



Appendix

**This appendix was part of the submitted manuscript and has been peer reviewed.
It is posted as supplied by the authors.**

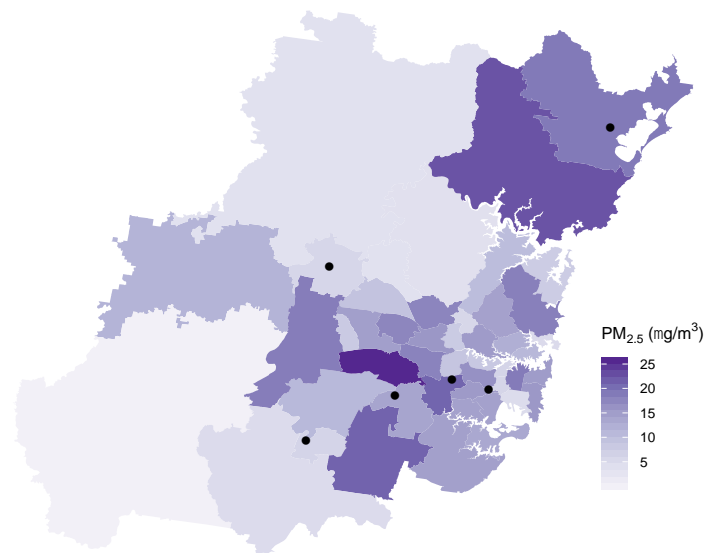
Appendix to: Horsley JA, Broome RA, Johnston FH, et al. Health burden associated with fire smoke in Sydney, 2001–2013. *Med J Aust* 2018; 208: 309-310. doi: 10.5694/mja18.00032.

Appendix – Detailed description of methods

Study Area

The study area was defined as the Australian Bureau of Statistics (ABS) Sydney Greater City Capital City Statistical Area (GCCSA). For each Statistical Area 3 (SA3) within the GCCSA, on each day affected by Landscape Fire Smoke (LFS) over the period 2001 to 2013, we estimated the number of premature deaths, cardiovascular hospitalisations and respiratory hospitalisations attributable to short-term exposure to smoke from LFS.

Figure 1: Map of the Sydney GCCSA SA3s with population-weighted average LFS-attributable $PM_{2.5}$ exposure indicated by shading and monitors shown as filled circles.



Estimating attributable exposure

Identification of smoke affected days

The identification of Landscape Fire Smoke (LFS) affected days in the validated landscape fire event database (1) was conservative. Because particulate matter (PM) levels were required to exceed the 95th percentile of the long-term city-wide average, days that were affected by lower levels of smoke were not designated as LFS days. In addition to not identifying all smoke-affected days, counter-factual exposure is likely over-estimated as non-LFS smoke levels likely include days that were smoke affected below the 95th percentile.

Exposure Scenarios

For each LFS day, three 24-hour average PM_{2.5} exposure scenarios were modelled:

1. actual exposure – including LFS,
2. counter-factual non-LFS exposure, and
3. a baseline exposure using the annual average.

Baseline exposure using the annual average is distinct from a particular day's actual exposure. The baseline exposure is chosen to coincide with available annual health outcome data in order to be used in the concentration response function described below.

Calculating counter-factual exposure

For each LFS day at each monitor, non-LFS PM_{2.5} levels were estimated using the average levels at that monitor from the 30 nearest non-LFS calendar days from all years. Daily actual and counter-factual concentration surfaces were interpolated (details below) over the Sydney GCCSA then averaged inside Statistical Area 3s (SA3s). Where the counter-factual SA3 estimate was lower, the difference was attributed to LFS.

Monitor interpolation

Under each exposure scenario daily average monitor readings were interpolated over a 500 × 500 grid covering the Sydney GCCSA (longitudes: 150.0 to 151.6, latitudes: -34.3 to -33.0) using kriging with squared inverse distance weighting.

For the counter-factual and baseline exposure estimates, averages were taken over time at each monitor before kriging according to the averaging periods described above. To account for varying amounts of missing data, weighting by sample size at each monitor location was applied to the kriging.

Estimating attributable health outcomes

Concentration response function

For each LFS day, SA3, and health outcome, the number of health outcomes was calculated for the actual and counter-factual exposure scenarios using the concentration response function:

$$\text{Cases} = \text{Baseline incidence} \times RR^{(x-x_b)/10} \times \text{Population}.$$

In the equation above, annual averages were used to obtain population, daily average baseline incidence and baseline exposure and:

- RR is the relative risk per 10 µg/m³ increase in PM_{2.5} derived from epidemiological studies,
- x is the 24-hour average exposure level in the current scenario, and
- x_b is the baseline exposure level, measured in µg/m³.

Attributable numbers

Attributable numbers due to LFS on each LFS day were calculated by taking the difference in the estimated number of cases under actual exposure and counter-factual exposure scenarios:

Attributable number = Cases under actual exposure – Cases under counter-factual exposure.

Baseline incidence

All-age annual death counts were available by SA3 from the [ABS](#) (2). All-age annual hospitalisation rates were available by Local Health District from the [NSW Ministry of Health](#) (3), and these were used to interpolate SA3 hospitalisation rates. To obtain baseline counts of SA3 hospitalisation, the SA3 hospitalisation rates were multiplied by Estimated Residential Population (ERP) from the ABS.

Relative Risks

We used relative risks recommended by the World Health Organisation Health risks of air pollution in Europe (HRAPIE) project (4) derived from meta-analyses of European studies. These relative risks reflect the effects of short-term (24-hour average) changes in PM_{2.5} exposure. Current evidence does not suggest that LFS-derived PM_{2.5} is less harmful than typical urban PM_{2.5} on which these relative risks are based.

Table 1: HRAPIE Relative Risks

Health outcome	Relative Risk per 10 µg/m ³
All-cause mortality	1.0123 (1.0045, 1.0201)
Respiratory hospitalisation	1.0190 (0.9982, 1.0402)
Cardiovascular hospitalisation	1.0091 (1.0017, 1.0166)

References

1. Johnston FH, Hanigan IC, Henderson SB, Morgan GG, Portner T, Williamson GJ, et al. Creating an integrated historical record of extreme particulate air pollution events in Australian cities from 1994 to 2007. *Journal of the Air & Waste Management Association*. 2011;61:390+.
2. Australian Bureau of Statistics. 3302.0 - Deaths, Australia, 2013 [Internet]. 2015 [cited 2017 Sep 5]. Available from: <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3302.02013?OpenDocument>
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4. WHO. Health risks of air pollution in Europe – HRAPIE project Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide. 2013.