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Review of "Analysis of death data during the Morwell mine fire," A. Barnett, working paper, unpublished (2014, Queensland University of Technology) and

"An updated analysis of death data during the Morwell mine fire," A. Barnett, working paper, unpublished (2015, Queensland University of Technology)

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Executive Summary

The working papers "Analysis of death data during the Morwell mine fire" by Adrian Barnett (2014, Queensland University of Technology, unpublished) and "An updated analysis of death data during the Morwell mine fire (2015, Queensland University of Technology, unpublished) are analyses of mortality data for the Latrobe Valley postcodes exposed to smoke from the Hazelwood coal mine fire, February-March 2014, compared to mortality up to ten years earlier.

The Barnett (2014) paper describes an analysis of the mortality data available at the time of the analysis, and includes temperature information to account for potential excess mortality in the four postcodes adjacent to the Hazelwood fire due to the summer heatwave during the weeks of the Hazelwood mine fire. The results show deaths in the months January to June 2009-14 in excess of the expected mortality for the 2009 and 2014 summers. The author concludes that there is an 80% probability that the excess mortality in the months of February-March 2014 was due to the fire, after adjusting for temperature. This assertion is not supported by the results reported in the paper.

The Barnett (2015) paper describes an expanded dataset for the analysis, including two additional postcodes further distant to the south and southeast of the fire, and additional mortality for the years 2004 to 2014, January to December. The author concludes that there is an 82% probability that the excess mortality in the months of February-March 2014 coincided with the dates of the fire, after adjusting for temperature. This assertion is not supported by the results reported in the paper.

These papers do not discuss the ambiguities in interpretation of estimates when such estimates are based on small datasets in the context of rare environmental events. There is no discussion of the decrease in deaths for the postcode (Morwell) where the Hazelwood mine is located and the fire occurred. Cause of death for these mortality data were not included in these analyses and strongly mitigate the author's assertions about the deaths at the time of the fire.

There is no statistical interpretation of evidence for any particular effect on the observed differences in reported mortality across the Latrobe Valley postcodes for the period of the Hazelwood coal mine fire. Although the fire's effect on mortality may be a supposition worthy of investigation, the data presented in these papers do not suggest strong evidence for the author's assertion of a significant effect of the period of the fire on mortality at that time. The mean increase in deaths (given as a relative risk with 95% credible intervals) for the February-March 2014 period with and without the seasonal temperature correction is not evidence of statistical significance.[1]

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[1] The 95% credible interval given with a point estimate in a Bayesian analysis is equivalent to the analyst's statement of a 95% degree of belief that the parameter in question is in fact contained within this interval. These intervals can be broader or narrower depending on several factors, including sample size and population variability. When the credible interval contains one (1), the evidence for an association/relationship is weak. We note that non-significant results in the case of small sample sizes

Strengths of the analysis with regard to choice of analytic methods
There are several possible methods to model the variation in mortality across the Latrobe Valley postcodes for February-March 2014 compared to previous years. The methods used in these papers are appropriate to the problem, notwithstanding the failure to explain their use and the inconclusive results reached using these methods.

The Poisson regression model used in these papers is appropriate to this research question. The description of the statistical model used is clear. In addition to the regression model, the analysis is framed in the Bayesian paradigm, and used to estimate the probability of the observed mortality. This is a useful analytic tactic given the small numbers in the dataset, and the uncertainty surrounding the rare event of the mine fire.

There are considerations made in the model to allow for nuances in interpreting the regional excess mortality in February-March 2014. These include a consideration of regional population movements, although the specific source and assumptions for the use of Latrobe City Council population data (Barnett 2014) and the 'qualitative evidence of exposures and evacuations' (Barnett 2015) are not made clear in the papers. The lack of methodological context for these data sources does limit their use in the interpretation of the results.

These papers include a consideration of the usual and expected seasonal peak in mortality during the Australian winter months. Most importantly, a consideration of the maximum monthly regional temperature was included in the model to account for the possible effect of higher-than-average summer temperatures on mortality. However important it is to consider temperatures in explaining the mortality at the time of the fire, it is equally important to understand that it is *extreme* fluctuations in temperature and their duration, rather than monthly averages, that impact mortality. The lack of such data covering the entire 2009-14 period for the affected area limits the interpretation of models that include a gross temperature variable as a covariate.

