Health risks of air toxics in bushfire smoke

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School of Population Health:
Overview of CRC Bushfire research

- Team leaders: Professor Phil WEINSTEIN, Dr Angus COOK, Dr Chantal TOMKINS, Mr Brian DEVINE
- Annemarie DE VOS, PhD:
  - Experimental trial of safety of protective masks/filters in bushfires; **short-term health effects of air toxic exposure in firefighters**
- Melissa FIXTER, PhD:
  - Occupational cohort study of **long-term cardio-respiratory health outcomes in firefighters**
- Yih-Pyng LEE, Masters:
  - **Community asthma admissions** in relation to bushfire events

OBJECTIVES/OVERVIEW (1)

→Scarcity of research on the potential health effects of exposure to combustion products generated by vegetation fires in Australasia

….. Yet, given the high annual frequency of bush-fires, the risk of inhalation injury to firefighters and communities is considerable.

OBJECTIVES/ OVERVIEW (2)

How can the current risk assessment research on air toxics and other environmental exposures guide our decisions on safety in the bushfire setting?

* Components of a risk assessment :
  - *Hazard identification*
  - *Dose-response assessment*
  - *Exposure assessment*
  - *Risk estimation and characterisation*

* Factoring in the uncertainty

* Recommendations

- The air toxics (or “toxic air pollutants”) encompass a category of airborne agents about which significant concerns have recently been raised, including by the USEPA and Australian National Environment Protection Council.

- Examples of **gaseous** toxic air pollutants include **formaldehyde, benzene, toluene and xylenes**

- Examples of air toxics typically associated with **particulate matter** include **heavy metals** such as cadmium, mercury, chromium, and lead compounds; and **semivolatile organic compounds such as polycyclic aromatic hydrocarbons (PAHs)** which are generally emitted within fine particles from the combustion of wastes and fossil fuels.

- Air toxics can enter the environment in a number of ways

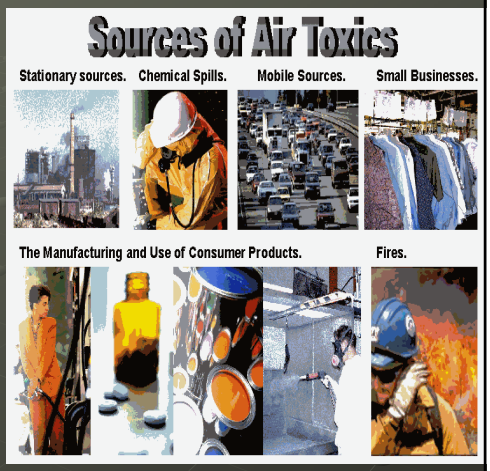
eg

‘mobile sources’ such as vehicle emissions; OR

‘area-level or point sources’ such as power generating processes; manufacturing; solvent use; wood burning

ALSO many **major indoor sources**

eg cigarette smoking; heating sources; carpets; furniture in homes and offices



RISK ASSESSMENT (1): *Hazard identification*

- CSIRO Melbourne and Chemistry Centre of Western Australia (CCWA) have taken repeated air samples during simulated and real burns and recorded a range of potentially toxic smoke components.

- These pollutants include **formaldehyde, acrolein, xylenes, toluene, benzene, terpenes and many other volatile compounds**

→ **these compounds capable of causing respiratory illness, neurological symptoms, cancer and a range of other health effects**

(*Agency for Toxic Substances and Disease Registry/CDC)

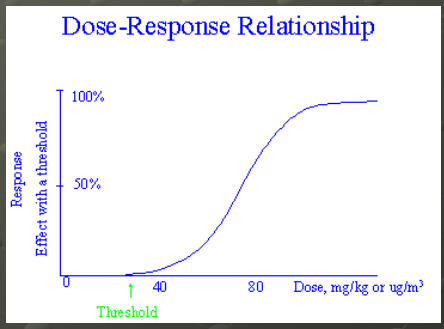
Example: Air toxics that induce or exacerbate asthma

