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HEALTH AND SOCIAL HARMS OF COAL MINING IN LOCAL COMMUNITIES



Spotlight
on the Hunter
Region

HEALTH AND SOCIAL HARMS OF COAL MINING IN LOCAL COMMUNITIES:



Commissioned by:
Beyond Zero Emissions (Australia)



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PURPOSE OF THE REPORT

The purpose of this report is to provide an objective overview of the available international and local evidence from the health and medical literature about the health effects and social justice impacts of *coal mining on local communities* and to discuss and relate these issues to the Hunter Region of New South Wales

ACARP	Australian Coal Association Research Program
AHS	Area Health Service
BEACH	Bettering the Evaluation and Care of Health
BRFSS	Behavioural Risk Factor Surveillance System
CO ₂	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
CVD	Cardiovascular diseases
DNA	Deoxyribonucleic acid
DQ	Developmental Quotient
EDS	Environmental Distress Scale
GDP	Gross domestic product
GHG	Greenhouse gas
GIS	Geographic Information Systems
GP	General practitioner
HNEAHS	Hunter New England Area Health Service
HRQOL	Health Related Quality of Life
LGA	Local Government Area
LTLI	Long term limiting illness
MTM	Mountain top mining
N ₂ O	Nitrous oxide
NMSC	Non-melanoma skin cancer
NSW	New South Wales (Australia)
NTDs	Neural Tube Defects
PAHs	Polycyclic aromatic hydrocarbons, polycyclic aromatic hydrocarbons
PAH –DNA	Polycyclic aromatic hydrocarbon-deoxyribonucleic acid
PFT	Pulmonary function test
PM _{2.5}	Particulate matter 2.5 micrometers or less in diameter
PM ₁₀	Particulate matter 10 micrometers or less in diameter
QLD	Queensland (Australia)
SCI	Stream Condition Index
SIA	Social impact assessments
SO ₂	Sulphur dioxide
TUNDRA	Tundra Degradation in the Russian Arctic
UK	United Kingdom
US	United States (of America)
VSL	Value of statistical life lost
8-OHdG	8-hydroxy-2-deoxyguanosine (a biomarker for oxidative stress)

Note:

1. Some studies cited in this Report used tonnes and others used tons as measures for quantifying amounts of coal extracted. It should be noted that these measures are not interchangeable and each term is used in the text according to which measure was reported by the authors of the research articles reviewed.

EXECUTIVE SUMMARY

Context

Australia is a major exporter of coal and relies heavily on coal powered electricity to meet the growing energy demands of its homes and offices, factories, retail outlets, and public facilities and services. Public concern about the environmental, community health, and social consequences associated with coal extraction and combustion has grown in tandem with the recent and rapid expansion of mining activity, and appears to be at an all time high.

These concerns are nowhere more apparent than in the Hunter Region of New South Wales (NSW) - Australia's oldest and most productive coal mining area - which has in excess of 30 mostly open-cut coal mines and six active coal-fired power stations. The Hunter Region includes 11 local government areas with a combined population of some 700,000 people whose livelihood is derived from a number of important industries including tourism, farming, grazing, wine growing and making, and race horse breeding, as well as coal mining. There have been multiple anecdotal reports of disease clusters associated with mining, and calls from various community organisations and local government for studies to explore and examine these issues.

Purpose, Scope and Methods

This independent Report was commissioned by Beyond Zero Emissions to examine and summarise what is known in the available research evidence from Australian and international health journals, and other relevant reports, about the health and social harms of mining activity for *people living in communities near coal mines and coal-fired power stations*, and to relate these issues to the Hunter Region of NSW.

After searching a variety of health databases and websites, a pragmatic review of the international peer reviewed health literature and selected reports from relevant government and non-government organisations was undertaken to identify background information and evidence that reflects what is known about the community health and social harms associated with coal mining activity and coal-fired power stations. Four central research questions were developed to guide the literature searches and provide a coherent reporting framework:

1. What specific diseases or other health problems are associated with coal mining in local communities?
2. Are there clusters of these diseases or other health problems in the Hunter Region of NSW?
3. Is social injustice associated with coal mining in local communities?
4. Is there an association between coal mining and social injustice in the Hunter Region of NSW?

Key Findings

There are clear indications from the international health research literature that there are serious health and social harms associated with coal mining and coal-fired power stations for people living in surrounding communities.

There are several studies about the social harms of coal mining from the Hunter Region but few Australian studies directly examine the health effects of coal mining or coal burning power stations on the health of local communities. Much of the peer reviewed literature comes from the Appalachian coal mining region of the United States (US). These studies, along with the majority of others we reviewed from the US, the United Kingdom (UK), Canada, Australia, Spain, Turkey, Israel, Eastern Europe and Asia

indicate serious health impacts for communities living near coal mines and coal combusting power stations. In the absence of current local research evidence and despite possible differences in mining practices, it is reasonable to assume that much of the international evidence - especially from similar economies such as the US, UK and Canada - would be applicable to Australia.

The evidence from our review reflects a mix of quantitative and qualitative research findings. Additional details of the studies reviewed are available in the *Evidence Tables* at Appendix A-C and is summarised below and set out in the body of the Report under *Research Questions 1-4* each of which is structured into four sections:

- a brief introduction
- a summary of the key findings
- a detailed description of the evidence
- authors' comments

Summary of key findings for Research Question 1 – Health harms

Adults in coal mining communities have been found to have:

- Higher rates of mortality from lung cancer, chronic heart, respiratory and kidney diseases
- Higher rates of cardiopulmonary disease, chronic obstructive pulmonary disease (COPD) and other lung diseases, hypertension, kidney disease, heart attack and stroke, and asthma
- Increased probability of a hospitalisation for COPD (by 1% for each 1,462 tons of coal mined), and for hypertension (by 1% for each 1,873 tons of coal mined).
- Poorer self-rated health and reduced quality of life

Children and infants in coal mining communities have been found to have:

- Increased respiratory symptoms including wheeze, cough and absence from school with respiratory symptoms although not all studies reported this effect
- High blood levels of heavy metals such as lead and cadmium
- Higher incidence of neural tube deficits, a high prevalence of any birth defect, and a greater chance of being of low birth weight (a risk factor for future obesity, diabetes and heart disease)

Adults (and whole population) in communities near coal-fired power stations and coal combustion facilities have been found to have:

- Increased risk of death from lung, laryngeal and bladder cancer
- Increased risk of skin cancer (other than melanoma)
- Increased asthma rates and respiratory symptoms

Children, infants, and fetal outcomes in communities near coal-fired power stations and coal combustion facilities have been found to have

- Oxidative deoxyribonucleic acid (DNA) damage
- Higher rates of preterm birth, low birth weight, miscarriages and stillbirths
- Impaired fetal and child growth and neurological development
- Increased asthma rates and respiratory symptoms.

Summary of key findings for Research Question 2 – Disease clusters in the Hunter Region

No specific research studies were found to confirm or refute the existence of mining related disease clusters among residents of the Hunter Region, or their possible causes if they do exist. In the absence of such evidence, we reviewed two reports of routine health monitoring data from the Hunter Region from the NSW Health Department (now known as the NSW Ministry of Health). These reports showed mixed results. For example, the NSW Health Report (2010a) included the whole of the Hunter Region and suggested higher rates of deaths and illness in some areas for some health problems when compared with the rest of NSW. However, the *Bettering the Evaluation and Care of Health* (BEACH) general

practice data for Singleton, Muswellbrook and Denman postcodes (NSW Health 2010b) did not demonstrate significantly higher rates of any problems managed, or medications prescribed or supplied, in general practice compared with the rest of non-metropolitan NSW.

Summary of key findings for Research Question 3 – Social injustice (other than in the Hunter Region)

For the purposes of this report, we defined social injustice as: *‘the unequal or unfair social distribution of rewards, burdens, and opportunities for optimising life chances and outcomes’*. This definition includes unfair imbalances in access to essential natural resources, opportunities for employment, education, political or social power and influence, and social or individual burdens such as financial costs, social or occupational disruption, and environmental damage.

Aside from studies focussing explicitly on the Hunter Region of NSW which are discussed in the next section, six peer reviewed articles were identified from the US, the UK, Russia and (Queensland) Australia that directly addressed social injustices associated with coal mining. While there were limitations to these, a central theme of the impact on local communities was both real and perceived environmental degradation and injustices. We categorised the evidence for social injustice as:

- **Environmental damage and perceptions of damage and health impacts**
 - slurry (fly ash) spills
 - lack of community awareness of damage
 - distress resulting from concerns and uncertainties about the health impacts of mining-related pollution
- **Water quality and human occupations (activities)**
 - The impact of water pollution on securing safe water for drinking, producing food, swimming and fishing
- **Social and economic costs**
 - the cost of environmental damage to communities and society
 - inability of the community to capture economic benefits
 - social changes inhibiting the generation of alternative means of economic capital to mining
 - socio-demographic changes resulting in labour shortages in other industries; reduced access to and affordability of accommodation; increased road traffic accidents
 - increased pressure on local emergency services
 - increases in criminal and other anti-social behaviours.

Summary of key findings for Research Question 4 – Social injustice in the Hunter Region

Six peer reviewed studies were identified on social aspects of mining in the Hunter Region. These studies detail a variety of impacts such as:

- **Social distress and environmental injustice** including concerns over the cumulative health impacts of mining, social divisions and inequalities, feelings of loss and disempowerment, pollution/poor air quality, environmental damage and the potential to impact negatively on future generations
- **Asymmetry of power and influence** including access to information, contestation over natural resources, and political conflicts of interest
- **Water access and rights** including changes to the NSW water grading system favouring the coal mining industry
- **Failure to protect** - specifically, the failure of government and the mining industry to exercise the precautionary principle and protect local communities from potential or actual harms.

Authors' comments

The evidence presented in this report is valid and objective. However, it is acknowledged that there are limitations to many of the studies cited. It should also be noted that there are inherent difficulties in designing population and community studies that can unequivocally attribute and precisely quantify associations. Conversely, there is a lack of long term prospective studies on the effect of coal mining and coal-fired power stations on local communities which may lead to potential causal associations between mining activity and diseases with a long time lag such as cancers to be underestimated.

Studies of air pollution were excluded from the review if the study did not specify coal mining or combustion as the pollution source. This may mean that death and illness in local communities due to coal dust may be underreported. Similarly several studies which found airborne toxins and pollutants known to be harmful to health in areas surrounding coal mines, coal washeries and power-plants were not included as evidence as they did not link their results to health outcomes. Further, some of the studies we reviewed on the health of local communities, including in the Hunter and surrounding areas, were conducted up to 20 years ago and it could be assumed that the huge expansion in coal mining over that period may have amplified any health impacts.

Given that there is minimal research evidence available on the health impacts of coal mining and combustion on Australian communities, the vast majority of the evidence cited in this Report is from international studies conducted in a variety of countries. While some of these countries (US, UK, Canada) share a similar cultural ethos and are economically and politically comparable, there is considerable variation in mining practices and regulatory standards between countries that needs to be taken into account when extrapolating the evidence from one country to another. There are also differences in techniques and tools for monitoring air quality which make comparisons difficult. However, emerging methods for measuring exposures are becoming increasingly accurate and replicable, thus measurement inconsistencies will likely be much less problematic in the future.

Costs and policy implications of coal mining

The financial and social costs of coal mining and combustion are enormous and may well outweigh any benefits (Hendryx & Ahern, 2009). According to one report (ATSE, 2009), health problems associated with coal-fired power stations cost Australia \$2.6 billion(AUD) annually. Burdens on the whole society such as government subsidies and benefits to the mining industry were recently detailed in a report by the Australia Institute and are rarely included in cost calculations (Richardson & Denniss 2011). Further, there is evidence from the international literature of the cost burden of environmental damage resulting from mining falling disproportionately on society rather than the industry.

These impacts have wide implications for policy and governance, and require prompt and thorough attention to reviewing and reforming government policies and regulations around the licensing and operating of coal mines and coal-fired power stations. While awaiting such reforms there is an urgent need for a policy response to ensure transparency in arrangements between government and the mining industry, redress tax anomalies, enforce standards of practice and community safeguards such as mandatory health impact assessments and penalties for non compliance with operating standards and regulations.

Most importantly, evidence from well designed local studies capable of accurately quantifying associations are required to underpin cost analyses and inform public and political debate and decisions about the balance of benefits and harms of coal mining activity, and guide policy and planning to minimise the harms and maximise the benefits.

Section 1:

THE CONTEXT

INTRODUCTION & RATIONALE

About coal mining

Australia is the largest coal exporter worldwide, exporting millions of tonnes annually and around 85% of Australian energy consumption comes from coal. For black coal alone, Australia's saleable production totalled 326.8 million tonnes in the 2007-08 financial year (Australian Department of Resources Energy and Tourism, 2011).

In recent years, the seemingly ever-increasing demand for coal to build and fuel Asia's rapidly growing cities and industries, especially China's, has resulted in massive increases in Australian coal production as has the need to power our own growing cities, towns and technologies. Concerns that the world has passed peak oil production, along with the increasing cost of oil compared with the relatively low cost of coal, and its importance to the manufacture of steel, have also driven recent demand.

New South Wales and Queensland (QLD) contain the majority of Australian coal reserves with other states, notably Victoria and Western Australia, also having sizeable deposits. The Sydney-Gunnedah basin, including the Hunter Region, holds almost all the coal resources in NSW with smaller quantities in the Gloucester and Oaklands basins. Recoverable coal reserves in NSW are estimated at 12 billion tonnes, and are contained within 60 operating mines and more than 30 major development proposals (NSW Department of Primary Industries, 2011). So, although as a nation, we must ultimately come to terms with the inevitable fact that our coal reserves are finite, and it appears that further expansion is likely before the current boom is over.

The Australian Coal Association describes two main methods of extracting coal ie i) underground or so-called deep mines and ii) open-cut mines which are often called open-cast or surface mines. The method is selected according to the distance (depth) of the coal seam from the land surface with underground mining accounting for the majority (approximately two thirds) of coal production worldwide. However, this figure is much lower in Australia where surface (open-cut) mining is relatively and increasingly, common - possibly because it yields a greater proportion of the coal deposit than underground mining (Australian Coal Association, 2008). The majority of coal mines in the Hunter Region are open-cut. In the US a third method is sometimes used whereby mountain tops situated over coal deposits are removed and deposited in the valleys below. This method is thought to pose additional risks to health and the environment over and above those associated with open-cast mining.

The role and impact of coal on society and the environment

Coal has been an important building block in human advancement throughout modern history. For example, coal powered the industrial revolution and, in doing so, opened up new and previously unimaginable changes to the way humans live, move around the world, communicate and do business, and provide life saving health care and technologies. But, there is a downside and, opponents argue that the benefits of coal mining come at a cost - to the communities in which coal mines and power stations operate, and to the nation as a whole.

The economy

Industry proponents claim that coal mining fuels economic growth and brings wealth and prosperity, creating jobs and reinvigorating rural and regional Australia, enhancing local quality of life and opportunity. However, Richardson & Denniss (2011) claim that around 80% of the profits go to foreign owners and investors and estimates of the contribution of coal to Australia's gross domestic product (GDP) vary considerably but seem to centre around 3-4%. There are also criticisms of the 'boom and bust' nature of mining based economies, and the relatively small numbers (circa 60,000 people) currently employed in the Australian mining industry.

The environment

Many reports, both formal and anecdotal, note the irreparable scarring of landscapes, soil degradation and the depletion of habitat and biodiversity as serious negative impacts of coal mining. In addition to direct damage to the natural environment, coal combustion makes a major contribution to generating greenhouse gasses (GHG). For example, in 2005 coal contributed 25% of global energy consumption but almost half (41%) of carbon dioxide (CO₂) emissions that year (Epstein et al, 2011). Since coal was reported in 2008 as contributing 40% of global electricity alone (Australian Coal Association, 2008), it might be assumed that resultant global CO₂ emissions have increased commensurately with the demands imposed by global population growth and urbanisation in the intervening years.

Air and water pollution and other health impacts

Coal mining generates dust and noise from blasting and operations, particularly from open-cast mining. Onder & Yigit (2009) claim that all major open-cast mining operations produce dust as a result of blasting, drilling, loading/unloading and transporting. Several studies cite coal washeries as creators of further dust exposure, and the heavy machinery required in mining generally uses industrial diesel fuels and may be noisy as well as producing harmful fumes. Coal burning generates a variety of pollutants; depending on the composition of the coal, and the measures taken to control emissions. Emissions may include heavy metals, potential carcinogens such as polycyclic aromatic hydrocarbons (PAHs), sulphur dioxide (SO₂) and nitrous oxides (N₂O) and fine particulate matter - especially particulate matter 2.5 micrometers or less in diameter (PM_{2.5}) which is more closely associated with adverse health effects than larger particulate matter 10 micrometers or less in diameter (PM₁₀) (Lockwood et al, 2009). These pollutants may spread widely and coal burning in the Northern Hemisphere has reportedly left a toxic heavy metal legacy in the Arctic. Examination of heavy metal deposits of thallium, cadmium and lead from a Greenland ice core identified coal burning in Europe and North America as the likely sources dating from 1860 onwards (Mc Connel & Edwards 2008).

Combustion waste products (fly ash) also pose health risks. Storage of these wastes is problematic and accidental leakage can cause the release of toxic pollutants. For example the 2008 Tennessee Valley Authority fly ash spill in the US resulted in 1 billion gallons of fly ash slurry containing contaminants spreading over 300 acres, and leaking into local rivers and household wells (Epstein et al, 2011). Coal combustion by-products are sometimes used as building materials which may also be associated with health hazards. Further, Castledon and colleagues (2011) cite evidence that 53 people were killed in Kentucky (US) mining areas and 536 injured from 2000-04 in accidents involving coal transport vehicles.

Social harms

Epstein and colleagues (2011) claim that all stages of the life cycle of coal pose potential risks to human health and wellbeing. Some of these risks and harms take the form of social injustices which, for the purpose of this report, we define as the 'unequal or unfair social distribution of rewards, burdens, and opportunities for optimising life chances and outcomes'. These are of central concern in the current debate about mining in Australia.

Purpose of the Report

This Report was commissioned to examine and summarise what is known in the available evidence from Australian and international health journals, and other reports, about the health and social harms of mining activity for communities living in or near coal mines and coal-fired power stations. This includes a 'spotlight' on the Hunter Region of NSW - Australia's oldest and one of its most active coal mining areas.

ABOUT THE HUNTER REGION

The Hunter Valley lies 160 kilometres north of Sydney. As with many of Australia's rural areas, the majority of its almost 700,000 strong population resides in the area's largest urban centre, in this case, the Newcastle Metropolitan Area. The Hunter Region contains the Hunter River and its tributaries with highland areas to the north and south and is one of the largest river valleys on the NSW coast. Table 1 shows the 11 Local Government Areas (LGAs) included in the Hunter Region and the population by LGA. The map shown in Figure 1 indicates the configuration of the Hunter Region LGAs.

Table 1: Population of the Hunter Region by Local Government Area

Local Government Area	Population in 2010
Cessnock City Council	51 706
Dungog Shire Council	8 673
Gloucester Shire Council	5 181
Great Lakes Council	35 924
Lake Macquarie City Council	200 849
Maitland City Council	70 296
Muswellbrook Shire Council	16 676
Newcastle City Council	156 112
Port Stephens Council	67 825
Singleton Council	24 182
Upper Hunter Shire Council	14 198
TOTAL	651 622

Source: Australian Bureau of Statistics, 2011. National Regional Profile 2006-2010.

Figure 1: Map of Local Government Areas in the Hunter Region



Source: New South Wales GenWeb Project, 2011. Hunter Valley GenWeb.

Newcastle is home to the biggest black coal exporting port in the world

Industries

Mining is only one of several important industries currently operating in the Hunter Region. A major issue in the current mining debate centres on contention over what is the most appropriate use of available natural resources (land and water) and the impact of mining activity on other local industries such as grazing, farming, race horse breeding, wine growing, and tourism.

Coal mining

As the site of the initial discovery of coal in Australia in 1791, the Hunter Region has a long history of mining. Over the past 30 years, there has been a sixfold increase in coal production and more mines or expansion of existing mines have been proposed. Table 2 shows the number of coal-fired power stations and the number, location and type of coal mines operating in the Hunter Region and adjacent coalmining area (Gunnedah) in 2009. The areas with the most intensive coal mining and power generation activities include the Upper and Lower Hunter clusters, and the Muswellbrook and Singleton LGAs. Despite the vastly increased production of coal, the numbers employed in the mining industry are less than in the 1970s, due to increased mechanisation, and account for about 8% of the jobs in this region.