In addition to the expanded dataset, Barnett (2015) includes a comparison of the complexity of the different models to account for temperature variation throughout the year and variable mortality across the different postcodes. Some postcodes reported fewer than expected deaths and some postcodes reported greater than expected mortality; no postcodes in this analysis reported statistically significant excess mortality (by mean relative risk with 95% credible interval). Barnett (2015) contains a useful graphic comparison of the mean relative risks across the postcodes. This showed that all 95% credible intervals overlap with

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are prone to misinterpretation, leading to the conclusion of an effect where there is none, or the conclusion of no effect where there is one (see Altman DG and Bland JM, 1995, Absence of evidence is not evidence of absence, *British Med J* 311:485).

each other, and also contain the relative risk 1.0, meaning no significant increase or decrease (Figure 3).

In the comparison of the different explanatory models, the best model in this analysis showed no adjustment for seasonal temperature, and a fixed rather than variable effect of the fire on mortality across postcodes (Barnett 2015). Use of the deviance information criteria (DIC, Barnett 2015) is one of the better information criteria methods to use for Bayesian modelling. There were very minor differences in the DIC and these were explained correctly; that is, the temperature variable provided insufficient information to warrant its inclusion in the model.

Further, the use of residual plots is suited to identifying 'spikes' in the death rates, but only if we can assume that the question posed by the method is correct. Thus, the question is not whether this method is suitable for identifying 'spikes' in the death rates. It is rather whether this model is adequate to explain enough variance to conclude the coal fire's influence on death rates; we conclude from these results this is not the case.

Limitations of the analysis

There is not one single analytic method or combination of methods that can overcome the limitations in these mortality data. These limitations include the small numbers of deaths and the lack of identifying information for these deaths (age, sex, cause of death, underlying comparison population). A more thorough analysis of the cause of deaths for this period would be required to explore common risk factors.

There are limitations of this analysis that hinder the reader's understanding of the potential significance of the results. One is the lack of even a brief discussion of the analytic issues of uncertainty analysis when evaluating rare environmental events. This discussion could cover the limitations of interpreting broad credible intervals that contain one (1) in the context of small sample sizes. Some acknowledgment of the small numbers in this dataset, and the variation in mortality observations over the study period is warranted, such as the high mortality in the 2009 summer heatwave, and the lower mortality in the Morwell postcode (location of the fire) during the February-March 2014 period.

The inclusion of a Bayesian estimate of the probability of the February-March 2014 mortality may be problematic for the general reader, as it is difficult to link the relative risks reported to the estimated probabilities of the fire's effects on mortality. The Barnett (2014) paper shows this ambiguity in Tables 1 and 2 (1.14, 95% credible interval 0.92-1.41, and temperature corrected 1.11, 95% credible interval 0.87-1.37 respectively) with the probability that the deaths in these postcodes coincided with the dates of the fire (0.89 and temperature corrected 0.80 respectively).

The updated Barnett (2015) paper reports even more ambiguous results. The relative risk corrected for temperature is 1.103, with 95% credible interval 0.895-1.337. The 0.82 probability that the death rate increased at the time of the fire is the amount of the credible interval that falls above 1.0. Thus postcodes 3842 (Churchill) and 3844 (Tralralgon), show a relatively high probability that the relative risk increased, because most of the 95% credible interval around the mean falls above 1.0. However neither of these probabilities reaches 0.95, and that is why the credible intervals include 1.0, and overlap with each other.

These results show in fact that there were *no* additional deaths, rather than the 0.8 deaths per postcode per month and 9.6 deaths per postcode over two months reported by Barnett (2015). The interpretation of, and subsequent media reports of, increased mortality due to the fire appear to be based on this misinterpretation of an ambiguous result.

Barnett (2015) shows much uncertainty around the estimated likelihood that the dates of the fire are associated with excess mortality. These results do not evaluate the posited increase in mortality due to fire by considering the alternative explanations such as no effect at all or a decrease in mortality. Thus, for the Morwell postcode (location of the fire) along with the Jumbuk and Boolara postcodes, there is a greater than 0.76 probability that the dates of the fire are associated with *decreased* mortality (Table 3).

The scarce data underlying these reported likelihoods present a problem in interpretation that can be better understood by converting the mean absolute deaths per postcode into the 95% credible intervals (Table 3). Thus, we are 95% certain that for Moe (postcode 3825) the dates of the fire are associated with as many as many as 4 or fewer *prevented* deaths, or as many as 8 or fewer *caused* deaths. For Morwell (postcode 3840, location of the fire), we can be 95% certain that the dates of the fire are associated with as many as 5 or fewer *prevented* deaths, or as many as 3 or fewer *caused* deaths.

The scarce data underlying these analyses prevent the confident conclusion that the period of the fire is associated with statistically significant increased mortality in the Latrobe Valley postcodes. These analyses are framed by support for the argument of association between the excess mortality in some postcodes at the time of the fire. However, these analyses are limited by their neglect of a fuller explanation of results.