Smoke from the Hazelwood mine fire and mortality. What magnitude of impact might be expected from existing concentration response relationships?

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Below I present a basic assessment of population exposure to $PM_{2.5}$ from mine fire smoke (Table 1) and apply a range of concentration response functions based on the available evidence (Table 2). Based on this assessment I conclude that a mortality increase of 3.6% would be a plausible upper bound consistent with current available evidence and that PM exposure from smoke is unlikely to explain a mortality increase as large as 30%. Other explanations for such a large statistical correlation should also be considered.

Table 1. Estimation of population weighted exposure of residents of the Latrobe Valley to $PM_{2.5}$ (µg/m^3) emitted from the Hazelwood mine fire between 9 February and 26 March 2014.

	Population 2011	**Proportion of population**	**PM 2.5 mean during the period of the fire (µg/m^3)**	**Background $PM_{2.5}$** (Mean 26-3-14 to 24-3-15)	**Difference from background during fire period (µg/m^3)**	**Mean increase in exposure * proportion affected.**
Morwell South of Commercial Rd	1,600	0.03	103.07 (best estimate)[1] 156.09 (worst case)[2]	6.6	96.47 149.49	2.89 4.48
Morwell North of Commercial Rd (Morwell East)	12,400	0.21	22.02 (best estimate)[1] 27.3 (worst case)[2]	6.5	15.52 20.8	3.26 4.37
Traralgon	24,000	0.41	17.8 (EPA via data provided to DHHS) 10.0 (DELWP/CRC unpublished, not used)	7.6	10.2 3.4	4.18
Moe and Churchill	15,000 + 5,000 = 20,000	0.34	17.8 (Estimated based on Traralgon data EPA)[3]	5.0[4]	12.8	4.35
Total	59,000	1.0			Sum of best estimates Sum of worst case scenario estimates	**14.68** **17.38**

Footnotes explaining some assumptions in Table 1.

1. There are no data for the first five days of the fire. 'Best estimate' assumes that the first five days had smoke impacts of the same order of magnitude as the following five days.
2. 'Worst case scenario estimate' assigns the highest daily $PM_{2.5}$ concentration ever recorded at a given location during the fire to each of the first five days of the fire.
3. The assumption that overall impacts in Moe and Churchill was comparable to Traralgon is based on mine fire emissions modelling by Emmerson et al [1] and available empirical data from the latter part of the fire period (Data from DHHS spreadsheet).
4. Background PM data for Moe and Churchill were not available to me. I assigned a level similar to but slightly lower than other towns in the Latrobe Valley. Above modelling suggests background is similar in Moe and in Traralgon but slightly lower in Churchill than in Traralgon. [1]

A recent meta-analysis of the magnitude of effect in daily mortality (all-cause all-age) is that a 10 $\mu g/m^3$ increment in $PM_{2.5}$ was associated with a 1.04% (95% CI 0.52% to 1.56%) increase in mortality. There was substantial regional variation (0.25% to 2.08%). There was evidence of small study bias. [2].

There are far fewer mortality studies of PM from landscape fires. Exposure assessment methods and results are more variable but generally consistent with results from the wider literature (Table 3).

Table 2 below shows a sensitivity analysis of how the estimated change in mortality is affected by applying a range of effect sizes to the populated weighted exposure estimates for the Latrobe Valley during the mine fire.

Table 2. Sensitivity analyses of the magnitude of increase in deaths associated with a 10µg rise in $PM_{2.5}$ assuming a range of mortality impacts from $PM_{2.5}$ from 1% to 5%. Baseline number deaths in the time period of the mine fire was assumed to be 65, the mean of the same time period of the previous 5 years (mortality data from DHHS spreadsheet).

Percent change in baseline mortality per 10µg rise in $PM_{2.5}$	**1%**	**2%**	**3%**	**4%**	**5%**
Best estimate	1.5 %	3%	4.5%	6%	7.5%
Worst case scenario	1.7%	3.4%	5.1%	6.8%	8.5%
Absolute change in deaths					
Best estimate	0.98	1.95	2.93	3.9	4.86
Worst case scenario	1.10	2.21	3.31	4.34	5.53

An upper bound of a plausible impact might be estimated if we take the **highest reasonable effect size** (2.08), multiply it by the **worst-case scenario** (17.38) then divide by the 10µg unit increase in $PM_{2.5}$. This produces an estimated increase in mortality of 3.62%. (ie 2.08 * 17.38 / 10 = 3.62%)

Table 3: A summary of all-cause mortality effect estimates from studies of landscape fire smoke including forest, peat and bushfires.

Citation	**Location and fire type**	**Exposure Assessment**	**RR (95% CI) per 10 $\mu g/m^3$ PM_{10} or with an episode (smoke day)**
Sastry 2002 [3]	Malaysia, peat and forest fires	Smoky versus non-smoky days (PM_{10} <210)	1.19 (0.98, 1.41)
Morgan et al. 2010 [4]	Sydney Bushfires	Monitored PM_{10}	1.01 (1.00, 1.02)
Johnston et al. 2011 [5]	Sydney Bushfires	Smoky versus non-smoky days ($PM_{2.5}$ or PM_{10} > 99th centile due to smoke)	1.05 (1.00, 1.10)
Faustini et al. 2015 [6]	Europe, Forest fires	Smoky versus non-smoky days PM_{10}	1.02 (0.99, 1.05)
Linares et al. 2014 [7]	Spain, Forest fire	Monitored PM_{10}	1.035 (1.011, 1.060)
Shaposhnikov et al. 2014 [8]	Moscow, forest and peat fires	Monitored PM_{10}	1.004 (1.001 – 1.008) at T <18°C 1.008 (1.004 – 1.011) at T=22°C 1.014 (1.010 – 1.019) at T=>30°C

Citations

1. Emmerson, K.M., et al., *Estimate of smoke exposure from the Hazelwood mine fire. CSIRO Australia.* 2015, CSIRO: Aspendale, Victoria.
2. Atkinson, R., et al., *Epidemiological time series studies of PM2. 5 and daily mortality and hospital admissions: a systematic review and meta-analysis.* Thorax, 2014: p. thoraxjnl-2013-204492.
3. Sastry, N., *Forest fires, air pollution, and mortality in southeast Asia.* Demography, 2002. **39**(1): p. 1-23.
4. Morgan, G., et al., *The effects of bushfire smoke on daily mortality and hospital admissions in Sydney, Australia, 1994 to 2002.* Epidemiology, 2010. **21**(1): p. 47-55.
5. Johnston, F.H., et al., *Extreme air pollution events from bushfires and dust storms and their association with mortality in Sydney, Australia 1994-2007.* Environmental Research, 2011. **111**: p. 811-816.
6. Faustini, A., et al., *Short-term effects of particulate matter on mortality during forest fires in Southern Europe: results of the MED-PARTICLES Project.* Occupational and environmental medicine, 2015: p. oemed-2014-102459.
7. Linares, C., et al., *Influence of advections of particulate matter from biomass combustion on specific-cause mortality in Madrid in the period 2004–2009.* Environmental Science and Pollution Research, 2015. **22**(9): p. 7012-7019.
8. Shaposhnikov, D., et al., *Mortality related to air pollution with the Moscow heat wave and wildfire of 2010.* Epidemiology (Cambridge, Mass.), 2014. **25**(3): p. 359.