Table 5. Hazardous air pollutants that can exacerbate or induce asthma

Chemical class	Compound[a]
Aldehydes	Acetaldehyde[b] Acrolein[b] Formaldehyde[b] Propionaldehyde
Anhydrides	*Maleic anhydride* *Phthalic anhydride*
Isocyanates	*Hexamethylene-1,6-diisocyanate* *Methylene diphenyl diisocyanate* *Methyl isocyanate* Toluene diisocyanate
Metals	Cadmium compounds[b] *Chromium compounds*[b] Cobalt compounds Manganese compounds[b] *Nickel compounds*[b]
Other compounds	Carbaryl *Chlorine* *Coke oven emissions*[b] *Diazomethane* *Diethanolamine* *Ethylene imine (aziridine)* *Ethylene oxide*[b] Hydrochloric acid *Methyl methylacrylate* *Styrene*

RISK ASSESSMENT (2): *Dose-response assessment*

- The disease burden associated for some air toxic levels has been estimated using the USEPA, Australian National Environment Protection Council protocols, and current toxicological literature on respiratory, cardiovascular, carcinogenic and other adverse effects

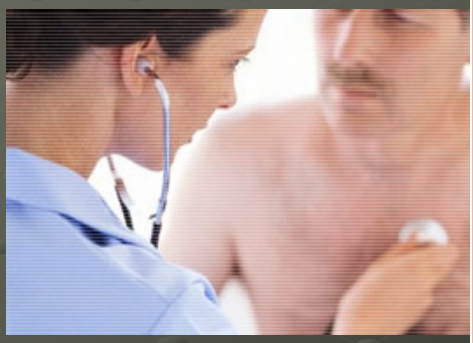


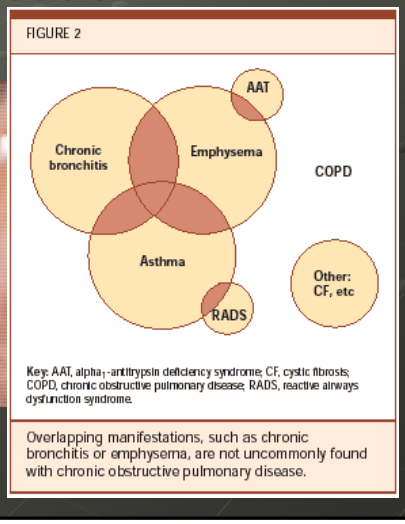
RISK ASSESSMENT (3): *Exposure assessment*

- The **relative levels and durations of exposure** for firefighters and communities is currently being assessed based on occupational histories and regional and urban bushfire alerts in Western Australia.


Summer wildfire in dry sclerophyll forest on Black Mountain, ACT.
Source: AM Gill, CSIRO Plant Industry.

RISK ASSESSMENT (4):
Risk estimation and characterisation





- Health outcomes can be conceived in terms of EXCESS RISK

Eg For polycyclic aromatic hydrocarbons (PAHs), excess disease risk/excess cases over that "expected" in a given population

α [BaP (benzo[a]pyrene, an indicator of PAHs) level in bushfire smoke
x inhalation rate
x total exposure duration over working lifetime
x proportion time used of protective equipment]

Example: it has been estimated (eg Armstrong, 1994) that after 40 years exposure at the current hygiene standard (0.2mg/m^3) for BaP = associated with a lifetime excess risk of lung cancer of 3.8%

[the risk of an exposed individual getting lung cancer in their lifetime is increased by 3.8% above the risk for the general population]

Risk can also be expressed in other ways

- Quote from 2002:

