Health effects of bushfire smoke
Michael Abramson

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• Unrelated consultancy for AstraZeneca
• Assistance with attendance at other conferences from Boehringer-Ingelheim and Sanofi
Work packages

- Australian Children’s Air Pollution Study (ACHAPS)
- Lane Cove Tunnel Investigation
- Older People’s Air Pollution Study (OPAS)
- Biomass smoke and health
- Ultrafine Particles from Traffic Emissions and Children’s Health (UPTECH)
- European Community Respiratory Health Survey (ECRHS)
- Tasmanian Longitudinal Health Study (TAHS)
- Melbourne Atopic Cohort Study (MACS) – TP011
- Childhood Asthma Prevention Study (CAPS)
- Burden of Obstructive Lung Disease (BOLD)
Overview

- Major Victorian bushfires
- Time series studies of bushfire smoke and hospital admissions / emergency presentations
- Case-crossover study of bushfire smoke exposure and out of hospital cardiac arrests
- Planned burn study – smoke impacts on community health and social perceptions
- Conclusions
Victorian Bushfires


Background

- Uncontrolled bushfires can result in adverse effects on physical health, death and loss of property and livelihood.
- There are increasing concerns that global warming will increase the frequency and severity of bushfires in the future.
- Bushfire smoke contains particulate matter, gases and VOC that disperse over long distances and can cause respiratory problems in communities not directly threatened by fire.
- In 2003 bushfires burnt over 1.12 Mha in north-eastern and Alpine Victoria and smoke spread over the state.
- The major pollutants produced were respirable particles (PM$_{10}$), visibility-reducing particles (API) and O$_3$. 
Methods

- Ecological study using routinely available data
- Victorian hospital admissions and emergency department (ED) attendances for selected respiratory conditions known to be affected by smoke:
  - acute bronchiolitis, bronchitis not specified as acute or chronic,
  - simple and mucopurulent chronic bronchitis,
  - Emphysema, other chronic obstructive pulmonary disease (COPD),
  - Asthma, status asthmaticus, bronchiectasis
- EPA air quality data: PM$_{10}$, Airborne Particle Index (API), O$_3$
- Bureau of Meteorology data: maximum temperature, rainfall, wind speed and average relative humidity.
- The bushfire season defined as October 2002 to April 2003.

Statistical methods

- Time series plots explored variations in air pollutants and respiratory-related hospital data
- A semi-parametric Poisson regression (single pollutant model) was used to evaluate the effect of bushfire marker pollutants on respiratory outcomes
- Penalized regression splines were used to estimate smooth terms in the models using Generalised Additive Models in R
- Possible lagged effects (1 day) were investigated
Results

PM$_{10}$ levels elevated from mid-January to mid-March 2003 with 6 days exceeding the NEPM one-day standard of 50μg/m$^3$. 2 extreme spikes due to a dust storm on 19-20 March 2003 12 days when API exceeded the EPA standard of 2.35

Results

Semiparametric models of respiratory outcomes in Melbourne

<table>
<thead>
<tr>
<th>Outcome</th>
<th>RR$^3$</th>
<th>95% CI</th>
<th>p</th>
<th>RR$^3$</th>
<th>95% CI</th>
<th>p</th>
<th>RR$^3$</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital admissions</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Model A</td>
<td>1.011</td>
<td>0.999 – 1.022</td>
<td>0.06</td>
<td>1.011</td>
<td>1.003 – 1.019</td>
<td>0.01</td>
<td>1.027</td>
<td>1.001 – 1.053</td>
<td>0.01</td>
</tr>
<tr>
<td>Model B</td>
<td>1.003</td>
<td>0.989 – 1.015</td>
<td>0.69</td>
<td>1.005</td>
<td>0.995 – 1.013</td>
<td>0.33</td>
<td>0.988</td>
<td>0.950 – 1.026</td>
<td>0.50</td>
</tr>
<tr>
<td>Emergency department attendances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Model A</td>
<td>1.028</td>
<td>1.015 – 1.040</td>
<td>&lt;0.001</td>
<td>1.010</td>
<td>1.000 – 1.021</td>
<td>0.02</td>
<td>1.026</td>
<td>0.996 – 1.056</td>
<td>0.07</td>
</tr>
<tr>
<td>Model B</td>
<td>1.018</td>
<td>1.004 – 1.033</td>
<td>0.01</td>
<td>1.008</td>
<td>0.996 – 1.019</td>
<td>0.2</td>
<td>0.988</td>
<td>0.943 – 1.034</td>
<td>0.57</td>
</tr>
</tbody>
</table>

RR for IQR increase in pollutant
Model A adjusted for day of week and trend
Model B also adjusted for temperature and relative humidity
Discussion

- Elevated levels of PM$_{10}$, rather than API or O$_3$, increased the risk for exposed people to attend an ED for respiratory conditions.

