Health Risk Assessment – Preliminary Work to Identify Concentration-Response Functions for Selected Ambient Air Pollutants

Report prepared for EPA Victoria

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Background

EPA Victoria wishes to identify health endpoints and relevant concentration-response functions (CRFs) associated with exposure to particulate matter less than 10μg (PM_{10}) and 2.5μg ($PM_{2.5}$) in diameter, nitrogen dioxide (NO_2), ozone (O_3) and sulphur dioxide (SO_2) in ambient air. This preliminary work is expected to form the basis of an exposure assessment and risk characterisation for a broader health risk assessment (HRA) project for the review of the National Environment Protection (Ambient Air Quality) Measure.

Scope of the project

The scope of the consultancy was as follows:

1. All relevant health endpoints for PM_{10}, $PM_{2.5}$, NO_2, O_3 and SO_2 to be identified.

2. For each health endpoint, the relevant associated CRF will be identified. In the first instance, CRFs from Australian studies will be identified. If Australian studies are either not available or not appropriate, then CRFs from international studies will be identified.

3. Health endpoints and associated CRFs to be identified solely from published reports, systematic reviews and meta-analyses. The grey literature from the United Kingdom (for example, Department of Health), United States (for example, US EPA), the European Union, World Health Organization and Australia, and electronic databases (for example, Medline, PubMed) will be searched for any published systematic reviews and meta-analyses. Literature reviews, systematic reviews or meta-analyses of primary studies will not be conducted.

4. Weight of evidence (WoE) assessments of primary studies will not be conducted. WoE requires interpretation of findings from all epidemiological and toxicological studies (of air pollutants in this instance) to form a considered opinion on the relevance and the significance of the findings overall. It involves evaluating the quality of measurement methods, size and power of study design, consistency of results across studies, and biological plausibility of CRFs and statistical associations. Such WoE assessments are beyond the scope of this consultancy. WoE outlined in reviews and reports identified under point 3 above will be assessed.

5. Information on the availability of routinely collected baseline health data at the state or national level where available will be provided.

Health effects of air pollution

Exposure to ambient air pollution has been linked to various health outcomes ranging from small transient changes in the respiratory tract and impaired lung function, restricted activity/reduced performance, emergency department visits and hospital admissions to mortality. There is also now strong evidence that there are important effects on the cardiovascular system. The most severe effects in terms of the overall health burden include a significant reduction in life expectancy of the average population which is linked to long-term exposure to high levels of particulate matter (PM). Documented health effects associated with air pollution exposures are shown in the table below (WHO Europe 2000; WHO Europe 2004).

Table: Health effects of ambient air pollution

Air pollutant	Effects related to short-term exposure	Effects related to long-term exposure
Particulate matter	• Lung inflammatory reactions • Respiratory symptoms • Adverse effects on the cardiovascular system • Increased medication use • Increased hospitalisations • Increased mortality	• Increase in lower respiratory symptoms • Reductions in lung function in children • Increase in chronic obstructive pulmonary disease • Reductions in lung function in adults • Reduction in life expectancy, mainly due to cardiopulmonary mortality and probably to lung cancer
Ozone	• Adverse effects on pulmonary function • Lung inflammatory reactions • Adverse effects on the respiratory system • Increased medication use • Increased hospitalisations • Increased mortality	• Reductions in lung function development
Nitrogen dioxide (an indicator of traffic-related air pollution)	• Effects on pulmonary function, especially in asthmatics • Increase in airway allergic inflammatory reactions • Increased hospitalisations • Increased mortality	• Reduction in lung function • Increased probability of respiratory symptoms
Sulphur dioxide	• Effects on pulmonary function, especially in asthmatics • Increased hospitalisations • Increased mortality	• Probable reduction in life expectancy

Brief overview of published health risk assessments and cost-benefit analyses

Health risk assessments (HRAs) are often undertaken to provide data for cost-benefit analyses (CBAs).

The World Health Organisation has suggested that health outcomes that are potentially relevant and should be considered in a HRA include the following (WHO Europe 2001):

Acute (short-term) outcomes

- Daily mortality
- Respiratory hospital admissions
- Cardiovascular hospital admissions
- Emergency room visits for respiratory and cardiac problems
- Primary care visits for respiratory and cardiac conditions
- Use of respiratory and cardiovascular medications
- Days of restricted activity
- Work absenteeism
- School days missed
- Self-medication
- Avoidance behaviour
- Acute symptoms
- Physiologic changes, for example, in lung function

Chronic (long-term) disease outcomes

- Mortality (in infants and adults) from cardiopulmonary disease
- Chronic respiratory disease incidence and prevalence (including asthma, chronic obstructive pulmonary disease (COPD))
- Chronic change in physiologic function
- Lung cancer
- Chronic cardiovascular disease

Reproductive outcomes

- Pregnancy complications (including foetal death)
- Low birth weight
- Pre-term delivery

However, in reviewing existing guideline documents it is clear that evidence for some of these outcomes is either inadequate or inconsistent, leading to difficulty in setting CRFs. Where data are adequate, CRFs have been established. Often these have been location specific with European agencies using data from European studies and the United States Environmental Protection Agency (USEPA) using data from US studies. Occasionally, CRFs have been chosen based on the results of one epidemiological study only. Reports of CBAs of air pollutants provide a good source of information on CRFs and these have been reviewed for this project.

A recent report summarised eight major CBAs (Jalaludin, Salkeld et al. 2009) from the USA (US EPA 1999; US EPA 2004), Europe (Seethaler 1999; AEA Technology Environment 2005; DEFRA 2006), New Zealand (Fisher, Kjellstrom et al. 2005) and Australia (BTRE 2005; DEC 2005). The pollutants commonly evaluated in CBAs include PM_{10}, $PM_{2.5}$, O_3, SO_2, NO_2 and carbon monoxide (CO). There is good evidence and a broad epidemiological literature to obtain CRFs for PM. While all of the eight CBAs assessed the effects of PM, four of them (Seethaler 1999; BTRE 2005; DEC 2005; Fisher, Kjellstrom et al. 2005) used PM as the only indicator of ambient air pollution for cost-benefit purposes. However, a concern is that selecting only one ambient air pollutant as the main pollutant may underestimate the magnitude of the health effects. Adding the health effect estimates of another air pollutant not correlated with PM (for example, O_3) can minimise the extent of this underestimation. Some of the reviewed CBAs have used this approach.

However, other CBAs also quantified the health effects of other air pollutants, for example, SO_2, NO_2 and CO, in addition to PM either in the main analysis or in sensitivity analyses. An issue here is that ambient concentration of some of these air pollutants are highly correlated making it difficult to separate out the effects of the individual pollutants. This is particularly the case for PM and NO_2, PM and SO_2 (overseas) and also sometimes for NO_2 and $O_{3.}$ It is therefore thought that NO_2 and SO_2 might be markers or surrogates of the effects of PM pollution and that they do not exert independent adverse effects on health. Therefore, simply summing the health effects associated with each of the specific pollutants can lead to an overestimation of the total health effects.

Some studies have used multi-pollutant models in their analyses in an attempt to distinguish the independent effects of each pollutant. In general, they have found that the estimates for the effects of PM pollution are robust and change minimally when pollutants such as NO_2 and SO_2 are added to the model. This implies that the majority of effects seen are likely to be due to exposure to PM in ambient air rather than to the other pollutants. In Australian studies, the effects of exposure to O_3 have been similarly robust and independent of the effects of other pollutants.

Therefore, in HRAs and CBAs, use is often made of a single index pollutant (or surrogate pollutant) or alternatively two pollutants. This approach encompasses the majority of effects of all other correlated pollutants, and avoids the issue of overestimation of effects. Currently, the USEPA (US EPA 2011) and the European Commission (European Commission 2005) focus only on PM and O_3 in their HRAs, for these reasons. The recent CBA from the United States (US EPA 2011) quantified and monetised health endpoints only for PM and O_3 as follows:

1. PM
    a. Premature mortality (long-term exposure)
    b. Chronic and acute bronchitis
    c. Hospital admissions for cardiovascular disease and respiratory disease
    d. Emergency department visits for asthma
    e. Non-fatal heart attacks
    f. Lower respiratory symptoms
    g. Minor restricted activity days
    h. Work loss days
    i. Asthma exacerbations (asthmatic population)
    j. Upper respiratory symptoms (asthmatic population)
    k. Infant mortality

2. O_3
    a. Premature mortality (short-term exposure)
    b. Hospital admissions for respiratory disease
    c. Emergency department visits for asthma
    d. Minor restricted activity days
    e. School loss days
    f. Outdoor worker productivity

Health effects associated with ambient air pollution are divided into two broad categories - premature mortality and morbidity. For PM (PM_{10}, $PM_{2.5}$), there is an established association with both long-term and short-term premature mortality. Only one CBA (DEFRA 2006) quantified both the long-term and short-term premature mortality. The other CBAs only quantified long-term premature mortality as any short-term mortality effects would be captured in the long-term mortality effects. The other two key health effects quantified for PM by all the CBAs were respiratory and cardiovascular hospital admissions.

Of the eight CBAs reviewed, four quantified the health effects associated with O_3 (US EPA 1999; US EPA 2004; AEA Technology Environment 2005; DEFRA 2006). The most common health effect quantified was respiratory hospital admissions. Two CBAs also quantified the short-term effect of ozone on premature mortality (AEA Technology Environment 2005; DEFRA 2006). Other health endpoints reported in at least two CBAs were emergency department visits for asthma and minor restricted activity days, although at least for the latter health outcome, quantification is based primarily on one study only.

Two CBAs quantified the effects of NO_2 (US EPA 1999; DEFRA 2006) and SO_2 (US EPA 1999; DEFRA 2006) and only one report quantified the effect of CO (US EPA 1999). For NO_2, the health effects that were quantified included respiratory and cardiovascular disease hospital admissions and respiratory illness; for SO_2 they included short-term mortality, cardiovascular disease hospital admissions and respiratory illness; and, for CO they included only respiratory and cardiovascular disease hospital admissions.

Brief overview of hazard assessment in Australia

In 2011, the National Environment Protection Council (NEPC) (National Environment Protection Council 2011) recommended the following approach to hazard assessment::

- Human-based studies are preferred.

- Epidemiological studies, especially those representative of the general population (including sensitive groups), should be used, if available. Controlled human exposure studies should only be used for short-term health outcomes, when appropriate epidemiological studies are not available. Toxicological studies should be used as supporting evidence of biological plausibility and coherence of effect. When no epidemiological human data are available, toxicological evidence can be used for standard setting, with the appropriate application of uncertainty factors.

- Any clinically significant effect of air pollution should be considered adverse.

- Mortality should be considered as a critical health outcome.

- More sensitive health outcomes (for example, hospital admissions, emergency department visits, exacerbation of asthma and other respiratory or cardiovascular diseases and reversible decrements in lung function) should also be used where CRFs are available. Particular attention should be paid to people with asthma, given the high prevalence of asthma in the Australian population.

- Broader quality-of-life issues, such as work loss days and school absenteeism, should be considered as health outcomes where data are available.

- Sensitive subpopulations within the general population should be taken into consideration; they include children, older adults, people with existing respiratory and cardiovascular disease, asthmatics, diabetics, and low socioeconomic groups.

- A non-threshold approach should be taken for the current criteria pollutants.

- CRFs obtained from meta-analyses or multi-city studies should be used, provided the primary data are homogeneous. If significant heterogeneity is present, then CRFs for single cities should be used, and risk assessed for the relevant cities for which data are available.

- CRFs from well-conducted Australian studies are preferred. If high-quality Australian data for a particular health outcome are not available, then CRFs from overseas studies should be used provided the nature of the exposure and demographics of the population are similar. If overseas data are used, then the uncertainties associated with the use of the data need to be well documented.

When individual epidemiological studies are used to derive CRFs, the National Health and Medical Research Council (National Health and Medical Research Council 2006) recommends the following steps to assess the validity and usefulness of such studies:

- *Step 1—Evaluate studies for internal validity*: that is, the adequacy of study design and the extent to which it has validly measured what it intends or purports to measure.

- *Step 2 —Evaluate studies for external validity*: that is, determine whether the results can be validly generalised, extrapolated or transferred to other settings (for example, climatic, demographic, pollution sources and levels).
- *Step 3 —Evaluate corroboration, contradiction and plausibility:* that is, consider whether the Bradford-Hill criteria may be useful here.
- *Step 4 —Make a choice*: that is, select the study or studies that best represent the endpoint of most relevance for setting an air quality standard.

Methods used in this report

For this report, we have broadly followed the approach recommended by the NEPC (National Environment Protection Council 2011). However, in view of the very short timeframe for the completion of this report, we have adopted the following approach:

1. Only human epidemiological studies were considered. We have not considered controlled human exposure studies and toxicological studies.

2. CRFs representative of the general population were selected where available.

3. Identification of relevant health endpoints and associated CRFs from published reports, systematic reviews and meta-analyses from:
    - United Kingdom (Committee on the Medical Effects of Air Pollutants 1998; Committee on the Medical Effects of Air Pollutants 2007; Committee on the Medical Effects of Air Pollutants 2009; Committee on the Medical Effects of Air Pollutants 2010);
    - United States (US EPA 2006; US EPA 2008; US EPA 2010; US EPA 2010; US EPA 2010; US EPA 2011);
    - European Commission (AEA Technology Environment 2005; European Commission 2005);
    - World Health Organization (WHO Europe 2000; WHO Europe 2003; WHO Europe 2004); and,
    - Australia (Curtin University of Technology 2009; Jalaludin, Salkeld et al. 2009).

4. Identification of relevant health endpoints and associated CRFs from individual Australian studies if systematic reviews and meta-analyses of Australian studies were not available.

5. Recommended CRFs from well-conducted Australian meta-analyses in the first instance. If CRFs from well-conducted Australian meta-analyses are not available, then CRFs from international reports are recommended. If CRFs from Australian meta-analyses and international reports are not available, then CRFs from individual Australian studies are recommended if appropriate.

For each of the air pollutants, we have tabulated the available health endpoints and associated CRFs. We have also provided references of the source reports and original publications from where the health endpoints and CRFs were derived. Finally, we have recommended CRFs that could be used for HRAs in the Australian context.

There may be assumptions and uncertainties associated with each of the health endpoints and CRFs. We therefore recommend that those who wish to use the health endpoints and associated CRFs also seek out the original reports and publications. CRFs derived from single studies (not meta-analyses or multi-city studies) or single locations should be used with caution as they may not be representative of the larger population.

CRFs for the five air pollutants are presented in Tables 1-5.

Availability of health outcome data

We have reported on the availability of relevant Australian health outcome data deemed useful for HRAs and CBAs (presented in Table 6). Relevant morbidity data will need to be accessed via each state health agency. While the Australian Institute of Health & Welfare does collate state data for some health outcomes, in most cases they will not be available to external users in the format required. Mortality data are available from the Australian Bureau of Statistics. Application to all agencies is necessary and for state agencies the timeframe for receipt of data may vary from a few weeks to a few months.

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Table 1: $PM_{2.5}$ health endpoints and associated concentration-response functions

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Long-term outcomes (annual average concentration)						
Mortality						
All cause	n/a[1]	1.06 (1.04-1.11) per 10 µg/m^3 1.06 (1.00-1.15) per 10 µg/m^3 to be used in a sensitivity analysis. (Pope, Burnett et al. 2002) (Committee on the Medical Effects of Air Pollutants 2009) Age: 30+ years.	1.05 per 10 µg/m^3 (95%CI not provided) Pooled estimate from (Pope, Burnett et al. 2002) (European Commission 2005) Age: 30+years.	1.06 (1.04-1.08) per 10 µg/m^3 (Krewski, Jerrett et al. 2009) (US EPA 2010) All ICD9 Age: 30+years.	1.14 (1.04-1.24) per 10 µg/m^3 (Dockery, Pope et al. 1993) (WHO Europe 2000) Age: 30+ years 1.07 (1.04-1.11) per 10 µg/m^3 (Pope, Thun et al. 1995) (WHO Europe 2000) Age: 30+years.	Recommended CRF: 1.06 (1.04-1.08) per 10 µg/m^3 (Krewski, Jerrett et al. 2009) (US EPA 2010)
Cardiopulmonary	n/a	1.09 (1.03-1.16) per 10 µg/m^3 (Pope, Burnett et al. 2002) (Committee on the Medical Effects of Air Pollutants 2009) Age: 30+ years.	n/a	1.14 (1.11-1.17 per 10 µg/m^3 (Krewski, Jerrett et al. 2009) (US EPA 2010) ICD9: 401-440, 460-519 Age: 30+ years.	n/a	Recommended CRF: 1.14 (1.11-1.17 per 10 µg/m^3 (Krewski, Jerrett et al. 2009) (US EPA 2010)
Ischaemic heart disease	n/a	n/a	n/a	1.24 (1.19-1.28) per 10 µg/m^3 (Krewski, Jerrett et	n/a	Recommended CRF: 1.24 (1.19-1.28) per 10 µg/m^3

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
				al. 2009) (US EPA 2010) ICD9: 410-414 Age: 30+ years.		(Krewski, Jerrett et al. 2009) (US EPA 2010)
Lung cancer	n/a	1.08 (1.01-1.16) per 10 µg/m^3 (Pope, Burnett et al. 2002) (Committee on the Medical Effects of Air Pollutants 2009) Age: 30+ years.	n/a	1.14 (1.06-1.123) per 10 µg/m^3 (Krewski, Jerrett et al. 2009) (US EPA 2010) ICD9: 162 Age: 30+ years.	n/a	Recommended CRF: 1.14 (1.06-1.123) per 10 µg/m^3 (Krewski, Jerrett et al. 2009) (US EPA 2010)
Infant (<12 months of age)	n/a	n/a	n/a	1.07 (0.93-1.24) for 10 µg/m^3 (Woodruff, Parker et al. 2006) (US EPA 2006) All ICD9 Age: <12 months	n/a	Recommended CRF: 1.07 (0.93-1.24) for 10 µg/m^3 (Woodruff, Parker et al. 2006) (US EPA 2006)
Life expectancy lost (years of life lost; YOLL)	n/a	6 months of life expectancy lost in the UK at current levels of anthropogenic $PM_{2.5}$ (~9 µg/m^3) (Committee on the Medical Effects of Air Pollutants 2010)	$6.02E^{-04}$ YOLL/ (person/year/µg/m^3) (Leksell and Rabl 2001) (European Commission 2005)	n/a	n/a	Recommended CRF: $6.02E^{-04}$ YOLL/ (person/year/µg/m^3) (Leksell and Rabl 2001) (European Commission 2005)
Morbidity						

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Incidence of chronic obstructive pulmonary disease (COPD) or chronic bronchitis	n/a	n/a	Chronic bronchitis: 1.181 (0.98-3.25) per 45 µg/m^3 OR 1.141 (0.996-1.30) per 10 µg/m^3 (Abbey, Lebowitz et al. 1995) (European Commission 2005) Adults (27+ years) with cough or sputum on most days for at least three months of the year for at least two years.	COPD: 1.81 (0.98-3.25) per 10 µg/m^3 (Abbey, Hwang et al. 1995) (US EPA 2006) Age: >26 years	Chronic bronchitis: 1.34 (0.94-1.99) per 10 µg/m^3 (Dockery, Cunningham et al. 1996) (WHO Europe 2000) ?Age	Recommended CRF for COPD: 1.81 (0.98-3.25) per 10 µg/m^3 (Abbey, Hwang et al. 1995) (US EPA 2006) Age: >26 years Chronic bronchitis: No CRF recommended.
Incidence of asthma	Ever had wheezing: No effect. Ever had asthma: No effect. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly. $PM_{2.5}$ over lifetime. Age: mean age10.0 years.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	2,860 children.					
Recent symptoms (in last 12 months)	No effect for asthma exacerbation, wheeze, cough or shortness of breath. (Bennett, Simpson et al. 2007) Melbourne N=1,446 Mean age: 37 years. 12-month average. No effect for wheeze, wheeze after exercise, current asthma, use of bronchodilators, cough, visit to doctor/hospital, rhinitis and itchy rash in single pollutant models. Increased risk for rhinitis in 2-pollutant model with O_3: 1.26 (1.04-1.53) per 2.16 µg/m^3 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane,	n/a	n/a	n/a	n/a	Recommended CRF only for rhinitis (Williams, Marks et al. 2012). No effect for other symptoms in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Canberra, Melbourne, Perth, Sydney. Average hourly. $PM_{2.5}$ over lifetime. Age: mean age10.0 years. 2,860 children.					
Lung function growth	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Change in forced expiratory volume in 1 second (FEV_1; litres)	No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly. $PM_{2.5}$ over lifetime. Age: mean age10.0 years. 2,860 children.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Change in forced vital capacity (FVC; litres)	No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Average hourly. $PM_{2.5}$ over lifetime. Age: mean age10.0 years. 2,860 children.					
Airway inflammation	No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly. $PM_{2.5}$ over lifetime. Age: mean age10.0 years. 2,860 children.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Birth outcomes						
Birth defects	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Prematurity	1.09 (0.97–1.23) per 10 Mm^{-1} bsp in first trimester 0.95 (0.85–1.06) per 8.2 Mm^{-1} bsp in last 90 days before birth (Hansen, Neller et	n/a	n/a	n/a	n/a	No CRF recommended. Inconsistent results from 2 Australian studies.