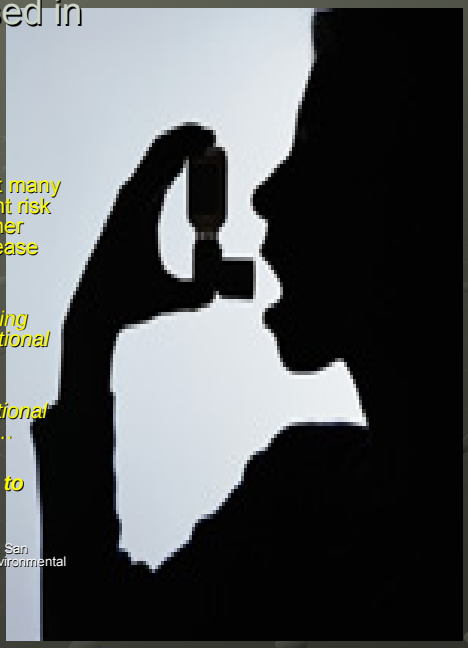
American Thoracic Society (ATS) is alerting physicians that occupational exposures put many workers – such as firefighters - at significant risk for chronic bronchitis, emphysema, and other kinds of chronic obstructive pulmonary disease (COPD).

"Many doctors think that COPD is due to smoking and don't necessarily consider that occupational exposure may also cause the disease.

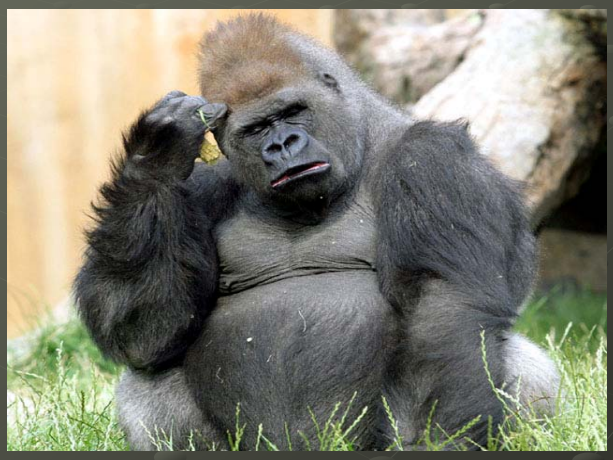
We now have very good evidence that occupational exposure contributes in a substantial way….

An estimated 15 percent of all COPD is due to exposure on the job"

- Dr John Balmes, a pulmonary specialist at University of California San Francisco and Director of the Center for Occupational and Environmental Health



RISK ASSESSMENT (5):
Factoring in the uncertainty



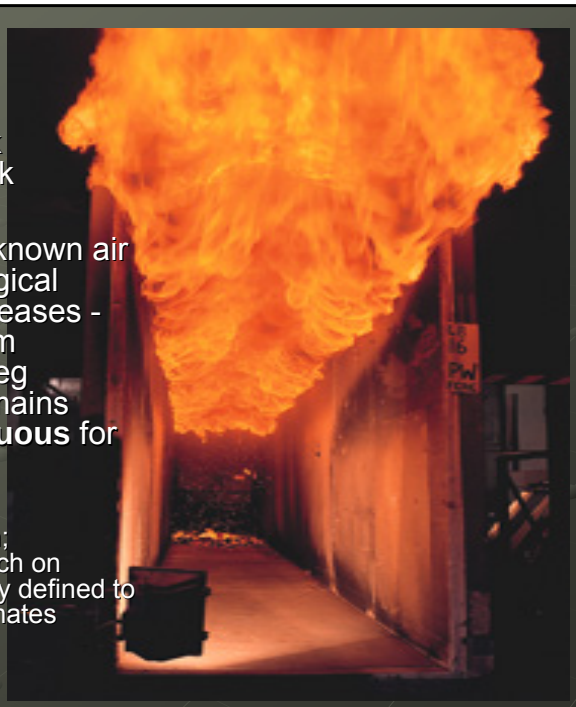
- Recent literature and analyses by CRC Bushfire have identified a number of recurring air toxics of concern:

  - **particulates / polycyclic aromatic hydrocarbons (PAHs)**
  - **formaldehyde**
  - **acrolein**