- Although this study had limited sample size, it used appropriate statistical models including nonlinear effects of time trend and other confounders. Therefore, the results are valid even though the observed increased risks were small.

- No significant associations between PM$_{10}$, API and O$_3$ on respiratory hospital outcomes in residents from Gippsland could be due to smaller population, greater distances to hospitals hence greater reliance on primary health care, or better knowledge of how to manage exposure to bushfire smoke.

MODIS Terra satellite image taken on 20/12/2006 (courtesy of NASA)

Melbourne

13th December 2006

2006/2007 bushfire season

Aim

- To measure the association between out-of-hospital cardiac arrest (OHCA) and bushfire smoke exposures in a large city during a severe bushfire season, and estimate the excess OHCA due to the fire smoke

Methods

- Case-crossover study of Melbourne adults > 35 years old
- Conditional logistic regression models to estimate % increase in OHCA per IQR increase in exposure
- Hourly air pollutant and meteorological data from central monitoring site
Outcome: Cardiac Arrest

- Abrupt cessation of blood circulation when the heart fails to contract effectively
- Grave prognosis without prompt treatment
- Potentially reversible if treated early enough
- Multiple causes including: cardiac disease, trauma, overdose, poisoning, terminal illness, hanging, drowning, electrocution, respiratory, etc

Victorian Ambulance Cardiac Arrest Registry

- Ambulance Victoria initiative funded by DoH
- Captures data for all Victorian OHCA attended by ambulance paramedics since 1999
- Includes any patient who is pulseless at any stage while attended by paramedics
Results

- 2046 OHCA occurred during the study period (July 2006 to June 2007) in metropolitan Melbourne
- 64% were men and the mean age was 71.8 ± 14.2 years.
- Of these, 783 (38%) occurred during the fire season (November 2006 to March 2007)
- Men were significantly younger than women when an OHCA occurred, 69.6 vs 75.8 years respectively ($p<0.01$)
- Highest hourly PM$_{2.5}$ exposure was 247.2µg/m$^3$ at 3pm on 20/12/2006.
- A total of 174 ‘fire-hours’ were identified during the 2006/2007 fire season, over 12 days (defined by PM$_{2.5}$, CO and air trajectory)
Estimated % difference in the rate of OHCA for IQR increase in air pollutants

<table>
<thead>
<tr>
<th>Study population</th>
<th>Hourly lags</th>
<th>PM$_{2.5}$ (%)</th>
<th>PM$_{10}$ (%)</th>
<th>CO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>95%CI</td>
<td>95%CI</td>
<td></td>
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<tr>
<td>Total (N = 783)</td>
<td>0</td>
<td>1.9 (-0.6-4.5)</td>
<td>3.0 (-1.4-7.5)</td>
<td>3.9 (-6.0-14.8)</td>
</tr>
<tr>
<td></td>
<td>0:24</td>
<td>3.5 (-0.1-7.3)</td>
<td>7.0 (0.8-13.6)*</td>
<td>16.5 (-0.1-35.8)</td>
</tr>
<tr>
<td></td>
<td>0:48</td>
<td>5.4 (0.9-10.2)*</td>
<td>7.7 (0.3-15.8)*</td>
<td>24.6 (4.5-48.0)*</td>
</tr>
<tr>
<td>Men (n = 500)</td>
<td>0</td>
<td>2.5 (-0.7-5.7)</td>
<td>4.5 (-1.0-10.3)</td>
<td>6.9 (-5.8-21.3)</td>
</tr>
<tr>
<td></td>
<td>0:24</td>
<td>4.7 (0.1-9.4)*</td>
<td>8.3 (0.6-16.6)*</td>
<td>24.6 (2.9-50.8)*</td>
</tr>
<tr>
<td></td>
<td>0:48</td>
<td>8.1 (2.3-14.1)**</td>
<td>11.1 (1.6-21.5)*</td>
<td>35.7 (9.0-68.9)**</td>
</tr>
<tr>
<td>Women (n = 283)</td>
<td>0</td>
<td>0.9 (-3.3-5.2)</td>
<td>0.4 (1.5-21.5)</td>
<td>-1.3 (-16.2-16.2)</td>
</tr>
<tr>
<td></td>
<td>0:24</td>
<td>1.1 (-4.9-7.6)</td>
<td>4.1 (-6.0-15.3)</td>
<td>0.9 (-22.4-31.4)</td>
</tr>
<tr>
<td></td>
<td>0:48</td>
<td>0.2 (-7.2-8.2)</td>
<td>1.3 (-10.4-14.4)</td>
<td>4.3 (-22.1-39.8)</td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.01