	Concentration-response function (95%CI)					
Health outcomes	Australian	UK	Europe	US EPA	WHO	Recommended
	al. 2006) Preterm: <37 weeks gestation. Brisbane 1.426 (1.264–1.608) per 1 µg/m^3 (Jalaludin, Mannes et al. 2007) Sydney Preterm: <37 weeks gestation. First trimester. Winter season.					
Low birth weight	No effect of bsp on birth weight or small for gestational age (<10th centile for age and gender) (Hansen, Neller et al. 2007) Brisbane 1.03 (1.01-1.05) for small for gestational age (<2 standard deviations for age and gender) per 1 µg/m^3 Second trimester -4.10 grams (-6.79 to -1.41 grams) per	n/a	n/a	n/a	n/a	No CRF recommended. Inconsistent results from 2 Australian studies.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	1 µg/m^3 Second trimester (Mannes, Jalaludin et al. 2005) Sydney					
Short-term outcomes (daily average concentration)						
Mortality						
Non-trauma	No effect. (Simpson, Williams et al. 2005) Pooled CRF from 3 cities (Sydney, Perth, Melbourne) ICD9: <800; ICD10: A-R, Z35.5, Z35.8 Age: All 0.9% (0.2-1.6%) per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Age: All ages. All year. Low heterogeneity. Meta-analysis of 4 cities - Brisbane,	n/a	n/a	0.98% (0.75 to 1.22%) per 10 µg/m^3 (Zanobetti and Schwartz 2009) (US EPA 2010) ICD10: A00-R99 All ages	1.00339 (0.99150-1.01542) per 10 µg/m^3 (Anderson, Bremner et al. 2001) (WHO Europe 2004) 1 study only ICD9: <800 All ages 1.015 (1.011-1.019) per 10 µg/m^3 (WHO Europe 2000) ?ICD codes ?All ages	Recommended CRF: 0.9% (0.2-1.6%) per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Melbourne, Perth Sydney. ICD9: <800; ICD10: A-R, Z35.5, Z35.8					
Cardiovascular	1.0439 (1.0090-1.0800) increase per 1 unit bsp ($10^{-4}.m^{-1}$) (Simpson, Williams et al. 2005) Pooled CRF from 4 cities (Sydney, Perth, Melbourne, Brisbane) ICD9: 390-459 ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58 Age: All ages. Lag 1 24-hour bsp. 1.5% (0.7-2.3%) per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01.	1.4% (0.7-2.2%) per 10 µg/m^3 (Committee on the Medical Effects of Air Pollutants 2006) 9 studies ICD9: 390-459 All ages.	n/a	0.85% (0.46 to 1.25%) per 10 µg/m^3 (Zanobetti and Schwartz 2009) (US EPA 2010) ICD10: I01-I59 Ages: All ages.	1.00507 (0.98808-1.02236) per 10 µg/m^3 (Anderson, Bremner et al. 2001) (WHO Europe 2004) 1 study only ICD9: 390-459 Age: All ages.	Recommended CRF: 1.5% (0.7-2.3%) per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Age: All ages. All year. No heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 390-459 ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58					
Respiratory	1.0948 (1.0174-1.1781) increase per 1 unit bsp ($10^{-4}.m^{-1}$) (Simpson, Williams et al. 2005) Pooled CRF from 4 cities (Sydney, Perth, Melbourne, Brisbane) ICD9: 460-519 ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8 Age: All ages. Lag 1 24-hour bsp.	n/a	n/a	1.68% (1.04 to 2.33%) per 10 $\mu g/m^3$ (Zanobetti and Schwartz 2009) (US EPA 2010) ICD10: J00-J99 Age: All ages.	0.99943 (0.96912- 1.03069) per 10 $\mu g/m^3$ (Anderson, Bremner et al. 2001) (WHO Europe 2004) 1 study only ICD9: 460-519 Age: All ages.	No CRF recommended. No effect in Australian 4- cities studies (Environment Protection and Heritage Council 2005) May use CRF from Zanobetti et al (Zanobetti and Schwartz 2009) In a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	No effect (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Age: All ages. All year. No heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 460-519 ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8					
Hospitalisation						
Cardiovascular	15-64 years: No effect 65+ years: 1.3% (0.6-2.0) increase per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Moderate	n/a	n/a	0.80% (0.59-1.10%) per 10 µg/m^3 (Bell, Ebisu et al. 2008) (US EPA 2010) ICD9: 426-428, 430-438,410-414, 429, 440-449 Age: 65-99 years	n/a	Recommended CRF: 65+ years: 1.3% (0.6-2.0) increase per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	heterogeneity for 65+ years. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 390-459; ICD10: I00–I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58					
Cardiac	5.1% (3.5-6.7% per 10 µg/m^3 (Environment Protection and Heritage Council 2005) (Simpson, Williams et al. 2005) Pooled estimate from 3 cities - Sydney, Melbourne, Perth. ICD9: 390-429; ICDI0: I00-I52, I97.0, I97.1, I98.1 Age: All ages. 1-hour maximum. 15-64 years: No	n/a	n/a	n/a	n/a	Recommended CRF: 65+ years: 1.9% (1.0-2.7%) increase per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005). May use the CRF from Simpson et al (Simpson, Williams et al. 2005) in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	effect 65+ years: 1.9% (1.0-2.7%) per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Moderate heterogeneity for 65+ years. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 390-429; ICDI0: I00-I52, I97.0, I97.1, I98.1					
Cardiac failure	15-64 years: No effect 65+ years: 3.6% (1.8-5.4%) per 3.78 µg/m^3 24-hour average. Lag 01. Moderate heterogeneity for 65+ years. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth	n/a	n/a	n/a	n/a	Recommended CRF: 65+ years: 3.6% (1.8-5.4%) increase per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Sydney. ICD9: 428; ICD10: I50					
Cerebrovascular	Stroke: 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Low heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 430-438; ICD10: I60-I66, I67 (excluding I67.0, I67.3), I68 (excluding I68.0), I69, G45 (excluding G45.3), G46	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005).
Ischaemic heart disease	15-64 years: No effect 65+ years: 1.6% (0.7-2.4%) per 3.78 µg/m^3 (Environment Protection and	n/a	n/a	n/a	n/a	Recommended CRF: 65+ years: 1.6% (0.7-2.4%) increase per 3.78 µg/m^3 (Environment Protection and

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Heritage Council 2005) 24-hour average. Lag 01. Low heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 410-413; ICD10: 120-122, 124, 125.2					Heritage Council 2005).
Arrhythmia	15-64 years: No effect. 65+ years: No effect. (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Low heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 437; ICD10: I46-I49	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005).
Myocardial infarction	15-64 years: No effect. 65+ years: 2.7%	n/a	n/a	n/a	n/a	Recommended CRF: 65+ years: 2.7%

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(1.3-4.2%) per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Low heterogeneity for 65+ years. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 410; ICDI0: I21, I22					(1.3-4.2%) increase per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005).
Respiratory	1.0401 (1.0045-1.0770) increase per 1 unit bsp ($10^{-4}.m^{-1}$) (Simpson, Williams et al. 2005) Pooled CRF from 4 cities - Sydney, Perth, Melbourne, Brisbane. ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8 Age: 65+ years. 24-hour bsp.	n/a	n/a	No effect. (Bell, Ebisu et al. 2008) (US EPA 2010) ICD9: 490-492, 463-466, 480-487 Age: 65-99 years. 2.07% (1.2-2.95%) per 10 µg/m^3 (Zanobetti and Schwartz 2009) (Abt Associates Inc 2011) ICD9: 460-519 Age: 65-99 years. 2-day average	0-14 years: No effect. 15-64 years: No effect. 65+ years: No effect. (Anderson, Bremner et al. 2001) (WHO Europe 2004) 1 study only ICD9: 460-519. Age: All ages.	Recommend CRF: CRFs from Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Lag 1. 0 year: 2.4% (1.0-3.8%) increase per 3.78 µg/m^3 1-4 years: 1.7% (0.7-2.7%) increase per 3.78 µg/m^3 5-14 years: No effect 15-64 years: 1.1% (0.0-2.1%) increase per 3.78 µg/m^3 65+ years: 1.6% (0.9-2.3%) increase per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Low heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8					
Asthma	1.0893 (1.0240-	n/a	n/a	1.04 (1.01-1.06) per	n/a	Recommend CRF:

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	1.1587) increase per 1 unit bsp ($10^{-4}.m^{-1}$) (Simpson, Williams et al. 2005) Pooled CRF from 4 cities (Sydney, Perth, Melbourne, Brisbane) ICD9: 493; ICD10: J45, J46, J44.8 Age: 15-64 years. Lag 3 24-hour bsp. 0 year: not calculated due to uncertain diagnosis. 1-4 years: No effect. 5-14 years: No effect. 15-64 years: 2.2% (0.7-3.6%) per 3.78 µg/m^3. 65+ years: No effect. (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Moderate heterogeneity for 15-64 years.			11.8 µg/m^3 (Sheppard 2003) (Abt Associates Inc 2011) Age: 0-64 years ICD9 493		CRFs from Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 493; ICD10: J45, J46, J44.8					
Chronic obstructive pulmonary disease (COPD)	15-64 years: No effect 65+ years: 1.6% (0.6-2.7%) per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Moderate heterogeneity for 15-64 years. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 490-492, 494-496; ICDI0: J40-J44, J47, J67	n/a	n/a	n/a	n/a	Recommend CRF: CRF for 65+ years from Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005).
Pneumonia and acute bronchitis	0 years: 1.0% (0.0-3.4%) per 3.78 µg/m^3 1-4 years: 2.4% (0.1-4.7%) per 3.78	n/a	n/a	n/a	n/a	Recommend CRF: CRFs from Australian 4-cities meta-analysis (Environment

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	µg/m^3 15-64 years: No effect 65+ years: 2.0% (0.8-3.2%) per 3.78 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Moderate heterogeneity for 15-64 years. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 466, 480-486; ICD10: J12-J17, J18.0, J18.1, Jl8.8, Jl8.9, J20, J21					Protection and Heritage Council 2005).
Emergency department visits						
Asthma	1.4% (0.9-1.8%) increase per 9.4 µg/m^3 (Jalaludin, Khalaj et al. 2008) Sydney. ICD9: 493. Age: 1-14 years.	n/a	n/a	1.0045 (1.0029-1.0062) per 1 µg/m^3 (Ito, Thurston et al. 2007) (US EPA 2010) ICD9: 493 Age: All ages. 24-hour average.	n/a	Recommended CRF: 1.4% (0.9-1.8%) increase per 9.4 µg/m^3 (Jalaludin, Khalaj et al. 2008) May use CRF from

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
				New York.		Ito et al (Ito, Thurston et al. 2007) in a sensitivity analysis.
Respiratory disease	n/a	n/a	n/a	1.00046 (0.99954-1.00136) per 1 µg/m^3 (Tolbert, Klein et al. 2007) (US EPA 2010) Age: All ages. 24-hour average. Atlanta. ICD9: 491-493, 786.07, 786.09, 496, 460-465, 460.0, 477, 480-486, 466.1, 466.11, 466.19	n/a	No CRF recommended. May use CRF from Tolbert (Tolbert, Klein et al. 2007) in a sensitivity analysis as the CRF is close to being statistically significant. Note that respiratory disease ICD codes include asthma.
Cardiovascular disease	n/a	n/a	n/a	1.00046 (0.99936-1.00154) per 1 µg/m^3 (Tolbert, Klein et al. 2007) (US EPA 2010) All ages. 24-hour average. Atlanta. ICD9: 410-414, 427-428, 433-437, 440, 443-445, 451-453	n/a	No CRF recommended. May use CRF from Tolbert (Tolbert, Klein et al. 2007) in a sensitivity analysis as the CRF is close to being statistically significant.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Incidence of myocardial infarction (heart attacks)						
Non-fatal heart attacks (24-hr PM)	n/a	n/a	n/a	1.62 (1.13-2.34) per 20 µg/m^3 (Peters, Dockery et al. 2001) (US EPA 2006) Age: 18+ years ICD9: 410	n/a	Recommended CRF: 1.62 (1.13-2.34) per 20 µg/m^3 (Peters, Dockery et al. 2001)
Lung function						
Change in forced expiratory volume in 1 second (FEV_1; litres)	No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean age 10.0 years. 270 children with current asthma.	n/a	n/a	n/a	-1.9% (-3.1 to -0.6%) per 10 µg/m^3 (Raizenne, Neas et al. 1996) Children	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Change in peak expiratory flow rate (PEF; litres per minute)	No effect of bsp. (Rutherford, Simpson et al. 2000) Brisbane and Ipswich Mixed-models Age: All	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(n=53) History of allergy to pollen or fungi on skin prick testing No effect. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean age 10.0 years. 270 children with current asthma.					
Minor morbidity						
Asthma exacerbation	n/a	n/a	n/a	n/a (not reported in Abt Associates 2011 or in USEPA 2006) Pooled estimate from Vedal 1998 and Ostro 2001 (US EPA 2006) Age: 6-18 years	n/a	No CRF recommended.
Increased airway hyper-responsiveness	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Restricted activity days (RAD)[2]	n/a	n/a	0.475% (0.417-0.533%) per 1 μg/m^3 (Ostro 1987) (European Commission 2005) Age: 15-64 years. In a sensitivity analysis, all ages used.	n/a	n/a	Recommended CRF: 0.475% (0.417-0.533%) per 1 μg/m^3 $PM_{2.5}$ (Ostro 1987) (European Commission 2005)
Minor restricted activity days (MRAD)[3]	n/a	n/a	0.74% (0.60-0.88%) per 1 μg/m^3 (Ostro and Rothschild 1989) (European Commission 2005) Age: 18-64 years.	1.0769 (1.0622-1.0918) per 10 μg/m^3 (Ostro and Rothschild 1989) (US EPA 2006) Age: 18-64 years.	n/a	Recommended CRF: 1.0769 (1.0622-1.0918) per 10 μg/m^3 (Ostro and Rothschild 1989) (US EPA 2006)
Work lost days (WLD)[2]	n/a	n/a	0.46% (0.39-0.53%) per 1 μg/m^3 (Ostro 1987) (European Commission 2005) CAFE CBA 2005 Age: 15-64 years.	1.0471 (1.0397-1.0545) per 10 μg/m^3 (Ostro 1987) (US EPA 2006) Age: 18-64 years.	n/a	Recommended CRF: 1.0471 (1.0397-1.0545) per 10 μg/m^3 (Ostro 1987) (US EPA 2006)
Acute bronchitis (incidence, 8-12 years)	n/a	n/a	n/a	1.5 (0.91-2.47) per 14.9 μg/m^3 (Dockery, Cunningham et al. 1996) (US EPA 2006) Annual average.	n/a	Recommended CRF: 1.5 (0.91-2.47) per 14.9 μg/m^3 (Dockery, Cunningham et al. 1996) (US EPA 2006)

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Lower respiratory symptoms	n/a	n/a	n/a	1.33 (1.11-1.58) per 15 µg/m^3 (Schwartz and Neas 2000) (US EPA 2006) Age: 7-14 years.	n/a	Recommended CRF: 1.33 (1.11-1.58) per 15 µg/m^3 (Schwartz and Neas 2000) (US EPA 2006)
Acute respiratory symptoms	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Wheeze	No effect. Rodriguez 2007 Age: 0-5 years. Perth. 1-hour maximum. No effect. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.	n/a	n/a	Only for African-American children (Ostro, Lipsett et al. 2001) (Abt Associates Inc 2011)	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Cough	1.006 (1.000-1.012) per ?1µg/m^3 (Rodriguez, Tonkin	n/a	n/a	Only for African-American children. (Ostro, Lipsett et al.	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	et al. 2007) Age: 0-5 years. Perth. 1-hour maximum. No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.			2001) (Abt Associates Inc 2011)		No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Shortness of breath	No effect. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.	n/a	n/a	Only for African-American children. (Ostro, Lipsett et al. 2001) (Abt Associates Inc 2011)	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Bronchodilator use	No effect. (Williams, Marks et al. 2012)	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Upper respiratory symptoms	Runny/blocked nose: No effect. (Rodriguez, Tonkin et al. 2007) Age: 0-5 years. Perth. 1-hour maximum.	n/a	n/a	Only for African-American children. (Ostro, Lipsett et al. 2001) (Abt Associates Inc 2011)	n/a	No CRF recommended. Only Australian study did not show any adverse effects.
Increased respiratory symptoms	Any day symptoms: No effect on any day symptoms - cough, wheeze, shortness of breath, runny nose, eye irritation, fever. Any night symptoms: No effect on any night symptoms - cough, wheeze, shortness of breath. (Williams, Marks et al. 2012)	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
General practitioner consultation for asthma	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
General practitioner consultation for upper respiratory disease	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

[1]n/a=not available
[2]A restricted activity days is defined as a day when a person is forced to alter his/her normal activity. A severe restriction include days when it necessary to stay in bed. For employed adults, restricted activity days include Work Loss Days; for children, it would include days off school (whether or not the child is confined to bed) (ExternE 1995).
[3]Minor restricted activity days do not involve work loss or bed disability but do include some noticeable limitation on 'normal' activity (ExternE 1995).