Table 2: Operating coal mines in the Hunter Region and adjacent coal mining areas

Coalfield Region	Coal-Fired Power Stations	Coal Mines		
		Open-cut	Underground	Combined (open-cut & underground)
Hunter	3	12	2	4
Newcastle	3	5	9	-
Gunnedah	-	4	-	-
TOTAL	6	21	11	4

Source: NSW Department of Primary Industries, 2009. 2009 New South Wales Coal Industry Profile.

Around 75% of the coal mined in the Hunter Region and adjacent areas is for export and the largest black coal exporting port in the world is located in Newcastle.

Agriculture

The Hunter Region is adjacent to the Liverpool Plains which is considered a prime agricultural region of NSW. It comprises 1.2million hectares which produce 37% of the nation's cereal crop and is an important 'food bowl' for Sydney and other parts of NSW and Australia. As demand grows and issues around food security increase, the sustainability of the Hunter and Liverpool Plains regions is critical to Australia's population carrying capacity. Approximately 4,000 people are employed in the agriculture, fishing and forestry sector in the Hunter Region and the gross value of its agricultural production was about \$382 million(AUD) in 2008-09, accounting for just over 4% of the total value of agricultural production for NSW (Thompson et al, 2011). Of the total agricultural production in the Hunter Region beef cattle were the most important produce, accounting for 37% (\$140million AUD); followed by poultry at 26% (\$100million AUD). The dairy industry also played a major role accounting for approximately 17% (\$64million AUD).

Winemaking

The Hunter Region is one of Australia's oldest wine producing areas and a principal winemaking area of NSW, producing 25.4million litres of wine per year valued at approximately \$203million(AUD) annually (NSW Department of Trade and Investment, 2012). Viticulture and winemaking are a significant component of the Hunter Region's agricultural industries, with wine-grape farms accounting for 5% (145 farms) of total farms in 2008-09 (Thompson et al, 2011).

Race horse breeding

The Upper Hunter Valley is not only Australia's main region for breeding thoroughbred horses (approximately 70%) but is one of the largest in the world. Australia's thoroughbred breeding and racing industry contributed sustainable employment of over 65,000 people - especially in regional Australia; over \$5.04billion(AUD) in value added to the national economy; investment of \$1.1billion(AUD) annually by breeders owners and trainers; and exports of over \$750 million(AUD) to 24 countries (Biopharm Australia, 2011) This industry relies on a certain rural attractiveness which co-exists along with local agribusiness industries such as dairy farming and winegrowing.

Tourism

Also heavily dependent on rural attractiveness, the Hunter Valley is a prime tourism location. According to a submission by Doctors for the Environment Australia (2011) statistics for the Hunter Region for 2008-09 estimate that \$1.3billion(AUD) was spent by visitors - 58% by domestic overnight visitors. A total of 6.3 million visitors went to the region – 68% were domestic day visitors. Fifty three per cent of domestic visits and 93% of international visits were related to food and wine. Fourteen per cent of domestic visits and 74% of international visits were related to nature-based activities (Tourism Research Australia, 2010).

Health service provision and monitoring

For the purpose of planning and providing health services and monitoring the health of the NSW population, the LGAs of the Hunter Region fall within what was, until recently, called the Hunter New England Area Health Service (HNEAHS). HNEAHS is one of several Area Health Services (geographically determined health administrative entities which were recently renamed Local Health Districts) in NSW. It covered 25 LGAs, 11 of which constitute the Hunter Region. HNEAHS is responsible for administration of local public hospital and community health services. In 2010 The NSW Health Department (recently renamed the NSW Ministry of Health) published a report entitled *Respiratory and Cardiovascular Diseases and Cancer in Residents of the Hunter New England Area Health Service* (2010a). Data from the NSW Health Report is cited in detail later in this document and provided the information below.

Smoking

Smoking rates for the background population need to be taken into account when analysing death or illness and disability for lung cancer or other respiratory diseases, as this could be a confounding factor in attributing cause and effect for airborne pollutants and toxins. The NSW Health Report (2010a) indicates that the overall self-reported smoking rate for HNEAHS (19.3%) is similar to that for NSW (19.2%). There is no significant difference in smoking rates across areas within the HNEAHS.

Drinking Water Quality

In accordance to National Health & Medical Research Council Drinking Water Guidelines, the NSW Health Drinking Water Monitoring Program specifies the number of samples that should be taken and tested for a range of chemicals. The NSW Health Report (2010a) indicates that the drinking water supplies for the towns near extensive open-cut mining and power generation activities are of comparable quality to that of other rural town water supplies. The quality of water in domestic rainwater tanks in NSW is not routinely monitored.

Socioeconomic status

The 2010 NSW Health Report also commented on socioeconomic disadvantage, another potential confounder for certain health outcomes particularly where there is a higher Aboriginal population, public housing and lower employment. Only Cessnock was listed among the 10 most socioeconomically disadvantaged LGAs in the HNEAHS.

Section 2:

SCOPE & METHODS

SCOPE OF THE REVIEW

The project brief

This Report deals exclusively with the effects of open-cut and underground coal mining and coal-fired power stations on local communities.

Commissioned by Beyond Zero Emissions, the project brief was to provide an objective overview of the international and local evidence from the health and medical literature about the health and social impacts of coal mining activity on local communities, highlighting those areas and aspects of the findings that were generated in, or can be extrapolated to current and planned mining activities in the Hunter Region.

The Report does not consider the occupational health and safety aspects of mining ie the health of mine workers. Nor does it consider the health consequences and implications of alternatives to coal such as coal seam gas or wind farming.

There is a sizeable international and national literature about the health effects of air pollution. Coal mining (particularly where open-cut methods of extraction are used), burning coal in coal-fired power stations and associated activities can contribute substantially to air pollution. However, there are also a number of other common sources of air pollution exposure such as vehicle exhaust fumes for communities living adjacent to major roadways. It should be noted that this review did not consider articles in which the source of air pollution was not clearly attributable to coal mining activity or where the pollution source was not stated.

Aims

Specifically, we aimed to:

- Undertake a rapid review of the available evidence about the health and related social harms of mining in local communities, drawing on the national and international peer reviewed health literature and relevant government and non-government reports
- Map any real or perceived ‘hotspots’ for mining related diseases and health problems in the Hunter Region of NSW, and comment on the outcomes
- Develop a report that identifies the significant, cumulative health impacts and major social impacts and trends associated with coal extraction and power generation in the general community/s living in the proximity of coal mines and/or coal-fired power stations.

A narrative review of the relevant national and international peer reviewed press, and reports and websites of government and non-government organisations was conducted.

Research questions and information sources

The methodological framework was built on four research questions ie:

1. What specific diseases or other health problems are associated with coal mining in local communities?
2. Are there clusters of these diseases or other health problems in the Hunter Region of NSW?
3. Is social injustice associated with coal mining in local communities?
4. Is there an association between coal mining and social injustice in the Hunter Region of NSW?

Articles from the peer reviewed medical and health literature were accessed through the University of Sydney Library and sourced from searches of the following health databases.

- | | |
|--------------------|----------------|
| ▪ Cochrane Library | ▪ Embase |
| ▪ Medline | ▪ Pre –Medline |
| ▪ Psycinfo | ▪ CinHal |

Technical reports and non-peer reviewed articles were accessed via web searches of relevant government and non-governmental organisations, and centred predominantly on Australia.

Searching and sorting the literature

The searches were jointly conducted by two members of the project team. Articles and technical reports were selected for the evidence review on the basis of pre-determined inclusion and exclusion criteria.

Journal articles and reports were included in the evidence review if they met the following criteria:

- addressed one or more of the research questions and were published in English
- reported on/involved humans living or working in local communities near coal mines
- were published during or since 1990 up to mid 2011
- included or were relevant to communities in the coal mining areas of NSW

Journal articles and reports were excluded from the evidence review if they:

- did not meet the inclusion criteria
- focussed on coal mining related occupational exposures, injury or accidents
- focussed on exposures to domestic coal use (cooking, heating)
- reported on air pollution without specifying the relative contribution of coal mining activity

Reviewing and synthesising the relevant literature

The research team reviewed and summarised the included papers and reports according to a standardised review guide ie the Johanna Briggs Institute Reviewers' Manual: 2008 Edition. More than 50% of the articles included in the report were reviewed by two members of the research team. The summaries were then collated by the authors to form a response to the research questions.

Section 3:

THE EVIDENCE

Research Question 1

What specific diseases or other health problems are associated with coal mining in local communities?

“Each step of the coal life cycle: mining, transportation, washing, combustion, and disposing of post-combustion wastes has impacts on human health”
Epstein et al, 2011.

Introduction

There have been few Australian studies that directly assess the health effects of coal mining or coal combustion in coal-fired power stations on the health of people living in surrounding communities. However, evidence from the international literature indicates that coal mining communities are at an increased risk of developing cardiopulmonary (heart/lung) disease, chronic obstructive pulmonary disease (COPD), other lung diseases, cancer, hypertension (high blood pressure), and kidney disease. Mortality rates for these diseases were higher in communities living in proximity to coal mines and coal-fired power stations.

We identified 38 relevant peer reviewed journal articles reporting on studies of the effects of coal mining and coal combustion on the health of local communities. Several of these studies are from the coal mining areas of West Virginia and Appalachian counties in the US, other parts of the US, and from Australia, Canada, the UK, Spain, Croatia, Poland, Slovakia, Turkey, Israel, China, Taiwan and Thailand. Three Australian studies from NSW were also included but were not recent, having been conducted around 20 years ago. A combined summary and detailed descriptions of each of the individual studies reviewed are reported below and further summarised in the Evidence Table in Appendix A. The evidence summary set out below is structured under the broad headings of:

- Coal mining
- Coal combusting power stations.

Under these two main headings, where possible, the evidence is further separated and reported under the following sub-headings:

- Adults
 - mortality (death)
 - morbidity (illness and disability)
 - hospitalisation
 - quality of life
- Children, infants, and fetal outcomes
 - respiratory disease
 - toxins
 - birth defects
 - fetal and infant growth and development

These categories were generated from the literature rather than by pre-determined by the authors of this Report.

Summary of Key Findings for Research Question 1

The available evidence indicates that there are negative health impacts for people living in communities near coal mines and coal combusting power stations. Much of the evidence comes from the Appalachian region of the US, where coal mining has been conducted for many years and which has higher morbidity and mortality rates than the rest of the US.

Evidence from the Appalachian studies along with evidence from other US studies, Australia, Canada, the UK, Slovakia, Croatia, Turkey, Israel, China, Taiwan and Thailand indicates that environmental exposure to particulate matter or toxic agents present in coal and released in coal mining and processing, and water contamination with toxicants found in coal and coal processing have been linked with health harms.

Health harms associated with coal mining

Adults in coal mining communities have been found to have:

- Higher rates of mortality from lung cancer, chronic heart, respiratory and kidney diseases
- Higher rates cardiopulmonary disease, chronic obstructive pulmonary disease (COPD) and other lung diseases, hypertension, kidney disease, heart attack and stroke, and asthma
- Increased probability of a hospitalisation for COPD (by 1% for each 1,462 tons of coal mined), and for hypertension (by 1% for each 1,873 tons of coal mined).
- Poorer self-rated health and reduced quality of life

Children and infants in coal mining communities have been found to have:

- Increased respiratory symptoms including wheeze, cough and absence from school with respiratory symptoms - however, not all studies reported this effect
- High blood levels of heavy metals such as lead and cadmium
- Higher incidence of neural tube deficits, a high prevalence rate of any birth defect, and a greater chance of being of low birth weight (a risk factor for future obesity, diabetes and heart disease).

Health harms associated with coal combusting power stations

Adults (and whole population) in communities near coal-fired power stations and coal combustion facilities have been found to have:

- Increased risk of death from lung, laryngeal and bladder cancer - particularly if living close to the plant
- Increased risk of skin cancer (other than melanoma) possibly due to exposure to arsenic
- Increased asthma rates and respiratory symptoms due to air pollutants and particulate matter

Children, infants, and fetal outcomes in communities near coal-fired power stations and coal combustion facilities have been found to have:

- Oxidative DNA damage possibly due to exposure to carcinogenic chromium and arsenic from coal combustion
- Higher rates of preterm birth, low birth weight, miscarriages and stillbirths associated with products of coal combustion, specifically sulphur dioxide
- Reduced fetal and child growth and neurological development associated with elevated levels of polycyclic aromatic hydrocarbons, of which power stations are a significant source
- Increased asthma rates and respiratory symptoms due to air pollutants and particulate matter.

Detailed Description of the Evidence for Research Question 1

A: COAL MINING - Adults

Mortality (death)

Hendryx and Ahern (2008) used census, geographical and environmental data for West Virginia, and cancer mortality rates from the US Centres for Disease Control to determine if residing in a coal mining county of Appalachia was an additional risk factor for mortality from lung cancer. The results of this retrospective analysis demonstrated that, after adjusting for confounding factors, lung cancer mortality was higher in areas of heavy coal mining. The effect of the coal mining exposure was significant for all levels and for both specifications of exposure used in the study (tonnage in millions and per capita exposure in tons), except for the lowest level in ton per million.

Another study in the same region aimed to determine if population mortality rates from heart, respiratory and kidney disease were higher as a function of the quantity of coal extracted (Hendryx, 2009). Four groups of counties were compared:

- Appalachian counties extracting more than four million tons of coal
- Appalachian counties extracting less than four million tons
- non-Appalachian counties with coal mining
- counties where there was no coal mining

Chronic heart, respiratory and kidney disease were compared with acute episodes of the same diseases. The results demonstrated that mortality rates in Appalachian counties extracting the largest quantities of coal were significantly higher than in non-mining areas for chronic heart, respiratory and kidney disease. Higher rates of acute heart and respiratory mortality were found for non-Appalachian coal mining counties. The authors concluded that higher chronic disease mortality in coal mining areas may partially reflect environmental exposure to particulate matter or toxic agents present in coal and released in its mining and processing.

In a subsequent study, Hendryx and colleagues (2010) compared cancer mortality rates using two different methods for calculating mining exposure. These were the Geographic Information Systems (GIS) method (a measure based on location of mines, processing plants, coal slurry impoundments and underground slurry injection sites relative to population levels) and a measure of exposure based on tons of coal mined. The GIS method is believed to be a more sensitive measure for calculating mining exposure for health impact purposes. The results of this study indicated that total, respiratory, and other age-adjusted cancer mortality rates in West Virginia were more closely associated with the GIS-exposure measure than tonnage measure of exposure. This effect was observed both before and after controlling for smoking rates.

Assessments of ecological integrity are commonly used in biological conservation but have been largely unused in public health. A study by Hitt and Hendryx (2010) tested the ecological integrity of streams in West Virginia, US, using the Stream Condition Index (SCI) to determine if such a methodology could be an indicator of human cancer mortality rates. The authors found as the SCI scores worsened, age-adjusted total cancer mortality increased. Respiratory, digestive, urinary, and breast cancer rates also increased with ecological disintegrity but genital and oral cancer rates did not. Coal mining was significantly associated with ecological disintegrity and higher cancer mortality and spatial analyses indicated cancer clusters that corresponded to areas of high coal mining intensity. The results from this study demonstrate significant relationships between ecological disintegrity and human cancer mortality in West Virginia.

Cardiovascular disease (CVD) mortality rates within Appalachia are comparatively higher than the rest of the US. Esch and Hendryx (2011) conducted a study to determine if there were differences in chronic CVD mortality rates (ie excluding acute CVD events) relating to the presence or absence of coalmining and/or the method of coal mining. The study also aimed to determine if there was an association between the total surface area of mining and CVD mortality rates. Age-adjusted CVD mortality rates from three counties were compared for residents of:

- mountain top coal mining areas
- non-mountain top mining areas
- non-mining areas

Mortality rates were found to be significantly higher in both categories of mining areas compared with non-mining areas but were highest in mountain top mining areas. Additionally, CVD mortality rates in mountain top mining areas were found to be related to the level/extent of surface mining.

Veugelers and Guernsey (1999) evaluated mortality patterns (focusing on life expectancy and life loss) for Cape Breton County, a coal mining area of Nova Scotia, Canada over five decades. Life loss refers to the difference in life expectancy of Cape Breton County residents and all Canadians. The study area, Cape Breton County, contains one of the most polluted areas in North America and is socioeconomically depressed. The data demonstrated that life expectancy in some municipalities of Cape Breton County was reduced by more than five years. Life loss for these residents was greater than for any single cause of death for Canadians overall. Life loss among Cape Breton County men was primarily attributable to CVD but among women it was primarily related to cancer. Life loss from all types of cancer was higher in the steel-producing communities whereas life loss from respiratory diseases and lung cancer was higher in the coal mining communities. The authors suggest that these differences may relate to environmental and occupational exposures associated with local coal mining, as well as to socioeconomic status and smoking rates.

Morbidity (illness and/or disability)

Hendryx and Ahern (2008) conducted a telephone survey and analysed self-reported presence or absence of specific health conditions in almost 16,500 West Virginian adults. They compared the data from the telephone survey with county-level coal production figures to investigate the relationship between health indicators and residential proximity to coal mining. The results indicated that, after controlling for possible demographic and social confounders, high levels of coal production were associated with worse health status and with higher rates of cardiopulmonary (heart/lung) disease, hypertension, lung disease, and kidney disease.

In a later study, Hendryx and Zullig (2009) analysed the US 2006 Behavioural Risk Factor Surveillance System (BRFSS) survey data (n = 235,783) to determine whether self-reported CVD rates were higher in Appalachian coal mining counties compared with other counties. After controlling for variables, the authors found that people in Appalachian coal mining areas reported a significantly higher risk of CVD, angina or coronary heart disease, and heart attack. These effects were present for both men and women, and the authors concluded that CVD is linked to both air and water contamination in ways consistent with toxicants found in coal and coal processing.

In response to government concerns regarding excess prescribing for asthma, a Welsh general practice (UK) audited its patient and treatment records for new asthma episodes (Temple & Sykes, 1992). A statistically significant increase in the number of weekly asthma episodes was evident from the audit following the opening of a nearby open-cast coal mine, even after controlling for seasonal and other transient factors.

Hospitalisation

In a retrospective analysis, Hendryx and colleagues (2007) investigated whether the volume of coal mining was related to population hospitalisation risk for diseases postulated to be sensitive or insensitive to coal mining by-products. Adult hospitalisation data from the records (n = 93,952) of 90 hospitals across West Virginia, Kentucky, and Pennsylvania (US), were merged with county-level coal production figures. After controlling for confounding variables, the results showed that the volume of coal mining was significantly related to hospitalisation risk for COPD and hypertension. The probability of a hospitalisation for i) COPD increased by 1% for each 1,462 tons of coal mined, and ii) for hypertension by 1% for each 1,873 tons of coal mined. Other conditions were not related to mining volume. This study indicates that exposure to particulates or other pollutants generated by coal mining activities is linked to increased risk of COPD and hypertension hospitalisations.

Quality of life

Zullig and Hendryx (2010), examined health-related quality of life (HRQOL) in mining and non-mining counties in and outside the Appalachian region of the US using the BRFSS survey (n = 349,247). Residents of coal mining counties, both in and outside Appalachia, reported significantly fewer healthy days for both physical and mental health, and poorer self-rated health when compared with non-coal mining counties. Disparities were greatest for people residing in Appalachian coal mining areas. The authors note that self-rated health has proven to be a more powerful predictor of mortality than detailed objective, physician-assessed health indicators. Thus, the persistent effect on impaired self-rated health among residents of Appalachia, and among residents in coal mining counties outside of Appalachia, support studies that have documented increased mortality associated with coal mining.

The health related quality of life (HRQOL) of residents in mountain top mining counties of Appalachia was examined more specifically in a subsequent study using the BRFSS survey results (Zullig & Hendryx, 2011). Data from 10,234 residents in three geographic areas were compared ie:

- mountain top coal mining areas
- non-mountain top mining areas
- non-mining areas

Residents of any coal mining areas were found to have significantly more days of poor physical, mental and activity limitation, and poorer self-rated health compared with residents of non-mining counties. Reductions in HRQOL were greatest for those residing in mountain top mining areas. These findings confirm the negative impact of mining activity generally on quality of life for local residents and suggest that the unique contribution of mountain top mining activity is responsible for the greatest negative effect.

