Long-term Exposure to Air Pollutants and Hospitalisation for Respiratory Diseases in Western Sydney

Introduction

Western Sydney potentially experiences the double burden of higher concentrations of ambient air pollution and has a population who may be more vulnerable to health outcomes associated with air pollution. Air pollution produced in Eastern Sydney is transported by the easterly wind to Western Sydney, where it adds to the local sources, leading to Western Sydney potentially experiencing poorer air quality compared with the Eastern Sydney (Philipps et al 2017). The level of socioeconomic status is generally lower in Western Sydney compared to eastern suburbs (Australian Bureau of Statistics 2016) and there is some evidence that lower socioeconomic groups may be more susceptible to the adverse health effects of exposure to air pollution (Cakmak et al. 2016). Therefore, this study aimed to investigate whether the effects of exposure to air pollution in Western Sydney differs from other Sydney areas.

This report is an appendix to the paper '*Long-term Exposure to Low Concentrations of Air Pollutants and Hospitalisation for Respiratory Diseases: A Prospective Cohort Study in Australia*' (Salimi et al. 2018). It includes the results of additional analyses of the sub-group of 45 and Up Study participants who lived in Western Sydney at time of the baseline survey (2006-2009). The results of the published paper are based on the 45 and Up Study participants who lived in Sydney metropolitan region (including Western Sydney). This report describes focuses on Western Sydney. It describes how the Western Sydney sub-group was defined and compares the baseline characteristics and exposure levels of the Western Sydney subgroup with other areas in Sydney. We also present the associations of long-term exposure to $PM_{2.5}$ and NO_2 with hospitalisation for respiratory diseases for the sub-group of Western Sydney residents compared with other Sydney residents.

Sydney Study Region and Western Sydney subset

The Sydney study region was defined as a 100 km × 100 km grid centred on Sydney airport (Sydney Metropolitan Region), due to availability of pollutant exposure estimates. Participants who lived in Western Sydney were identified based on the Statistical Area Level 3 (SA3) code of their residential addresses. The participants whose residential addresses were in the following SA3 codes were grouped into Western Sydney sub-group: 12701, 12702, 12703, 12301, 12302, 12303, 12401, 12402, 12403, 12404, 12405, 11503.

(http://www.abs.gov.au/AUSSTATS/abs@.nsf/allprimarymainfeatures/9593E06A9325683BCA257FED001561EA). The "Other Sydney" subgroup was defined as all other (non-Western Sydney) residents of the Sydney study region.

Methods

The published paper describes the methods in detail, covering exposure assessment, health outcome definitions and statistical analyses. Exposure assessment for NO_2 was based on a Satellite-based land use regression model and $PM_{2.5}$ exposure was based upon a Chemical Transport Model (CTM). Exposures were estimated for one year (i.e. 2007 for NO_2 and 07/2010-07/2011 for $PM_{2.5}$). In this appendix we quantify the associations between exposure to $PM_{2.5}$ and NO_2 at baseline with hospitalisation for all respiratory diseases over a 7-year follow-up. We have not considered sub-groups of respiratory disease as the numbers are not sufficient to provide adequate statistical power for the analysis. All respiratory illness such as Asthma, COPD, Pneumonia, and Bronchitis, identified by the following International Classification of Diseases, 10th revision (ICD- 10) codes: J00–J99 excluding J95.4 to J95.9, R09.1, R09.8, were included in the analyses.

Cox proportional hazards model with age as the underlying time were used to assess the association between exposure to air pollutants and first hospitalisation for all respiratory illness. The models were adjusted for confounders, defined a priori, in three steps:

Model 1) age (underlying time in years), sex and year of enrolment (continuous in years);

Model 2) Model 1 plus adjustment for marital status (categorical variable: married/partnered or single/divorced/widowed), education (categorical variable: below high school, high school or university), employment status (categorical variable: employed or unemployed/retired), smoking status (categorical variable: current, previous or non-smoker), smoking duration (for current/ past smokers in years), smoking intensity (for current smokers in cigs/ day) and body mass index (BMI) (categorical variable: underweight (BMI < 18.5 kg/m^2), normal (18.5 kg/m^2 < BMI < 25 kg/m^2), overweight (25 kg/m^2 < BMI < 30 kg/m^2), obese (BMI > 30 kg/m^2);

Model 3 (Main model) Model 2 plus further adjustment for area level socioeconomic status (SES) indicator (quartiles).

All models were tested for proportional hazard assumptions. To allow comparison with other studies, the effects of exposure to $PM_{2.5}$ and NO_2 were estimated for either 1, 5, or 10 $\mu g.m^{-3}$ increase in each pollutant, whichever was closest to the interquartile range. The above Cox models were initially run on the participants living in Sydney Metropolitan Region.