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Table 2: PM_{10} health endpoints and concentration-response functions

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Long-term outcomes (annual average concentration)						
Mortality						
All cause	n/a[1*]	n/a	0.386% (0.295-0.477%) per 1 µg/m^3 (Pope, Thun et al. 1995) (European Commission 1995) ICD9: All Age: 30+ years	n/a	1.10 (1.03-1.18) per 10 µg/m^3 (Dockery, Pope et al. 1993) (WHO Europe 2000) ?ICD codes ?Age	Recommended CRF: 0.386% (0.295-0.477%) per 1 µg/m^3 (Pope, Thun et al. 1995).
Cardiopulmonary	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Ischaemic heart disease	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lung cancer	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Infant all cause (<12 months age)	n/a	n/a	4% (2-7%) per 10 µg/m^3 (Woodruff, Grillo et al. 1997) (European Commission 2005)	n/a	n/a	Recommended CRF: 4% (2-7%) per 10 µg/m^3 (Woodruff, Grillo et al. 1997).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
			ICD9: All Age: <12 months			
Life expectancy (Years of life lost; YOLL)	n/a	2-6 months per death brought forward. (DEFRA 2006)	2.69E-04 YOLL / (person/yr/µg/m^3) (European Commission 2005) Applies CRF from Pope 1995 to whole population.	n/a	n/a	Recommended CRF: 2.69E-04 YOLL / (person/yr/µg/m^3) (European Commission 2005).
Morbidity						
Incidence of chronic obstructive pulmonary disease (COPD) or chronic bronchitis	n/a	n/a	Chronic bronchitis: 1.15 (0.99-1.33) per 20 µg/m^3 (Abbey, Hwang et al. 1995) (European Commission 2005) (AEA Technology Environment 2005) Adults (27+ years) with cough or sputum on most days for at least three months of the year for at least two years.	n/a	Chronic bronchitis: 1.29 (0.96-1.83) per 10 µg/m^3 (Dockery, Cunningham et al. 1996) (WHO Europe 2000) ?Age	No CRF recommended for chronic bronchitis. Both the reported CRFs are statistically non-significant. May be used in a sensitivity analysis.
Incidence of asthma	Ever had wheezing: No effect	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Ever had asthma: No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly PM_{10} over lifetime. Age: mean age10.0 years. 2,860 children.					No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Recent symptoms (in last 12 months)	Nigh cough: 1.34 (1.19-1.53) per 10 $\mu g/m^3$ Chest colds: 1.43 (1.12-1.82) per 10 $\mu g/m^3$ (Lewis, Hensley et al. 1998) Children in school years 3-5. Illawarra/Hunter. Annual mean PM_{10}. No effect or protective effects for wheeze, wheeze after exercise, current asthma, use of bronchodilators,	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012). May use the CRFs from the study by Lewis et al (Lewis, Hensley et al. 1998) in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	cough, visit to doctor/hospital, rhinitis and itchy rash in various single pollutant and 2-pollutant models. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly PM_{10} over lifetime. Age: mean age10.0 years. 2,860 children.					
Lung function growth	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Change in forced expiratory volume in 1 second (FEV_1; litres)	No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly PM_{10} over lifetime. Age: mean age10.0 years.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	2,860 children.					
Change in forced vital capacity (FVC; litres)	No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly PM_{10} over lifetime. Age: mean age10.0 years. 2,860 children.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Airway inflammation	1.04 (1.01-1.06) per 1 µg/m^3 in single pollutant model. Estimates are similar in 2-pollutant models with $PM_{2.5}$, NO_2, SO_2 and CO (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly PM_{10} over lifetime. Age: mean age10.0 years.	n/a	n/a	n/a	n/a	Recommended CRF: 1.04 (1.01-1.06) per 1 µg/m^3 (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	2,860 children.					
Birth outcomes						
Birth defects	Mixed results from only Australian study (Hansen, Barnett et al. 2009) Brisbane	n/a	n/a	n/a	n/a	No CRF recommended. Only 1 Australian study.
Prematurity	1.462 (1.267-1.688) per 1 µg/m^3 Autumn First trimester 1.343 (1.190-1.516) per 1 µg/m^3 Winter First Trimester (Jalaludin, Mannes et al. 2007) Preterm: <37 weeks gestation. Sydney 1.15 (1.06–1.25) per 4.5 µg/m^3 First trimester (Hansen, Neller et al. 2006) Preterm: <37 weeks gestation. Brisbane	n/a	n/a	n/a	n/a	No CRF recommended. Few Australian studies.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Low birth weight	1.01 (1.00-1.04) per 1 µg/m^3 for small for gestational age (<2 standard deviations for age and gender). Second trimester -2.05 (-3.36 to -0.74) grams per 1 µg/m^3 for small for gestational age (<2 standard deviations for age and gender). Second trimester (Mannes, Jalaludin et al. 2005) Sydney No effect on birth weight or small for gestational age (<10thcentile for age and gender). (Hansen, Neller et al. 2007) Brisbane	n/a	n/a	n/a	n/a	No CRF recommended. Few Australian studies.
Short-term outcomes (daily average concentration)						
Mortality						
Non-trauma	All ages: No effect (Simpson, Williams	0.074% (0.062-0.086%) per 1	1.0105 (1.0025-1.0186) per 10	n/a	1.0074 (1.0062-1.0086) per 10	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	et al. 2005) Pooled CRF from 3 cities - Brisbane, Sydney, Melbourne. ICD9: <800 ICD10: A-R, Z35.5, Z35.8 1.3% (0.4-2.3%) per 10 μg/m^3 (Morgan, Sheppeard et al. 2010) Sydney Age: All ages. 24-hour average ICD9: <800; ICD10: A-R, Z35.5, Z35.8 All ages: No effect (Environment Protection and Heritage Council 2005) 24-hour average Lag 01 All year High heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: <800; ICD10: A-R, Z35.5, Z35.8	μg/m^3 (Committee on the Medical Effects of Air Pollutants 1998) CRF is a WHO summary finding based on 17 international studies ICD: All Age: All ages.	μg/m^3 (Schwartz 1993) (European Commission 1995) ?ICD ?Age		μg/m^3 (WHO Europe 2000) ?ICD ?Age 1.006 (1.004-1.008) per 10 μg/m^3 (WHO Europe 2004) 33 studies ICD9: <800 Age: All ages.	No effect in 2 Australian meta-analyses (Environment Protection and Heritage Council 2005; Simpson, Williams et al. 2005). CRF from Morgan et al (Morgan, Sheppeard et al. 2010) or WHO (WHO Europe 2004) may be used in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Cardiovascular	1.4 (0.0-2.9%) per 10 µg/m^3 (Morgan, Sheppeard et al. 2010) Sydney Age: All 24-hour average ICD9: 390-459; ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58 1.8% (0.6-3.0%) per 7.53 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average Lag 01 Age: All ages. All year. No heterogeneity Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 390-459;	0.9% (0.7-1.2%) per 10 µg/m^3 (Committee on the Medical Effects of Air Pollutants 2006) CRF not intended for health risk assessment purposes. 40 studies ICD9: 390-459 Age: All ages.	n/a	n/a	1.009 (1.005-1.013) per 10 µg/m^3 (WHO Europe 2004) 17 studies ICD9: 390-459 Ages: All ages.	Recommended CRF: 1.8% (0.6-3.0%) per 7.53 µg/m^3 (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58					
Respiratory	No effect (Morgan, Sheppeard et al. 2010) Sydney Age: All ages. 24-hour average ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8 All ages: No effect (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01 Age: All ages. All year High heterogeneity Meta-analysis of 4 cities - Brisbane, Melbourne, Perth	n/a	n/a	n/a	1.013 (1.005-1.020) per 10 μg/m^3 (WHO Europe 2004) 18 studies ICD9: 460-519 Age: All ages.	No CRF recommended. No effect in Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005) and in study by Morgan et al (Morgan, Sheppeard et al. 2010). CRF from WHO (WHO Europe 2004) may be used in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Sydney. ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8					
Hospitalisation						
Cardiovascular	15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 24-hour average Lag 01 Low heterogeneity Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 390-459; ICD10: I00–I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58 1.22% (0.41 to 2.03%) per 10	0.8 per 10 µg/m^3 (no 95%CI provided) (DEFRA 2006) (based on COMEAP 1998) No effect (Committee on the Medical Effects of Air Pollutants 2006) CRF not intended for health risk assessment purposes. 6 studies ICD9: 390-459 Age: All ages.	0.6% (0.3-0.9%) per 10 µg/m^3 (AEA Technology Environment 2005) ICD9: 390-429 Age: All ages.	n/a	n/a	No CRF recommended. No effect in Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005). CRF from the study by Morgan et al (Morgan, Sheppeard et al. 2010) may be used in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	µg/m^3 (Morgan, Sheppeard et al. 2010) Sydney Age: All ages. 24-hour average ICD9: 390-459; ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58					
Cardiac	2.4% (1.5-3.4%) per 10 µg/m^3 (Simpson, Williams et al. 2005) Pooled estimate from 3 cities (Sydney, Melbourne, Brisbane) ICD9: 390-429; ICDI0: I00-I52, I97.0, I97.1, I98.1 Age: All ages. 1-hour maximum. 15-64 years: No effect 65+ years: 1.4%	n/a	n/a	n/a	n/a	Recommended CRF: 65+ years: 1.4% (0.5-2.2%) per 7.53 µg/m^3 (Environment Protection and Heritage Council 2005). This is a more recent study compared to the Simpson et al study (Simpson, Williams et al. 2005). Use CRF from Simpson et al (Simpson, Williams

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(0.5-2.2%) per 7.53 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Low heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 390-429; ICDI0: I00-I52, I97.0, I97.1, I98.1					et al. 2005) in a sensitivity analysis. Note that this study is for all ages and has a larger CRF.
Cardiac failure	15-64 years: No effect 65+ years: 3.6% (2.0-5.2%) per 7.53 µg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Moderate heterogeneity for 65+ years. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth	n/a	n/a	n/a	n/a	Recommended CRF: 65+ years: 3.6% (2.0-5.2%) per 7.53 µg/m^3 (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Sydney. ICD9: 428; ICD10: I50					
Cerebrovascular	Stroke: 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 24-hour average Lag 01. Low heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 430-438; ICD10: I60-I66, I67 (excluding I67.0, I67.3), I68 (excluding I68.0), I69, G45 (excluding G45.3), G46					No CRF recommended. No effect in Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005).
Ischaemic heart disease	15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005)	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 4-cities meta-analysis (Environment

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	24-hour average Lag 01 Low heterogeneity Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 410-413; ICD10: 120-122, 124, 125.2					Protection and Heritage Council 2005).
Arrhythmia	15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Low heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 437; ICD10: I46-I49	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005).
Myocardial infarction	15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 4-cities meta-analysis

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	2005) 24-hour average Lag 01 Low heterogeneity Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 410; ICDI0: I21, I22					(Environment Protection and Heritage Council 2005).
Respiratory	0 year: 2.3% (0.2-4.3%) increase per 7.53 µg/m^3 1-4 years: 2.3% (0.9-3.8%) increase per 7.53 µg/m^3 5-14 years: 2.3% (0.2-4.4%) increase per 7.53 µg/m^3 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 24-hour average. Lag 01. Low heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney.	0.080% (0.048-0.112%) per 1µg/m^3 (Committee on the Medical Effects of Air Pollutants 1998) CRF is a WHO summary finding based on 6 cities All respiratory causes Age: All ages.	1.14% (0.62-1.67%) per 10µg/m^3 (AEA Technology Environment 2005) Age: All ages. ICD9: 460-519	n/a	1.0080 (1.0048-1.0112) per 10 µg/m^3 (WHO Europe 2000) ?ICD ?Age 0-14 years: 1.010 (0.998-1.021) per 10 µg/m^3 3 studies 14-64years: 1.008 (1.001-1.015) per 10 µg/m^3 3 studies 65+ years: 1.007 (1.002-1.013) per 10 µg/m^3 8 studies (WHO Europe 2004) ICD9: 460-519	Recommended CRF: CRFs from the Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005). May use CRF from the study by Morgan et al (Morgan, Sheppeard et al. 2010) in a sensitivity analysis. This CRF is for all ages but from one location only.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8 2.7% (1.0-5.9%) per 10 µg/m^3 in 2-pollutant model with O_3 (Chen, Mengersen et al. 2007) Brisbane 24-hour average Age: All ages ICD9: 460-519 (excluding 487); ICD10: Joo-J99 (excluding J11) 1.04% (0.02-2.07%) per 10 µg/m^3 (Morgan, Sheppeard et al. 2010) Sydney Age: All ages. 24-hour average. ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8				Age: All ages.	

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Asthma	0 year: not calculated due to uncertain diagnosis 1-4 years: No effect 5-14 years: No effect 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 24-hour average Lag 01 Low to moderate heterogeneity Meta-analysis of 4 cities - Brisbane, Melbourne, Perth. Sydney. ICD9: 493; ICD10: J45, J46, J44.8 1-14 years: No effect 15-64 years: No effect (Morgan, Sheppeard et al. 2010) Sydney. ICD9: 493; ICD10:	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian studies including the Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005). .

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	J45, J46, J44.8 24-hour average					
Chronic obstructive pulmonary disease (COPD)	15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 24-hour average Lag 01 Low heterogeneity Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 490-492, 494-496; ICDI0: J40-J44, J47, J67	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 4-cities meta-analysis (Environment Protection and Heritage Council 2005).
Pneumonia and acute bronchitis	0 years: No effect 1-4 years: No effect 15-64 years: No effect 65+ years: 1.0% (0.2-3.8%) per 7.53 μg/m^3 (Environment Protection and Heritage Council 2005) 24-hour average Lag 01	n/a	n/a	n/a	n/a	Recommended CRF: 65+ years: 1.0% (0.2-3.8%) per 7.53 μg/m^3 per 7.53 μg/m^3 (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Low heterogeneity for 65+4 years Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 466, 480-486; ICD10: J12-J17, J18.0, J18.1, Jl8.8, Jl8.9, J20, J21					
Emergency department visits						
Asthma	Inner Melbourne: 1.17 (1.05-1.31) per 34.3 µg/m^3 Eastern Melbourne: 1.09 (1.01-1.18) per 34.3 µg/m^3 (Erbas, Kelly et al. 2005) Melbourne ICD10: J45, J46 Age: 1-15 years Modelled air pollution data using TAPM 1-hour maximum 1.4% (0.8-2.0%) per 7.6 µg/m^3 (Jalaludin, Khalaj et al. 2008) Sydney	n/a	1.0374 (1.0121-1.0633) per 10 µg/m^3 (Schwartz, Slater et al. 1993) (European Commission 1995) Age: All ages.	n/a	n/a	Recommended CRF: 1.4% (0.8-2.0%) per 7.6 µg/m^3 (Jalaludin, Khalaj et al. 2008). There are few Australian studies. The study by Erbas et al (Erbas, Kelly et al. 2005) used modelled air pollution data.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Age: 1-14 years ICD9: 439					
Respiratory disease	n/a	n/a	COPD: 5.7% (4.56-6.84%) per 25 µg/m^3 (Sunyer, Saez et al. 1993) (European Commission 1995) Age: All ages.	n/a	n/a	No CRF recommended. The CRF from Sunyer et al (Sunyer, Saez et al. 1993) may be used in a sensitivity analysis.
Cardiovascular disease	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Incidence of myocardial infarction (heart attacks)						
Non-fatal heart attacks	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lung function						
Change in forced expiratory volume in 1 second (FEV_1; litres)	No effect in single pollutant models, but significant effects in 2-pollutant models with 1-hour SO_2 and 24-hour SO_2 With 1-hour SO_2: -0.0041 (-0.0076 to -0.0006) per 1	n/a	n/a	n/a	-1.2% (-2.3 to -0.1%) per 10 µg/m^3 (Raizenne, Neas et al. 1996) (WHO Europe 2000) Children ?Age -1.0% (95%CI not available) per 10	Recommended CRF: -0.0043 (-0.0078 to -0.0008) per 1 µg/m^3 (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	µg/m^3 24-hour average Lag 2 With 24-hour SO_2: -0.0043 (-0.0078 to -0.0008) per 1 µg/m^3 24-hour average Lag 2 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean age 10.0 years. 270 children with current asthma.				µg/m^3 (Ackermann-Liebrich, Leuenberger et al. 1997) (WHO Europe 2000) Adults ?Age	
Change in peak expiratory flow rate (PEF; litres per minute)	No effect (Jalaludin, Chey et al. 2000) Sydney 125 children with a history of wheezing in previous 12 months. Age: mean age about 9.6 years. No effect (Jalaludin, Smith et	n/a	n/a	n/a	-0.13% (-0.17 to -0.09%) per 10 µg/m^3 (WHO Europe 2000) ?Age Change in peak expiratory flow relative to mean.	Recommended CRF: -0.8187 (-1.3325 to -0.3048) per 1 µg/m^3 (Williams, Marks et al. 2012). Note inconsistencies in CRFs from Australian single site studies.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	al. 2000) Sydney 32 children (mean age about 9.2 years) with a history of wheezing in previous 12 months. -0.0036 (-0.0067 to -0.0005) per 1 $\mu g/m^3$ (Rutherford, Simpson et al. 2000) Brisbane and Ipswich Mixed-models 4-day lag Age: All ages. 53 people with history of allergy to pollen or fungi on skin prick testing. No effect in single pollutant models, but significant effects in 2-pollutant models with 1-hour ozone, 1-hour SO_2 and 24-hour SO_2 With 1-hour ozone: -0.3674 (-0.7291 to -0.0057)					

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	24-hour average Lag 2 With 1-hour SO_2: -0.7972 (-1.33148 to -0.2796) per 1 µg/m^3 24-hour average Lag 2 With 24-hour SO_2: -0.8187 (-1.3325 to -0.3048) per 1 µg/m^3 24-hour average Lag 2 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Age: mean age 10.0 years 270 children with current asthma					
Minor morbidity						
Asthma exacerbation	n/a	n/a	n/a	1.05 (0.95-1.16) per 10 µg/m^3 (Yu, Sheppard et al. 2000) (US EPA 2006)	n/a	No CRF recommended. CRF from Yu et al (Yu, Sheppard et al. 2000) was not