B. COAL MINING – Children and infants

Respiratory disease

Brabin and colleagues (1994) conducted a cross-sectional survey of parents, using a questionnaire, to determine if school children in a specific locality exposed to pollution from steam coal dust have more respiratory symptoms compared with children in control areas. A total of 1,872 primary school children (aged 5-11 years) from five primary schools in the Bootle dock area of Liverpool in the UK (exposed area) were compared with five primary schools in South Sefton (control area) and five primary schools in Wallasey (control area). The two selected control groups, located 3-8km from the coal terminal, were demographically similar. Analysis of the results showed that respiratory symptoms were significantly more common in the exposed area, including wheeze, excess cough, and school absences for respiratory symptoms. These differences remained significant even when parental employment and smoking status were taken into consideration. A further analysis confirmed, after adjusting for confounding factors, that the exposed zone was a significant risk factor for absenteeism from school due to respiratory symptoms.

This study confirmed an increased prevalence of respiratory symptoms in the primary school children exposed to coal dust.

Two studies examined whether living near open-cast mines affects acute and chronic respiratory health in children (Pless-Mulloli et al, 2000; Pless-Mulloli et al, 2001). Children, aged 1-11 years, from five socioeconomically matched pairs (exposed/control) that resided in rural and semi-urban communities in Northern England were selected to participate. Patterns of the daily variation of particulate matter 10 micrometers or less in diameter (PM₁₀) were not statistically different in open-cast and control communities but there was a tendency for PM₁₀ to be higher in open-cast areas. Open-cast sites were also a measurable contributor to PM₁₀ in adjacent areas. However, associations between daily PM₁₀ concentrations and acute health events were similar in open-cast and control communities. Not surprisingly, little evidence was found of associations between living near an open-cast site and an increased prevalence of respiratory illnesses or asthma severity, but children in four out of the five open-cast communities had significantly more respiratory consultations than children in control communities. There was considerable unexplained variation in some health outcomes (such as the use of asthma medication, the number of severe wheezing attacks in the past year and tonsillitis) without a discernible pattern. The studies concluded that although children residing in close proximity to open-cast mines were exposed to a small but significant amount of additional PM₁₀, past and present respiratory health was similar. The authors proposed that the apparent contradictory results were due to the level of variation between communities and pairs, even though community pairs were well matched for lifestyle and socio-economic factors. It may also be possible that there was insufficient difference in the density of particulate matter between the study and the control areas to cause detectable differences.

Toxins - lead and cadmium levels

A Turkish study in the coal mining area of Yatagan, in Western Turkey, investigated asymptomatic lead poisoning prevalence and cadmium exposure in preschool children aged 6 months to 6 years (Yapici et al, 2006). In 85% of all children, the mean blood cadmium level was found to be at a level considered to be toxic. A negative association was found between age and blood lead and cadmium levels. While it was not possible to calculate what proportion of the biological lead and cadmium came from mining waste and what proportion came from other sources, such as paint and gasoline residue deposited in soil and air, the results indicate that asymptomatic lead poisoning and cadmium exposure are significant problems in children living in the Yatagan area.

Birth defects

Neural tube defects (NTDs) are a group of congenital malformations of the brain and spinal cord caused by failure of the neural tube to close shortly after conception. They are associated with infant death and major forms of permanent disability such as spina bifida.

A spatial analysis of NTDs was carried out in the rural coal mining area of Heshun, Shanxi Province, China (Liao et al, 2010). The Shanxi province provides 25% of China's coal production and 5.6% of world production. This region has one of the highest reported prevalence rates of NTDs in the world, due in part to socioeconomic factors, soil type distribution and a complicated geological background. The study investigators tested whether residence in a coal mining area was an additional risk factor for a NTD. A cluster of NTDs was detected within six kilometres of the coal mines for almost every year during a seven year study period. An analysis revealed that there may be an association between production in coal mines and prevalence of NTDs in coal mining areas. A concern expressed by the authors was that there may have been a significant amount of under-reporting, as not all the birth records were complete. The authors surmised that there is a possibility that environmental contamination from the coal mining industry causes NTDs.

Two studies from Appalachia looked at birth outcomes (Ahern et al, 2011a; Ahern et al, 2011b). The first retrospectively examined birth defects in mountain top coal mining areas and compared these with other coal mining areas and non-mining areas of central Appalachia (n = 1,889,071) (Ahern et al, 2011a). Mountain top mining has been increasing in this area and results in greater environmental impacts than other types of open-cut mining. Statistical models that controlled for variables showed the prevalence rate for any birth defect was significantly higher in mountain top mining areas compared with non-mining areas but not in the non-mountain top mining areas. Birth defect rates were also significantly higher in mountain top mining areas for: circulatory/respiratory, central nervous system, musculoskeletal, gastrointestinal, urogenital, and 'other' defects. Elevated birth defect rates can be partly a function of socioeconomic disadvantage, but remained elevated after controlling for these factors. There was also evidence that the detrimental effects of mountain top mining were worsening and that they influenced birth defects in neighbouring counties.

The second study, was a cross-sectional, retrospective analysis to determine if there was an association between low birth weight (< 2.5 kg) and the mother's residence in relation to coal mining areas in West Virginia, US (n = 42,770) (Ahern et al, 2011b). The study found, after controlling for confounders, that residing in coal mining areas of West Virginia posed an independent risk of low birth weight. Odds ratios suggested a dose-response effect meaning that, relative to counties with no coal mining, living in areas with higher levels of coal mining increased the likelihood of a low birth weight infant.

C. COAL COMBUSTING POWER STATIONS – Adults (and whole population)

Mortality, morbidity (illness and/or disability)

A Spanish study investigated whether there might be excess mortality from tumours of the lung, larynx and bladder in the population residing near Spanish combustion installations included in the European Pollutant Emission Register (García-Pérez et al, 2009). The results indicated that lung cancer mortality increased for all types of fuel used in power stations, whereas for laryngeal and bladder cancer the increase was only associated with coal-fired industries. Furthermore a relationship between cancer and proximity to combustion installations was found. From these outcomes, the authors concluded there is a significant association between risk of lung, laryngeal and bladder cancer mortality and proximity to Spanish combustion installations.

A case-control study was conducted to estimate the non-melanoma skin cancer (NMSC) risk associated with arsenic exposure from a coal-fired power station in the district of Prievidza, Slovakia (Pesch et al, 2002). The area studied currently has the highest incidence of NMSC in Slovakia. A significant risk between NMSC and arsenic exposure was found. The authors concluded that there is evidence of the impact of environmental arsenic exposure from power station emissions on NMSC development in the district of Prievidza.

Another study in the same area of Slovakia evaluated trends in the incidence of NMSC associated with arsenic exposure from the power station emissions from data collected over a 20 year time period (Bencko et al, 2009). Analysis of the data demonstrated a positive relationship between human cumulative exposure to arsenic and incidence of NMSC. Furthermore, the incidence of skin cancer showed an upward trend during the most recent five years of the study in the regions considered to be less polluted. The individuals living in this area had been exposed to lower levels of arsenic over a prolonged period of time suggesting that arsenic may have a cumulative effect on the incidence of NMSC.

The International Agency for Research on Cancer reviewed global cancer risks for the general population and occupational groups from the fossil fuel cycle, the nuclear fuel cycle, and renewable cycles (Boffetta et al, 1991). Cancer risks from waste disposal, accidents and misuses, and electricity distribution were also considered. The reviewers concluded that no cycle seems to be free from cancer risk. They also reported that cancer risks related to the operation of renewable energy sources were negligible, although there may be some risks from the construction of such installations. As the review is 20 years old, it is probable that possible carcinogenic outcomes from more recent energy cycles may have increased since the time of this publication.

A Turkish case-control study investigated the respiratory effects from the stack emissions of the Seyitömer coal-fired thermal power station in the Kütahya Province (Karavus et al, 2002). The exposed group was composed of residents from three villages within a five kilometre radius of the power station. They were compared with two demographically similar villages 30km away (control). People in the exposed group were found to have a statistically significant higher rate of complaints such as chest tightness and repeated coughing attacks present for more than one year. The results were however only significant above the age of 35 years. When further analysed, the respiratory parameters were worse in the exposed group for non-smokers, but not smokers. The authors concluded measures to prevent adverse pulmonary health effects caused by living near the power station are especially important for non-smokers. The Turkish power station is fuelled by lignite coals, which differ from those used in Australia so application of these results to the Hunter Region and other Australian coal mining areas may be limited.

A number of studies have investigated the health of people residing in the vicinity of a coal-fired power station in Hadera, Israel. Goren and colleagues (1995) aimed to detect spatial or temporal changes in the health status of a population residing within a 10km radius of a coal-fired power station. The survey results showed that among adults, a seasonal trend of more frequent use of outpatient clinics due to respiratory complaints was observed. The major explanatory factor for use of outpatient clinics was lower ambient temperatures; the other was a flu epidemic. Interestingly, a significant increase in the use of outpatient clinics was observed for certain years, while in other years there was a decrease. The investigators found that the follow-up failed to demonstrate any deterioration in lung function or differences in the severity of respiratory complaints as compared with a similar population residing in a rural, clean area with no major environmental polluting source. Air pollution levels measured around the coal-fired power station in Hadera were low and may explain these results.

D. COAL COMBUSTING POWER stations – Children, infants, and fetal outcomes

Respiratory disease

A further Israeli study by Goren and Hellmann (1997) in the vicinity of the same coal combustion assessed signs and symptoms of respiratory disorders in schoolchildren in three communities with different expected levels of air pollution. Follow up comparisons were undertaken every three years. A significant increase in the prevalence of asthma was observed among the data from the fifth grade children in all three communities. At the same time a significant rise in the prevalence of wheezing accompanied by shortness of breath was observed. A similar trend could not be found for the prevalence of bronchitis and other respiratory conditions. As expected, pulmonary function tests (PFTs) of children suffering from asthma or from wheeze accompanied by shortness of breath were worse than those of healthy children. Changes in the prevalence of possible contributing factors could not explain the significant rise in asthma. The authors concluded that this effect and related respiratory conditions coupled with reduced PFTs suggest a true increase in morbidity and not a reporting bias. However, the increased prevalence of asthma could be observed in all the communities studied thus not appearing to be connected with the operation of the power plant.

A subsequent Israeli study assessed whether fine particles were a risk to lung function in a group of school children (n = 285) with asthma living near two power stations in the region (Peled et al, 2005). This nested cohort study compared three communities which each had a fine particle monitoring station. After controlling for confounders known to affect lung function, air pollution by ultra-fine particles (PM₁₀ and PM_{2.5}) were found to be significantly associated with decreased lung function. It is noteworthy that this adverse respiratory effect was observed at levels below the Israeli air quality standards.

In yet another Israeli study, researchers analysed the association between children's lung function development and their long-term exposure to air pollution using GIS tools (Dubnov et al, 2007). Data collected three years apart on 1,492 school children living in the vicinity of a coal-fired power station, indicated that PFT results deteriorated as estimated individual levels of air pollution increased. Other factors were evaluated for possible effects on lung function but none were found to be statistically significant. The authors concluded that air pollution from the coal-fired power station, although not exceeding local pollution standards, had a negative effect on children's lung function development. A more recent analysis of these children evaluated the effects of exposure to air pollution on lung function, characterised by health status (Yogev-Baggio et al, 2010). The children were subdivided into three health status groups: i) healthy children, ii) children experiencing chest symptoms, and iii) children with asthma or spastic bronchitis. After controlling for socio-demographic characteristics and living conditions, exposure to air pollution appeared to have had the greatest effect on children with chest symptoms.

A study from Maemoh, northern Thailand, evaluated the association of short-term exposure to increased ambient sulphur dioxide (SO₂) and daily lung function changes among children aged 6-14 years with and without asthma who resided near a coal-fired power station (Aekplakorn et al, 2003). The results demonstrated an adverse effect of short-term exposure to air pollution on lung function in children with symptoms of asthma. It was concluded that declines in lung function among asthmatic children are associated with increases in particulate air pollution, rather than with increases in SO₂. The authors noted that the concentrations of pollutants were relatively low, possibly due to recent measures to mitigate SO₂ emissions, and may have limited the study outcomes. The application of these results to the Hunter Region may be limited as this is a lignite coal-fired power station.

Undertaken a little over 20 years ago, a study in Lake Munmorah, a NSW coastal town between two coal-fired power stations, investigated respiratory problems in primary school children (Henry et al, 1991a). A prevalence survey and longitudinal follow-up study were conducted one year apart. Both studies found that the prevalence of 'ever wheezed', 'current wheezing', 'breathlessness', 'wheezing with exercise', diagnosed asthma, and use of drugs for asthma were all approximately double compared with the NSW control town of Nelson Bay – a coastal non mining area. Airway test results were impaired in the study group in the first survey but not statistically significant at follow-up. The authors concluded that the impaired respiratory results were due to an environmental cause.

In a further study to assess the effect of living in Lake Munmorah on children with asthma, 94 children with asthma were studied for one year and compared with a similar group living in Nelson Bay (Henry et al, 1991b). Air quality measurements of SO₂ and nitrogen oxides were well within Australian recommended limits in both areas although they were several times higher at Lake Munmorah where marked weekly fluctuations were observed in the prevalence of cough, wheezing, and breathlessness in the study group compared with the control group in Nelson Bay. However, these differences were not statistically significant. The authors concluded that air quality measurements were not associated with the occurrence of respiratory symptoms.

Halliday and colleagues (1993) undertook a third study in this series. This was a cross-sectional survey of school children (aged 5 to 12 years) from the same exposed group as previous studies but with a different socioeconomically matched control population (Dungog, Hunter Valley). The authors compared respiratory measurements and asthma symptoms between the two groups. Baseline lung function was lower and reported symptoms of asthma were higher in children from the power station town, but airway test results were similar. These results confirm the increased presence of reported symptomatic illness in the town near the power stations.

Toxins – arsenic, chromium, and oxidative stress

Oxidative DNA stress is believed to play an important role in certain diseases and conditions including cancer and premature ageing.

A cross-sectional study in Taiwan comparing school children (aged 10-12 years) from three different elementary schools was undertaken to investigate possible associations between proximity to a power station and urinary levels of arsenic, chromium, and nickel and the level of DNA oxidative stress (Wong et al, 2005). Of the selected schools, one (exposed) was adjacent to a power station, with eight coal-fired generation units. The remaining schools (controls) were located in suburban communities, approximately 8km and 18km north-eastern and upwind from the power station. The results indicated that children in the exposed elementary school had higher urinary 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels than did those at the control schools - 8-OHdG being a biomarker of oxidative stress. The authors further reported that children with higher urinary arsenic or chromium had greater urinary 8-OHdG. There was also a significant trend between children with high urinary arsenic and chromium and children with high urinary 8-OHdG levels, followed by those with low arsenic/high chromium, and low arsenic/low chromium. No obvious relationship between the levels of urinary nickel and 8-OHdG was found. From these results the authors concluded that environmental carcinogenic metal exposure to chromium and arsenic may play an important role in oxidative deoxyribonucleic acid damage in children.

Infant and fetal outcomes

Mohorovic (2004) studied pregnant women residing in the vicinity of a coal power station in the Croatian town of Labin. The power station is the single major air polluter in the area and the coal burnt there has a very high sulphur content (9-11%). This retrospective epidemiological study investigated what was the most critical gestation period for adverse effects of coal combustion products in relation to preterm delivery (< 37 weeks) and low birth weight (< 2.5 kg). The analysis indicated that a greater and longer exposure to SO₂ emissions during the initial two months of pregnancy resulted in a significantly shorter gestation and lower birth weight. The authors concluded that these results confirm the role of inhaled environmental toxins in the early development of the human embryo and in adverse pregnancy course caused by permanent oxidative stress, misbalanced production of reactive oxygen, nitrogen and sulphur species as well as other unfavourable metabolic processes on early embryo development and growth, resulting in growth-arrested cells.

A more recent epidemiologic study by Mohorovic and colleagues (2010) investigated the relationship between exposure to products of coal combustion and complications in pregnancy. Records of miscarriages, premature births and stillbirths were compared across two periods:

- the control period when the plant was closed for almost 7 months
- the exposure period when the plant was operating.

Analysis of data on 260 pregnant women found that the frequency of miscarriages and stillbirths were significantly lower in the control period compared with the exposure period. Additionally, stillbirths and a blood biomarker (methemoglobin) for adverse environmental effects on the mother and fetus, recorded over the exposure period, were significantly higher than in the control period.

In another study, researchers from Columbia University examined the relationship between prenatal polycyclic aromatic hydrocarbon (PAH) exposure and fetal and child growth and development in Tongliang, China (Tang et al, 2006). A seasonally operated coal-fired power station is the major pollution source in the vicinity. PAHs are an important class of toxic pollutants released by fossil fuel combustion. Polycyclic aromatic hydrocarbon-deoxyribonucleic acid (PAH-DNA) adducts provide a measure for calculating PAH exposure, and have been associated with increased risk of cancer and adverse birth outcomes. Results from a group of non-smoking women and their newborn infants indicated high PAH-DNA adduct levels (above the median detectable level) which were associated with decreased birth head circumference, birth length, reduced children's weight and height at 18, 24, and 30 months of age. The findings indicate that PAHs from coal burning power stations are harmful to the developing fetus and child.

A two year follow-up of the same subjects evaluated the association between levels of PAH-DNA adducts, lead, and mercury (Tang et al, 2008). The data from the mother-child pairs found that decrements in one or more developmental areas (motor, adaptive, language, and social) were significantly associated with cord blood levels of PAH-DNA adducts and lead, but not mercury. Increased adduct levels were also associated with a significantly decreased motor area developmental quotient (DQ) and average DQ, after adjusting for variables. The DQs the authors assessed were motor, adaptive, language and social areas. From the results, the authors concluded that in utero exposure to PAHs from the coal-fired power station adversely affected the development of children living in Tongliang.

The permanent closure of the Tongliang power station (China) provided an opportunity to evaluate the effect of the closure on neuro-behavioral development in women and their newborns (Perera et al, 2008). Two identical prospective cohort studies (pre- and post-plant shutdown) were compared. Significant associations between elevated PAH-DNA adducts and decreased motor area DQ and average DQ previously seen in the pre-plant shutdown study were not observed in the post-plant shutdown cohort. However, the direction of the relationship did not change. The findings suggest that neurobehavioural development in Tongliang children benefited from the elimination of PAH exposure from the coal burning plant.

Author's comments

Studies from a number of countries show clear associations between coal mining and combustion activity and health harms from major impacts, up to and including excess deaths, to minor respiratory complaints such as coughs and wheezing. However, it should be noted that there are inherent difficulties in designing population and community studies that can unequivocally attribute and precisely quantify associations as it is often not possible to control the many factors and confounders that impact on the research subjects. The main limitation to the evidence cited in this section is the difficulty in accurately, precisely and reliably measuring exposure in studies involving air quality, although these methodologies are improving rapidly. It should also be noted that mining practices and regulatory standards vary across countries and may account for different effects. For example, mountain top removal for mining purposes as carried out in parts of the US may cause additional negative health effects and is not used in Australia to our knowledge.

Conversely, there are a number of factors which may result in underestimation and /or under reporting of coal related health harms for local communities. There is a lack of long term prospective studies which may mean that causal associations between mining activity and diseases with a long time lag, such as cancers, may be underestimated. Some of the studies we reviewed were conducted up to 20 years ago, including the few Australian studies, and it could be assumed that the huge expansion in coal mining over that period may have amplified any health impacts. Further, we excluded studies of air

pollution from our reviews if the study did not specify coal mining or combustion as the pollution source - although it may well have been a contributor in some studies.

Several international studies highlight the presence of harmful airborne pollutants and toxins associated with coal extraction and combustion but do not link these with health outcomes and were therefore not included in our evidence review. However, it is reasonable to assume that these pollutants and toxicants had adverse health effects on local residents. For example, a study conducted in the highly polluted area of Silesia in Poland in the 1990's showed high levels of PAHs in environmentally exposed individuals compared with others in Western Europe, and compared to non-exposed individuals in the same region (Øvrebo, 1995). Another study in the highly polluted area of Lodz in Poland, which is associated with three coal-fired power stations, found a 20% increase in gamma radiation producing nucleotides attributable to power station emissions (Bem et al, 2002). Several studies from India, the world's third largest coal producer, have looked at dust production from open-cast mining. A study of one large open-cast coal mining project found that the total dust emitted was estimated to be 9368kg/day. The various sources of emissions including fugitive emissions; dust from vehicular traffic on haul roads; and wind erosion from stockpiles were found to be significant sources of dust (Ghose & Majee, 2007). The authors conducted a further study collecting worksite data and ambient air quality monitoring for a year at five locations. The authors found high levels of PM₁₀, total respirable matter and benzene soluble matter (benzene is a known human carcinogen). A previous study in India also found high levels of dust associated with coal washeries that exceeded local standards; 50% of soluble particulate matter was less than PM₁₀, and high levels of benzene soluble matter were found including ambient air measurements (Ghose & Banerjee, 1995).