Lastly, for the all of Sydney models, a Western Sydney interaction term with exposure ($PM_{2.5}$ or NO_2) was added to the models in order to estimate the differences between the effects of exposure to air pollution in Western Sydney compared to other areas in Sydney.

Results

Figure 1 illustrates the map of the Sydney metropolitan area with Western Sydney distinguished by colour.

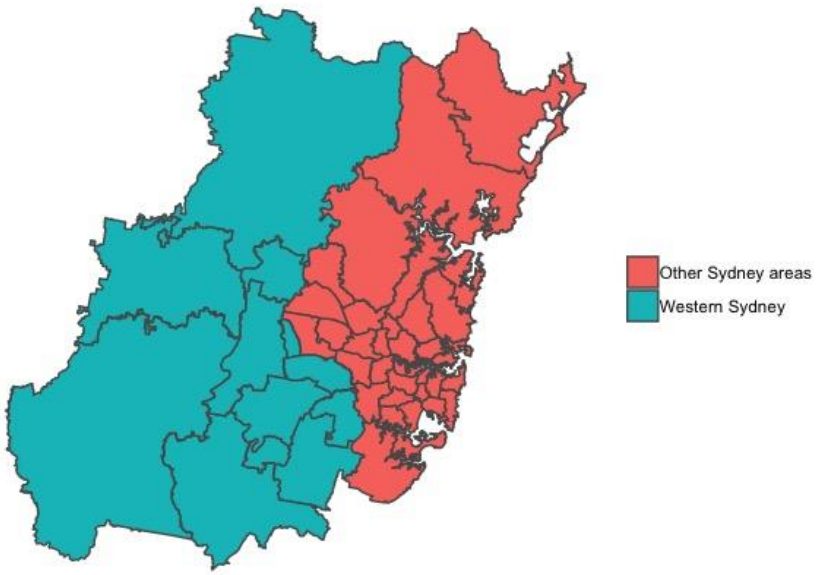

Figure 1: Map of Western Sydney and other Sydney areas.

Figure 2 compares the distribution of annual average exposure to $PM_{2.5}$ and NO_2 for participants residing in Western Sydney with other areas in Sydney. While the median annual concentration of $PM_{2.5}$ was slightly lower for Western Sydney residents compared to other Sydney (4.1 $\mu g.m^{-3}$ vs 4.6 $\mu g.m^{-3}$), the maximum $PM_{2.5}$ concentrations were higher for residents in Western Sydney compared with other areas in Sydney (13.8 $\mu g.m^{-3}$ vs 8.11 $\mu g.m^{-3}$). Median annual concentration of NO_2 was lower in Western Sydney compared with other areas in Sydney.