Conclusions

Excess arrests attributable to bushfire smoke

- Model-derived: 23.9 (95%CI: 3.1, 40.2) excess arrests associated with ‘fire-hours’
- Direct calculation: 28.9 (95%CI: 3.8, 52.9) excess arrests associated with ‘fire-hours’

- Delayed or cumulative associations with PM$_{2.5}$ and CO
- ?Greater cardiovascular risk factors in men
- Mechanisms: systemic inflammation with hypercoagulability, autonomic dysfunction with lethal arrhythmias
- Limitation: one central monitoring station in Melbourne
- Implications for public health messages, planning of emergency services during fire seasons
Smoke impacts on community health and social perceptions
Research team

Investigators from CAR

- Dr Fay Johnston, University of Tasmania
- Prof Guy Marks, Woolcock Institute
- Prof Bin Jalaludin, University of NSW and NSW Health
- A/Prof Geoff Morgan, University of Sydney and NSW Health
- Prof Michael Abramson, Monash University

Investigators with specific expertise

- Dr Martine Dennekamp, Monash University (bushfire smoke research)
- Dr Fabienne Reisen, CSIRO (smoke exposure assessment)
- Dr Anna Lyth, University of Tasmania (social research)

Planned burning in Victoria

- Burning landscapes under controlled conditions to reduce fuel loads in order to minimise the intensity & severity of bushfires

- Code of practice for bushfire management on public land (2012) supports delivery of an expanded planned burning program

- The levels of exposure and the health risks in communities affected by smoke from prescribed burning is uncertain

Code of Practice for bushfire management on public land. DSE Victoria June 2012
Planned Burns Project

AIM: To assess the cardiovascular and respiratory health effects from exposure to air pollutants emitted from bushfire smoke and planned burning in the rural and urban communities in Victoria

Clinical Research Study

- Autumn seasons 2013-15
- Panel study of 107 volunteers
  - 50% participants > 65 years
  - Spend > 12 hours per day within the study area
- Recruitment via local newspapers, local radio, internet, Community Health Centres, General Practices and external CATI company
- Exposure data – PM$_{2.5}$

Hourly concentrations of PM$_{2.5}$ during planned burning in Warburton

![Graph showing PM$_{2.5}$ concentrations over time](image)
Individual health outcomes

Daily measured health outcomes (3-4 weeks)
- Diary
  - Day and night symptoms
  - Medication use
  - Health services utilisation
- Lung function measurements
  PiKo6 electronic lung function monitor (FEV₁ and FEV₆)

Health outcomes measured on 2-3 occasions
- Lung inflammation test (exhaled NO)
- Blood pressure
- Heart rate variability & ischaemia
- Peripheral arterial tone
- Blood markers of inflammation

Conclusions

- Bushfires are a major natural hazard in Australia and likely to become more frequent and severe with climate change
- Apart from the direct effects of fires, smoke contains high levels of fine particulates which can be transported into population centres
- Bushfire smoke exposure is associated with emergency presentations and hospital admissions for respiratory diseases
- Bushfire smoke exposure is also associated with an excess of out of hospital cardiac arrests
- Our current research is focused on the cardiac and respiratory effects of smoke exposure from planned fuel reduction burns
Acknowledgments

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- Fay Johnston, Anna Lyth, Guy Marks, Bin Jalaludin, Geoff Morgan, Fabienne Reisen

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- Centre for Air quality & health Research & evaluation
- NHMRC, Bushfire & Natural Hazards CRC
- Department of Sustainability & Primary Industries

Agencies: Ambulance Victoria
- EPA Victoria, Bureau of Meteorology