A review of air pollution and cardiopulmonary disease in Australia published in 2005 (Howie et al, 2005) concluded that the weight of Australian studies reviewed (n=13) indicated that air pollutants (eg PM₁₀, SO₂ and nitrogen oxide) were associated with an increase in cardiovascular and respiratory mortality and hospital admissions, consistent with the international evidence, and that these effects occur at even lower levels than the current national standards. The authors also noted significant gaps in the literature such as defining exposure thresholds, determining population exposures distributions, disentangling the effect of one air pollutant from another and the interactive effects of pollutants and other environmental factors. New associations with air pollution are also emerging; studies are finding an association between diabetes and particulate matter in the US (Pearson et al, 2010). The International Collaboration on Air Pollution and Pregnancy Outcomes was formed in 2007 to further understand relationships between air pollution and adverse birth outcomes, following evidence from numerous studies showing adverse outcomes, including low birth weight, preterm delivery and infant mortality (Woodruff et al, 2010).

The American Heart Association's 2010 Scientific Statement on Particulate Matter Air Pollution and Cardiovascular Disease (Brook et al, 2004) includes advice that exposure to PM_{2.5} or less over a few hours to weeks can trigger CVD deaths as well as non-fatal events. Longer term exposure increases the risk of CVD mortality in more exposed individuals and reductions in PM_{2.5} lead to reductions in CVD mortality within a few years. Exposure to PM_{2.5} is deemed a modifiable factor that contributes to CVD morbidity and mortality. CVD is listed as the leading cause of death in Australia.

The limited amount of evidence available for Australia is disappointing but, in the absence of current local studies it is reasonable to extrapolate the international evidence to Australia – particularly where that evidence comes from comparable countries.

Are there clusters of these diseases or other health problems in the Hunter Region of NSW?

Introduction

Australian data on the health impacts of coal mining are very limited and we found no Australian studies reporting specific disease clusters or ‘hot-spots’ in communities living near coal mines. Notwithstanding this, there are numerous anecdotal reports of perceived disease clusters in the Hunter Region including for cancer and type 1 diabetes, and concomitant high levels of concern within local communities living near mining sites.

In 2010, in response to community concerns, the NSW Chief Health Officer convened an Expert Advisory Panel to look into the issue of air quality in the Hunter Region. This panel produced the report cited below as the “NSW Health Report”. At the time of writing our report on the *The Health and Social Harms of Coal Mining in Local Communities*, we believe that the NSW Ministry of Health (formerly known as the NSW Department of Health) is in the advanced stages of planning a study of air quality in the Hunter Region. We understand that this study will draw on information from 14 air monitoring stations, with two of these stations monitoring PM_{2.5} particles ie those that pose the greatest health risks.

While we await the NSW Ministry of Health study, it is reasonable to assume that the evidence from the US and other developed countries would be applicable in the Australian context. In the interim, to determine the status of disease clusters in the Hunter Region we reviewed the publicly available data on the health of people living in the (former) Hunter-new England Area Health Service (HNEAHS) which covers all but 9% of the population of the Hunter Region, and relevant sections of the BEACH general practice data.

The information summarised below and described in detail on the following pages is contained in two reports which analyse and present routinely collected health monitoring data ie:

- A report published in 2010 by the Population Health Division, NSW Department of Health entitled ***“Respiratory and cardiovascular diseases and cancer among residents in the Hunter New England Area Health Service”*** (NSW Health 2010a). Available at: http://www.health.nsw.gov.au/pubs/2010/pdf/HNE_Respi_Cardio_Disease.pdf
- A report providing results of data analysis from the Bettering the Evaluation and Care of Health (BEACH) Program (NSW Health 2010b) entitled ***“Analysis of BEACH general practitioner encounter data to examine the potential health effects of the mining industry and other exposures in Singleton, Muswellbrook and Denman”***. Available at: http://www.health.nsw.gov.au/pubs/2010/beach_report.html.

Summary of Evidence for Research Question 2

There is no direct research evidence available on coal related disease clusters in the Hunter Region and the evidence from analyses of routine monitoring data shows variable and inconclusive results.

For example, comparisons of the two geographical areas with extensive open-cut mining and power generation activities showed that the death rate from all causes was significantly higher in the Lower Hunter cluster but significantly lower in the Upper Hunter cluster than the death rate for NSW as a whole. Further, the two geographical areas reporting higher (but not statistically significantly higher) rates were not particularly exposed to extensive open-cut coal mining or power generation. Lung cancer incidence was not significantly different to the whole of NSW and although some other types of cancer were more commonly reported these were not cancers usually associated with coal mining or coal combustion.

Nonetheless, the NSW Health Report on residents of the HNEAS who may be exposed to air pollution from mining activity concluded that:

“Compared with the rest of NSW, one or both of Upper Hunter and Lower Hunter, the geographical regions of HNEAHS most affected by open-cut coal mining and power generation plants, have higher rates of:

- Emergency department attendance for asthma and respiratory disease (but also for all other conditions, which may indicate a general tendency to greater use of emergency departments in these regions)
- Hospital admission for all respiratory conditions together and for asthma (Upper Hunter only)
- Hospital admission for cardiovascular disease
- Death from all causes and cardiovascular disease (Lower Hunter only).”

The BEACH Report found that the rates of illness in people presenting to general practitioners (GPs) in the Upper Hunter were similar to comparable areas of NSW and did not find any significantly higher rates of any problems managed, or medications prescribed or supplied in the Upper Hunter Region compared with the rest of non-metropolitan NSW. It concluded that is reasonable to assume that the minor differences in the GP data for Singleton, Muswellbrook and Denman are likely due to chance rather than actual differences in disease rates, but it conceded that asthma may be a more important issue in the Upper Hunter.

The BEACH Report recommended that further study of the health effects of the mining industry and other exposures in the Hunter Region should focus particularly on asthma and other respiratory diseases.

Details of the Evidence for Research Question 2

For administrative purposes NSW was, until recently, geographically divided into Area Health Services (AHSs). These are now known as Local Health Districts but there is little difference between the boundaries of the Districts and the former AHSs. As Table 2 shows, the HNEAHS covered 25 LGAs grouped into eight clusters. Most of these LGAs are included in the Hunter Region and only 9% of the population covered by the HNEAHS falls outside the Hunter Region.

Table 3 HNEAHS estimated total residential population by cluster and LGAs

HNEAHS cluster	LGA	Population
Greater Newcastle	Lake Macquarie	195 479
	Newcastle	153 171
	Port Stephens	67 144
	Subtotal	415 794
Lower Hunter	Cessnock	49 751
	Dungog	8 539
	Maitland	69 878
	Singleton	23 747
	Subtotal	151 913
Lower Mid North Coast	Gloucester	4 995
	Greater Lakes	35 986
	Greater Taree	47 866
	Subtotal	88 847
McIntyre	Inverell	16 169
	Gwydir	5 421
	Subtotal	21 591
Mehi	Moree Plain	14 427
	Narrabri	13 454
	Subtotal	27 881
Peel	Gunnedah	11 840
	Tamworth	57 066
	Walcha	3 291
	Subtotal	72 197
Tablelands	Armidale Dumaresq	24 538
	Guyra	4 404
	Tenterfield	6 812
	Uralla	6 008
	Glen Innes Severn	9 065
	Subtotal	50 827
Upper Hunter	Muswellbrook	16 167
	Upper Hunter Shire	13 524
	Liverpool Plains	7 825
	Subtotal	37 516
HNEAHS combined	TOTAL	866 566

Source: NSW Health, 2010a. Respiratory and cardiovascular diseases and cancer among residents in the Hunter New England Area Health Service.

OVERVIEW OF FINDINGS FROM THE NSW HEALTH REPORT (2010A)

According to the NSW Department of Primary Industry (2009) there are six coal-fired power stations in the Hunter-Newcastle Coalfield Region and Table 4 indicates the location and number of coal mines in the HNEAHS.

Table 4: Number of operating coal mines in the Hunter New England Area Health Service, April 2010

LGA	Coal mines		
	Open-cut	Underground	Combined (open-cut & u/ground)
Singleton	11	2	4
Muswellbrook	5	-	1*
Cessnock	1	1	1
Lake Macquarie	1	5	-
Gloucester	1	-	-
Great Lakes	1	-	-
Gunnedah	3	-	-
Liverpool Plains	1	-	-
Narrabri	2	1	-
TOTAL	26	9	6

*The combined open-cut and underground coal mine in the Muswellbrook LGA also falls across into boundary of Singleton LGA. Not included in data set for Singleton LGA.

Source: Adapted from NSW Health, 2010a. Respiratory and cardiovascular diseases and cancer among residents in the Hunter New England Area Health Service.

The NSW Health Report (2010a) focused on diseases and causes of death previously associated in the international health literature with exposure to air pollutants, and on certain diseases of concern to communities in the HNEAHS. It presents emergency department data by postcode; hospital separations rates by LGA; and mortality and self-reported health data by HNEAHS cluster. The purpose of the Report was to i) assess the health of the residents of the HNEAHS, ii) compare the health of HNEAHS residents with the health of residents of other parts of NSW, and iii) examine variations in health within HNEAHS in relation to the distribution of coal mining and coal-fired power generation in the area. The main health conditions and health reviewed in the NSW Health Report are described below under the following headings:

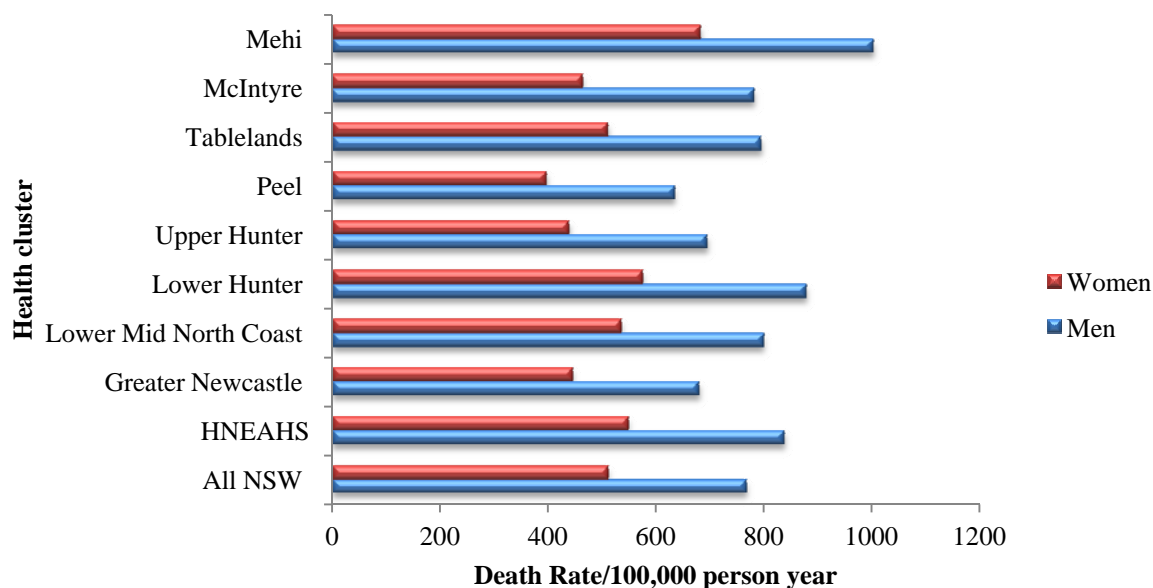
- Mortality (death)
- Cancer
- Emergency department presentations for respiratory illness and asthma
- Hospital separations from respiratory diseases (including asthma and cardiovascular diseases)
- Self-reported data on overall health, asthma and smoking.

Mortality (death)

All-cause mortality

The death rate from all causes is significantly higher in the Lower Hunter cluster (Rate/100,000 person year 703.87) but significantly lower in the Upper Hunter cluster (Rate/100,000 person year 555.96) (the two clusters with extensive open-cut mining and power generation activities) than the death rate for NSW as a whole (Rate/100,000 person year 624.01). Within HNEAHS, the death rate from all causes is highest in the Mehi cluster (Rate/100,000 person year 832.14). Mehi has a higher proportion of Aboriginal residents.

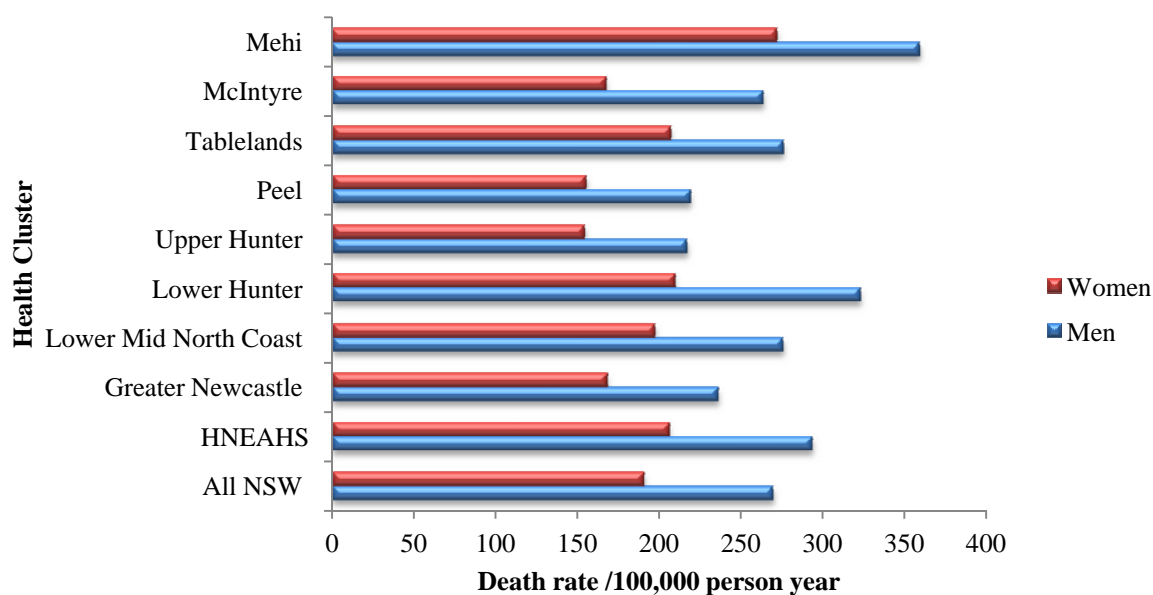
Figure 2: All cause mortality in males and females by HNEAHS cluster, HNEAHS and NSW



Cardiovascular disease mortality

For the period 2002-07, the CVD death rate was significantly higher for HNEAHS (Rate/100,000 person year 245.83) than for NSW (Rate/100,000 person year 225.06). The Lower Hunter cluster had a significantly higher rate of CVD deaths (Rate/100,000 person year 256.51), while the Upper Hunter cluster had a significantly lower rate (Rate/100,000 person year 184.84) of CVD deaths than NSW as a whole. Two LGAs (Gunnedah and Narrabari) had a rate more than 50% higher than the state average.

Figure 3: Cardiovascular diseases mortality in males and females by HNEAHS cluster, HNEAHS and NSW

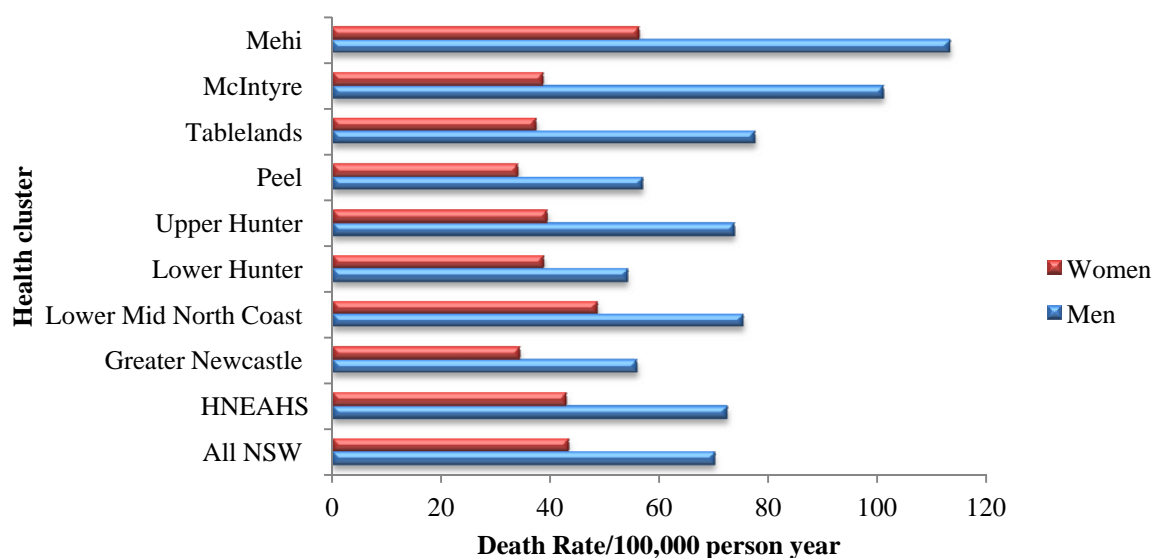


All respiratory disease mortality

The death rate from all respiratory disease for HNEAHS (Rate/100,000 person year 54.67) was not significantly different to NSW as a whole (Rate/100,000 person year 53.98). The clusters with extensive open-cut mining and power generation activities, the Upper and Lower Hunter clusters, have rates of death from respiratory disease that are similar to but lower than the HNEAHS as a whole. The rates were:

- Upper Hunter: Rate/100,000 person year 54.26
- Lower Hunter: Rate/100,000 person year 45.10
- HNEAHS: Rate/100,000 person year 54.67

Figure 4: All respiratory disease mortality in males and females by HNEAHS cluster, HNEAHS and NSW



Cancer

Cancer incidence and mortality data for the period 2003-07 indicated that HNEAHS had significantly higher incidence rates for all cancer (Rate/100,000 person year 469.3 vs 448.9) and a higher rate of death from cancer (Rate/100,000 person year 192.8 vs 178.3) than NSW overall. However, the higher rates which contributed to this effect were for colorectal and prostate cancers, and melanoma which are not thought to be associated with air pollution.

Lung Cancer

Lung cancer incidence for HNEAHS for all persons, (Rate/100,000 person year 39.7) was similar to the rate for NSW (Rate/100,000 person year 40.3), and was not significantly higher in any of the areas with extensive open-cut mining and power generation activities. Within HNEAHS, the lung cancer incidence rate for all people in the Mehi cluster (Rate/100,000 person year 60.2) was higher than for other clusters, consistent with the higher (but not statistically significantly higher) smoking rates reported for the Mehi cluster.

The incidence of lung cancer in men in the Upper Hunter (Rate/100,000 person year 69) was also higher than that for men in NSW (Rate/100,000 person year 54.6). This effect was not statistically significant, nor was it true for men in Lower Hunter (Rate/100,000 person year 55.4), the other cluster with extensive open-cut mining activities, or for women in either of these clusters (Figure 5).

Lung cancer mortality rates for all persons for HNEAHS (Rate/100,000 person year 34.9) were also similar to the rate for NSW (Rate/100,000 person year 33.5), and were not significantly higher in any of the areas with extensive open-cut mining and power generation activities (Figure 6).

Figure 5: Lung cancer – new cases in males and females by HNEAHS cluster, HNEAHS and NSW.