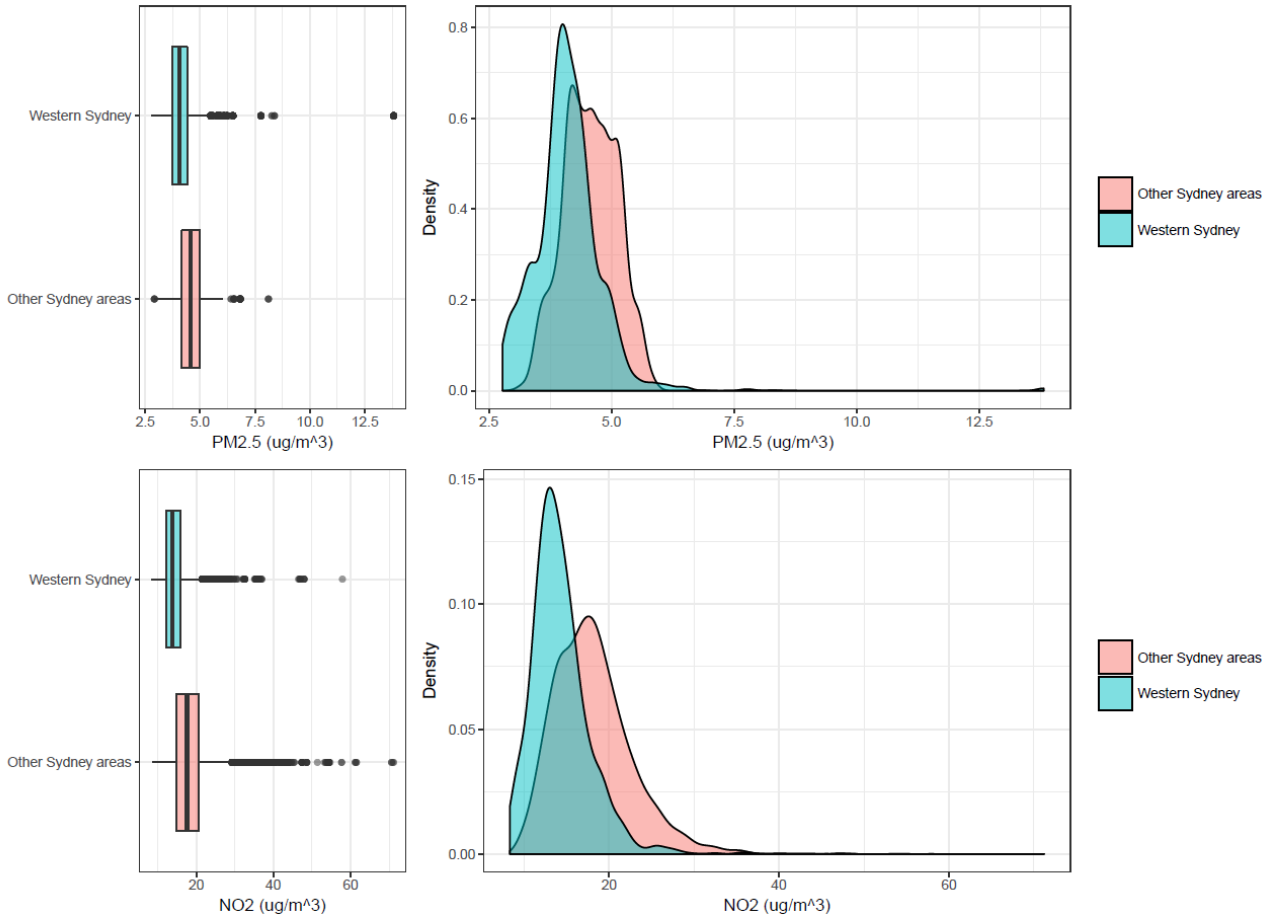

Figure 2: Distribution of annual mean exposure to $PM_{2.5}$ and NO_2 for participants residing in Western Sydney compared with other Sydney areas (45 and Up cohort)

Table 1 compares baseline characteristics of participants residing in Western Sydney with other areas in Sydney. Compared with other areas in Sydney, participants in Western Sydney were on average younger and lived in areas with lower area-level SES. SES is known to have adverse associations with health (Williams et al. 2010). In addition, Western Sydney had higher proportion of smokers and obese participants. There were no significant differences between Western Sydney and the rest of Sydney in the cumulative incidence of asthma and hospitalisation for respiratory diseases during follow up.

Table 1; Age, area level SES measure, cumulative incidence of asthma and first time hospitalisation for respiratory diseases after baseline.

	Western Sydney (n = 12,779)	Other Sydney areas (n = 71,506)
Age (mean and 95% CI)	59.8 (59.6 – 59.9)	62.7 (62.6 – 62.8)
Sex (female percent and 95% CI)	52.8 (52.0 - 53.7)	52.1 (51.7 - 52.5)
Marital status (percent of partnered and 95% CI)	76.9 (76.2 - 77.6)	74.1 (73.8 - 74.4)
Education level (percent and 95% CI)		
Below high school:	38.6 (37.8 - 39.5)	24.3 (24.0 - 24.6)
High school graduate:	44.6 (43.8 - 45.5)	41.2 (40.8 - 41.5)
University:	16.8 (16.1 - 17.4)	34.6 (34.2 - 34.9)

Employment status (percent of employed and 95% CI)	47.6 (46.7 - 48.5)	53.5 (53.1 - 53.9)
Smoking status (percent and 95% CI)		
Current smoker:	9.9 (9.4 - 10.4)	5.4 (5.3 - 5.6)
Past smoker:	32.4 (31.6 - 33.2)	32.5 (32.2 - 32.8)
Never smoker:	57.8 (56.9 - 58.6)	62.1 (61.7 - 62.4)
BMI category (percent and 95% CI)		
Underweight:	1.0 (0.8 - 1.2)	1.5 (1.4 - 1.6)
Normal:	30.4 (29.6 - 31.2)	42.2 (41.8 - 42.5)
Overweight:	39.8 (39.0 - 40.7)	38.5 (38.1 - 38.8)
Obese:	28.7 (28.0 - 29.5)	17.9 (17.6 - 18.2)
Index of Relative Socioeconomic Disadvantage and 95% CI (percent and 95% CI)		
Level1(lowest):	47% (46.1 - 47.8)	21.1% (20.8 - 21.4)
Level2:	38.6% (37.8 - 39.4)	22.6% (22.3 - 22.9)
Level3:	11.6% (11.0 - 12.2)	27.4% (27.1 - 27.7)
Level4 (highest):	2.8% (2.6 - 3.2)	29.0% (28.6 - 29.3)
Asthma (%) and 95% CI	10.4 (9.9 – 11.0)	10.3 (10.1 – 10.5)
First time hospitalisation for respiratory diseases (%) and 95% CI	4.4 (4.0 – 4.7)	4.2 (4.0 – 4.3)

Table 2 presents the Hazard Ratios (HRs) for the associations between exposure to $PM_{2.5}$ and NO_2 and hospitalisation for all respiratory diseases. No associations were observed in the Sydney Metropolitan Region and HRs attenuated as the models were further adjusted for additional covariates.