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
				(Abt Associates Inc. 2005) Asthmatic children Age: 5-13 years At least one asthma symptom: wheeze, cough, chest tightness, shortness of breath.		statistically significant.
Restricted activity days (RAD)[2]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Minor restricted activity days (MRAD)[3]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Work lost days (WLD)[2]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Acute bronchitis (incidence)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lower respiratory symptoms	No effect on wheezing. (Jalaludin, O'Toole et al. 2004) 148 children (mean age about 9.6 years) with a history of wheezing in previous 12 months. Sydney.	0-15 years: 0.330% (0.134-0.526%) per 1 µg/m^3 15+ years: No effect. (Roemer, Hoek et al. 1993) (Dusseldorp, Kruize et al. 1995) (Committee on the	5-14 years: 1.004 (1.002-1.006) per 10 µg/m^3 (Ward and Ayres 2004) (European Commission 2005) (AEA Technology Environment 2005) CRF from meta-	n/a	1.0324 (1.0185-1.0464) per 10 µg/m^3 (WHO Europe 2000) ?Age	Recommended CRFs: 5-14 years: 1.004 (1.002-1.006) per 10 µg/m^3 (Ward and Ayres 2004) from a meta-analysis. 20+ years: 1.017 (1.002-1.032) per

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Wheezing: 3.149 (1.495-6.631) per 10 µg/m^3 (Jalaludin, O'Toole et al. 2004) 32 children (mean age about 9.2 years) with a history of wheezing in previous 12 months. Sydney.	Medical Effects of Air Pollutants 1998) CRFs for those with asthma. NOT included in impact assessment in the UK because of doubts about the transferability of the data and lack of UK studies.	analysis. All children. Lower respiratory symptoms include wheeze, chest tightness, shortness of breath, cough. 20+ years: 1.017 (1.002-1.032) per 10 µg/m^3 (European Commission 2005) (AEA Technology Environment 2005) CRF from meta-analysis of five panel studies. Symptomatic adults only: wheeze, chest tightness, phlegm, shortness of breath, cough.			10 µg/m^3 (European Commission 2005) from a meta-analysis. Australian studies are single site studies CRFs are for individual symptoms.
Acute respiratory symptoms	n/a	n/a	1.0049 (0.9999-1.0098) per 1 µg/m^3 (Krupnick, Harrington et al. 1990) (European Commission 1995) All ages Whole population. Only for sensitivity	n/a	n/a	No CRF recommended. CRF from Krupnick et al (Krupnick, Harrington et al. 1990) may be used in a sensitivity analysis. Note that CRF is statistically

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
			analysis Presence of any one of 19 respiratory-related symptoms including: head cold, chest cold, sinus trouble, croup, cough with phlegm, sore, throat, asthma, hay fever, wheeze, ear infection, bronchitis, bronchiolitis, pneumonia, influenza.			marginally non-significant.
Wheeze	Day wheeze: 1.0288 (1.0049-1.0534) per 1 µg/m^3 in 2-pollutant model with 1-hour NO_2 24-hour average Lag 1 Night wheeze: 1.0453 (1.0143-1.0774) per 1 µg/m^3 in 2-pollutant model with 8-hour CO 24-hour average Lag 2 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane,	n/a	n/a	n/a	n/a	Recommended CRF: Use CRF from Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Cough	No effect. (Jalaludin, O'Toole et al. 2004) 148 children (mean age about 9.6 years) with a history of wheezing in previous 12 months. Sydney. Day cough: 1.0229 (1.0006-1.0456) per 1 μg/m^3 in 2-pollutant model with 8-hour CO 24-hour average Lag 1 Night cough: 1.0277 (1.0003-1.0559) per 1 μg/m^3 in 2-pollutant model with 24-hour SO_2 24-hour average Lag 2 (Williams, Marks et al. 2012)	0-15 years: 0.508% (0.226-0.790%) per 1 μg/m^3 15+ years: No effect (Dockery and Pope 1994) (Dusseldorp, Kruize et al. 1995) (Committee on the Medical Effects of Air Pollutants 1998) CRFs for those with asthma. NOT included in impact assessment in the UK because of doubts about the transferability of the data and lack of UK studies.	5-14 years: 1.004 (1.002-1.006) per 10 μg/m^3 (Ward and Ayres 2004) (European Commission 2005) (AEA Technology Environment 2005) All children 20+ years: 1.043 (1.005-1.084) per 10 μg/m^3 (Ward and Ayres 2004) (European Commission 2005) (AEA Technology Environment 2005) CRF from meta-analysis. Symptomatic adults only: cough, nocturnal cough, cough+phlegm	8% (0-16%) per 10 μg/m^3 (Vedal, Petkau et al. 1998) (US EPA 2006) (Abt Associates Inc. 2005) Asthmatic children. Age: 6-13 years.	1.0356 (1.0197-1.0518) per 10 μg/m^3 (WHO Europe 2000) ?Age 5-15 years: 0.999 (0.987-1.011) per 10 μg/m^3 34 studies. Symptomatic children. 16-70 years: 1.043 (1.005-1.084) per 10 μg/m^3 3 studies. Symptomatic adults. (WHO Europe 2004)	Recommended CRF: Use CRF from Australian 6-cities study (Williams, Marks et al. 2012). May use CRFs from Ward et al (Ward and Ayres 2004) in a sensitivity analysis. CRFs from a meta-analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Shortness of breath	Day SOB: No effect Night SOB: 1.0417 (1.0031-1.0819) per 1 µg/m^3 in 2-pollutant model with CO 8-hour average 24-hour average Lag 2 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.	n/a	n/a	n/a	n/a	Recommended CRF: 1.0417 (1.0031-1.0819) per 1 µg/m^3 (Williams, Marks et al. 2012).
Bronchodilator use (people with asthma)	No effect. (Jalaludin, O'Toole et al. 2004) 148 children (mean	0-15 years: 0.230% (0.073-0.3876%) per 1µg/m^3	5-14 years : No effect 20+ years: No effect (WHO Europe	n/a	1.0305 (1.0201-1.0410) per 10 µg/m^3 (WHO Europe	No CRF recommended. No effect in

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	age about 9.6 years) with a history of wheezing in previous 12 months. Sydney. No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Age: mean 10.0 years 270 children with current asthma	15+ years: 0.180% (0.004-0.357%) per 1µg/m^3 (Roemer, Hoek et al. 1993) (Dusseldorp, Kruize et al. 1995) (Committee on the Medical Effects of Air Pollutants 1998) CRFs for those with asthma. NOT included in impact assessment in the UK because of doubts about the transferability of the data and lack of UK studies.	2004) (European Commission 2005) (AEA Technology Environment 2005) People with asthma.		2000) ?Age 5-15 years: No effect 31 studies Symptomatic children. 16-70 years: No effect 3 studies Symptomatic adults. (WHO Europe 2004)	Australian 6-cities study (Williams, Marks et al. 2012). Inconsistent CRFs reported. There is generally a lack of an effect.
Upper respiratory symptoms	n/a	n/a	n/a	1.0367 (1.0066-1.0676) per 10 µg/m^3 (Pope, Dockery et al. 1991) (US EPA 2006) Asthmatics 9-11 years. At least one of the following symptoms: runny/stuffy nose, wet cough, burning, aching or red eyes.	n/a	No CRF recommended. The CRF from Pope et al (Pope, Dockery et al. 1991) may be used in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Increased respiratory symptoms	Any day symptoms: With 1-hour SO_2: 1.0257 (1.00189-1.0502) per 1 μg/m^3 (Any cough, wheeze, shortness of breath, runny nose, eye irritation, fever) 24-hour average Lag 1 With 24-hour SO_2: 1.0253 (1.0015-1.0496) per 1 μg/m^3 (Any cough, wheeze, shortness of breath, runny nose, eye irritation, fever) 24-hour average Lag 1 Any night symptoms: 1.0163 (1.0029-1.0298) per 1 μg/m^3 (any cough, wheeze, shortness of breath) 24-hour average Lag 2 (Williams, Marks et al. 2012) Six cities –					Recommended CRF: Use CRFs from Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
General practitioner consultation for asthma	1.11 (1.04-1.19) per 12 µg/m^3 (Jalaludin, O'Toole et al. 2004) 125 children (mean age about 9.6 years) with a history of wheezing in previous 12 months. Sydney.	n/a	0-14 years: 2.5% (0.0-5.2%) per 10 µg/m^3 15-64 years: 3.1% (1.2-5.0%) per 10 µg/m^3 65+ years: 6.3% (2.1-11.2%) per 10 µg/m^3 (Hajat, Haines et al. 1999) (European Commission 2005) (AEA Technology Environment 2005) CRFs for warm season only. CRFs only used for sensitivity analysis	n/a	n/a	No recommended CRF. CRFs from Jalaludin et al (Jalaludin, O'Toole et al. 2004) and Hajat et al (Hajat, Haines et al. 1999) may be used in may be used in sensitivity analyses.
General practitioner consultation for upper respiratory disease	n/a	n/a	0-14 years: No effect 15-64 years: 1.8% (0.9-2.8%) per 10 µg/m^3 65+ years: 3.3%	n/a	n/a	No recommended CRF. CRFs from Hajat et al (Hajat, Anderson et al. 2002) may be

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
			(1.7-5.0%) per 10 µg/m^3 (Hajat, Anderson et al. 2002) (European Commission 2005) (AEA Technology Environment 2005) ICD9: 460-3, 465, 470-5, 478. CRFs only used for sensitivity analysis			used in may be used in sensitivity analyses.

[1]Not available
[2]A restricted activity days is defined as a day when a person is forced to alter his/her normal activity. A severe restriction include days when it necessary to stay in bed. For employed adults, restricted activity days include Work Loss Days; for children, it would include days off school (whether or not the child is confined to bed). (ExternE 1995)
[3]Minor restricted activity days do not involve work loss or bed disability but do include some noticeable limitation on 'normal' activity (ExternE 1995).

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Table 3: O_3 health endpoints and associated concentration-response functions

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Long-term outcomes(annual average concentration)						
Mortality						
All cause	n/a[1]	n/a	n/a	No effect (Jerrett, Burnett et al. 2009) (Abt Associates Inc 2011) Age: 30-99 years. Annual 1-hour average.	n/a	No CRF recommended.
Cardiopulmonary	n/a	n/a	n/a	Cardiovascular disease: No effect (Jerrett, Burnett et al. 2009) (Abt Associates Inc 2011) Age: 30-99 years. Annual 1-hour average.	n/a	No CRF recommended.
Ischaemic heart disease	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lung cancer	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Respiratory	n/a	n/a	n/a	1.040 (1.013-1.067) per 10 ppb (Jerrett, Burnett et al. 2009) (Abt Associates Inc 2011) ICD9: 460-519 Age: 30-99 years. Annual 1-hour average. Adjusted for $PM_{2.5}$.	n/a	No CRF recommended. Insufficient evidence - only 1 study.
Infant (<12 months age)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Life expectancy lost (years of life lost)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Morbidity						
Incidence of chronic obstructive pulmonary disease (COPD) or chronic bronchitis	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Incidence of asthma	Ever had wheezing: Protective effect in single and 2-pollutant models with PM, NO_2, SO_2 and CO.	n/a	n/a	2.8% (0.1-5.6%) per 1 ppb (McDonnell, Abbey et al. 1999) (US EPA 1999) Age: Non-asthmatic males 27+ years.	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Ever had asthma: Protective effect in single and 2-pollutant models with PM, NO_2, SO_2 and CO. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly O_3 over lifetime. Age: mean age10.0 years. 2,860 children.			Annual average 8-hour ozone.		Study by McDonnell et al (McDonnell, Abbey et al. 1999) may be used in a sensitivity analysis.
Recent symptoms (in last 12 months)	Cough: 1.14 (1.01-1.29) per 3.12 ppb in single pollutant model. 1.26 (1.06-1.50) per 3.12 ppb in 2-pollutant model with CO. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth,	n/a	n/a	n/a	n/a	Recommended CRF: Cough: 1.26 (1.06-1.50) per 3.12 ppb in 2-pollutant model with CO (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Sydney. Average hourly O_3 over lifetime. Age: mean age10.0 years. 2,860 children.					
Lung function growth	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Change in forced expiratory volume in 1 second (FEV_1; litres)	No effect. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly O_3 over lifetime. Age: mean age10.0 years. 2,860 children.	n/a	n/a	n/a	n/a.	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Change in forced vital capacity (FVC; litres)	No effect. (Williams, Marks et al. 2012)] Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly O_3 over lifetime.	n/a	n/a	n/a	n/a.	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Age: mean age10.0 years. 2,860 children.					
Airway inflammation	Protective effect in single and 2-pollutant models with PM, NO_2, SO_2 and CO (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly O_3 over lifetime. Age: mean age10.0 years. 2,860 children.	n/a	n/a	n/a	n/a.	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Birth outcomes						
Birth defects	Pulmonary artery & valves: 2.96% (1.34- 7.52%) per 5 ppb (Hansen, Barnett et al. 2009) Brisbane. Birth addresses <6km of air monitoring station.	n/a	n/a	n/a	n/a	No CRF recommended. Only 1 Australian study.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Prematurity	1.26 (1.10-1.45) per 7.1 ppb (Hansen, Neller et al. 2006) CRF not linear. Brisbane. Preterm: <37 weeks 1st trimester exposure. 1.604 (1.268-2.030) per 1 ppb 1st month gestation for women living <5km of air quality monitor. No effect for all Sydney. Preterm: <37 weeks. 1.014 (1.005-1.022) per 1 ppb Sydney wide Preterm: <37 weeks gestation 1st trimester exposure. 0.807 (0.668-0.976) per 1 ppb	n/a	n/a	n/a	n/a	No CRF recommended. Only 2 Australian studies are available and evidence is conflicting regarding CRF.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	for women living <5 km of air quality monitor. Preterm: <37 weeks gestation. 1^{st} trimester exposure. Sydney. (Jalaludin, Mannes et al. 2007)					
Low birth weight	No effect. Brisbane. (Hansen, Neller et al. 2007) Small for gestational age: 1.00 (1.00-1.01) per 1 ppb 1-hour maximum Sydney Small for gestational age >2 standard deviations below the mean birth weight by sex and gestational age. Exposure in 1^{st}, 2^{nd} or 3^{rd} trimesters. Birth weight: grams (-0.12 to -0.09 grams) per 1 ppb 2^{nd} trimester	n/a	n/a	n/a	n/a	No CRF recommended. Only 2 Australian studies available.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	exposure. Sydney. (Mannes, Jalaludin et al. 2005)					
Head circumference Crown-heel length	No effect on either head circumference or crown-heel length. (Hansen, Neller et al. 2007) Brisbane.	n/a	n/a	n/a	n/a	No CRF recommended. Only 1 Australian study available.
Short-term outcomes(daily average concentration)						
Mortality						
Non-trauma	1.0004 (0.9999-1.0010) per 1 ppb 4-hour maximum Lag 0 1.0004 (0.9999-1.0008) per 1 ppb 1-hour maximum Lag 0 (Simpson, Williams et al. 2005) Pooled CRF from 4 cities - Sydney, Perth, Melbourne, Brisbane. ICD9: <800	0.059% per 1 $\mu g/m^3$ (Sunyer, Castellsague et al. 1996) (European Commission 2005) Age: All ages. 1.027 (1.013-1.039) per 50 $\mu g/m^3$ (Committee on the Medical Effects of Air Pollutants 1998) 8-hour average. Age: All ages. All non-trauma	0.3% (0.1-0.43%) per 10 $\mu g/m^3$ (Anderson, Atkinson et al. 2004) (European Commission 2005) WHO meta-analysis. Daily maximum 8-hour average O_3. Assuming linearity without threshold. 0.3% (0.1-0.4%) change per 10 $\mu g/m^3$	0.5-1% increase per 30 ppb (US EPA 2006) 8-hour maximum average. n/a (Abt Associates Inc 2011) Meta-analysis of 6 studies.	0.3% (0.1-0.43%) increase per 10 $\mu g/m^3$ (Anderson, Atkinson et al. 2004) (AEA Technology Environment 2005) WHO meta-analysis. Daily maximum 8-hour average. All ages. 1.003 (1.001-1.004) per 10 $\mu g/m^3$ (8-hour average).	Recommended CRF: 1.4% (0.3-2.4%) per 9.83 ppb (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	ICD10: A-R, Z35.5, Z35.8 Age: All ages. 1.4% (0.3-2.4%) per 9.83 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Age: All ages. All year. No heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: <800; ICD10: A-R, Z35.5, Z35.8	deaths. Meta-analysis of 5 European cities.	(AEA Technology Environment 2005)		Estimate revised for possible publication bias 1.002 (1.000-1.003). (Anderson, Atkinson et al. 2004) 0.3-0.5% increase in daily mortality per 10 $\mu g/m^3$ 8-hour average O_3 above 70 $\mu g/m^3$. (WHO 2006)	
Cardiovascular	1.0008 (0.9999-1.0016) per 1 ppb (4-hour maximum) (lag0) 1.0006 (0.9999-1.0013) per 1 ppb 1-hour maximum Lag 0 Pooled CRF from 4 cities - Sydney, Perth, Melbourne,	0.4% (0.3-0.5%) change per 10 $\mu g/m^3$ (Committee on the Medical Effects of Air Pollutants 2006) 8-hour average No evidence of publication bias. CRF not intended for health risk assessment	n/a	n/a	1.004 (1.003, 1.005) per 10 $\mu g/m^3$ Estimate revised for possible publication bias 1.004 (1.003-1.005). (Anderson, Atkinson et al. 2004) 8-hour average.	Recommended CRF: 2.1% (1.1-3.1%) per 9.83 ppb (Environment Protection and Heritage Council 2005). Note that CRFs from Simpson et al (Simpson, Williams et al. 2005) are very