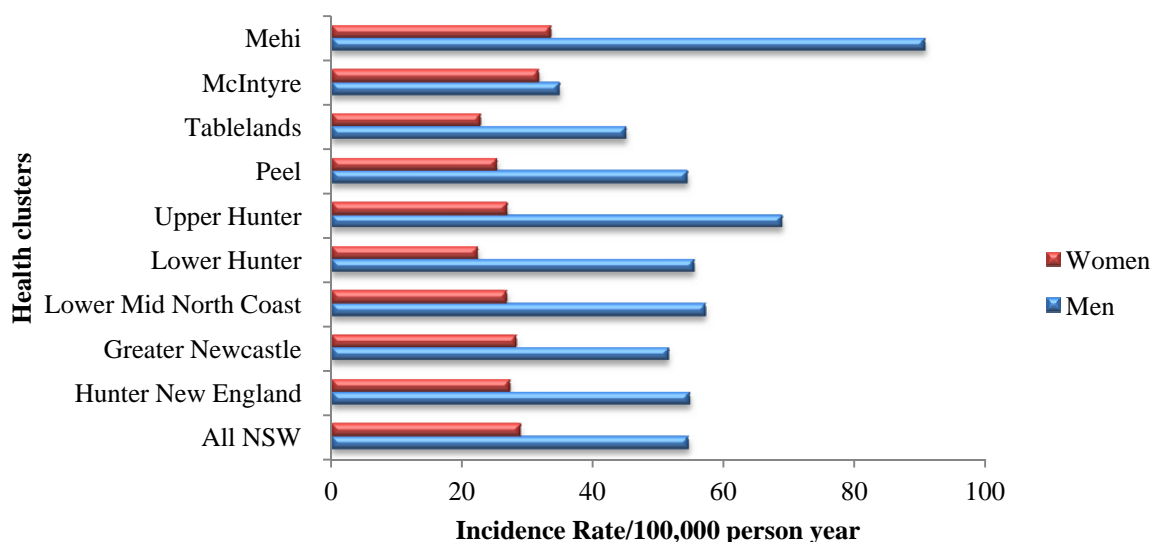
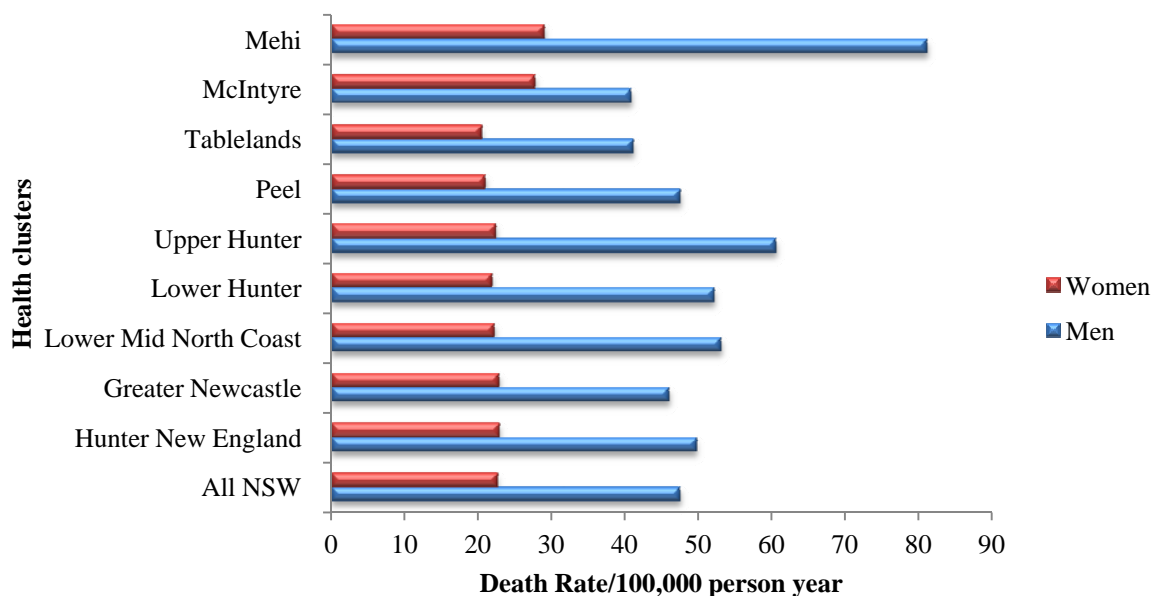


Figure 6: Lung cancer – mortality in males and females by HNEAHS cluster, HNEAHS and NSW



Brain cancer cluster

The NSW Health Report (2010a) cited an investigation of five cases of brain cancer reported occurring within two streets in Singleton. These cases were diagnosed between 1979-2008. A cluster investigation was undertaken and concluded that the geographical location of these brain tumour cases was most likely to be a chance occurrence. A report on this investigation is available at:

http://www0.health.nsw.gov.au/resources/news/singleton_cancer_pdf.asp

Emergency department presentations for respiratory illness and asthma

Data for the total number of residents in HNEAHS who presented to emergency departments and who were assigned a diagnosis of any respiratory condition (including asthma) were obtained from the NSW Emergency Department Data Collection for the period 2007-09 inclusive and showed that:

- Rates of presentation for all respiratory illnesses in Muswellbrook and Singleton postcodes ranked below those of Tamworth, Gunnedah and Cessnock in all age groups
- The Muswellbrook area had high rates for emergency department presentation for asthma, but not the highest in HNEAHS
- Singleton ranked highly for rates of emergency department presentations for asthma in people aged 15-64 years
- Muswellbrook and Singleton were equally highly ranked for rates of other emergency department presentations for conditions unrelated to air pollution.

Hospital separations for respiratory diseases, asthma and cardiovascular disease

NSW Admitted Patients Data Collection and population estimates from the NSW Centre for Epidemiology and Research highlighted the following:

- Singleton and Muswellbrook LGAs had significantly higher rates of hospital separations for CVD than all of HNEAHS or NSW
- Other LGAs in HNEAHS that do not have open-cut coal mines or power generating plants also had higher rates of CVD hospital separations
- Muswellbrook had a significantly higher separation rate for respiratory disease, whereas Singleton had a lower, but not significant, separation rate compared with NSW
- Asthma separation rates also showed a mixed pattern, with significantly higher rates in Muswellbrook and Narrabri, but lower rates in Cessnock and Singleton, compared with all of HNEAHS and NSW.

Self-reported data on overall health, asthma and smoking

Overall health

No difference in overall self-rated health was found between residents of HNEAHS and NSW, or between residents in any of the areas within HNEAHS clusters.

Asthma

- There was no statistically significant difference in self-reported asthma in adults in the HNEAHS compared with the rest of NSW. The only areas reporting higher asthma prevalence were Mehi and Peel. Neither of these regions is exposed to extensive open-cut coal mining or power generation industries
- The rate of parent/carer-reported asthma for children aged 15 years or younger was similar in all regions of the HNEAHS and was significantly higher than for the rest of NSW. The higher asthma rates were reported in those LGAs that contain the greatest concentration of open-cut coal mines and power stations, and also in LGAs containing few or no coal mining.

OVERVIEW OF THE BEACH PROGRAM: GENERAL PRACTICE DATA FOR THE THE UPPER HUNTER

To determine potential community health effects at general practice level, the BEACH Program collected data from 1000 GPs randomly selected across Australia. Each GP provided data on the problems managed and treatment provided for 100 consecutive patients. In 2010, in response to health concerns raised by members of the Singleton Shire Healthy Environment Group, sub-analysis of the data from the BEACH program was conducted to examine the potential health effects of the mining industry and exposure in Singleton, Muswellbrook and Denman postcodes. This sub-analysis aimed at examining if there was a difference in the type of health problems managed by GPs for residents of Singleton, Muswellbrook and Denman postcodes combined (in this analysis it is called Hunter Region postcodes) compared with residents of all other non-metropolitan NSW postcodes.

For the Hunter Region, BEACH encounter data were provided by 18 different GPs representing seven general practices. Of relevance to the context of this report it provided the following information on the Hunter Region:

- Over the period 1998-2010, the BEACH Program data showed that there were no significantly higher rates of any problems managed or medications prescribed or supplied in the Hunter Region than in the rest of non-metropolitan NSW
- Rates per 100 GP encounters for management of COPD and asthma combined (4.4 vs 3.7), sinusitis (2.1 vs 1.3), tonsillitis (1.6 vs 0.9), and acute otitis media (1.4 vs 1.1) were higher in the Hunter Region postcodes than in the rest of non-metropolitan NSW but these increases were not statistically significant.

Higher rates (per 100 problems) of bronchodilators (2.1 vs 1.8) and asthma preventive medications (1.9 vs 1.4) were prescribed for residents in the Hunter Region postcodes compared with other non-metropolitan NSW postcodes but these differences were also not statistically significant.

Author's comments

There have been no specifically designed studies to determine the cause of disease patterns in the Hunter Region. The available data to address this question are taken from reliable, routine health monitoring sources but are variable and difficult to interpret, and contain some unexplained results.

There are many potentially confounding variables and inherent methodological difficulties in designing studies that can accurately measure exposure to pollution and toxins and contaminants from mining and explain observed associations. Consequently, the lack of research evidence does not necessarily mean there is no problem. Rather, it may simply mean that a study capable of determining the extent of the problem has not yet been undertaken. Therefore, we note that:

- a) there is an urgent need to determine the nature and extent of health impacts on people living in communities close to coal mines and coal-fired power stations in the Hunter Region
- b) the NSW Ministry of Health is believed to be planning a study of the health effects of air pollution in the Hunter Region.

Is social injustice associated with coal mining in local communities?

“Among the most basic and commonly understood meanings of justice is fairness or reasonableness, especially in the way people are treated or decisions are made. Justice stresses fair disbursement of common advantages and the sharing of common burdens. But it does more than that by demanding equal respect for all members of the community”
Gostin, 2007.

Introduction

There are multiple definitions of social injustice, with notions of distributive and participatory injustice commonly occurring. Therefore, for the purposes of this Report, we defined social injustice as:

‘the unequal or unfair social distribution of rewards, burdens, and opportunities for optimising life chances and outcomes’.

Our literature searches found relatively few peer reviewed journal articles from the international literature that address social injustice in people living in communities near coal mines or coal fired power stations. We identified six peer reviewed journal articles directly addressing social injustice associated with coal mining. These covered a wide geographical range ie the UK, US, Russia and Australia (QLD). While there were some limitations to the studies we reviewed, the central theme of social distress and impact on local communities of both real and perceived environmental degradation is consistent with the Australian literature cited under Research Question 4 of this Report and included:

- Environmental damage and perceptions of damage and related health impacts
- Water quality and changes to means of local livelihood
- Social and economic impacts.

These categories were generated from the literature rather than being pre-determined by the authors of this Report.

Summary of Key Findings for Research Question 3

Social injustices associated with mining in local communities

Aside from the six studies from the Hunter Region, which are detailed under Research Question 4 (page 38), we found few studies focussing on social injustice in relation to mining in the broader international literature. However, despite some limitations, the six journal articles we reviewed from the US, the UK, Russia and QLD detailed a range of social injustices including:

Environmental damage and perceptions of damage and health impacts

- Slurry spills
- Lack of community awareness of damage
- Distress resulting from concerns and uncertainties about direct health impacts of mining-related pollution as well as associated impacts.

Water quality and human occupations (activities)

Human occupation in this context refers to a range of human activity from everyday house-hold activities to activities associated with income earning, and social and recreational activity.

- Three types of occupational injustice are noted in the literature: i) occupational deprivation, ii) occupational imbalance, iii) occupational alienation
- Water pollution resulting from coal mining activity rendering local water sources unsafe to drink, unsafe for growing agricultural produce, and unsafe for recreational activities such as swimming or fishing
- More than one study notes the adverse smell of clothes washed in water polluted from mining activity and the additional cost and inconvenience of being forced to buy bottled water due to unsafe drinking water.

Social and economic costs

- Disproportionate damage imposed on local communities versus the minor penalties imposed on mining companies to compensate for the damage
- Government (society) bearing the cost of regeneration programs to redress damage caused by mining activity
- Inability of the community to capture economic benefits
- Social changes inhibiting the generation of alternative means of economic capital to survive mining downturns
- Socio-demographic changes resulting in shortages of skilled labour in other industries; reduced access to and affordability of accommodation; increased road traffic and fatigue-related road accidents; increased pressure on local (volunteer) emergency services; and increases in criminal and other anti-social behaviours.

Detailed Description of the Evidence for Research Question 3

Environmental damage and perception of damage and related health impacts

A study was undertaken in the Letcher County of Kentucky, US, to explore water pollution associated with coal mining activities (Blakeney & Marshall, 2009). The authors noted numerous polluting events which led the US Environmental Protection Agency to place restrictions on human contact with water in the Letcher County area. For example, there is a 'no bodily contact' advisory for an 86 mile stretch of river. A further 633 miles of the river basin is considered unsafe for any human use. A number of accidents have occurred with coal slurry spills, including loss of life and homes. In the year 2000 one such spill released 300 million gallons of slurry, causing the contamination of 27,000 homes and the local water supply. The outcome of the spill was a \$5,500(USD) fine for the party responsible for the damage. The disproportionate outcome of the spill, with large scale environmental damage resulting in an insignificant fine for the perpetrator, is a clear indication of environmental injustice.

A qualitative study exploring the health and environmental concerns of parents living close to open-cut mines in the UK (Moffatt & Pless-Mulloli, 2003) was undertaken in tandem with an epidemiological study conducted by Pless-Mulloli and colleagues (2000) into the health effects of open-cut mining. In the qualitative study, the researchers carried out in-depth semi-structured interviews with 31 parents selected from four of the five sites of the epidemiological study. The authors focussed on non-activist participants since their claims are unknown and unexplored. While the aim of the study was to determine the usefulness of undertaking concurrent qualitative and quantitative studies, the results included findings relevant to the question of social injustice.

For example, the main theme that emerged from the interviews centred on environmental concerns and all participants felt that there was some impact in their area from mining activity. Other key themes were the social, economic, and health impacts of open-cut mining. A unifying feature between the sites was participants' affinity with the landscape and surrounding countryside, and the disruption characterised by losing "reliability of *places*" (Moffatt & Pless-Mulloli, 2003). Concern over social and economic impacts varied depending on perceived economic advantages and any contributions to local wellbeing such as funding for community projects. Health impact themes related to uncertainty and anticipation, and the most common concern was about asthma caused by open-cut mining. Health and environmental risk perceptions did not vary between parents with or without children with asthma. Participants expressed that their concern of increased asthma had been ignored by relevant authorities in the planning stages of mines, thus expressing the well documented theme of mistrust of official sources of information. However, consistent with the finding that there has been no increase in the prevalence of asthma from the epidemiological study, parents expressed uncertainty and speculation on increasing asthma rates generally and only one parent reported that their child had been adversely affected. Concerns about the direct impact of open-cut mines were lower in priority than associated concerns such as traffic accidents and danger from the increased number of strangers in the community.

There were a number of limitations to this study including a low response rate. However, the authors noted that the concurrence of parents' views and the epidemiological findings (no increase in asthma but more dust and more GP visits) is unusual. They also note that uncertainty about health effects is sometimes used to assist the mining industry in denying the effects of open-cut mines, but it can also be used by local communities to help oppose applications for mines due to the precautionary principle.

A study in northeast Russia from 1998-2001 compared residents' perceptions of pollution with quantitative assessment of pollutants from the Tundra Degradation in the Russian Arctic (TUNDRA) project and was sponsored by the European Commission (Walker et al, 2006). Participants were selected from among town dwellers and six rural villages in two separate socio-geographical areas:

- a coal mining area including the town of Vorkuta
- the gas and oil industry dominated area including the town of Usinsk

The authors cite coal mining and combustion as the principal source of SO₂ emissions and heavy-metal pollution in the Usa Basin. The methods used to determine the perceptions of environmental issues differed between urban and rural participants. Semi structured interviews on environmental perceptions, awareness of socioeconomic problems, and solutions to environmental problems were used for the urban dwellers, who were industrial workers, teachers, and managers/administrators. Rural participants were mainly from the reindeer industry and were interviewed informally with guiding questions and field notes recorded. The exception to this method for rural participants was for those who were deemed 'experts' (ie managers and administrators) who instead received semi structured questionnaires. The number of interviews undertaken in the two study areas was about equal.

The results showed that social problems were perceived to be of higher priority than environmental issues for both the Usinsk and Vorkuta participants. Although the town of Vorkuta has more scientific evidence of environmental problems than Usinsk, residents of Usinsk reported worse perceptions of environmental issues than residents from Vorkuta – possibly as a result of an oil spill in Usinsk in 1994 which was mentioned by every participant from there as a concern. Residents of Vorkuta cited air pollution as the biggest environmental problem and based their observations on direct experience such as respiratory problems, discoloration of clothing, and discoloration of snow. Participants from both towns reported concern over water quality and that this has resulted in infringements on recreational activities such as fishing and swimming. Residents from both Usinsk and Vorkuta were both concerned for their health due to polluted water.

The quantitative component of the study undertaken as part of the TUNDRA project assessed pollution by satellite imagery of vegetation changes, lake water and sediment analysis, and snow, soil and lichen chemistry. This was undertaken across three areas covering industrial to pristine locations. Scientific measurements showed elevated contaminants associated with coal mining and coal combustion in lakes, soil, and snow samples. Furthermore, there were more changes to vegetation around Vorkuta than Usinsk, although environmental concerns are more prominent in Usinsk which was relatively unpolluted. The authors suggest this is due to the gradual nature of the pollution as opposed to the acute nature of the oil spill that occurred in 1994 in Usinsk. This constitutes environmental injustice as residents of Vorkuta were largely unaware of the pollution levels in their town due to the hidden nature of levels of many contaminants. It is noted by the authors that the rise of environmental activism in several communities has resulted in residents collecting their own data on the health situation, a phenomenon they term 'popular epidemiology'.

The main finding of the study was that residents' perceptions of environmental pollution are not necessarily influenced by scientifically shown measures of pollution. Rural inhabitants were aware of vegetation changes but perceived them more gradually and when visible due to a very high level of pollution, such as an oil spill. The authors state that both perceived and measured levels of pollution are 'real' in their own right. The main limitation of this study was that the selection method of the participants was not made explicit. The scientific measurements appear to be thorough.

Water quality and human occupations (activities)

The study by Blakeney and Marshall of water pollution in the Letcher County of Kentucky also explored the link between water qualities and human occupation. The authors defined 'occupation' as all human activities, not just employment (Blakeney & Marshall, 2009). The study involved face to face interviews with Letcher County health professionals (n=122) on water and occupation, and telephone interviews with Letcher County adult citizens (n=40) about their experiences with water.

The analyses of the interviews were presented in three key themes of i) occupational injustice/occupational deprivation, ii) occupational imbalance and iii) occupational alienation indicating that Letcher County residents experience occupational injustice in a multifaceted way. The study concluded that the watershed in the Letcher County of Kentucky has been polluted due to coal mining in the area, and that local social injustices due to water quality degradation are directly related to mining. Examples given were:

- reduced ability to gain income by growing and selling local produce
- unsafety of garden produce irrigated with contaminated water
- restrictions on outdoor activities including loss of recreational options such as swimming
- unpleasant odour and dingy appearance of clothes washed in the local water supply
- the need to plan water use eg visit relatives/friends with a cleaner water supply for cooking water
- the imperative to use water filters and the time and effort required to maintain these
- the imperative to buy bottled water and the added cost of this
- restrictions to facilities and everyday habits most Americans take for granted

The authors acknowledge limitations to the study such as interviews being confined to those who had telephones. This is particularly pertinent since the Letcher County has a high poverty rate with many of the poorest families having no telephone, thus being automatically excluded from participation in the study. The possibility that the study did not include residents who did not believe there was a problem was also acknowledged as a possible limitation.

Social and economic impacts

Riva and colleagues (2011) used data from the Health Survey for England to determine if i) there was a 'coalfield effect' on health irrespective of socioeconomic demographics, ii) if such an effect is mediated by deprivation, social cohesion or rurality and iii) if there are geographical or social inequalities in health across coal field areas. The authors contextualise their study by outlining historical adverse social impacts of coal mining in England such as periods of heavy job losses and a legacy of environmental degradation.

The study found that people in former coalfields are significantly more likely to report long term limiting illnesses (LTLI) and poorer self rated health, and that this is independent of socioeconomic factors. Furthermore, the 'coalfield effect' was still found to be significant for LTLI after considering area level deprivation, social fragmentation, and rurality. Rural areas tended to report more ill health, but not LTLI or mental health problems. Overall mental health was not significantly different across former coalfields when compared with England as a whole. The study included analysis of individual level characteristics, including health behaviours such as smoking and alcohol status. Accounting for individual characteristics explained some, but not all, of the variation in health across coalfields.

Limitations include the cross-sectional nature of the study which did not allow consideration of in and out migration effects or a longitudinal study of the exposure to the socioeconomic conditions. Some of the areas studied had undergone specific regeneration programmes funded mainly by the government and delivered through both public and private schemes. The reference to the various regeneration projects also raised the issue of who should be paying for regeneration programmes; they appear to be mostly government sponsored and therefore represent an additional cost resulting from but not borne by the coal industry.