Table 2: Hazard Ratios and 95% Confidence Intervals from Cox Proportional Hazards Models with increasing covariate adjustment for the association between 1 and 5 µg.m^{-3} changes in $PM_{2.5}$ and NO_2 concentrations respectively and hospitalisation for all respiratory diseases, 45 and up Study, NSW.

45-and Up Population	Pollutant	First time hospitalisation for all respiratory diseases Hazard ratios and 95% confidence intervals		
		Model 1	Model 2	Model 3
Sydney Metropolitan Region	$PM_{2.5}$ (µg.m^{-3})	1.04 (0.98 – 1.10)	1.02 (0.96 -1.08)	0.98 (0.92 -1.04)
	NO_2 (µg.m^{-3})	1.01 (0.98 – 1.05)	1.01 (0.97 -1.04)	0.99 (0.95 – 1.03)

Hazard ratios are for 1 and 5 µg.m^{-3} changes in $PM_{2.5}$ and NO_2 levels, respectively.
Model 1: adjusted for age (time variable), year of enrolment and sex
Model 2: model 1 plus marital status, education, employment status, and smoking status/during/intensity, and BMI

Model 3: model2 plus area level socio-economic status

Models including Western Sydney interaction terms showed that generally HRs in Western Sydney were lower than other Sydney areas (Table 3). However, the interaction terms were not statistically significant for both NO_2 and $PM_{2.5}$ (Table 3).

Table 3: Hazard Ratios and 95% Confidence Intervals from Cox Proportional Hazards Model with Western Sydney added as an interaction term. Models were adjusted for age (time variable), year of enrolment, sex, marital status, education, employment status, smoking status/duration/intensity, BMI, and area level socio-economic status. Associations are between 1 and 5 $\mu g.m^{-3}$ changes in $PM_{2.5}$ and NO_2 concentrations respectively and hospitalisation for all respiratory diseases

45-and Up Population	Pollutant	First time hospitalisation for all respiratory diseases Hazard ratios and 95% confidence intervals	P-value - interaction term
Western Sydney	$PM_{2.5}$ ($\mu g.m^{-3}$)	0.94 (0.82-1.06)	0.17
	NO_2 ($\mu g.m^{-3}$)	0.93 (0.82 – 1.04)	0.14
Other Sydney areas	$PM_{2.5}$ ($\mu g.m^{-3}$)	1.04 (0.97 – 1.11)	0.17
	NO_2 ($\mu g.m^{-3}$)	1.04 (0.97 – 1.12)	0.14

Discussion

Compared with other areas in Sydney, participants in Western Sydney were exposed to slightly lower annual average $PM_{2.5}$ and NO_2 concentrations. However, the peak concentration of $PM_{2.5}$ was higher in Western Sydney, while for NO_2 it was lower. Western Sydney participants were on average younger, had lower level of education, and higher level of unemployment. Western Sydney participants also lived in areas with lower area level SES. There were no significant differences for percentage of new asthmatic cases and hospitalisation for respiratory diseases during follow up.

Similar to the results for the whole of Sydney (Salimi et al. 2018), we found no associations between exposure to air pollutants and hospitalisation for all respiratory diseases in Western Sydney. The hazard ratios estimated for Western Sydney participants had larger confidence intervals due to smaller sample size. Estimated HRs decreased as the model were adjusted for further risk factors and area level SES. Similar attenuating effects were observed in the Sydney study. Interaction terms were found to be statistically non-significant. Therefore, we found no evidence that the effects of air pollution on hospitalisation for respiratory diseases in Western Sydney is significantly different from other Sydney areas.

This study is a large cohort with comprehensive individual level information. However, this study had limited follow up of around 7 years which limited the statistical power. The spatial resolution of $PM_{2.5}$ exposure model was 1 km^2 and this may have caused exposure misclassification that might have attenuated the estimated HRs.

Dividing a cohort into smaller areas with the purpose of detecting local effects of air pollution leads to smaller sample size and consequently lower statistical power. In addition, smaller areas usually have lower exposure variability and therefore lowers the chance of detecting relatively small risk estimates associated with exposure to air pollution. Despite these limitations, we recommend this analysis should be revised when new data becomes available with increased cohort length of follow up in the coming years.

References

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