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Brisbane. ICD9: 390-459; ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58 Age: All ages. (Simpson, Williams et al. 2005) 2.1% (1.1-3.1%) per 9.83 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Age: All ages. All year. No heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 390-459; ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3),	purposes.				close to being statistically significant.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	G46, M30, M31, R58					
Respiratory	1.0023 (1.0005-1.0042) per 1 ppb 4-hour maximum. Lag 0. 1.0020 (1.0003-1.0036) per 1 ppb (Simpson, Williams et al. 2005) 1-hour maximum. Lag 0. Pooled CRF from 4 cities - Sydney, Perth, Melbourne, Brisbane. ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8 Age: All ages. 2.4% (0.1-4.7%) per 9.83 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Age: All ages.	n/a	n/a	n/a	1.000 (0.996-1.005) per 10 $\mu g/m^3$ Estimate revised for possible publication bias to 0.999 (0.995-1.004). (Anderson, Atkinson et al. 2004) 8-hour average.	Recommended CRF: 2.4% (0.1-4.7%) per 9.83 ppb (Environment Protection and Heritage Council 2005). The EPHC study (Environment Protection and Heritage Council 2005) used as it is the more recent than the study by Simpson et al (Simpson, Williams et al. 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	All year. No heterogeneity. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8					
Hospitalisation						
Cardiovascular	15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 390-459 ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31,	No effect. (Committee on the Medical Effects of Air Pollutants 2006) 8-hour average. No evidence of publication bias. CRF not intended for health risk assessment purposes.	No strong evidence of association between daily O_3 and cardiovascular disease admissions. (European Commission 2005)	n/a	n/a Insufficient studies for meta-analysis (Anderson, Atkinson et al. 2004)	No CRF recommended. No effect in Australian meta-analysis (Environment Protection and Heritage Council 2005) and in COMEAP study (Committee on the Medical Effects of Air Pollutants 2006).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	R58					
Cardiac	All ages: No effect. 15-64 years: 1.0009 (1.0001-1.0017) per 1 ppb. 4-hour average. Lag 3. Pooled estimate from 4 cities - Sydney, Brisbane, Melbourne, Perth. ICD9: 390-429 ICDI0: I00-I52, I97.0, I97.1, I98.1 (Simpson, Williams et al. 2005) 15-64 years: No effect. 65+ years: No effect. (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth, Sydney. Low heterogeneity. ICD9: 390-429;	n/a	n/a	n/a	n/a	No CRF recommended. No effect in more recent Australian meta-analysis (Environment Protection and Heritage Council 2005). CRF for 15-64 years from Simpson et al (Simpson, Williams et al. 2005) may be used in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	ICDI0: I00-I52, I97.0, I97.1, I98.1					
Cardiac failure	15-64 years: No effect. 65+ years: No effect. (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 4 cities - Brisbane, Canberra, Melbourne, Perth Sydney. Moderate heterogeneity in 15-64 years. ICD9: 428; ICD10: I50	n/a	n/a	n/a	n/a	No CRF recommended. No effect in the EPHC study (Environment Protection and Heritage Council 2005).
Cerebrovascular disease	Stroke: 15-64 years: No effect. 65+ years: No effect. (Environment Protection and Heritage Council 2005) 1-hour maximum.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in the EPHC study (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Lag 01. Meta-analysis of 4 cities - Brisbane, Canberra, Melbourne, Perth Sydney. Low heterogeneity. ICD9: 430-438 ICD10: I60-I66, I67 (excluding I67.0, I67.3), I68 (excluding I68.0), I69, G45 (excluding G45.3), G46					
Ischaemic heart disease	15-64 years: No effect. 65+years: No effect. (Environment Protection and Heritage Council 2005) Meta-analysis of 4 cities - Brisbane, Melbourne, Perth, Sydney Low heterogeneity ICD9: 410-413 ICD10: 120-122, 124, 125.2 No effect. (Simpson, Williams et al. 2005)	-0.1% (-0.7 to 0.4%) per 10 $\mu g/m^3$ (Committee on the Medical Effects of Air Pollutants 2006) 8-hour average No evidence of publication bias. CRF not intended for health risk assessment purposes.	n/a	n/a	n/a	No CRF recommended. No effect in the EPHC study (Environment Protection and Heritage Council 2005), Simpson study (Simpson, Williams et al. 2005) and in COMEAP study (Committee on the Medical Effects of Air Pollutants 2006).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Pooled estimate from 4 cities - Sydney, Brisbane, Melbourne, Perth. All ages and 65+ years.					
Arrhythmia	15-64 years: No effect. 65+ years: No effect. (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. Low heterogeneity. ICD9: 437; ICD10: I46-I49	n/a	n/a	n/a	n/a	No CRF recommended. No effect in the EPHC study (Environment Protection and Heritage Council 2005).
Myocardial infarction	15-64 years: No effect. 65+ years: No effect. (Environment Protection and Heritage Council 2005) 1-hour maximum.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in the EPHC study (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Lag 01. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. High heterogeneity. in 65+ years ICD9: 410; ICDI0: I21, I22					
Respiratory	65+ years: No effect. (Simpson, Williams et al. 2005) 1-hour maximum. ICD9: 460-519 ICD10: J00-J99 (excluding J95.4-J95.9), R09.1, R09.8. Pooled analysis from 4 cities - Brisbane, Sydney, Melbourne, Perth. All ages: 1.023 (1.003-1.043) per 1 pphm 0-4 years: Protective effect. 1-hour maximum Lag 0 5-14 years: No effect.	All ages: 3.5% per 50 µg/m^3 15-64 years: 1.031 (1.013-1.049) per 50 µg/m^3 (Committee on the Medical Effects of Air Pollutants 1998) Whole population. 8-hour average. Meta-analysis of 4 European cities. ICD9: 460-519	Various age groups analysed: effect close to significant for 65+ years only. 65+ years: No effect. (Anderson, Atkinson et al. 2004). (European Commission 2005) 8-hour average. Meta-analysis of 5 European cities.	n/a Pooled analysis of a number of studies – unable to locate CRF. (Abt Associates Inc 2011)	n/a All ages: 5% increase per 25 µg/m^3 (8-hour average) and 30 µg/m^3 1-hour average (WHO Europe 2000) 0-14 years: Insufficient numbers for meta-analysis 15-64 years: 1.001 (0.991-1.012) per 10 µg/m^3 65+ years: 1.005 (0.998-1.012) per 10 µg/m^3 (Anderson, Atkinson et al. 2004) 8-hour average.	No CRF recommended. Results are inconsistent. The Brisbane CRFs (Petroeschevsky, Simpson et al. 2001) and the 4-cities meta-analysis (Environment Protection and Heritage Council 2005) may be used in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	1-hour maximum Lag 0 15-64 years: 1.045 (1.013-1.079) per 1 pphm 8-hour average Lag 2 65+ years: 1.054 (1.016-1.094) per 1 pphm 8-hour average Lag 3 (Petroeschevsky, Simpson et al. 2001) Brisbane ICD9: 460-519 All ages: No effect 0-14 years: No effect. 65+ years: No effect. Perth. (Hinwood, De Klerk et al. 2006) 0 year: No effect. 1-4 years: 1.9% (0.5-3.4%) per 9.83 ppb 1-hour maximum. Lag 01. All year.					

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	No heterogeneity. 5-14 years: No effect. 15-64 years: No effect. 65+ years: No effect. (Environment Protection and Heritage Council 2005) Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 460-519 ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8					

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Asthma	No effect on three age groups: all ages; <15 years; 65+ years. Perth. (Hinwood, De Klerk et al. 2006) 1-14 years No effect. 15-64 years: No effect. (Morgan, Corbett et al. 1998) Sydney. All ages: 1.090 (1.042-1.141) per 1 pphm Lag 5 average 0-14 years: 1.064 (1.015-1.115) per 1 pphm Lag 1 15-64 years 1.084 (1.037-1.133) per 1 pphm Lag 2 (Petroeschevsky, Simpson et al. 2001) 8-hour average. Brisbane.	n/a	n/a	n/a	n/a	No CRF recommended. Australian results are inconsistent. The Brisbane CRFs (Petroeschevsky, Simpson et al. 2001) and the 4-cities meta-analysis (Environment Protection and Heritage Council 2005) may be used in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	No effect. (Simpson, Williams et al. 2005) Age: 15-64 years ICD9: 493, ICD10: J45, J46, J44.8 Pooled analysis from 4 cities - Brisbane, Sydney, Melbourne, Perth. Age: 1-4 years 0.5% (0.3-0.7%) per 1 ppb 1-hour maximum. Lag 01. Warm season: November-April. No heterogeneity. (Environment Protection and Heritage Council 2005) Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 493; ICD10: 45, J46, J44.8					
Chronic obstructive pulmonary disease (COPD)	All ages: No effect. <15 years: No effect. 65+ years: No	65+ years: 1.038 (1.018-1.058) per 50 $\mu g/m^3$ (Committee on the	n/a	n/a	n/a	No CRF recommended. Inconsistent results

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	effect. (Hinwood, De Klerk et al. 2006) Perth. 65+ years: No effect (Morgan, Corbett et al. 1998) Sydney. Asthma+COPD: 65+ years: 1.0013 (1.0001-1.0026) per 1 ppb (Simpson, Williams et al. 2005) 4-hour average. Lag 0. Asthma: ICD9: 493; ICD10: J45, J46, J44.8 COPD: ICD9: 490-492, 494-496; ICD10: J40-J44, J47, J67 Pooled analysis from 4 cities - Brisbane, Sydney, Melbourne, Perth. 15-64 years: No effect 65+ years: No effect (Environment	Medical Effects of Air Pollutants 2002) 8-hour average Meta-analysis of 4 European cities.				from the two Australian multi-city studies. CRF from Simpson et al (Simpson, Williams et al. 2005) may be used in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Protection and Heritage Council 2005) 1-hour maximum Lag 01 Moderate to high heterogeneity Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney ICD9: 490-492, 494-496 ICDI0: J40-J44, J47, J67					
Pneumonia and acute bronchitis	All ages: No effect <15 years: No effect 65+ years: No effect (Hinwood, De Klerk et al. 2006) Perth No effect. (Simpson, Williams et al. 2005) 65+ years. ICD9: 466, 480-486 ICD10: J12-J17, J18.0, J18.1, Jl8.8, JI8.9, J20, J21 Pooled analysis from 4 cities - Brisbane, Sydney,	n/a	n/a	n/a	n/a	No CRF recommended. No effect shown in Australian studies.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Melbourne, Perth. 0 years: No effect 1-4 years: No effect 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) High heterogeneity for 15-64 years only. Meta-analysis of 4 cities - Brisbane, Melbourne, Perth Sydney. ICD9: 466, 480-486 ICD10: J12-J17, J18.0, J18.1, Jl8.8, JI8.9, J20, J21					
Emergency department visits						
Asthma	1-4 years: 2.3% (1.4-3.2%) per 13.6 ppb 5-9 years: 2.1% (0.7-3.5%) per 13.6 ppb 10-14 years: No effect. 1-14 years: 1.8%	n/a	n/a	1.022 (0.996-1.049) per 25 ppb (Peel, Tolbert et al. 2005) (Wilson, Wake et al. 2005) (Abt Associates Inc 2011) Pooled results from	n/a	Recommended CRF: 1-14 years: 1.8% (1.1-2.5%) per 13.6 ppb (Jalaludin, Khalaj et al. 2008).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(1.1-2.5%) per 13.6 ppb (Jalaludin, Khalaj et al. 2008) 1-hour maximum. Lag 01. Greater significant effects in warm months but not cool months. ICD9: 493 Children Sydney 1-15 years Non-linear significant response for Western & South/South Eastern regions (No CRFs available). No effect of O_3 for Inner Melbourne or Eastern Melbourne regions. (Erbas, Kelly et al. 2005) ICD10: J45, J46 Melbourne.			3 cities and 2 studies. 8-hour maximum. Age: 0-99 years.		
Respiratory disease	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Cardiovascular	n/a	n/a	n/a	n/a	n/a	No CRF

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
disease						recommended.
Incidence of myocardial infarction (heart attacks)						
Non-fatal heart attacks	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lung function						
Change in forced expiratory volume in 1 second (FEV_1; litres)	No effect of 1-hour maximum, 4-hour average and 8-hour average on PEF either in all year analysis or in warm season only analysis (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Age: mean 10.0 years (n=270) 270 children with current asthma	n/a	n/a	n/a	n/a Lung function deficits seen in exercising children exposed to daily maximum 8-hour average of 160 $\mu g/m^3$. (WHO 2006) 10% change in FEV_1 at 160$\mu g/m^3$ (8-hour average) and 350$\mu g/m^3$ (1-hour average). 5% change in FEV_1 at 120$\mu g/m^3$ (8-hour average) and 250$\mu g/m^3$ (1-hour average) (WHO Europe 2000) Controlled exposure studies.	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Change in peak expiratory flow rate (PEF; litres per minute)	Average change in PEF: -0.8823 l/min (-0.0542 to -1.7104 l/min) per 1 pphm (Jalaludin, Chey et al. 2000) Mean daytime ozone. 148 children with history of wheezing in last 12 months. Mean age: 9.6 years. Sydney. 15-54 years: -0.2047 l/min (-0.2760 to -0.03342 l/min) per 1 pphm 8-hour average 3-day average Spring 55+ years: -0.1568 l/min (-0.2864 to -0.0272 l/min) per 1 pphm 8-hour average Lag 2 Winter (Rutherford, Simpson et al. 2000) Brisbane	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Asthmatics allergic to at least one pollen or fungal allergen. No effect of 1-hour maximum, 4-hour average and 8-hour average on PEF either in all year analysis or in warm season only analysis. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Minor morbidity						
Asthma exacerbation (asthmatics)	n/a	n/a However, CRF from Whittemore and Korn 1980 used in health risk assessment	n/a	1.0018 (1.0004-1.0032) per 1 ppb (Whittemore and Korn 1980) (US EPA 1999) Asthmatics of all ages	n/a	Recommended CRF: 1.0018 (1.0004-1.0032) per 1 ppb (Whittemore and Korn 1980) (US EPA 1999)

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
				1-hour maximum		
Asthma/ respiratory exacerbations (whole population)	n/a	n/a	No effect. (Hoek and Brunekreef 1995; Declerq and Macquet 2000)) (European Commission 2005) Whole population of children aged 5-14 years France. 8-hour daily maximum .	n/a	n/a 25% increased symptoms in adults or asthmatics per 100 $\mu g/m^3$ (8-hour average) and 200 $\mu g/m^3$ (1-hour average). (WHO Europe 2000)	No CRF recommended. CRF from European Commission (European Commission 2005) is not statistically significant and CRFs from WHO (WHO Europe 2000) do not have associated confidence limits.
Increased airway hyper-responsiveness	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Restricted activity days (RAD)[2]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Minor restricted activity days (MRAD)[3]	n/a	1.48% (0.57-2.38%) per 10 $\mu g/m^3$ 8-hour average 0.11% (0.043-0.179%) per 1 $\mu g/m^3$ (Ostro and Rothschild 1989) in	1.48% (0.57-2.38%) per 10 $\mu g/m^3$ 8-hour average 0.11% (0.043-0.179%) per 1 $\mu g/m^3$ 1-hour maximum (Ostro and Rothschild 1989).	1.0022 (1.0009-1.0035) per 1 ppb (Ostro and Rothschild 1989) (US EPA 1999) (Abt Associates Inc 2011) 1-hour maximum. Age: 18-65 years.	n/a	Recommended CRF: 1.0022 (1.0009-1.0035) per 1 ppb (Ostro and Rothschild 1989) (US EPA 1999) (Abt Associates Inc 2011)

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
		(European Commission 1995) (AEA Technology Environment 2005) Age: Adults. 1-hour maximum O_3 adjusted for $PM_{2.5}$ in study.	(European Commission 2005) Age: 18+ years. Whole population. O_3 adjusted for $PM_{2.5}$ in study.	O_3 adjusted for $PM_{2.5}$ in study.		
Work lost days (WLD)[2]	n/a	n/a	n/a	n/a Pooled estimate from 2 studies – unable to locate CRF. (Abt Associates Inc 2011)	n/a	No CRF recommended.
Acute bronchitis	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Upper respiratory illness	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lower respiratory symptoms	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Acute respiratory symptoms	No effect on cough, wheeze, runny/blocked nose. (Rodriguez et al, 2007) Perth.	n/a	Presence of any 19 acute respiratory symptoms: 1.0055 (1.0002-1.0109) per 10 ppb (Krupnick, Harrington et al.	Presence of any 19 acute respiratory symptoms: 1.0001 (1.0000-1.0003) per 1 ppb (Krupnick, Harrington et al.	n/a	No CRF recommended. CRF by Krupnick et al (Krupnick, Harrington et al. 1990) may be used

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
			1990) (European Commission 1995). (AEA Technology Environment 2005)	1990) (US EPA 1999) Age: 18-65 years. Whole population. 1-hour maximum.		in a sensitivity analysis. This endpoint not used by US EPA in its most recent cost-benefit analysis (US EPA 2011).
Wheeze	No effect. (Rodriguez et al, 2007) Perth. Evening wheeze: No effect (Jalaludin, O'Toole et al. 2004) 148 children. Mean age 9.6 years. Sydney. Day wheeze: No effect of 1-hour maximum, 4-hour average or 8-hour average in either all year analysis or warm season only analysis except for protective effect for 8-hour average in all year analysis.	n/a	n/a	n/a	n/a	No CRF recommended. No effects have been shown in Australian studies including the 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Night symptoms: Protective effects for 1-hour maximum, 4-hour average and 8-hour average in both all year analysis and warm season only analysis (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Age: mean 10.0 years 270 children with current asthma					
Cough	No effect. (Rodriguez et al, 2007) Perth Evening dry/wet cough: No effect. (Jalaludin, O'Toole et al. 2004) 148 children. Mean age 9.6 years.	n/a	Incidence night cough: No effect (Just et al. 2002) (European Commission 2005) Based on 1 study (82 children aged 7-15 years with doctor diagnosed asthma taking daily asthma medications).	n/a	n/a	No CRF recommended. No effects have been shown in Australian studies including the 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Sydney. Day cough: No effect of 1-hour maximum, 4-hour average and 8-hour average in either all year analysis or in warm season only analysis. Night cough: No effect of 1-hour maximum, 4-hour average and 8-hour average in either all year analysis or in warm season only analysis. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.		8-hour daily average. Prevalence cough: No effect. (Declerq and Macquet 2000) (European Commission 2005) Whole population of children aged 5-14 years. France.			
Shortness of breath	Day SOB: No effect of 1-hour maximum, 4-hour average and	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	8-hour average in either all year analysis or in warm season only analysis. Night SOB: No effect of 1-hour maximum, 4-hour average and 8-hour average in either all year analysis or in warm season only analysis (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					No effects shown in Australian 6-cities study (Williams, Marks et al. 2012).
Bronchodilator use	No effect (Jalaludin, O'Toole et al. 2004) 148 children Mean age 9.6 years Sydney Day use: No effect	n/a	Days of supplementary bronchodilator use. 5-14 years: 1.41 (1.05-1.89) per 10 $\mu g/m^3$ (Gielen, van der Zee et al. 1997; Just,	n/a	n/a	No CRF recommended. No effects shown in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	of 1-hour maximum, 4-hour average and 8-hour average in either all year analysis or in warm season only analysis Night use: No effect of 1-hour maximum, 4-hour average and 8-hour average in either all year analysis or in warm season only analysis (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.		Segala et al. 2002) Recommended using as upper limit for sensitivity analyses only, as based on 1 study (82 children aged 7-15 years with doctor diagnosed asthma taking daily asthma medications) only with high odds ratios. Odds ratios based on days when children not taking corticosteroids. (European Commission 2005) Adults 20+ years: No effect. (ECRHS 1996; Hiltermann, Stolk et al. 1998). (European Commission 2005) Adults with well-established asthma. 8-hour maximum moving average.			
Upper respiratory symptoms	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Increased respiratory symptoms	Day symptoms: No effect of 1-hour maximum, 4-hour average or 8-hour average on any day symptoms (cough, wheeze, shortness of breath, runny nose, eye irritation, fever) in either all year analysis or warm season only analysis except for protective effect for 8-hour average in all year analysis. Night symptoms: No effect of 1-hour maximum, 4-hour average or 8-hour average on any night symptoms (cough, wheeze, shortness of breath) in either all year analysis or warm season only analysis (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane,	n/a	n/a	n/a	n/a	No CRF recommended. No effects shown in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Canberra, Melbourne, Perth, Sydney Age: mean 10.0 years 270 children with current asthma					
General practitioner consultation for asthma	No effect (Jalaludin, O'Toole et al. 2004) 148 children Mean age 9.6 years Sydney	n/a	n/a	n/a	n/a	No CRF recommended.
General practitioner consultation for upper respiratory disease	n/a	n/a	Consultations for allergic rhinitis: 0-14 years: 8.2% (5.1-11.6%) per 10 $\mu g/m^3$ 15-64 years: 5.5% (4.2-7.0%) 10 $\mu g/m^3$ (Hajat, Haines et al. 2001) in (Hurley, Hunt et al. 2005) (European Commission 2005) London (ICD9: 477) Lag 0-3 8-hour daily maximum Recommended using only for	n/a	n/a	No CRF recommended. May use CRFs from paper by Hajat et al (Hajat, Haines et al. 2001) in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
			sensitivity analyses as based on 1 study only.			

