for respiratory GP presentations, PM2.5 concentrations and temperature in Bunbury, WA for selected periods of May, July and September 2004

Results from Poisson regression analysis between average $PM_{2.5}$ concentration per hour from 6:00pm to 12:00am and upper respiratory tract (URT) as well as lower respiratory tract (LRT) presentations on the day of exposure for all selected periods, are presented in table 2.

	URT Symptoms			LRT Symptoms		
Age (years) Coefficient	**0-18** -0.026	**19-50** 0.023	**>50** -0.019	**0-18** -0.079	**19-50** -0.14	**>50** 0.18
Standard Error	0.043	0.061	0.084	0.083	0.11	0.13
z	-0.60	0.38	-0.23	-0.96	-1.3	1.40
P>|z|	0.55	0.71	0.82	0.34	0.20	0.18
95% Confidence Interval	-0.11 –0.059	-0.096– 0.14	-0.18 –0.14	-0.24 –0.083	-0.36 –0.074	-0.082 –0.45

Table 2- Poisson regression examining relationship between average PM2.5 and frequency of upper respiratory tract (URT) and lower respiratory tract (LRT) symptoms

The values of the coefficients obtained show that for all ages there is no significant relationship between $PM_{2.5}$ levels and respiratory presentations on the same day. Poisson regression analysis of mean peak $PM_{2.5}$ concentration per day and URT as well as LRT presentations on the day of exposure (i.e. lag factor of 0) also showed no significant relationship between peak $PM_{2.5}$ concentration and GP respiratory presentations.

The relationship between the percentage of general practice presentations that were respiratory presentations and exposure to $PM_{2.5}$ with a lag factor of 1-7 days was also examined using line graphs. This data similarly showed no consistent relationship between $PM_{2.5}$ exposure and respiratory presentations to the GP. This was not analysed using a statistical test, as the graphs did not depict an association for any lag factor.

4.0 Discussion

This study provided an opportunity to examine the impact of air pollution, in particular smoke from wood fire heaters, and respiratory health presentations to GPs. The results show that, across all age categories, there are no significant relationships between mean peak $PM_{2.5}$ (at levels recorded in this study at this specific location) and GP consultations for either upper or lower respiratory tract symptoms. Examination of the effect of an increasing lag (from 1 to 7 days) also failed to provide evidence of an impact on presentation of respiratory symptoms to GPs.

Overall, it appears that $PM_{2.5}$ is a poor predictor of GP presentations for respiratory complaints.

There are several possible explanations for this absence of an observable effect.

It is possible that exposure to the levels of $PM_{2.5}$ measured in this study does not trigger a deterioration in respiratory symptoms to a degree which compelled individuals to present to their GP. A study using this design fails to capture those who elect to self-manage their symptoms (e.g. by using medications found over-the-counter at a local pharmacy), or, at the other extreme, those who present to hospital rather than attending a general practice.

Additionally, exposure assessment was constrained by the use of the only available $PM_{2.5}$ data from a single source, which may have failed to take into account an uneven dispersion of particles across the residential areas of Bunbury. Therefore, it could have been possible for residents to have had different exposures to $PM_{2.5}$ that were not adequately represented by measurements taken in the airshed.

This study is not isolated in suggesting that $PM_{2.5}$ is a poor predictor of GP presentations. Villeneuve *et al.* (2006) reported no significant associations between daily levels of air pollutants (including $PM_{2.5}$) in Toronto and physician visits for allergic rhinitis in the elderly. However, the current findings are contrary to those of Wong *et al.* (2006) who found a relationship between GP visits for respiratory diseases in Hong Kong and a range of air pollutants, also including $PM_{2.5}$. The present study principally aimed to investigate the impact of air pollution related to wood fire smoke, using $PM_{2.5}$ as a marker, whereas Wong's study examined exposures to air pollutants in general. In addition, in Hong Kong, it is likely that other pollutants (particularly from vehicle sources and not wood smoke heaters) contribute significantly to the $PM_{2.5}$ levels, which may be more of an irritant. This may explain the differences in results.

In Hong Kong, average levels of $PM_{2.5}$ are much higher and fluctuations much greater than in our study. For example, Wong *et al.* (2006) recorded a mean $PM_{2.5}$ concentration of 35.7_g/m^3 with a standard deviation of 16.7 over a study period of 725 days (during 2000-2002). In Bunbury, the 2004-2005 mean $PM_{2.5}$ concentration was 7.2_g/m^3 with a standard deviation of 5.8. This could indicate fluctuation in $PM_{2.5}$ at the relatively low levels recorded in Bunbury is not associated with respiratory symptoms severe enough to require GP presentation. In comparison, where average PM levels are very high, fluctuation may moderately or severely exacerbate respiratory conditions. This would be detected by an increase in GP presentations.

5.0 Conclusions

Using elevated $PM_{2.5}$ as a representation of wood smoke exposure, results from our study do not support an association between $PM_{2.5}$ levels from wood smoke in Bunbury and GP presentations for respiratory or irritant exposure symptoms. Therefore, our results suggest that fluctuations of PM levels within the guidelines set by the National Environment Protection Council are not associated with health implications severe enough to require GP presentation. These results alone are not adequate to inform public health policy regarding the use of wood fire heaters. Further research into this area is needed, to expand the timeframe of the study and include other health statistics (e.g. hospital presentations, personal symptom diaries) and other air pollutant indices in order to generate more conclusive data.

4.0 References

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