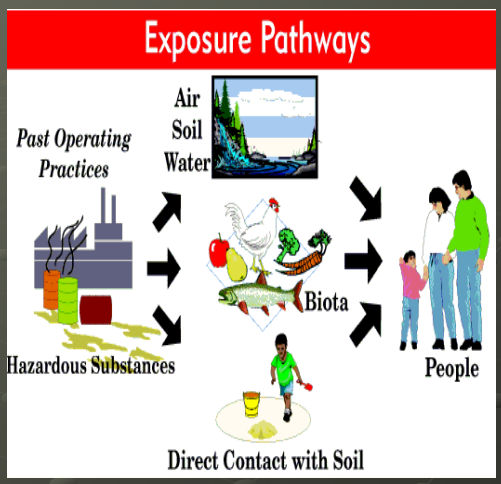
BUT despite the ideal appearance of the risk assessment framework

→ Even for these better known air toxics, the epidemiological evidence for many diseases - especially for long-term respiratory outcomes eg asthma; cancers – remains **incomplete** or **ambiguous** for many compounds

Eg acrolein – very little known; formaldehyde – the research on cancer risk is still too poorly defined to generate specific risk estimates



How to assess and predict the health impacts of the extensive range of compounds present in bushfire smoke?



→ This issue confronts many occupational and environmental epidemiologists attempting to address air, water and food contaminants = many hundreds of possible agents may be detected

BUT which are important?

- Often, compounds present at low concentrations are dismissed or thrown out of exposure models

- One emerging alternative may be to assess exposure to multiple agents through **the risk quotient**

→ this is modelled on **combined ecotoxicological estimates for chemical pollutants**, where individuals are exposed to multiple agents

Risk estimates for agents (Q) =

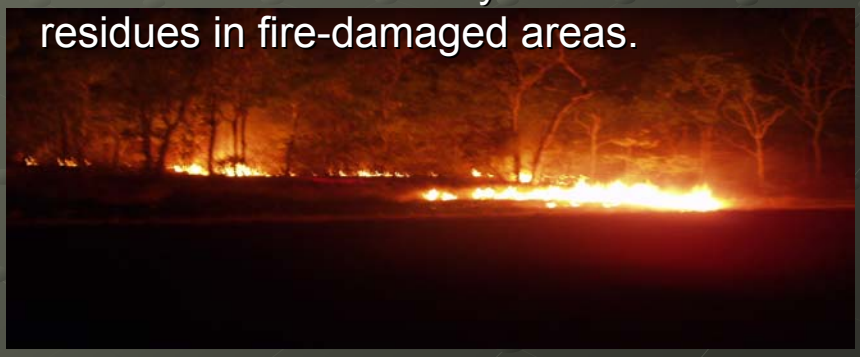
$$\frac{\text{Exposure Reference Values}}{\text{Toxicity Reference Values}}$$

→ These are cumulatively totalled for agents present at lower concentrations

= Q values greater than 1.0 signify the likelihood or potential for adverse effects to occur THUS need to be monitored on an ongoing basis, while Q values less than one imply no hazard to organisms and no further risk assessment.

SUMMARY (1)

Our analysis has indicated that numerous air toxics are present in bushfire smoke and thus pose potential risks for occupational groups – such as firefighters – as well as communities affected by smoke haze and residues in fire-damaged areas.



SUMMARY (2)

TWO MAJOR COMPLICATING FACTORS IN ANY RISK ASSESSMENT:

- Information on the compounds present at higher levels often remains inconclusive – especially with regard to longer-term health effects
- Many individual air toxics are present at levels well below occupational standards and their attributable risk of exposure is probably negligible in bushfire settings

BUT

we need to quantify these agents consistently in some way + allow for their fact they could exceed safety limits in combination

RECOMMENDATIONS

- **Need to prioritise which airborne compounds are associated with an established disease risk AND which are present in significant concentrations in the fireground**
  eg formaldehyde; acrolein; PAHs
- **Need to ensure maximal protection against these prioritised air toxics**
  eg ensure training is provided with an emphasis on minimising smoke exposure + that optimal protective equipment is always available and consistently used
- **Need to improve risk assessment in a quantifiable manner for the array of detectable agents measured over a range of bushfire scenarios**
  eg using the risk quotient
- **Ongoing surveillance of health outcomes is required to ascertain health risks and ensure the adequacy of protective/safety measures in Australasian communities and FESA employees during and following bushfires.**