[1]n/a=not available
[2]A restricted activity days is defined as a day when a person is forced to alter his/her normal activity. A severe restriction include days when it necessary to stay in bed. For employed adults, restricted activity days include Work Loss Days; for children, it would include days off school (whether or not the child is confined to bed) (ExternE 1995).
[3]Minor restricted activity days do not involve work loss or bed disability but do include some noticeable limitation on 'normal' activity (ExternE 1995).

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Table 4: NO_2 health endpoints and associated concentration–response functions

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Long-term outcomes (annual average concentration)						
Mortality						
All cause	n/a[1]	n/a	n/a	n/a Results inconsistent. (US EPA 2008)	n/a	No CRF recommended.
Infant (<12 months age)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Life expectancy lost (years of life lost; YOLL)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Morbidity						
Incidence of chronic obstructive pulmonary disease (COPD) or chronic bronchitis	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Incidence of asthma	Ever had wheezing: No effect in single pollutant model. Largest effect in 2-	n/a	n/a	n/a Results inconsistent. (US EPA 2008)	n/a	Recommended CRF for asthma incidence: 1.27 (1.04-1.56) per 4.31

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	pollutant model with $PM_{2.5}$: 1.15 (1.01-1.31) per 4.31 ppb Ever had asthma: No effect in single pollutant model. Largest effect in 2-pollutant model with CO: 1.27 (1.04-1.56) per 4.31 ppb (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly NO_2 over lifetime. Age: mean age10.0 years. 2,860 children.					ppb (in 2-pollutant model with CO) (Williams, Marks et al. 2012).
Recent symptoms (in last 12 months)	Wheeze: 1.25 (1.07-1.46) per 4.31 ppb in 2-pollutant model with $PM_{2.5}$ Wheeze after exercise: 1.43 (1.05-1.96) per 4.31 ppb in 2-pollutant model with CO	n/a	n/a	n/a	n/a	Recommended CRFs: Wheeze: 1.25 (1.07-1.46) per 4.31 ppb in 2-pollutant model with $PM_{2.5}$ Wheeze after exercise: 1.43 (1.05-1.96) per 4.31

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Current asthma: 1.51 (1.08-2.12) per 4.31 ppb in 2-pollutant model with CO Visit to doctor/hospital: 1.51 (1.04-2.19) per 4.31 ppb in 2-pollutant model with O_3 Use of bronchodilators: 1.35 (1.05-1.76) per 4.31 ppb in 2-pollutant model with CO (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly NO_2 over lifetime . Age: mean age10.0 years. 2,860 children.					ppb in 2-pollutant model with CO Current asthma: 1.51 (1.08-2.12) per 4.31 ppb in 2-pollutant model with CO Visit to doctor/hospital: 1.51 (1.04-2.19) per 4.31 ppb in 2-pollutant model with O_3 Use of bronchodilators: 1.35 (1.05-1.76) per 4.31 ppb in 2-pollutant model with CO (Williams, Marks et al. 2012).
Lung function growth	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Change in forced expiratory volume in 1 second (FEV_1; litres)	-26.2 mls (-42.2 to -10.1 mls) per 4.31 ppb in single pollutant model Minimal change in estimates in 2-pollutant models with $PM_{2.5}$, PM_{10}, O_3. Effect increased in 2-pollutant model with CO: -45.4 mls (-74.3 to -16.5 mls) per 4.31 ppb (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly NO_2 over lifetime. Age: mean age10.0 years. 2,860 children.	n/a	n/a	n/a	n/a	Recommended CRF: -45.4 mls (-74.3 to -16.5 mls) per 4.31 ppb (in 2-pollutant model with CO) (Williams, Marks et al. 2012).
Change in forced vital capacity (FVC; litres)	-25.3 mls (-40.6 to -10.0 mls) per 4.31 ppb in single pollutant model.					Recommended CRF: -43.1 mls (-72.2 to -14.1 mls) per 4.31 ppb (in 2-

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Minimal change in estimates in 2-pollutant models with $PM_{2.5}$, PM_{10}, O_3. Effect increased in 2-pollutant model with O_3: -43.1 mls (-72.2 to -14.1 mls) per 4.31 ppb (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly NO_2 over lifetime. Age: mean age10.0 years. 2,860 children.					pollutant model with O_3) (Williams, Marks et al. 2012).
Airway inflammation	1.03 (1.01-1.05) per 1 ppb in single pollutant model. Remains significant in 2-pollutant models with $PM_{2.5}$, PM_{10}, O_3 and SO_2 and CO. (Williams, Marks et	n/a	n/a	n/a	n/a	Recommended CRF: 1.03 (1.01-1.05) per 1 ppb (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly NO_2 over lifetime. Age: mean age10.0 years. 2,860 children.					
Birth outcomes						
Birth defects	No significant associations for cleft lip and/or palate and cardiac defects. (Hansen, Barnett et al. 2009) Brisbane	n/a	n/a	n/a	n/a	No CRF recommended. Only 1 Australian study.
Prematurity	1.03 (0.86–1.23) per 4.5 ppb (Hansen, Neller et al. 2006) Brisbane 24-hour average Exposure period 3 months preceding birth. 1.006 (0.993-1.019) per 1 ppb	n/a	n/a	n/a	n/a	No CRF recommended. Only 2 Australian studies - no effect shown.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(Jalaludin, Mannes et al. 2007) Sydney 1-hour maximum Exposure period 3 months preceding birth.					
Low birth weight	1.01 (1.00-1.02) per 1 ppb for small for gestation age -1.48 (-2.70 to -0.26) grams per 1 ppb (Mannes, Jalaludin et al. 2005) Sydney 1-hour maximum Exposure period third trimester for both metrics. Small for gestation age <2 standard deviations from mean for sex and gestational age.	n/a	n/a	n/a	n/a	No CRF recommended. Only a few Australian studies.
Short-term outcomes(daily average concentration)						
Mortality						
Non-trauma	1.0012 (1.0006-	3.5% (1.6-5.4%) per	n/a	n/a	n/a	Recommended

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	1.0018) per 1 ppb (Simpson, Williams et al. 2005) Pooled CRF from 4 cities ICD9: <800; ICD10: A-R, Z35.5, Z35.8 Age: All 1.7% (0.3-3.2%) per 8.98 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Age: All All year. Moderate heterogeneity. Meta-analysis of 5 cities-Brisbane, Canberra, Melbourne, Perth, Sydney. ICD9: <800; ICD10: A-R, Z35.5, Z35.8	100 ug/m^3 (Touloumi, Katsouyanni et al. 1997) (Committee on the Medical Effects of Air Pollutants 1998) Pooled CRF from 6 cities.		(US EPA 2008) Suggestive but not sufficient to infer a causal relationship as it is difficult to attribute effects to NO_2 alone. However, estimates were robust to adjustment for co-pollutants.		CRF: 1.7% (0.3-3.2%) per 8.98 ppb (Environment Protection and Heritage Council 2005).
Cardiovascular	1.0018 (1.0008-1.0027) per 1 ppb (Simpson, Williams et al. 2005) Pooled CRF from 4	1.0% (0.8-1.3%) per 10 ug/m^3 (Committee on the Medical Effects of Air Pollutants 2006)	n/a	n/a Suggestive but not sufficient to infer a causal relationship as it is difficult to	n/a	Recommended CRF: 1.6% (0.4-2.8%) per 8.98 ppb (Environment Protection and

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	cities. ICD9: 390-459; ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58 Age: All 1.6% (0.4-2.8%) per 8.98 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Age: All ages All year No heterogeneity. Meta-analysis of 5 cities-Brisbane, Canberra, Melbourne, Perth, Sydney. ICD9: 390-459 ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31,	Moderate evidence of publication bias. CRF not intended for health risk assessment purposes.		attribute effects to NO_2 alone. However, estimates were robust to adjustment for co-pollutants. (US EPA 2008)		Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	R58					
Respiratory	1.0038 (1.0017-1.0058) per 1 ppb (Simpson, Williams et al. 2005) Pooled CRF from 4 cities. ICD9: 460-519 ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8 Age: All 3.9% (0.6-7.4%) per 8.98 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Age: All ages All year No heterogeneity Meta-analysis of 5 cities-Brisbane, Canberra, Melbourne, Perth, Sydney. ICD9: 460-519 ICD10: J00-J99 (excluding J95.4 to	No effect. (Zmirou, Schwartz et al. 1998) (Committee on the Medical Effects of Air Pollutants 1998)	n/a	n/a	n/a	Recommended CRF: 3.9% (0.6-7.4%) per 8.98 ppb (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	J95.9), R09.1, R09.8					
Hospitalisation						
Cardiovascular	n/a for all cardiovascular disease Four cities study. (Simpson, Williams et al. 2005) No effect (Petroeschevsky, Simpson et al. 2001) Brisbane ICD9: 390-459 Age: All Heart disease: 7.52% (5.21-9.88%) per 17 ppb (Morgan, Corbett et al. 1998) Sydney Age: All ICD9: 410, 413, 427, 428 24-hour average 15-64 years: 1.3% (0.3-2.3%) per 8.98 ppb	n/a	n/a	n/a	n/a	Recommended CRF: 1.3% (0.3-2.3%) per 8.98 ppb in 15-64 years; 2.6% (1.8-3.3%) per 8.98 ppb in 65+ years (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	65+ years: 2.6% (1.8-3.3%) per 8.98 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 (Barnett, Williams et al. 2005) Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney Low heterogeneity ICD9: 390-459; ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58					
Cardiac	1.0022 (1.0016-1.0028) per 1 ppb (Simpson, Williams et al. 2005) Pooled estimate from 4 cities (Sydney, Perth, Melbourne,	1.3% (1.0-1.7%) per 10 ug/m^3 (Committee on the Medical Effects of Air Pollutants 2006) No evidence of publication bias. CRF not intended	n/a	n/a Inadequate evidence for causal relationship, but generally positive associations seen with cardiovascular disease	n/a	Recommended CRF: 15-64 years: 1.2% (0.0-2.4%) per 8.98 ppb in 15-64 years; 3.3% (2.4-4.3%) per 8.98 ppb in 15-64 years (Environment

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Brisbane) ICD9: 390-429 ICDI0: I00-I52, I97.0, I97.1, I98.1 Age: All 1-hour maximum 15-64 years: 1.2% (0.0-2.4%) per 8.98 ppb 65+ years: 3.3% (2.4-4.3%) per 8.98 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney Low heterogeneity ICD9: 390-429; ICDI0: I00-I52, I97.0, I97.1, I98.1	for health risk assessment purposes.		hospitalisations or emergency department presentations. (US EPA 2008)		Protection and Heritage Council 2005). Chosen as it is a more recent study. In a sensitivity analysis use the following CRFs: 1.0022 (1.0016-1.0028) per 1 ppb (Simpson, Williams et al. 2005). This study applies to all ages.
Cardiac failure	15-64 years: No effect 65+ years: 7.5% (5.3-9.7%) per 8.98 ppb	1.3% (0.4-2.3%) change per 10 ug/m^3 (Committee on the Medical Effects of	n/a	n/a	n/a	Recommended CRF: 7.5% (5.3-9.7%) per 8.98 ppb in 65+ years (Environment

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney Low heterogeneity ICD9: 428; ICD10: I50	Air Pollutants 2006) Weak evidence of publication bias. CRF not intended for health risk assessment purposes.				Protection and Heritage Council 2005).
Cerebrovascular	Stroke: 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney. Low heterogeneity. ICD9: 430-438; ICD10: I60-I66, I67 (excluding I67.0,	0.4% (0.0-0.8%) per 10 ug/m^3 (Committee on the Medical Effects of Air Pollutants 2006) No evidence of publication bias. CRF not intended for health risk assessment purposes.	n/a	n/a	n/a	No CRF recommended. This CRF may be used in a sensitivity analysis: 0.4% (0.0-0.8%) per 10 ug/m^3 (Committee on the Medical Effects of Air Pollutants 2006). However note that CRF not intended for health risk assessment purposes.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	I67.3), I68 (excluding I68.0), I69, G45 (excluding G45.3), G46					
Ischaemic heart disease	1.0017 (1.0007-1.0027) per 1 ppb (Simpson, Williams et al. 2005) Pooled estimate from 4 cities (Sydney, Perth, Melbourne, Brisbane) ICD9: 410-413; ICDI0: I20-I22, I24, I25.2 Age: All 1-hour maximum 15-64 years: No effect 65+ years: 2.7% (1.5-4.0%) per 8.98 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Meta-analysis of 5 cities - Brisbane, Canberra,	0.6% (-0.1 to 1.4%) per 10 ug/m^3 (Committee on the Medical Effects of Air Pollutants 2006) No evidence of publication bias. CRF not intended for health risk assessment purposes.	n/a	n/a	n/a	Recommended CRF: 1.0017 (1.0007-1.0027) per 1ppb (Simpson, Williams et al. 2005). The following CRF may be used in a sensitivity analysis: 2.7% (1.5-4.0%) per 8.98 ppb in 65+ years (Environment Protection and Heritage Council 2005). Note the restricted agegroup.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Melbourne, Perth, Sydney. Low heterogeneity. ICD9: 410-413; ICDI0: I20-I22, I24, I25.2					
Arrhythmia	15-64 years: 3.4% (0.7-6.3%) per 8.98 ppb 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney. Low heterogeneity. ICD9: 437; ICD10: I46-I49	n/a	n/a	n/a	n/a	Recommended CRF: 3.4% (0.7-6.3%) per 8.98 ppb in 15-64 years (Environment Protection and Heritage Council 2005).
Myocardial infarction	15-64 years: No effect 65+ years: 4.8% (2.3-7.4%) per 8.98 ppb (Environment Protection and Heritage Council	n/a	n/a	n/a	n/a	Recommended CRF: 4.8% (2.3-7.4%) per 8.98 ppb in 65+ years (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	2005) 1-hour maximum Lag 01 Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney. Low heterogeneity. ICD9: 410; ICDI0: I21, I22					
Respiratory	65+ years: 1.0016 (1.0006-1.0026) per 1 ppb Pooled estimate from 4 cities - Sydney, Perth, Melbourne, Brisbane. ICD9: 460-519 ICDI0: J00-J99 (excluding J95.4-J95.9), R09.1, R09.8 1-hour maximum 1-4 years: 3.6% (1.5-5.7%) per 9.0 ppb 5-14 years: 4.0% (1.1-7.1%) per 9.0 ppb 15-64 years: 1.6%	No effect (Spix, Anderson et al. 1998) (Committee on the Medical Effects of Air Pollutants 1998), Pooled CRF from 5 cities. 2.5% (95%CI not available) per 10 ug/m^3 (DEFRA 2006) (Committee on the Medical Effects of Air Pollutants 1998) ICD9: 460-519	n/a	n/a Consistent evidence of positive associations. (US EPA 2008)	n/a	Recommended CRF: 1-4 years: 3.6% (1.5-5.7%) per 9.0 ppb; 5-14 years: 4.0% (1.1-7.1%) per 9.0 ppb; 15-64 years: 1.6% (0.5-2.8%) per 9.0 ppb (Environment Protection and Heritage Council 2005). 65+ years: 1.0016 (1.0006-1.0026) per 1 ppb (Simpson, Williams et al. 2005)

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(0.5-2.8%) per 9.0 ppb 65+ years: No effect. (Environment Protection and Heritage Council 2005) Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney. Low heterogeneity. ICD9: 460-519; ICDI0: J00-J99 (excluding J95.4-J95.9), R09.1, R09.8 1-hour maximum					
Asthma	1-14 years: 5.29% (1.07-9.68%) per 29 ppb (Morgan, Corbett et al. 1998) Sydney ICD9: 493 1-hour maximum No effect (Simpson, Williams et al. 2005) Pooled CRF from 4	2.6% (0.6-4.9%) per 50 ug/m^3 (Sunyer, Spix et al. 1997) (Committee on the Medical Effects of Air Pollutants 1998) Pooled CRF from 4 cities. 24-hour average ?Age	n/a	n/a Consistent evidence of positive associations, particularly for asthma. (US EPA 2008) 0-29 years: 1.0243 (1.0084-1.0405) per 10 ppb 30-99 years: 1.0141 (1.0042-1.0241) per	n/a	No CRF recommended. 2 Australian multi-cities studies have shown no effects. May use either Morgan et al (Morgan, Corbett et al. 1998) CRF in a sensitivity analysis. Note the restricted