Closer to home, Lockie and colleagues (2009) undertook local social impact assessments (SIAs) in 2002-03 and 2006-07, approximately five and nine years after the Coppabella Mine commenced operations at Nebo in the coal-rich Bowen Basin area of Central QLD, Australia. The SIAs included mine workers, residents, local businesses and local aboriginal communities. The SIAs were conducted outside the QLD legislative framework for environmental impact assessment and project approval on the basis that such

frameworks are limited to new projects and therefore are unable to account for cumulative impacts of mining projects. The project was funded by Macarthur Coal.

The methodology was based on two phases. Phase 1 included a scoping exercise to determine the potential positive and negative impacts of mining cited in other similar studies, and Phase 2 was a baseline assessment of impacts and mitigation strategies. Issues examined included demographic changes, housing, social integration, traffic and fatigue, business opportunities and constraints, cultural heritage, and opportunities for indigenous people.

The analysis showed that in 2003, many of the social impacts evident at that stage of the resource community cycle related to a failure by the community to capture positive benefits, particularly economic benefits, despite increasing dependence on mining for employment and income. At the same time, whilst mining was responsible for only a small increase in population, rapid demographic and social changes occurred which undermined the ability for the community to generate alternative economic and cultural capital to assist in enduring future mining sector downturns. However, the results also acknowledged that Macarthur Coal had engaged with some stakeholders—indigenous groups in particular—in a manner that enhanced capacity and social capital.

The cumulative impact of multiple mine expansions and developments from 2003-06 saw the magnification of these issues and the emergence of several acute social impacts, including severe shortages of skilled labour in other industries; reduced access to and affordability of accommodation; increased road traffic and fatigue-related road accidents; increased pressure on emergency services (particularly those provided by volunteers); and increases in criminal and other anti-social behaviours. The increase in anti-social behaviour between the two studies appeared to be linked to the declining density of acquaintanceship and informal surveillance associated with population growth.

The most apparent effect was the exponential growth in the temporary resident population between 2003-06. The report also noted the progressive masculinisation of the permanent resident population and that a large and demographically unbalanced mobile population reduces the attractiveness of Nebo as a residential location for women and families. Overall the changes between the SIAs appear fairly limited but with both positive and negative effects. A comparison with the area before the mine commenced would have been useful.

Author's comments

We found only a few studies in the international literature that directly set out to explore and analyse social injustice in relation to coal mining and coal combusting in power stations. Further, given the socio-cultural, economic differences and differences in mining practices and regulations between Australia and other countries (Russia, for example) it is difficult to know with certainty, to what degree some findings might be applicable to the Australian context. Nonetheless, local anecdotal reports point to a high level of stress, social distress and fears about local environmental and social changes, and about health impacts and it is clear from the literature that this in itself constitutes a social injustice.

The lack of definitive evidence to address uncertainties about the applicability of the international evidence further adds to the argument that there is a need for well designed qualitative studies of the social justice impacts of mining to be undertaken locally.

Research Question 4

Is there an association between coal mining and social injustice in the Hunter Region of NSW?

Introduction

This section deals with social injustice in relation to coal mining and coal combustion in coal-fired power stations specifically in the Hunter Region.

The literature searches for this question yielded six relevant peer reviewed journal articles which explored social impacts associated with coal mining specifically in the Hunter Region. The authors of these studies used mainly qualitative methods to explore issues and impacts associated with coal mining and combustion through the perceptions and experience of local residents.

We also reviewed three relevant non-peer reviewed reports. One of these was published by the Hunter Public Health Unit (Dalton, 2003), another by the Australian Coal Association Research Program (Brereton et al, 2008) and the third by the Australia Institute (Richardson & Denniss, 2011). These report did not all deal specifically with social injustice as a definitive concept but all explored key issues which fall under the rubric of social injustice such as air quality and other environmental issues, and unfair distribution of social and economic benefits and burdens.

The peer reviewed reports dealt with a range of social and environmental issues, such as the inequalities in power and influence between community and private interests. They also touch on the dilemma that faces governments everywhere: the trade off between the imperative for economic growth versus the physical and social well being of the community. We report this evidence under the following themes:

- Social distress and environmental injustice
- Asymmetry of power and influence
- Water access and rights
- Failure to protect.

These categories were generated from the literature rather than being pre-determined by the authors of this Report.

Summary of Evidence for Research Question 4

Social injustices associated with mining in the Hunter Region

The evidence presented in this section illustrates multiple examples and variations of social injustices associated with coal mining and combustion in the Hunter Region of NSW.

There are numerous anecdotal reports of local community concerns being ignored due to the perceived overall benefit of mining. Further, the lack to date of a population study to determine the health impacts of mining and power generation activity on local residents is seen by many local community members as evidence of the failure of relevant authorities to heed community concerns. Broadly, these concerns fell under the following themes:

Social distress and environmental injustice

- Feelings of loss and distress resulting from changes in the local environment ('solastalgia')
- Feelings that the local was marginalised and not accorded full stakeholder status
- Deepening social divisions within the community due to the increasingly unequal distribution of wages, inequalities in land compensation arrangements, and changes to the organisational structure of work
- Concerns over the cumulative impact of mining on human health
- Environmental damage and the likelihood of this affecting future generations
- Concerns about air quality, noise pollution and negative impacts on human and environmental health associated with coal-related pollution.

Asymmetry of power and influence

- Difficulties obtaining crucial information disempowers local communities and works to 'divide and rule' communities
- Conflicting interest within authorities, eg the NSW Department of Primary Industries (formerly the NSW Department of Mineral Resources) is charged with regulating the mining industry but is also a major mining advocate
- Claims on resources such as land have become politicised and contested with asymmetries in power favouring the mining industry.

Water access and rights

- The mining industry obtains preferential water rights through the changes to the NSW water licensing system. Since 2005 this system uses classifications to determine priority uses of water and grades coal mining as a higher priority than pastoral industries.

Failure to protect

- This refers specifically to the failure of policy makers - both government and industry - to exercise the 'precautionary principle' and adequately protect local communities from real and/or perceived risks and harms.

The evidence we have reviewed from the formal literature about social injustice in relation to coal mining in the Hunter Region gives considerable credence to recent and current anecdotal reports on this subject.

Detailed Description of the Evidence for Research Question 4

Social distress and environmental injustice

The first of the six research articles described the early stages and preliminary results of an ongoing study of environmental change and human distress in the Upper Hunter Valley (Connor et al, 2004). This area comprises Murrurundi, Scone, Muswellbrook, Singleton and Merriwa which are also home to rural industries of farming and grazing, race horse breeding and wine growing. The authors discuss historical changes of land use from the previous two centuries and use the term 'solastalgia' (derived from nostalgia) to describe the feelings such changes can evoke. The study explored residents' understandings and perceptions of environmental change, as well as local responses to the changes. In addition, the study reports the threats that arise from the expansion of open-cut mining and other industrial activities in the area. The authors identify indicators of distress linked to environmental degradation (emotional, physical, behavioural and social), as well as dimensions of individual's place identity and attachment to locality.

The researchers gathered and analysed qualitative data from i) in-depth interviews with key informants, ii) group interviews, and iii) semi-structured surveys of community residents. Three broad interrelated themes emerged which characterise the respondents' expressions of distress as:

- threat to ecosystem health
- threat to personal health (physical and mental)
- perceptions of being subject to environmental injustice

Excerpts from the interviews exploring these themes note that although respondents acknowledged that mining brings regional economic benefits, they felt that social divisions had deepened due to the associated high wages and changes to the organisation of work. Respondents also stated that there has been a loss of environmental quality, a rise in living costs, and social disruption from the high resident turnover. They felt that pollution and land compensation arrangements created 'winners' and 'losers' among those whose land was bought outright versus those left on the fringes of open-cut mines respectively. Concerns about negative health effects from mining such as respiratory illnesses and cancers were common.

A follow up study by the same group (Higginbotham et al, 2006) built on the initial findings by developing and validating a survey instrument known as the environmental distress scale (EDS). The study tested the ability of the EDS to discriminate between individuals exposed to different levels of environmental disturbance (discriminatory ability) as well as measurement precision (internal consistency, reliability and repeatability), and appraised the contribution of 'solastalgia' as a key component of environmental distress. Participants in this postal survey were randomly selected from two sites: i) Singleton - an area of high environmental disturbance from mining and ii) Dungog - an area of low environmental disturbance from mining. The overall survey response rate was 41% and the demographics of respondents from both areas were similar. The results showed that the two groups did not differ on their perceptions of the trustworthiness of environmental information sources, rating both industry and state government information as dubious. However, there were significant differences in the scores for environmental distress with the Singleton respondents reporting significantly more personally observed and experienced environmental hazards, perceived threat and health impact hazards, and feelings of 'solastalgia'. Residents of Singleton were less likely to be upset by thoughts of having to leave. Although the study does not explicitly address the reason for this, it suggests that it may relate to the extent of the changes in their area. When the components of the EDS scale were combined to give a single score, the difference between the two groups remained significant.

In a study of the Hunter Valley Higginbotham and colleagues (2010), define environmental injustice as: *“the disproportionate exposure of socially vulnerable groups to pollution and its associate effects on health and the environment, as well as the unequal environmental protection provided through laws, regulations and enforcement”* and further break this concept down to:

- a) *distributive environmental injustice* ie when vulnerable groups are disproportionately affected by environmental hazards
- b) *procedural injustice* which refers to the inequitable distribution of environmental hazards in terms of underlying socio-cultural factors, including the burden of risk imposed on culturally disadvantaged groups and lack of public participation in decision making process.

They cite evidence of increasing emissions in the Upper Hunter Valley of fine particles and other pollutants over the previous decade. Their study also explores some of the impacts associated with increased fine particles and pollutants, such as community concerns about air pollution and the rise in complaints to the Environmental Protection Authority Hotline from the major residential centres of Muswellbrook, Singleton and Maitland. They discuss the intensification of community pressure on government for a health study in the Upper Hunter and note that residents were being marginalised by the relevant authorities, thus resulting in procedural injustice as community and environmental groups were not being considered as stakeholders. The example was given of a Federal Minister from a Hunter electorate at the time who was cited as suggesting that opponents to the Anvil Hill Mine were conducting a ‘jihad’ with the intention of closing down the entire coal industry.

The authors comment on the changing position of Local Government from being generally supportive of coal mining to becoming increasingly concerned about the cumulative impact of mining on human health, and joining the call for a local health study. They also point to a decrease in the ability of Local Government to facilitate action to address the concerns of local communities. For example, since 2005 changes in state planning laws removed the input of Local Government in the approval process for of mining projects, thereby effectively eliminating the key procedural avenue for local influence in decisions about mining expansion.

In response to increasing concerns from community groups about the cumulative health impacts from growing industrial development, the HNEAHS Public Health Unit (Dalton, 2003) reported on surveys of 665 selected residents of the Hunter Valley aged over 15 years. Environmental Health Managers in all 11 LGAs and members of the Area Health Services Health Councils were also surveyed. The results indicated that air pollution followed by water pollution were the major concerns for all three groups. Motor vehicle emissions were also a primary source of concern, and it should be noted that numerous reports refer to the impact of noise, air pollution, and road trauma associated with transport involved in coal mining. The survey found that environmental health concerns varied significantly by LGA and appeared to be influenced by road/traffic density and large industrial polluters such as coal mines and power stations. There were high rates of concern about air pollution in Singleton and Muswellbrook specifically, both of which are located near coal mines and power stations.

Despite increasing concerns about climate change neither the government nor the mining industry appear to have been called to account for the environmental ramifications of the \$922 million(AUD) expansion of the Newcastle coal port (Connor et al, 2009).

Asymmetry of power and influence

An Australian Coal Association Research Program (ACARP) sponsored study examining the cumulative impact of mining, using Muswellbrook as the focal point, under the four headings of i) employment, ii) visual amenity, iii) water quality in the Hunter River, and iv) social impacts (Brereton et al, 2008). The Project Steering Committee comprised coal industry members who felt that the community was ‘over-

consulted' and therefore proceeded to review mine complaints instead of undertaking further consultation with the community. Nonetheless, the researchers conducted and reported on four focus groups, including one with an anti-mining group, and members of mine community consultation committees. Themes emerging from these focus groups referred to perceived social injustices such as:

- the disproportionate power of the mining industry
- the perception that regulatory authorities sided with industry and arbitrated without the interests of the community in mind
- changes to legislation in favour of the mining industry

Economic benefits from employment associated with mining were acknowledged. However this was tempered by perceptions that there were increasingly limited opportunities for employment of locals. Additionally, employment patterns at mines were felt to have a negative impact on community activities such as volunteer work. Social cohesion was not seen to be eroded, as the number of displaced landholders was too small to have a discernable impact. There was limited discussion of visual amenity (the extent to which mined land was visible from Muswellbrook).

Connor and colleagues (2009) examined the arguments employed by both pro and anti-mining groups in relation to the proposal for the Anvil Hill Coal Mine in the Hunter Valley. They explored changes in environmental knowledge and oppositional practices of coal-affected residents in the Hunter Valley. They commented on the growth and improved organisation of mining opposition into formal civil society groups such as the Anvil Hill Project Watch Association. In addition, the authors noted that the incorporation of global issues such as climate change into the community discourse has given local communities more political leverage - as demonstrated by a successful legal challenge to the Land and Environment Court in December 2006. However, despite inadequate environmental assessments relating to the Anvil Hill Mine, the NSW government approved the project in 2007 and further legal challenges were unsuccessful.

The authors commented on difficulties experienced by protestors in obtaining information from the various government departments. 'Gag clauses' commonly imposed by mining companies in land acquisition contracts were noted as a power issue which can effectively serve to generate divisions in the community through what appears to be a divide and rule tactic. They also note the imbalance of resources between the mining industry and its opponents, and that the mining industry generally enjoys a closeness to state and corporate power that civil society does not. The authors also cited the state approval, in 2007, of the \$922 million(AUD) expansion of the coal port of Newcastle as an example of the systemic entrenchment of political capital in favour of commercial mining interests. This is because public sector investments of this magnitude assure ongoing state government commitment to further coal mining expansion in order to support export markets, thereby justifying the investment.

In this article, Connor and colleagues described the mining industry's role in pro-industry lobbying, analysing how it obtains political capital (by making the case of perceived economic benefits), and how it gains bilateral political party support through membership of regional organisations such as business chambers. The authors take the stance that in the face of continuing and growing concern about climate change, political support is not sufficient to give mining companies a 'social licence to operate'. This concept is defined by the NSW Minerals Council (the peak industry body) as the unwritten social contract that a company earns and maintains through good performance on the ground and social trust.

Higginbotham and colleagues (2010) also analysed the political economy of coal mining in NSW. They cited mining royalties to the state government estimated at \$1.3 billion(AUD) for 2009-10, and point out that this presents a strong incentive for the government to allow ongoing expansion of coal mining. They note that this has resulted in the cynical view among residents and mining opponents that it is not in the interest of the NSW Government to examine the health effects of mining. The authors discuss the

imbalance of power and access to information between mining companies and community groups, and that self regulation of air quality and pollution by mining companies has become contentious due to a lack of action on pollution breaches. The authors also state that there is an inherent conflict of interest which facilitates procedural injustice, since the NSW Department of Primary Industries (formerly the NSW Department of Mineral Resources) is responsible for coal mining regulation but is also the primary mining advocate. In addition, the authors cite the absence of an independent air monitoring scheme which could assist with a health study and risk analysis, and that there is no consideration for a more comprehensive cumulative risk assessment process that would enable a health impact assessment to be undertaken alongside the environmental impact assessment process.

The cost of the life cycle of coal to the community - notably the cost of electricity generation - is immense. The Australia Institute (Richardson & Denniss, 2011) cites evidence that government subsidies to support the extraction of fossil fuels in Australia amounts to \$10 billion(AUD) annually. The authors highlight areas indicated by the Productivity Commission in which state governments provide assistance to the mining industry as:

- the provision of a variety of tax concessions eg holiday, payroll
- fast tracking development arrangements
- the provision of cheap water and power
- the provision of infrastructure to support mining operations eg airports, ports, housing for employees
- lax regulation of environmental impacts

Water access and rights

Researchers from the same group undertook a further study responding to a new proposal for the first open-cut mine by Bickham Coal in the town of Murrurundi in the Upper Hunter Valley (Connor et al, 2008). The researchers noted that there is increasing contestation over water in relation to the competing needs of the mining industry and traditional pastoral industries. The article discusses the traditional methods of negotiations between local farmers in the area concerning water allocation, as well as the measures that they have been taking to adapt to the decreasing availability/greater demand for water. The article also reports on the policy changes encapsulated in the NSW Water Management Act (2000) which separates land and water rights, and establishes a water licence system using graded classifications to aid with the trading of water as a commodity. With these policy changes mining companies' water licenses have been rated as 'high security' whilst water for farming use is given the lower licence rating of 'general security'.

In particular, Connor and colleagues describe the struggles of the local communities and environmentalists to combat the Bickham Coal mine on the basis of its potential to damage local landscape and waterways, notably the Pages River. Evoking concepts of custodianship of the land by both indigenous and non-indigenous residents, and the "sentience of nature and its inalienable right to exist", the authors report strong feelings of community anger, revulsion and resentment about the potential carnage to the landscape. In addition, the potential loss of history, heritage and place occasioned by the mine proposal are explored. The key issues raised are central to the concept of social injustice. These include inequalities in water rights; enforced changes to the pastoral nature of the local industries; and the disregard for the area's more distant history as hunting and fishing grounds for the Wanarua people whose descendants still maintain a relationship with this land.

The authors conclude that conflicts over critical resources such as water will multiply as the push for more mines in the Hunter Valley escalates, postulating that fresh water is and will be "unable to satisfy the principle of plenitude ie enough so that no-one needs to fight over it". They discuss access as a matter of political contestation where those with greater power, such as coal companies, succeed in achieving their objectives at the expense of less powerful groups. Connor and colleagues go on to point

out that, in this type of scenario, the precautionary principle (the burden to prove the absence/lack of harm) is often overlooked in favour of commercial interests. Nonetheless, mining opponents can and do take advantage of the deficits and uncertainties in aspects of scientific modelling in the wider global climate change arena to challenge the mining industry. Connor and colleagues also note that climate change science has not yet become part of the legal-bureaucratic framework of state government environmental planning and mine approvals and that there are powerful interests against this.

Failure to protect

In their analysis of coal mining related environmental injustice in the Hunter Valley, Higginbotham and colleagues (2010) discuss pressure from the local community, Local Government, and local medical practitioners for a health study in the Upper Hunter. They state that the barriers to achieving a health study include a “lack of political will and regulatory inertia”, thereby citing both political and institutional failures. The absence of an independent air monitoring mechanism and a more comprehensive cumulative assessment process is stated by the authors as a clear violation of social justice since policy makers have a duty to enact the ‘precautionary principle’ into policy making (ie to act before rather than after damage has occurred). While the authors acknowledge constraints in terms of study design and assessment issues, they state that the ‘precautionary principal’ is of paramount importance since intergenerational environmental injustice occurs as a result of the long time lag between certain risk exposures and disease onset, citing asbestos as an example.

Relevant to this topic, Harris and colleagues published a peer reviewed report based on a survey that examined the focus of environmental assessments (2009). The findings of the survey led Harris and colleagues to conclude that considerations of health in the NSW requirements are glaringly absent, or at best vague and indirect, in environmental assessments of new development applications of any kind.

Author’s comments

There is a surprisingly rich literature describing various aspects of the social injustice in relation to coal mining activity in the Hunter Region. This evidence is predominantly qualitative in nature and is consistent with the evidence reviewed for Research Question 3 which looks at a broader geographical research base.

Some of the studies we reviewed note the absence of a specific study to examine the health impact/s of coal mining and combustion in the Hunter Region, and cite this as a source of serious concern to the local community. It should be noted that, at the time of writing this report we understand that the NSW Ministry of Health is planning to undertake a study of the health impacts of air pollution in conjunction with air quality monitoring stations.

Section 4:

COSTS AND POLICY IMPLICATIONS

COSTS & POLICY IMPLICATIONS

The literature searches for this Report did not specifically focus on the financial cost of coal to society. However, some of the studies identified to answer the research questions included information on costs.