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	cities (Sydney, Perth, Melbourne, Brisbane) ICD9: 493; ICDI0: J45, J46, J44.8 1-hour maximum 1-4 years: No effect 5-14 years: No effect 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney. Moderate heterogeneity Brisbane, Canberra, Melbourne, Perth, Sydney. ICD9: 493; ICDI0: J45, J46, J44.8 1-hour maximum			10 ppb (Linn, Szlachcic et al. 2000) (US EPA 2010) (Abt Associates Inc 2011) ICD9: 493 All ages		age group.
Chronic obstructive pulmonary disease (COPD)	65+ years: 1.0019 (1.0005-1.0033) per 1 ppb	1.9% (0.2-4.7%) per 50 ug/m^3 (Anderson, Spix et	n/a	Pooled CRF from 2 analyses shown below (pooled CRF	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(Simpson, Williams et al. 2005) Pooled estimate from 4 cities - Sydney, Perth, Melbourne, Brisbane. ICD9: 490-496; ICDI0: J40-47, J67 1-hour maximum Asthma+COPD 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) Moderate heterogeneity for 65+ years. Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney. ICD9: 490-492, 494-496; ICDI0: J40-J44, J47, J67 1-hour maximum	al. 1997) (Committee on the Medical Effects of Air Pollutants 1998) Pooled CRF from 6 cities		not available) LA County: 1.0182 (1.0144-1.0219) per 10 ppb Cook County: 1.0243 (1.0083-1.0405) per 10 ppb (Moolgavkar 2003) (US EPA 2010) (Abt Associates Inc 2011) ICD9: 490-496 Age: > 65 years		No effect in the 5-cities meta-analysis (Environment Protection and Heritage Council 2005). May use the CRF (65+ years: 1.0019 (1.0005-1.0033) per 1 ppb) from Simpson et al (Simpson, Williams et al. 2005) in a sensitivity analysis.
Pneumonia and acute bronchitis	65+ years: 1.0018 (1.0002-1.0033) per	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	1 ppb (Simpson, Williams et al. 2005) Pooled estimate from 4 cities - Sydney, Perth, Melbourne, Brisbane. ICD9: 466, 480-486; ICD10: J12-J17, J18.0, J18.1, Jl8.8, JI8.9, J20, J21 0 years: No effect 1-4 years: No effect 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) Moderate heterogeneity. Meta-analysis of 5 cities - Brisbane, Canberra, Melbourne, Perth, Sydney. ICD9: 466, 480-486; ICD10: J12-J17, J18.0, J18.1, Jl8.8, JI8.9, J20, J21					No effect in the 5-cities meta-analysis (Environment Protection and Heritage Council 2005). May use the CRF (65+ years: 1.0018 (1.0002-1.0033) per 1 ppb) from Simpson et al (Simpson, Williams et al. 2005) in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
Emergency department visits						
Asthma	Western Melbourne: 1.15 (1.03-1.27) per 28.9 ppb (Erbas, Kelly et al. 2005) Melbourne ICD10: J45, J46 Age: 1-15 years Modelled air pollution data using TAPM. Lag 2 daily 1-hour maximum. Single pollutant model: 2.3% (1.4, 3.2%) per 9.5 ppb Two pollutant model with $PM_{2.5}$: 1.1% (0.6-1.6%) per 9.5 ppb (Jalaludin, Khalaj et al. 2008) Sydney Age: 1-14 years 1-hour maximum 1.21 (1.03–1.43) per 1ppb (Pereira, Cook et al. 2010)	n/a	n/a	No CRF Consistent evidence of positive associations. (US EPA 2008) Pooled CRF from 3 studies (pooled CRF unavailable). 1.14 (1.09-1.19) per 24 ppb (Ito, Thurston et al. 2007) 1.08 (1.00-1.17) per 34 ppb (NYDOH 2006) 1.047 (1.011-1.085) per 20 ppb (Peel, Tolbert et al. 2005) 1-hour maximum (US EPA 2010) (Abt Associates Inc 2011) ICD9: 493 Age: All	n/a	Recommended CRF: Two pollutant model with $PM_{2.5}$: 1.1% (0.6-1.6%) per 9.5 ppb (Jalaludin, Khalaj et al. 2008). US EPA (Abt Associates Inc 2011) pooled CRF, if available, would be more suitable as it applies to all ages.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Perth Age: 0-4 years 24-hour average					
Cardiovascular disease	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Respiratory disease	n/a	n/a	n/a	No CRF Consistent evidence of positive associations. (US EPA 2008)	n/a	No CRF recommended.
Incidence of myocardial infarction (heart attacks)						
Non-fatal heart attacks (24-hour PM)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lung function						
Change in forced expiratory volume in 1 second (FEV_1; litres)	Morning FEV_1: -0.0025 (-0.0047 to -0.0002) per 1 ppb (Williams, Marks et al. 2012) 1-hour maximum Lag 2 Two-pollutant model with O_3 Six cities – Adelaide, Brisbane, Canberra,	n/a	n/a	n/a Inconsistent evidence. (US EPA 2008)	n/a	Recommended CRF: Morning FEV_1: -0.0025 (-0.0047 to -0.0002) per 1 ppb (Williams, Marks et al. 2012)..

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Change in peak expiratory flow rate (PEF; litres per minute)	No effect. (Jalaludin, Chey et al. 2000) Sydney 125 children with a history of wheezing in previous 12 months Age: mean age about 9.6 years No effect. (Rutherford, Simpson et al. 2000) Brisbane and Ipswich Mixed-models Age: All (n=53) History of allergy to pollen or fungi on skin prick testing Morning PEF: -0.4042 (-0.7318 to -0.0767) per 1 ppb	n/a	n/a	n/a	n/a	Recommended CRF: Morning PEF: -0.4042 (-0.7318 to -0.0767) per 1 ppb (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(Williams, Marks et al. 2012) 1-hour maximum Lag 2 Two-pollutant model with O_3 Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Minor morbidity	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Asthma exacerbation	n/a	n/a	n/a	Pooled CRF from 3 studies (pooled CRF unavailable). Not clear from the reports how asthma symptoms were combined. (O'Connor, Neas et al. 2008) Slow play, missed school days, Night-time asthma. (Ostro, Lipsett et al.	n/a	No CRF recommended. Uunable to locate pooled CRF used by US EPA.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
				2001) Cough, cough (new cases), shortness of breath, shortness of breath (new cases), wheeze, wheeze (new cases). (Schildcrout, Sheppard et al. 2006) One or more symptoms. (US EPA 2010) (Abt Associates Inc 2011) Age: 4–12 years No effect (Delfino, Zeiger et al. 2002) (US EPA 2010) (Abt Associates Inc 2011) Asthmatic children Age: 13–18 years One or more symptoms 8-hour maximum		
Increased airway hyper-responsiveness	n/a	n/a	n/a	n/a Increases observed in healthy adults with 1.5-2.0ppm (3-	n/a (WHO 2006) Chamber studies of bronchial	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
				hour) and in asthmatics with 0.3ppm (30 minutes) or 0.1ppm (60 minutes). (US EPA 2008)	responsiveness in asthmatics-effects seen > 200 µg/m3 (1-hour average).	
Restricted activity days (RAD)[2]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Minor restricted activity days (MRAD)[3]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Work lost days (WLD)[2]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Acute bronchitis (incidence, 8-12 years)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lower respiratory symptoms	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Acute respiratory symptoms	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Wheeze	No effect. (Rodriguez, Tonkin et al. 2007) Age: 0-5 years Perth 24-hour average No effect.	n/a	n/a	n/a	n/a	Recommended CRF in sensitivity analysis: *24-hour average* Day wheeze: 1.0722 (1.0130-1.1348) per 1 ppb in 2-pollutant model

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	(Jalaludin, O'Toole et al. 2004) 148 children (mean age about 9.6 years) with a history of wheezing in previous 12 months Sydney. *1-hour maximum* Day wheeze: 1.0356 (1.0130-1.0586) per 1 ppb Lag 0 Day wheeze: No effect in 2-pollutant model with O_3 Night wheeze: No effect *24-hour average* Day wheeze: 1.0722 (1.0130-1.1348) per 1 ppb in 2-pollutant model with O_3 Lag 0 Night wheeze: 1.0640 (1.0186-1.1114) per 1 ppb Night wheeze: No effect in 2-pollutant model with O_3 (Williams, Marks et					with O_3 (Williams, Marks et al. 2012). Note inconsistency of results between single and 2-pollutant models. Also note that two other Australian studies have not shown any effects.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Cough	1.028 (1.002-1.055) per ?1 ppm (Rodriguez, Tonkin et al. 2007) Age: 0-5 years Perth 24-hour mean Not clear from the paper the metric for NO_2 concentration used in the calculation of CRF. Wet cough: 1.05 (1.00-1.10) per 8.2 ppb Dry cough: No effect. (Jalaludin, O'Toole et al. 2004) 148 children (mean age about 9.6 years) with a history	n/a	n/a	1.17 (0.94-1.46) for a 10 ppb (Schwartz, Dockery et al. 1994) (US EPA 2010) (Abt Associates Inc 2011) Age: 7-14 years Lag 0-4 days	n/a	Recommended CRF in sensitivity analysis: *24-hour average* Night cough: 1.0447 (1.0015-1.0898) per 1 ppb in 2-pollutant model with O_3 (Williams, Marks et al. 2012). Note inconsistency of results between single and 2-pollutant models.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	of wheezing in previous 12 months. Sydney. *1-hour maximum* Day cough: 1.0186 (1.0013-1.0362) per 1 ppb Lag 2 Day cough: No effect in 2-pollutant model with O_3 Night cough: 1.0282 (1.0096-1.0473) per 1 ppb Lag 2 Night cough: No effect in 2-pollutant model with O_3 *24-hour average* Day cough: 1.0535 (1.0219-1.0861) per 1 ppb Lag 0 Day cough: No effect in 2-pollutant model with O_3 Night cough: 1.0447 (1.0015-1.0898) per 1 ppb in 2-pollutant model with O_3 Lag 3 (Williams, Marks et					

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Age: mean 10.0 years 270 children with current asthma					
Shortness of breath (SOB)	*1-hour maximum* Day SOB: No effect Night SOB: No effect *24-hour average* Day SOB: 1.0594 (1.0134-1.1075) per 1 ppb Lag 0 Day SOB: No effect in 2-pollutant model with O_3 Night SOB: 1.0771 (1.01835-1.1392) Lag 3 Night SOB: No effect in 2-pollutant model with O_3 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane,	n/a	n/a	n/a	n/a	No CRF recommended as no effect in 2-pollutant models in ACHAPS (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
	Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Bronchodilator use	No effect (Jalaludin, O'Toole et al. 2004) 148 children (mean age about 9.6 years) with a history of wheezing in previous 12 months. Sydney. No effect of either 1-hour maximum or 24-hour average (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.	n/a	n/a	n/a	n/a	No CRF recommended.
Upper respiratory	Runny/blocked	n/a	n/a	n/a	n/a	No CRF

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
symptoms	nose: No effect. (Rodriguez, Tonkin et al. 2007) Age: 0-5 years Perth 24-hour mean					recommended.
Increased respiratory symptoms	No effect on any day symptoms (cough, wheeze, shortness of breath, runny nose, eye irritation, fever) in 2-pollutant models with O_3. No effect on any night symptoms (cough, wheeze, shortness of breath) in 2-pollutant models with O_3. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.	n/a	n/a	n/a. Increased symptoms & medication use in asthmatic children seen for median ranges of 18-26 ppb (24-hour average) (Schildcrout, Sheppard et al. 2006) and mean NO_2 of 32 ppb (4-hour average) (Mortimer, Neas et al. 2002) (US EPA 2008) 2.8% (0.2-5.5%) per 1ppb (US EPA 1999)	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**US EPA**	**WHO**	**Recommended**
General practitioner consultation for asthma	No effect. (Jalaludin, O'Toole et al. 2004) 148 children (mean age about 9.6 years) with a history of wheezing in previous 12 months. Sydney.	n/a	n/a	n/a	n/a	No CRF recommended.
General practitioner consultation for upper respiratory disease	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

[1]n/a=not available
[2]A restricted activity days is defined as a day when a person is forced to alter his/her normal activity. A severe restriction include days when it necessary to stay in bed. For employed adults, restricted activity days include Work Loss Days; for children, it would include days off school (whether or not the child is confined to bed) (ExternE 1995).
[3]Minor restricted activity days do not involve work loss or bed disability but do include some noticeable limitation on ‘normal’ activity (ExternE 1995).

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Table 5: SO_2 health endpoints and associated concentration-response functions

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
Long-term outcomes (annual average concentration)						
Mortality						
All cause	n/a[1]	n/a	n/a	n/a Evidence is inadequate to confer causal relationship. (US EPA 2008)	n/a	No CRF recommended.
Infant (<12 months of age)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Life expectancy lost (years of life lost; YOLL)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Morbidity						
Incidence of chronic obstructive pulmonary disease (COPD) or chronic bronchitis	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Incidence of asthma	Ever had wheezing: No effect in single pollutant model and	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	protective effects in 2-pollutant models with CO. Ever had asthma: No effect in single pollutant model and protective effects in 2-pollutant models with NO_2 and CO. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Average hourly SO_2 over lifetime Age: mean age10.0 years 2,860 children					No effects in Australian 6-cities study (Williams, Marks et al. 2012).
Recent symptoms (in last 12 months)	Wheeze, night cough or chest cold: No effect. (Lewis, Hensley et al. 1998) Hunter and Illawarra regions. Primary school children. No effect or	n/a	n/a	n/a	n/a	No CRF recommended. No effects in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	protective effects for wheeze, wheeze after exercise, current asthma, use of bronchodilators, cough, visit to doctor/hospital, rhinitis and itchy rash in various single and 2-pollutant models. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Average hourly SO_2 over lifetime Age: mean age10.0 years. 2,860 children.					
Lung function growth	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Change in forced expiratory volume in 1 second (FEV_1; litres)	No effect in single pollutant model. -6.62 mls (-12.3 to -0.96 mls) per 0.74 ppb in 2-pollutant model with NO_2	n/a	n/a	n/a	n/a	Recommended CRF: -6.62 mls (-12.3 to -0.96 mls) per 0.74 ppb in 2-pollutant model with NO_2 (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	(Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Average hourly SO_2 over lifetime Age: mean age10.0 years 2,860 children					
Change in forced vital capacity (FVC; litres)	No effect in single pollutant model -8.92 mls (-16.0 to -1.84 mls) per 0.74 ppb in 2-pollutant model with NO_2 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Average hourly SO_2 over lifetime Age: mean age10.0 years 2,860 children	n/a	n/a	n/a	n/a	Recommended CRF: -8.92 mls (-16.0 to -1.84 mls) per 0.74 ppb in 2-pollutant model with NO_2 (Williams, Marks et al. 2012).
Airway inflammation	Protective effect in	n/a	n/a	n/a	n/a	No CRF

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	single and 2-pollutant models with PM, NO_2, O_3 and CO (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney Average hourly SO_2 over lifetime Age: mean age10.0 years 2,860 children					recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Birth outcomes						
Birth defects	Cleft lip±cleft palate: 1.27 (1.01, 1.62) per 0.6ppb All births Aortic artery and valve: 10.76 (1.50, 179.83) per 0.6ppb Births within 6km of air monitoring station (Hansen, Barnett et al. 2009) Brisbane	n/a	n/a	n/a Evidence is inconsistent. (US EPA 2008)	n/a	No CRF recommended. Only 1 Australian study.
Prematurity	First trimester,	n/a	n/a	n/a	n/a	No CRF

Health outcomes	Concentration-response function (95%CI)					
	Australian	UK	Europe	USEPA	WHO	Recommended
	autumn: 6.489 (4.365–9.648) per 1ppb. First trimester, winter: 1.323 (1.027–1.704) per 1ppb 3 months preceding birth: 2.330 (1.344–4.040) per 1 ppb. Births within 5km of air monitoring station (Jalaludin, Mannes et al. 2007) Sydney 1-hour maximum					recommended. Only 1 Australian study.
Low birth weight	Not assessed (Mannes, Jalaludin et al. 2005) Sydney Not assessed (Hansen, Neller et al. 2007) Brisbane	n/a	n/a	n/a	n/a	No CRF recommended.
Short-term outcomes (daily average concentration)						
Mortality						