For example, elevated mortality rates in Appalachian coal mining areas have been examined in terms of value of statistical life (VSL) lost relative to the economic benefits of the coal mining industry (Hendryx & Ahern 2009). The value of statistical life is an estimate of the financial value society places on reducing the average number of deaths by one. Mortality estimates across four county groups (Appalachia with high levels of coal mining, Appalachia with lower mining levels, Appalachia without coal mining, and other counties in the nation) were converted to VSL estimates and compared with the economic contribution of coal mining. Before adjusting for variables, the yearly number of excess age-adjusted deaths in coal mining areas ranged from \$3,975 to \$10,923(USD), depending on the years studied and the comparison group. Corresponding VSL estimates ranged from \$18.563 to \$84.544 billion(USD), greater than the \$8.088 billion(USD) contribution of coal mining to the economy. After adjusting for variables that affect mortality risk, the corresponding VSL estimates were greater than the economic contribution of coal mining. Consequently, the authors concluded the human cost of the Appalachian coal mining economy outweighs its economic benefits.

Another study of coal-fired power stations examined the uncertainties and variability associated with estimating health related costs (Levy et al, 2009). This study analysed data for 407 coal-fired power stations across the US focussing on premature mortality associated with PM_{2.5}. The authors modelled PM_{2.5} emissions and the influence of SO₂ and nitrogen oxide emissions on secondary particle formation. Mortality estimates of PM_{2.5} were based on a central estimate of a 1.2% increase in mortality per ug/m³ increase in average annual PM_{2.5} levels. VSL was used in the cost estimation. The median of the plant-specific uncertainty distributions damages ranged from \$30,000 to \$500,000(USD) per ton of PM_{2.5}, \$6,000 to \$50,000(USD) per ton of SO₂ and \$500 to \$15,000(USD) per ton of nitrogen oxide. This equated to an additional cost of \$0.02 to \$1.57(USD) or 2c to 157c per kilowatt-hour (kW/h) of electricity generated. The variability in damage estimates was mostly explained by population exposure per unit emissions, and meteorological conditions and distance from the power station affecting population exposure. The authors note that the costs are large relative to the consumer cost of electricity and if these were included in the consumer cost it would have significant ramifications for fuel choice. They note that this would make older power stations uneconomic, due to their less efficient technology. Such modelling would be difficult to undertake in Australia due to lack of PM_{2.5} data.

Another US analysis evaluated and monetised all stages in the life cycle of coal, where possible, based on figures for the coal mining region of Appalachia (Epstein et al, 2011) including extraction, transport, by-products/waste and combustion. The authors included health costs and the cost of measures to reduce CO₂, such as carbon capture and storage. Some impacts such as ecological damage were not assigned a monetary value. The total cost estimated was \$345 billion(USD), or 17.8c/kW/h (\$0.17/kWh) of electricity generated. In a study comparing the cost of health impacts across various methods of generating electricity, Markandya & Wilkinson (2007) attributed 24.5 deaths per terawatt hours of coal combustion. However, some of these costs were generated from occupational health impacts.

An Australian report estimated the costs of the negative health and environmental externalities of coal mining in Australia (ATSE, 2009) and put the health costs associated with coal-fired power stations at \$2.6 billion(AUD) per year. The cost of the combined health and environmental impacts of black coal as an energy source was estimated at \$42(AUD) per megawatt-hour.

Implications for policy and planning

There is no current, definitive local evidence that comprehensively describes the associated health and social costs of coal extraction and combustion. There is therefore no solid basis for determining the balance of public harm versus public good. The health, social and financial costs of coal mining and combustion may well outweigh any benefits and additional burdens on the whole society since government subsidies and benefits to the mining industry are rarely included in cost calculations (Richardson & Denniss, 2011). Further, many of the negative consequences of the disruption, displacement and lost opportunities such as occupational tradition and choice, and all of the irreparable environmental damage caused by coal mining and combustion activity in Australia will not stop with the present but will likely have negative impacts on future generations – and it is probable that these effects will continue long after our coal reserves are exhausted.

These impacts have wide implications for policy and governance, and require prompt and thorough attention to reviewing and reforming government policies and regulations around the licensing and operating of coal mines and coal-fired power stations. While awaiting such reforms there is an pressing need for a policy response to i) ensure transparency in arrangements between government and the mining industry, ii) redress tax anomalies, iii) enforce standards of practice and community safeguards such as mandatory health impact assessments and penalties for non compliance with these.

Most importantly, well designed local studies capable of identifying or refuting associations between coal mining and health need to be commissioned and undertaken as a matter of urgency. Until this evidence is available it is not possible to accurately weigh up and meaningfully debate the benefits versus the harms of coal mining for Australia.

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EVIDENCE TABLES FOR RESEARCH QUESTION 1

What specific diseases or other health problems are associated with coal mining in local communities?
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Appendix A: Summary of Evidence for Research Question 1

Table 1: Coal mining – adults

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Esch & Hendryx 2011 US	Retrospective study. Age-adjusted chronic CVD mortality rates from 1999-2006 for counties where MTM occurs were linked with county coal mining data in non-MTM areas.	404 records from four Appalachian states (Kentucky, Tennessee, Virginia and West Virginia). - 32 from MTM areas. - 58 from mining in non-MTM areas. - 314 from non-mining areas.	Mortality rates. Surface area of coal mines in MTM areas.	<ul style="list-style-type: none"> Chronic CVD mortality rates were significantly highest in MTM areas, followed by mining in non-MTM areas, and lastly in non-mining areas $F(2,401) = 32.35; p < 0.001$. After adjustment for covariates, mortality rates in MTM areas remained significantly higher and increased as a function of greater levels of surface mining. Higher obesity and poverty rates and lower college education rates also significantly predicted CVD mortality overall and in rural counties. 	Covariates included smoking, rural-urban status, gender, physician supply, obesity, diabetes, poverty, race/ethnicity, education and Appalachian county.
Hendryx 2009 US	Retrospective analysis. Age-adjusted mortality rates from 2000-2004 for heart, respiratory and kidney disease were investigated in relation to tons of coal mined.	Four county groups: - Appalachian counties with > 4 million tons of coal mined ($n = 63$). - Appalachian counties with < 4 million tons ($n = 66$). - non-Appalachian counties with coal mining ($n = 97$). - other non-coal mining counties across the US ($n = 2,914$).	Mortality rates from heart, respiratory and kidney disease.	<ul style="list-style-type: none"> Mortality rates from chronic heart ($RR = 1.28$, 95% CI: 1.25-1.30), chronic respiratory ($RR = 1.07$, 95% CI: 1.04-1.10) and kidney disease ($RR = 1.19$, 95% CI: 1.13-1.25) were significantly higher in coal mining areas of Appalachian counties with the highest level of coal mining compared to non-mining areas. Higher rates of acute heart ($RR = 1.06$, 95% CI: 1.04-1.08) and respiratory ($RR = 1.05$, 95% CI: 1.13-1.25) mortality were found for non-Appalachian coal mining counties. 	Results were adjusted for gender, education, poverty, race/ethnicity, physician supply, rural-urban status, smoking and a Southern regional variable.

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Hendryx & Ahern 2008 US	Retrospective analysis. Telephone survey data were merged with county-level coal production and other covariates to investigate the relationship between health indicators and proximity to coal mining.	16,493 residents of West Virginia aged ≥ 19 years. Survey response rate: 55%.	Self-reported health status. Rates of cardio-pulmonary disease, COPD, hypertension, lung disease and kidney disease.	<ul style="list-style-type: none"> Residential proximity to heavy coal mining was significantly associated with self-reported poorer health status. The highest level of mining (≥ 4 million tons) predicted greater adjusted risk for cardiopulmonary disease, lung disease, hypertension, COPD, kidney disease and poorer adjusted health status ($p < 0.005$). 	<p>Covariates included smoking, obesity, poverty, age, gender, income, education and presence or absence of health insurance.</p> <p>Individual smoking and occupational exposure to coal was not able to be assessed.</p>
Hendryx & Ahern 2009 US	Retrospective analysis. Age-adjusted mortality rates and socioeconomic conditions in coal mining areas from 1979-2005 were converted to VSL estimates and compared the results with the economic contribution of coal mining.	Four county groups: <ul style="list-style-type: none"> Appalachian counties with levels of coal mining above the median ($n = 70$). Appalachian counties with levels of coal mining below the median ($n = 69$). Appalachian counties without coal mining ($n = 274$). other counties in the nation ($n = 2,728$). 	VSL estimates.	<ul style="list-style-type: none"> VSL estimates ranged from \$18.563-\$84.544 billion, with a point estimate of \$50.010 billion, greater than the \$8.088 billion economic contribution of coal mining. After adjusting for covariates, VSL costs continued to exceed the benefits of mining. 	<p>Covariates included smoking, rural-urban location, gender, physician supply, a regional South variable, poverty, race/ethnicity and education.</p>

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Hendryx & Zullig 2009 US	Retrospective analysis. Using the 2006 US BRFSS data, self-reported CVD rates were compared between coal mining counties and other counties.	235,783 residents, aged ≥ 18 years, from 1,148 counties in the US. <ul style="list-style-type: none"> - Appalachian counties with coal mining (n = 9,330). - Appalachian counties without coal mining (n = 9,622). - Non-Appalachian counties with coal mining (n = 9,089). - Non-Appalachian counties without coal mining (n = 207,742). 	Self-reported morbidity rates for CVD.	After adjusting for covariates, people in Appalachian coal mining areas reported significantly higher risks for: <ul style="list-style-type: none"> • CVD (OR = 1.22, 95% CI: 1.14-1.30). • Angina or CHD (OR = 1.29, 95% CI: 1.19-1.39). • Heart attack (OR = 1.19, 95% CI: 1.10-1.30). 	Variables included coal mining, smoking, BMI, alcohol intake, physician supply, diabetes, age, race/ethnicity, education and income.
Hendryx et al 2007 US	Retrospective analysis. Hospitalisation data from 2001 were merged with county-level coal production figures.	93,952 patients from West Virginia, Kentucky and Pennsylvania.	Hospitalisation patterns.	Hospitalisation for COPD and hypertension were significantly elevated as a function of Appalachian coal mining: <ul style="list-style-type: none"> • For COPD, it increased 1% for each 1,462 tons of coal. • For hypertension, it increased 1% for each 1,873 tons of coal, and with higher rates for women. 	Results were adjusted for age, gender, insurance, co-morbidities, hospital teaching status, poverty and county social capital. Smoking and obesity were not measured.
Hendryx et al 2008 US	Retrospective analysis. Contributions of smoking rates, socioeconomic variables, coal-mining intensity and other variables related to age adjusted lung cancer mortality were compared between counties from 2000-2004.	<ul style="list-style-type: none"> - Heavy Appalachian coal mining (n = 66). - Other Appalachian (n = 347). - Rest of the nation (n = 2615). 	Age-adjusted lung cancer mortality rates.	Age-adjusted lung cancer mortality was significantly higher in Appalachia compared to the rest of the US; 67.06 vs. 56.55 per 100,000 (two-tailed t = 12.67, df = 3026; p < 0.001).	Results were controlled for gender, education, poverty, race/ethnicity, insurance, physician supply, rural-urban status, smoking, Southern state and Appalachian county. Individual exposure to both smoking and coal were not able to be assessed.

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Hendryx et al 2010 US	Retrospective analysis. Two GIS techniques tested alternative specifications of exposure to mining activity in relation to the prediction of age-adjusted cancer mortality rates for 1979-2004.	West Virginian cancer mortality data from the CDC.	Age-adjusted cancer mortality rates.	Total ($r = 0.51$; $p < 0.001$), respiratory ($r = 0.53$; $p < 0.001$) and "other" ($r = 0.44$; $p < 0.001$) age adjusted cancer rates were more closely associated with GIS exposure measure to coal mining activities than tonnage measure.	The GIS techniques compared location of mines, processing plants, coal slurry impoundments and underground slurry injection sites relative to population levels to exposure based on tons mined at the county level. The analysis was controlled for smoking rates.
Hitt & Hendryx 2010 US	Retrospective analysis. The relationship between West Virginia SCI and cancer mortality rates from 1979-2005 was analysed.	West Virginian cancer mortality data from the CDC.	Cancer mortality rates. Ecological integrity (SCI). Coal mining intensity.	<ul style="list-style-type: none"> Respiratory, digestive, urinary and breast cancer rates increased with ecological disintegrity, but genital and oral cancers did not. Coal mining was significantly associated with ecological disintegrity and higher cancer mortality ($p < 0.01$). Spatial analyses also indicated cancer clusters that corresponded to areas of high coal mining intensity ($p < 0.01$). 	
Temple & Skyes 1992 UK	Cohort study. Medical records of new episodes of asthma were collated from before and after an open-cast coal mine began operating.	All patients presenting to the Glynneath Medical Practice, Wales.	Changes in the number of weekly episodes of asthma.	Before mining operations began the mean weekly number of new episodes of asthma was 4.4 (95% CI: 3.6-5.2) and after mining began it was 7.9 (95% CI: 7.0-8.6; $p < 0.001$).	Data collection was blinded proving the results were not due to seasonal or other transient factors.

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Veugelers & Guernsey 1999 Canada	Retrospective analysis. Annual disease-specific mortality counts by gender, age and geographic location from Statistics Canada from 1950-1995 were compared.	Cape Breton County, it's municipalities Glace Bay and Sydney, and Canada as a whole.	Life loss.	<ul style="list-style-type: none"> Life expectancy in some municipalities of Cape Breton County was reduced by more than 5 years compared to the rest of Canada. Life loss among Cape Breton County women was primarily attributable to cancer (life loss = 0.87 years) and among men to CVD (life loss = 1.25 years). Life loss from cancer was higher in the steel-producing communities; whereas life loss from respiratory diseases and lung cancer was higher in the coal mining communities. 	Extrapolating the trends in the most recent five decades, a further increase of the health deficiencies of Cape Breton County is anticipated.
Zullig & Hendryx 2010 US	Retrospective analysis. Telephone health surveys from the 2006 national BRFSS on HRQOL were compared between coal mining counties and other counties.	236,195 adults, aged ≥ 18 years. <ul style="list-style-type: none"> - Appalachian counties with coal mining (n = 9,339). - Appalachian counties with no coal mining (n = 9,626). - Non-Appalachian counties with coal mining (n = 9,092). - Other non-coal mining counties across the US (n = 208,138). 	Self-rated HRQOL. <ul style="list-style-type: none"> - Number of poor physical days. - Number of poor mental days. - Activity limitation days. 	<ul style="list-style-type: none"> Residents of coal mining counties reported significantly fewer healthy days for both physical and mental health, and poorer self-rated health ($p < 0.0005$) when compared with referent non-coal mining counties (OR = 1.11, 95% CI: 1.05-1.18). Disparities were greatest for people residing in Appalachian coal mining areas. 	Results remained consistent in separate analyses by gender and age. Limitations included lack of accurate exposure data as county of residence is a crude measure of exposure.

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Zullig & Hendryx 2011 US	Retrospective analysis. Telephone health surveys from the 2006 national BRFSS on HRQOL were compared between MTM areas, coal mining in non-MTM areas and non-mining areas.	10,234 adults, aged ≥ 18 years. - MTM areas (n = 19). - Coal mining in non-MTM areas (n = 23). - Non-coal mining areas (n = 78).	Self-rated HRQOL. - Number of poor physical days. - Number of poor mental days. - Activity limitation days. Healthy days index.	<ul style="list-style-type: none"> Before and after adjusting for variables, residents of MTM counties reported significantly more days of poor physical, mental and activity limitation and poorer self-rated health ($p < 0.01$) compared with the other county groupings. Residents in other mining counties had 1.30 greater odds of reporting fair or poor self-rated health (95% CI: 1.15-[-1.48]; $p < 0.001$) compared with non-coal mining counties. After adjusting for variables these differences were not significant. 	Variables included metropolitan status, physician supply and BRFSS behavioural and demographic variables.

Table 2: Coal mining – children and infants

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Ahern et al 2011a US	Retrospective analysis. National Center for Health Statistics natality files from 1996-2003 were used to analyse live births in MTM areas, coal mining in non-MTM areas and non-mining areas.	1,889,071 live birth health from residents of Kentucky, Tennessee, Virginia and West Virginia. - 109,315 from MTM areas. - 112,771 from mining in non-MTM areas. - 1,666,985 from non-mining areas.	Birth defects.	<ul style="list-style-type: none"> The PRR for any birth defect was significantly higher in MTM areas compared to non-mining areas (PRR = 1.26, 95% CI: 1.21-1.32), but was not higher in the non-MTM areas, after controlling for covariates. Rates were significantly higher in MTM areas for circulatory/respiratory, central nervous system, musculoskeletal, gastrointestinal and urogenital defects. 	<p>Covariates included mother's age, race, education, alcohol intake, smoking, diabetes, prenatal care and infants gender.</p> <p>Socioeconomic and environmental factors in MTM areas may be contributing factors.</p>
Ahern et al 2011b US	Cross-sectional, retrospective analysis. The association between low birth weight and mother's residence in coal mining areas from 2005-2007.	42,770 live birth records from hospitals in West Virginia.	<p>Low birth weight (< 2.5 kg).</p> <p>Coal mining areas and production.</p>	<ul style="list-style-type: none"> Residence in coal mining areas of West Virginia posed an independent risk of low birth weight. Evidence of dose effective response for low birth rates in high coal mining (OR = 1.16, 95% CI: 1.08-1.25; p < 0.0002) and moderate coal mining (OR 1.14, 95% CI: 1.04-1.25; p < 0.003). Adjusted findings show that living in areas with high levels of coal mining elevates the odds of a low birth weight infant by 16%, and by 14% in areas with lower mining levels, relative to counties with no coal mining. 	<p>Covariates included mothers' demographics, behaviors and insurance.</p>

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Brabin et al 1994 UK	Cross sectional survey. Health questionnaires completed parents and children in 1991-1993 were compared between school children exposed to different levels of steam coal dust.	1,872 children, aged 5-11 years old, from five primary schools in the Bootle dock area of Liverpool (exposed area), five primary schools in South Sefton (control area), and five primary schools in Wallasey (control area). Survey response rate: 92%	Respiratory symptoms (cough, wheezing, and shortness of breath), allergy and atopy. Air pollution levels.	<ul style="list-style-type: none"> Respiratory symptoms were significantly more common in the exposed area children, including wheeze (25.0%, 20.6%, and 17.5%; $p < 0.01$), excess cough (40.0%, 23.4%, and 25.1%; $p < 0.001$), and school absences for respiratory symptoms (47.5%, 35.9%, and 34.9%; $p < 0.001$). Differences remained significant after adjusting for parents smoking and employment status. Multiple logistic regression analysis confirmed the exposed zone as a significant risk factor for absenteeism from school due to respiratory symptoms (OR = 1.55, 95% CI: 1.17-2.06) after adjusting for confounding factors. 	<p>Confounding factors included history of respiratory disease, existence of current respiratory illness and severity.</p> <p>Standard dust deposit gauges on three schools confirmed a significantly higher dust burden in the exposed zone.</p>
Liao et al 2010 China	Retrospective analysis. Analysis of all live and still hospital births from 1998-2005 records in a coal mining area.	7,880 births in Heshun, Shanxi Province, China.	NTDs.	<ul style="list-style-type: none"> The prevalence of NTDs in Heshun was 237.31 per 10,000 births (187/7880). 58.3% of births with NTDs lived in the coal region. Residing within 6 km of coal mining areas was associated with an increased risk of NTD (RR = 1.34, 95% CI: 1.00-1.78). 	Individual exposure levels, home birth data were not available.