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
Non-trauma	Not assessed in 4 cities study (Simpson, Williams et al. 2005) Brisbane, Melbourne, Perth, Sydney No effect. (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01 Age: All ages. All year. Moderate heterogeneity. Meta-analysis of 2 cities – Brisbane, Sydney. ICD9: <800; ICD10: A-R, Z35.5, Z35.8 22.3% (6.4-40.5%) per 1 pphm in multi-pollutant models (Hu, Mengersen et al. 2008) Sydney 24-hour average. Age: All ages.	1.029 (1.035-1.023) per 50 ug/m^3 (Committee on the Medical Effects of Air Pollutants 1998) 24-hour average. APHEA estimates for 7 western European cities.	n/a	Non-trauma mortality: range 0.4-2% per 10 ppb (US EPA 2008) 24-hour average. Effects reduced when co-pollutants added to model.	n/a Various studies showed increased mortality with levels between 5-10 ug/m^3 24-hour average. (Burnett, Stieb et al. 2004) (WHO 2006)	No CRF recommended. No effect in Australian 2-cities study (Environment Protection and Heritage Council 2005). May use CRF from COMEAP (Committee on the Medical Effects of Air Pollutants 1998) or Hu et al (Hu, Mengersen et al. 2008) in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	All causes (ICD codes not stated).					
Cardiovascular	Not assessed in 4 cities study (Simpson, Williams et al. 2005) Brisbane, Melbourne, Perth, Sydney. No effect. (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Age: All ages. All year. Moderate heterogeneity. Meta-analysis of 2 cities – Brisbane, Sydney. ICD9: 390-459; ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58	0.8% (0.6-1.0%) per 10 ug/m^3 (Committee on the Medical Effects of Air Pollutants 2006) Random effects estimate. 24-hour average. Moderate-strong evidence of publication bias. CRF not intended for health risk assessment. 1.04 (1.01-1.06) per 50 ug/m^3 (Committee on the Medical Effects of Air Pollutants 1998) 24-hour average. APHEA estimates for 5 western European cities.	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005). May use the CRF from COMEAP (Committee on the Medical Effects of Air Pollutants 1998) in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
Respiratory	Not assessed in 4 cities study (Simpson, Williams et al. 2005) Brisbane, Melbourne, Perth, Sydney. No effect. (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Age: All ages. All year. Moderate heterogeneity. Meta-analysis of 2 cities – Brisbane, Sydney ICD9: 460-519; ICD10: J00-J99 (excluding J95.4 to J95.9), R09.1, R09.8.	1.05 (1.03-1.07) per 50 ug/m^3 (Committee on the Medical Effects of Air Pollutants 1998) 24-hour average. APHEA estimates for 5 western European cities.	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005). May use the CRF from COMEAP (Committee on the Medical Effects of Air Pollutants 1998) in a sensitivity analysis.
Hospitalisation						
Cardiovascular	Not assessed in 4 cities study (Simpson, Williams	0.6% (0.1-1.2%) per 10 ug/m^3 (Committee on the	n/a	n/a Some evidence from	n/a However, cited Hong Kong study	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	et al. 2005) 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Meta-analysis of 2 cities - Brisbane, Sydney. Low heterogeneity. ICD9: 390-459; ICD10: I00-I99 (excluding I67.3, I68.0, I88, I97.8, I97.9, I98.0), G45 (excluding G45.3), G46, M30, M31, R58	Medical Effects of Air Pollutants 2006) Random effects estimate. 24-hour average. Weak evidence of publication bias. CRF not intended for health risk assessment.		epidemiological studies but inconsistent toxicological studies, and effect estimate not robust to co-pollutant adjustment. (US EPA 2008)	which showed no evidence of threshold for effect at 5-40ug/m^3 24-hour average. (Wong, Atkinson et al. 2002) (WHO 2006)	No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005). May use the CRF from COMEAP (Committee on the Medical Effects of Air Pollutants 2006) in a sensitivity analysis.
Cardiac	Not assessed in 4 cities study (Simpson, Williams et al. 2005) 15-64 years: No effect 65+ years: No effect (Environment Protection and	2.4% (1.6-3.3%) per 10 ug/m^3 (Committee on the Medical Effects of Air Pollutants 2006) Random effects estimate. 24-hour average. No evidence of publication bias.	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 2 cities - Brisbane, Sydney. High heterogeneity. for 65+ years ICD9: 390-429; ICDI0: I00-I52, I97.0, I97.1, I98.1	CRF not intended for health risk assessment.				May use the CRF from COMEAP (Committee on the Medical Effects of Air Pollutants 2006) in a sensitivity analysis.
Ischaemic heart disease	Not assessed in 4 cities study (Simpson, Williams et al. 2005) 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 2 cities - Brisbane, Sydney. Low to moderate heterogeneity. ICD9: 410-413; ICDI0: I20-I22, I24,	1.2% (0.5-1.9%) per 10 ug/m^3 (Committee on the Medical Effects of Air Pollutants 2006) Random effects estimate. 24-hour average. No evidence of publication bias. CRF not intended for health risk assessment.	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005). May use the CRF from COMEAP (Committee on the Medical Effects of Air Pollutants 2006) in a sensitivity analysis.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	I25.2					
Cardiac failure	15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 2 cities - Brisbane, Sydney. Low to moderate heterogeneity. ICD9: 428; ICD10: I50	No effect (Committee on the Medical Effects of Air Pollutants 2006) Random effects estimate. 24-hour average. No evidence of publication bias. CRF not intended for health risk assessment.	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005).
Cerebrovascular	Not assessed in 4 cities study (Simpson, Williams et al. 2005) Stroke: 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01.	No effect (Committee on the Medical Effects of Air Pollutants 2006) Random effects. estimate 24-hour average. No evidence of publication bias. CRF not intended for health risk assessment.	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	Meta-analysis of 2 cities - Brisbane, Sydney. Low heterogeneity. ICD9: 430-438; ICD10: I60-I66, I67 (excluding I67.0, I67.3), I68 (excluding I68.0), I69, G45 (excluding G45.3), G46					
Arrhythmia	15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 2 cities - Brisbane, Sydney. Low heterogeneity. ICD9: 437; ICD10: I46-I49	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005).
Myocardial infarction	15-64 years: No effect. 65+ years: No effect. (Environment Protection and	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 2 cities - Brisbane, Sydney. Moderate to high heterogeneity. ICD9: 410; ICDI0: I21, I22					(Environment Protection and Heritage Council 2005).
Respiratory	Not assessed in 4 cities study (Simpson, Williams et al. 2005) 0 years: No effect 1-4 years: No effect 5-14 years: No effect 15-64 years: No effect 65+ years: 2.8% (1.0-4.7%) per 5.4 ppb (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 2 cities - Brisbane,	65+ years: 1.020 (1.005-1.046) per 50 ug/m^3 15-64 years: No effect. (Committee on the Medical Effects of Air Pollutants 1998) Based on APHEA estimates for 5 western European cities.	0.5% per 10 ug/m^3 (AEA Technology Environment 2005)	n/a Effect ranges from -5 to +20% risk per 10 ppb increase in SO_2 (24-hour average), with effects observed at levels of 4 ppb, but marked increases in effect at only higher SO_2 (>90th percentile values). (US EPA 2008) 0.4% (0-1.02%) per 1 ppb (US EPA 1999)	n/a	Recommended CRF: For 65+ years age-group, 2.8% (1.0-4.7%) per 5.4 ppb from Australian study (Environment Protection and Heritage Council 2005). No CRF recommended for all other age-groups as there were no effects in the Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	Sydney. High heterogeneity in 5-14 years only. ICD9: 460-519; ICDI0: J00-J99 (excluding J95.4-J95.9), R09.1, R09.8					
Asthma	1-4 years: No effect 5-14 years: No effect 15-64 years: No effect 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 2 cities - Brisbane, Sydney. High heterogeneity. in 5-14 years only ICD9: 493; ICDI0: J45, J46, J44.8 Age: 0-14 years	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005).
Chronic obstructive pulmonary disease (COPD)	15-64 years: No effect 64+ years: No effect (Environment	n/a	n/a	n/a	n/a	No CRF recommended. No effect in

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	Protection and Heritage Council 2005) 1-hour maximum. Lag 01. Meta-analysis of 2 cities - Brisbane, Sydney. Moderate to high heterogeneity ICD9: 490-492, 494-496; ICDI0: J40-J44, J47, J67					Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005).
Pneumonia and acute bronchitis	0 years: No effect. 1-4 years: 8.5% (3.0-14.3%) per 5.4 ppb. 1-4 years, two pollutant model with $PM_{2.5}$: No effect. 15-64 years: No effect. 65+ years: No effect (Environment Protection and Heritage Council 2005) 1-hour maximum Lag 01 Meta-analysis of 2 cities - Brisbane, Sydney Moderate to high	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 2-cities meta-analysis (Environment Protection and Heritage Council 2005).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	heterogeneity ICD9: 466, 480-486; ICD10: J12-J17, J18.0, J18.1, J18.8, J18.9, J20, J21					
Emergency department visits						
Asthma	Not assessed. (Erbas, Kelly et al. 2005) Melbourne 1.6% (0.7- 2.4%) per 0.8 ppb. (Jalaludin, Khalaj et al. 2008) Sydney ICD9: 493 Age: 1-14 years. 24-hour average. Not assessed. (Pereira, Cook et al. 2010) Perth	n/a	n/a	n/a	n/a	Recommended CRF: 1.6% (0.7-2.4%) per 0.8 ppb (Jalaludin, Khalaj et al. 2008).
Incidence of myocardial infarction (heart attacks)						
Non-fatal heart attacks (24-hr PM)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
Lung function						
Change in forced expiratory volume in 1 second (FEV_1; litres)	No effect of 1-hour maximum or 24-hour average. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.	n/a 3-8% decrements in FEV_1 in children are associated with ambient annual SO_2 and SO_4 concentrations >100 ug/m^3. (Lebowitz 1996) (Committee on the Medical Effects of Air Pollutants 1998)	n/a	n/a. Toxicological studies: Reduction in FEV_1 (≥15%) and increased airway resistance (≥100%) in 5-30% of exercising asthmatics at 0.2-0.3 ppm and 20-60% at 0.4-1.0 ppm (5-10 minutes exposure). Epidemiological studies: inconsistent for lung function effects in children and adults. (US EPA 2008)	n/a However, cited chamber studies that showed changes in lung function at levels >500 ug/m^3 after 10 minutes leading to air quality guidelines of 500 ug/m3 (10-minute average). (WHO 2006) No CRF, but set guideline of 125 ug/m$_3$ (0.04 ppm) (24-hour average) and 50 ug/m^3 (annual average). (WHO Europe 2000)	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Change in peak expiratory flow rate (PEF; litres per minute)	*1-hour maximum* No effect. *24-hour average* Morning PEF: 1.2686 (0.0857-2.4514) per 1 ppb. Lag 2 Morning PEF: No effect in model with	n/a	n/a	n/a	n/a	No CRF recommended. SO_2 shows a positive effect on lung function in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	PM_{10}. Evening PEF: 1.6946 (0.1918-3.1973) per 1 ppb in model with PM_{10}. Lag 0 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Minor morbidity						
Asthma exacerbation	n/a However, based on evidence recommends that SO_2 not exceed 0.175 ppm (500 ug/m^3) (10 minute average). (Streeton 1997)	n/a No CRF reported, but judgement is that 60-140 ug/m^3 and 140-200 ug/m^3 SO_2 (annual mean of 24-hour mean) associated with increased respiratory symptoms in adults and children respectively. No threshold level	n/a	n/a Toxicological studies: increase in severity and incidence of symptoms in asthmatic adults with increasing SO_2 between 0.2-0.6 ppm for 5-10 minutes. Epidemiological studies: increased symptoms in	n/a Recommended that 500 ug/m^3 (0.175 ppm) not be exceeded (10 minute exposure). Based on clinical studies of exercising asthmatics. (WHO Europe 2000)	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
		evident. UK Department of Health Advisory Group, cited in COMEAP, 1998 (Committee on the Medical Effects of Air Pollutants 1998)		children (especially those with asthma or chronic respiratory) at median range of 17-37 ppb (3-hour average) and for 2.2-7.4 ppb (24-hour average). Epidemiological evidence for adults is inconsistent for short-term SO_2 concentrations. (US EPA 2008) 0.6% (0.1-1.1%) per 1 ppb (US EPA 1999)		
Increased airway hyper-responsiveness	n/a	n/a	n/a	n/a Limited evidence of an effect of airway hyper-responsiveness in atopic individuals. (US EPA 2008)	n/a	No CRF recommended.
Restricted activity days (RAD)[2]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Minimal restricted activity days (MRAD)[3]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
Work lost days (WLD) days[2]	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Acute bronchitis (incidence, 8-12 years)	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Lower respiratory symptoms	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Acute respiratory symptoms	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Wheeze	Day wheeze: Protective effects of 1-hour maximum and 24-hour average in 2-pollutant models with PM_{10}. Night wheeze: No effect of 1-hour maximum or 24-hour average in 2-pollutant models with PM_{10}. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	Age: mean 10.0 years. 270 children with current asthma.					
Cough	Day cough: No effect of 1-hour maximum or 24-hour average in 2-pollutant models with PM_{10}. Night cough: No effect of 1-hour maximum or 24-hour average in 2-pollutant models with PM_{10}. (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).
Shortness of breath	*1-hour maximum* Day SOB: No effect in 2-pollutant. models with PM_{10} Night SOB: No	n/a	n/a	n/a	n/a	No CRF recommended. No effect in Australian 6-cities

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	effect in 2-pollutant models with PM_{10}. *24-hour average* Day SOB: No effect in 2-pollutant models with PM_{10}. Night SOB: Protective effect in 2-pollutant models with PM_{10}. Lag 3 (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					study (Williams, Marks et al. 2012).
Bronchodilator use	*1-hour maximum* Night use: 1.0247 (1.0021-1.0478) per 1 ppb in 2-pollutant models with PM_{10} *24-hour average* No effect (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane,	n/a	n/a	n/a	n/a	Recommended CRF for night bronchodilator use: 1.0247 (1.0021-1.0478) per 1 ppb in 2-pollutant models with PM_{10} from Marks et al (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years. 270 children with current asthma.					
Upper respiratory symptoms	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
Increased respiratory symptoms	No effect on any night symptoms (cough, wheeze, shortness of breath) in 2-pollutant models with PM_{10} No effect on any day symptoms (cough, wheeze, shortness of breath, runny nose, eye irritation, fever) in 2-pollutant models with PM_{10} (Williams, Marks et al. 2012) Six cities – Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney. Age: mean 10.0 years.					No CRF recommended. No effect in Australian 6-cities study (Williams, Marks et al. 2012).

	Concentration-response function (95%CI)					
Health outcomes	**Australian**	**UK**	**Europe**	**USEPA**	**WHO**	**Recommended**
	270 children with current asthma.					
General practitioner consultation for asthma	n/a	n/a	n/a	n/a	n/a	No CRF recommended.
General practitioner consultation for upper respiratory disease	n/a	n/a	n/a	n/a	n/a	No CRF recommended.

[1]n/a=not available
[2]A restricted activity days is defined as a day when a person is forced to alter his/her normal activity. A severe restriction include days when it necessary to stay in bed. For employed adults, restricted activity days include Work Loss Days; for children, it would include days off school (whether or not the child is confined to bed) (ExternE 1995).
[3]Minor restricted activity days do not involve work loss or bed disability but do include some noticeable limitation on 'normal' activity (ExternE 1995).

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Table 6: Sources of health data

Type of health data	Data custodian	Years of available data	Variables in dataset	Process for accessing data	Time frame for accessing data
Mortality	ABS (aggregate and coded data available to SLA level (lowest geographic idenitifier)).* Individual State Registrars of Births, Deaths and Marriages (unit record data available but not coded).	ABS: 2002-2012 (last 10 years). Some data back to 1968 but would incorporate ICD8, ICD9 and ICD10 coding.	Variables include : age or DOB, gender, underlying cause of death (ABS), multiple causes of death (ABS), SLA (geographic identifier), ICD codes.	National Information Referral Service (NIRS) 1300 135 070 or complete Inquiry form located at http://www4.abs.gov.au/web/survey.nsf/inquiryform/ Specify requirements and work is quoted. Minimum charge of $650 for 3 hrs. State level data available free of charge at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3302.02010?OpenDocument	Up to 1 month.
Hospitalisation	National Hospital Morbidity Database (NHMD) administered by AIHW. State health agencies, eg. NSW Ministry of Health.	NSW Admitted Patient Data - 1988/89-current (June 2011)	Data by State; annual frequency of reporting (Australian Institute of Health and Welfare). Data to SLA & postcode levels. Other geographic level may be available on request. Variables include: age,	AIHW, Head, Hospitals Data Unit, 02 6244 1157; hospitaldata@aihw.gov.au Apply in writing to NSW Chief Health Officer whereupon data needs will be assessed. Data Custodian: Director	2 weeks to a few months, depending on nature of request.

Type of health data	Data custodian	Years of available data	Variables in dataset	Process for accessing data	Time frame for accessing data
			DOB, gender, postcode, primary diagnosis, additional diagnoses, readmission within 28 days, date of admission and date of separation, length of stay, ICD codes, other demographic & hospital data.	Demand & Performance Evaluation Branch, NSW Ministry of Health Tel: 02 9391 9590.	
Emergency department (ED) visits	State health agencies, for example, NSW Ministry of Health. ED visit data for asthma available for NSW, Victoria & WA, but method of data collection differs (ACAM 2011).	For example, NSW Emergency Department Database; July 1996-year to date (2012).	Data to SLA & postcode levels. Other geographic level may be available on request. Age, DOB, gender, postcode, arrival date and time, triage date and time, diagnosis- ICD9 and ICD 10, type of visit, mode of separation, other demographic data.	Apply in writing to NSW Chief Health Officer whereupon data needs will be assessed. Data Custodian: Director Demand & Performance Evaluation Branch, NSW Ministry of Health Tel: 02 9391 9590	2 weeks to a few months, depending on nature of request.
Perinatal	State health agencies, for example, NSW Ministry of Health.	For example, Perinatal Data Collection (PDC), encompasses all live births >20 weeks gestation or ≥400 grams birth weight. 1987-1988; 1989 (missing); 1990-current (2009).	Data to SLA & postcode levels of mother's residence. Other geographic level may be available on request. Variables include: mother's demographic details, baby's DOB, gender; date of last menstrual period, birth order, gestational age,	Apply in writing to NSW Chief Health Officer whereupon data needs will be assessed Data Custodian: Manager, Surveillance Methods Centre for Epidemiology & Research, NSW Ministry of Health	2 weeks to a few months, depending on nature of request.

Type of health data	Data custodian	Years of available data	Variables in dataset	Process for accessing data	Time frame for accessing data
			birth weight, APGAR scores (1 & 5 minutes), mother's smoking status, diabetes status. Other details related to pregnancy.	Tel: 02 9391 9223	
Chronic obstructive pulmonary disease (COPD) incidence	No geographic based data for COPD incidence. Data available for hospital separations for COPD. Data on COPD mortality and hospitalisations- national estimates (Australian Institute of Health and Welfare 2005). Prevalence of COPD in 2007-08 National Health Survey estimated at 5.3%, but is likely to be an under-estimation (ACAM 2011). COPD (Stage 2) prevalence from BOLD study (Sydney) 9.4% (Buist, McBurnie et al. 2007). Prevalence in Australia BOLD study (Stage 2 or higher) 7.5% in 40 years+ and 29.2% in 75 years+ (Toelle 2012).				

Type of health data	Data custodian	Years of available data	Variables in dataset	Process for accessing data	Time frame for accessing data
	Incidence data will have to be obtained from published studies and reports.				
Asthma prevalence	Asthma prevalence estimated at 9.8% in 16+ years; 17.8% in 0-15 years. Prevalence of “current asthma” in adults 9.8% (9.2-10.4%) and in children 10.4% (9.1-11.7%) (ACAM 2011).				
Asthma incidence	Cumulative incidence of diagnosed “ever asthma or illness with wheezing” 24.4 (23.5-25.3) per 100 person years (infant cohort at 4-5 years); and 22.0 (21.0-23.0) per 100 person years (Kindergarten cohort aged 8-9 years). Source: Longitudinal Study of Australian Children, Australia, 2004-2008, in (ACAM 2011).				
Asthma exacerbation	No standardised routine data collection. Asthma exacerbation will have to be obtained from published studies and reports.				

Type of health data	Data custodian	Years of available data	Variables in dataset	Process for accessing data	Time frame for accessing data
Lung function	No standardised data collection. Data available will have to be obtained from published studies and reports.				
GP encounters for asthma	In 2009-2010: 8.6 encounters per 100 adults; 16.9 encounters per 100 children (ACAM 2011).				
Mortality attributed to asthma	1.6 deaths per 100,000 population (0.29% of all deaths) for 2009. Rate fell 45% between 1997 and 2009 (ACAM 2011).				
Activity restriction & disability (time off work or school)	8.2% of people with asthma reported to have some level of disability associated with asthma (2003 Survey of Disability, Ageing and Carers in (Australian Institute of Health and Welfare 2005)). National Health Survey, 2007-2008, reports on days away from work, school or study in last 12 months: 5+ years: with asthma 24.2% (22.2-26.2%): without asthma 8.8% (8.2-9.4%) (ACAM,				

Type of health data	Data custodian	Years of available data	Variables in dataset	Process for accessing data	Time frame for accessing data
	2011, from National Health Survey, 2007-2008).				

ABS Australian Bureau of Statistics
SLA Statistical Local Area (geographic identifier). The following information is sourced directly from the ABS website: http://www.abs.gov.au/websitedbs/D3110124.NSF/24e5997b9bf2ef35ca2567fb00299c59/53bbe9630b24d6f4ca256c3a000475b8!OpenDocument#Statistical%20Local%20Area%20(SLA) The Statistical Local Area (SLA) is an Australian Standard Geographical Classification (ASGC) defined area which consists of one or more Collection Districts (CDs). SLAs are Local Government Areas (LGAs), or parts thereof. Where there is no incorporated body of local government, SLAs are defined to cover the unincorporated areas. SLAs cover, in aggregate, the whole of Australia without gaps or overlaps. CDs are the smallest geographic area defined in the ASGC. They are designed for use in the Census of Population and Housing as the smallest unit for collection, processing and output of data. A CD is represented by a unique seven digit code. For the 2001 Census there is an average of about 225 dwellings in each CD. In rural areas the number of dwellings per CD declines as population densities decrease. CDs are defined for each census and are current only at census time. For the 2001 Census, there are about 37,000 CDs throughout Australia.
*A project is underway to pilot the process for release of national coded unit record data.

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