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Pless-Mullooli et al 2000 UK	Matched pairs case control study. Health information was obtained from a postal questionnaire, a daily symptom diary and GP records, these were compared between communities at different proximities to an open-cast mine.	4,860 children, aged 1-11 years, in Northern England. - 2,443 from five communities close to open-cast coal mine. - 2,417 in from five communities away from active open-cast coal mine.	The cumulative and period prevalence (2 and 12 months) of wheeze, asthma, bronchitis and other respiratory symptoms. Prevalence and incidence of daily symptoms and GP consultations. Air pollution levels.	<ul style="list-style-type: none"> • Little evidence was found for associations between living near an open-cast site and an increased prevalence of respiratory illnesses, asthma severity, or daily diary symptoms. • Children in four of the five open-cast communities had significantly more respiratory consultations than control communities. (1.5 v 1.1 per person-year; OR = 1.42, 95% CI: 1.13-1.79). • Small but significant associations were found between daily respiratory symptoms and daily concentrations of PM. • Particulate matter levels were higher in open-cast areas: mean ratio 1.14, 95% CI: 1.13-1.16. 	There was the level of variation between the communities and pairs, even though they were well matched for lifestyle and socioeconomic factors.
Pless-Mullooli et al 2001 UK	Matched pairs case control study. A health and lifestyle postal questionnaire between communities at different proximities to an open-cast mine.	4,860 children, aged 1-11 years, in Northern England. - 2,443 from five communities close to open-cast coal mine. - 2,417 in from five communities away from active open-cast coal mine.	The cumulative and period prevalence (2 and 12 months) of wheeze, asthma, bronchitis and other respiratory symptoms.	<ul style="list-style-type: none"> • The cumulative prevalence of wheeze was 36% in open-cast communities and 37% in the other communities. • The cumulative prevalence of asthma was 22% in both communities (range: 12-24%). • Little evidence for associations between living near an open-cast site and an increased prevalence of respiratory illnesses, or asthma severity. Some outcomes such as allergies, hayfever, or cough varied little across the study communities. Others, such as the use of asthma medication, the number of severe wheezing attacks in the past year or tonsillitis showed large variation. 	The similarities and variations were not explained by differences in lifestyle factors or differences in health service delivery and remain unexplained.

Author, year country	Study type & method	Study population	Outcomes	Relevant results	Comments
Yapici et al 2006 Turkey	Cohort study. Blood was assessed for levels of lead and cadmium from children residing in a coal mining area.	236 children, aged 6 months-6 years old, from Yatagan, Turkey.	Lead and cadmium blood levels.	<ul style="list-style-type: none"> 95.7% of children had a blood lead level of > 10ug/dL and 87.6% had > 20 microg/dL. The blood cadmium level was above the risk limit of 0.5g/dL in 85% of the children. Analysis showed a statistically significant negative correlation between blood lead levels and blood cadmium levels and age in both sexes (p < 0.001). 	<p>Asymptomatic lead poisoning was defined as > 10ug/dL.</p> <p>The risk limit for cadmium levels in the blood was accepted at 0.5g/dL.</p>

Table 3: Power stations – adults (and whole population)

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Bencko et al 2009 Slovakia	Population-based survey. NMSC cases from 1977-1996 were collected from a town in close proximity to a power plant and compared to a control town.	Prievidza district, Slovakia. - Exposed group resided \leq 7.5 km of the power plant. - Control group resided $>$ 7.5 km away from the power plant.	NMSC cases. Arsenic content in hair and urine samples.	<ul style="list-style-type: none"> During the 5 year period 1977-1981 there was a dramatic increment in the incidence of NMSC in the most polluted region of Prievidza district (RR = 2.05; $p = 0.05$). This upward trend gradually reversed during the next 5 year periods following reduction in the arsenic emissions from the power plant. 	
Boffetta et al 1991 Global	Literature review. Cohort studies on morbidity and mortality rates between groups of populations with different levels of environmental exposures were collated.	167 published epidemiological studies from 1965-1990 focusing on cancer risks related to fossil fuel-based industrial processes.	Cancer risks.	Air emissions from fossil-fuelled power plants represent one of the exposures of major concern for carcinogenicity of electricity production.	The review was completed by the International Agency for Research on Cancer, France.
Garcia-Perez et al 2009 Spain	Population-based study. Sex-specific standardised mortality ratios for lung, laryngeal and bladder tumors from 1994-2003 were calculated and an association with air pollution exposure was made.	8,073 Spanish towns included in the European Pollutant Emission Register. - $<$ 5 km from a power plant. - \leq 5 km from any industrial installation other than a power plant. - No industry within 5 km of residence.	Standardised mortality ratios for lung, laryngeal and bladder tumors. Pollution exposure. Effect of type of fuel used.	<ul style="list-style-type: none"> Excess mortality was detected in the vicinity of pre-1990 installations for lung cancer (RR = 1.07, 95% CI: 1.04-1.09) and laryngeal cancer among men (RR = 1.07, 95% CI: 0.99-1.15). Lung cancer displayed excess mortality for all types of fuel used, whereas in laryngeal and bladder cancer, the excess was associated with coal-fired industries. There was a risk gradient effect in the proximity of a number of installations. 	

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Goren et al 1995 Israel	Cohort study. Yearly analyses of mortality rates, health services data and LFTs of individuals in communities located in close proximity to a coal-fired power plant from 1980-1990 were obtained.	30,000 adults and children, residing ≤ 10 km of a power plant in Israel.	Use of outpatient clinics. Air pollution levels.	<ul style="list-style-type: none"> No consistent trend of change in the use of adult clinics due to respiratory tract complaints was observed between 1982-1990. Air pollution levels measured were low and did not cause adverse health effects. 	<p>Ambient air pollution levels did not exceed the Israeli air quality standards.</p> <p>The survey results were not able to distinguish between acute and planned visits nor were able to identify multiple visits of the same patients which may have compromised results.</p>
Karavus et al 2002 Turkey	Case control study. The effects of exposure to a coal-fired power plant on respiratory status using questionnaires, spirometric parameters and power plant ash in 1999 were calculated.	People > 15 years from villages in Kutahya Province, Turkey. <ul style="list-style-type: none"> 277 residing ≤ 5 km from the power plant. 225 residing > 30 km away from the power plant. 	Respiratory complaints and spirometric parameters. Air pollution levels.	<ul style="list-style-type: none"> Among people living in the villages around power plant, 46.2% had complaints of chest tightness ($p = 0.001$) and 29.2% repeated coughing attacks present for more than one year ($p = 0.024$). These percentages were 28.0% and 20.4% in the control villages respectively. 50.7% of individuals in the exposure group aged 35-54 had significantly more complaints of chest tightness than the 21.3% of individuals from the control group aged 35-54 ($p = 0.0006$). Mean spirometric parameters were significantly lower in individuals in the exposure group compared to the individuals in the control group ($p = 0.0001$). These measures were not statistically significant for current smokers ($p > 0.05$). 	No individuals in the study worked at the power plant.
Pesch et al 2002 Slovakia	Case control study. Geographical and environmental data with medical records from 1996-1999 investigated the risk of arsenic exposure on NMSC development.	Prievidza, Slovakia. <ul style="list-style-type: none"> 264 patients with a confirmed diagnosis of NMSC. 286 individuals without NMSC. 	Arsenic exposure assessed by: <ul style="list-style-type: none"> residential history. annual power plant emissions. nutritional habits. 	<ul style="list-style-type: none"> Age and gender adjusted risk estimates for NMSC in the highest exposure category (90th v 30th percentile) were ($OR = 1.90$, 95% CI: 1.39-2.60). No interaction was found between arsenic exposure and dietary and residential data. 	

Table 4: Power stations – children, infants, and fetal outcomes

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Aekplakorn et al 2003 Thailand	Observational study. The association between daily exposure to SO ₂ and PM with pulmonary function was investigated.	175 children, aged 6-14 years, residing in 4 villages within ~7 km of a coal-fired power plant in Maemoh, Thailand. - 83 asthmatics. - 92 non-asthmatics.	Pulmonary function. Air pollution levels.	<ul style="list-style-type: none"> In asthmatic children, a daily increase in SO₂ was associated with negligible declines in pulmonary function, but a small negative association was found between PM and pulmonary function. No consistent associations between air pollution and pulmonary function were found for non-asthmatic children. 	The 24 hour average PM and SO ₂ levels were below Thai standards.
Dubnov et al 2007 Israel	Cohort studies. The association between children's lung function development and their long-term exposure to air pollution was collected and examined from two cohort studies conducted in 1996 and 1999.	1,492 children residing in two communities ≤ 10 km from a major coal-fired power plant in the Hadera district of Israel.	Pulmonary function. Air pollution levels.	Children exposed to higher levels of air pollution from the coal-fired power station were more likely to be hindered in their pulmonary growth (p < 0.001).	Results were controlled for road proximity, duration of residence in the area, housing density, father's education, gender, passive smoking and pulmonary diseases. Ambient air pollution levels did not exceed the Israeli air quality standards.
Goren & Hellmann, 1997 Israel	Cross sectional study. Long term study in three communities in Israel using health questionnaires, measuring lung function and health services data from 1980-1989.	School children in 2 nd , 5 th and 8 th grade located within 19km of the power plant were followed up every 3 years. - 834 children in 1980. - 957 children in 1983. - 1,074 children in 1986. - 802 children in 1989.	Effects on asthma prevalence in school children living in proximity to a power plant station.	<ul style="list-style-type: none"> A significant increase in the prevalence of asthma could be observed among 5th grade children in all three communities studied between 1980-1989 (p = 0.002). There was also a significant rise in the prevalence of wheezing and shortness of breath (p = 0.02). 	

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Halliday et al 1993 Australia	Cross sectional survey. The effect of residing in the proximity of power plants was measured using a questionnaire to parents as well as by lung function and bronchial hyperreactivity measurements.	851 children, aged 5-12 years, from Lake Munmorah, NSW (a town near two power stations) and Dungog, NSW (control town). Survey response rate: 92% in Lake Munmorah and 93% in Dungog.	Lung function (wheeze, bronchial hyperreactivity and symptoms of asthma).	<ul style="list-style-type: none"> Current wheeze was reported in 24.8% of the Lake Munmorah children compared with 14.6% of the Dungog children. Bronchial hyperreactivity was similar for both groups although baseline FEV was significantly lower in Lake Munmorah ($p < 0001$). After adjusting for variables, the odds of current wheeze in Lake Munmorah compared with Dungog was 2.16 (95% CI: 1.45-3.15). 	Variables included age, gender, passive smoking and dust mite allergy.
Henry et al 1991a Australia	Prevalence survey and longitudinal follow-up study. The effect of residing in the proximity of power plants was measured using a questionnaire to parents as well as lung function measurements. These were obtained at two intervals, 1 year apart.	602 children in the prevalence survey and 529 in the follow-up study from Lake Munmorah, NSW (a town near two power stations) and Nelson Bay, NSW (control town). Survey response rate: 76% and 91% in Lake Munmorah; and 70% and 86% in Nelson Bay.	Lung function (respiratory symptoms and bronchial reactivity).	<ul style="list-style-type: none"> Prevalence of ever wheezed, current wheezing, breathlessness, wheezing with exercise, diagnosed asthma, and use of drugs for asthma at Lake Munmorah were all approximately double the prevalence at Nelson Bay (all p values < 0.01). Prevalence of bronchial reactivity was only significantly greater ($p < 0.01$) in Lake Munmorah at the first but not the second survey. 	Asthma was more common in the community near power stations than in the control area.
Henry et al 1991b Australia	Longitudinal study. The effect of living in the vicinity of coal-fired power stations on children with asthma was studied for 1 year, using daily diaries and measurements of air quality.	99 school children with a history of wheezing in the previous 12 months from Lake Munmorah, NSW (≤ 5 km of two power stations) and Nelson Bay, NSW (control town).	Respiratory symptoms and asthma treatment. Air pollution levels.	<ul style="list-style-type: none"> Marked weekly fluctuations occurred in the prevalence of cough, wheezing, and breathlessness, without any substantial differences between the towns. The overall prevalence of symptoms was low. 	Measurements of SO_2 and NO_x at Lake Munmorah were well within recommended guidelines although they were several times higher than at Nelson Bay.

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Mohorovic 2004 Croatia	Retrospective analysis. Prenatal and birth data from 1987-1989 was obtained to examine the effect of coal power plant exposure and related SO ₂ emissions in pregnant women.	704 pregnant women, in the vicinity of a coal power plant in Labin, Istria, Croatia.	Pregnancy complications and birth weight. Air pollution levels.	Greater and longer exposure to SO ₂ emissions during the initial two months of pregnancy resulted in significantly shorter gestation (p = 0.008) and in lower birth weight infant (p = 0.02).	
Mohorovic et al 2010 Croatia	Cross control study. Prenatal exposure to products of coal combustion and complications in pregnancy were compared between two groups.	Pregnant women living near a power plant Istria, Croatia. - 122 during its operation. - 138 during the power plant closure.	Miscarriages, premature births and stillbirths.	Significant increase in still births in women living near the power plant during the time of its operation compared to the control group (p = 0.02).	
Peled et al 2005 Israel	Nested cohort study. Health questionnaires, PEF results and daily measurements of humidity and particulate matter were compared between communities living in close proximity to a power plant.	285 children, aged 10-12 years, with confirmed asthma from three communities living in close proximity to a power plant in Israel.	Lung function. Air pollution levels.	Exposure to air pollution with ultra fine particles was significantly associated with asthma attacks, increased use of asthma medications and decreased lung function in children with asthma (p = 0.000).	Results were controlled for temperature, barometric pressure, BMI, severity of asthma and socio-demographic parameters. Limitations included that the study did not cover all four seasons for each child and there was no data on parents smoking habits.
Perera et al 2008 China	Prospective cohort studies. The association between PAH exposure and neuro-developmental outcomes, measured by the Gesell Development schedules at 2 years of age, were compared between a cohort during the operation of the power plant and when it had shut down.	Non-smoking mother-child pairs residing ≤ 2 km of a coal-fired power plant in Tongliang, China. - Cohort 1: 150 pairs; 133 retained. - Cohort 2: 158 pairs; 122 retained.	PAH-DNA adducts from cord blood. DQs in motor, adaptive, language and social areas.	The significant associations between elevated PAH's in umbilical cord blood and decreased motor area DQ (p = 0.04) and average DQ (p = 0.04) seen at 2 years of age in the first cohort were not observed in the second cohort study (p = 0.56 and p = 0.15), which was conducted post mine shutdown.	

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Tang 2006 China	Cohort study. The relationship between prenatal exposure to PAH on fetal and child growth and development was examined.	150 non-smoking women and their newborns, residing ≤ 2.5 km of a coal-fired power plant in Tongliang, China.	PHA-DNA adducts from maternal and umbilical cord blood. Fetal and child growth and development measures.	<ul style="list-style-type: none"> Prenatal exposure to elevated levels of PAH was associated with decreased birth head circumference ($p = 0.057$) and reduced child's weight at 18 ($p = 0.03$), 24 ($p = 0.03$) and 30 months of age ($p < 0.05$). Longer duration of prenatal exposure was associated with reduced birth length ($p = 0.03$) and reduced children's height at 18 ($p = 0.001$), 24 ($p < 0.001$) and 30 months of age ($p < 0.001$). 	
Tang et al 2008 China	Cohort study. The association between prenatal PAH exposure, measured in umbilical cord blood, and neurodevelopmental outcomes, measured by the Gesell Development schedules at 2 years of age.	150 non-smoking women and their newborns, residing ≤ 2.5 km of a coal-fired power plant in Tongliang, China.	PHA-DNA adducts. Lead and mercury in umbilical cord blood. DQs in motor, adaptive, language and social areas.	<ul style="list-style-type: none"> Decrements in one or more DQs were significantly associated with cord blood levels of PAH-DNA adduct and lead, but not mercury. Increased adduct levels were associated with decreased motor area DQ ($p = 0.04$), language area DQ ($p = 0.059$), and average DQ ($p = 0.05$) after adjusting for confounders. High cord blood lead level was significantly associated with decreased social area DQ ($p = 0.009$) and average DQ ($p = 0.04$). 	

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Wong et al 2005 Taiwan	Cross-sectional study. The association between internal concentrations of arsenic, chromium and nickel and the level of oxidative stress to DNA from a power plant was investigated.	142 children, aged 10-12 years, attending three elementary schools in Taichung county, Taiwan. - 49 from Longgang school, adjacent to the Taichung power plant. - 45 from Shalach school (control). - 48 from Shuntain school (control).	Urinary levels of arsenic, chromium and nickel. 8-OHdG levels.	<ul style="list-style-type: none"> No obvious relationship between the levels of urinary nickel and 8-OHdG was found. Multiple linear regression analysis showed that children with higher urinary chromium had greater urinary 8-OHdG than did those with lower urinary chromium. Subjects with higher urinary arsenic had greater urinary 8-OHdG than did those with lower urinary arsenic. Children with high urinary arsenic and chromium levels had the highest 8-OHdG levels vs. low arsenic/low chromium ($p < 0.01$); followed by low arsenic/high chromium, high arsenic/low chromium and low arsenic/low chromium; the trend was significant ($p < 0.001$). 	
Yogev-Baggio et al 2010 Israel	Prospective cohort Study. The effect of exposure to air pollution on the development of pulmonary function was evaluated between children characterised by different respiratory health status.	1,181 school children, residing near a major coal-fired power plant in the Hadera district of Israel. - Healthy children. - Children experiencing chest symptoms. - Children with asthma or spastic bronchitis.	Pulmonary function tests. Air pollution levels.	<ul style="list-style-type: none"> When controlling for cofounders, a significant negative association was found between changes in PFT results and individual exposure estimates to air pollution ($p < 0.01$). Long-term exposure to ambient air pollution has more detrimental effects on pulmonary function growth among children with chest symptoms and healthy children than among asthmatics. 	Results controlled for height, age, gender, parental education, passive smoking and residential status.

Abbreviations: 8-OHdG 8-hydroxy-2-deoxyguanosine, BMI body mass index, BRFS Behavioural Risk Factor Surveillance System, CDC Centers of Disease Control, CHD coronary heart disease, CI confidence interval, COPD chronic obstructive pulmonary disease, CVD cardiovascular disease, DQ developmental quotient, FEV forced expiratory volume, GIS Geographic Information System, GP general practitioner, HRQOL health related quality of life, LFT lung function test, MTM mountain top mining, NMSC non-melanoma skin cancer, NO_x nitrogen oxides, NTD neural tube defect, OR odds ratio, PAH polycyclic aromatic hydrocarbons, PAH-DNA polycyclic aromatic hydrocarbon-deoxyribonucleic acid, PEF peak expiratory flow, PM particle matter, PRR prevalence rate ratio, RR relative risk, SCI Stream Condition Index, SO₂ sulphur dioxide, UK United Kingdom, US United States, VSL value of statistical life lost.

EVIDENCE TABLES FOR RESEARCH QUESTION 3

<p>Are there clusters of these diseases or other health problems in the Hunter Region of New South Wales</p>

Appendix B: Summary of Evidence for Research Question 3

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Blakeney & Marshall 2009 US	Cross sectional study. Three phase study investigating water quality. Surveyed health professionals and community members in Letcher county, Eastern Kentucky.	40 adults aged ≥ 18 years living in Letcher county. - 23 men. - 17 women.	Association between water quality, health and human occupations.	<ul style="list-style-type: none"> The watershed in Letcher county, Kentucky is polluted as a result of specific coal mining practices and a lack of adequate infrastructure. Citizens experience occupational injustice in the form of occupational imbalance, occupational deprivation and occupational alienation. 	
Lockie et al 2009 Australia	Social impact assessment. Semi-structured interviews of stakeholders to scope potential impacts of mine, and a desktop study to identify further potential impacts. Two phase study in 2002-2003 and 2006-2007. Baseline assessment of impacts and mitigation strategies through community interviews, analysis from data provided from other agencies, and short quantitative surveys.	'Stakeholders' i.e. those who were affected by or involved in the Coppabella coal mine, QLD: - community. - representatives. - local businesses. - mine workers. - residents of Nebo.	Social impacts of the Coppabella coal mine.	<ul style="list-style-type: none"> While mining was only responsible for a small increase in population, demographic and social changes undermined the likely ability of the community to generate alternative economic and cultural futures. Other social impacts from mining included: severe shortages of skilled labour in other industries, reduced accommodation access and affordability, an increase in traffic and fatigue related road accidents, increased pressure on emergency services and increases in criminal and anti-social behaviour. 	Research was funded by Macarthur Coal. Social impact assessments were conducted outside Queensland's legislative framework to tailor the assessments to focus on cumulative impacts.

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Moffatt & Pless-Mulloli 2003 UK	Retrospective study. Face to face interviews on health and the environment with parents living in four communities < 750 m away from an open-cast coal mine in North East England. Taken in tandem with an epidemiological investigation to establish if open-cast mining adversely affects children's respiratory health.	Total of 31 interviews of parents living in one of 4 communities chosen: - 28 mothers only. - 2 fathers only. - 1 both parents.	Parents perceptions of the health and environmental impact of open-cast mining.	<ul style="list-style-type: none"> 23 participants were of the view that there was an increase in asthma levels among children citing traffic pollution and open-cast mining as causes. The epidemiological findings showed no increase in asthma prevalence but higher rates of GP consultations for respiratory conditions. 	Scepticism and distrust of official sources of information was a common feature.
Pless-Mulloli et al 2000 UK	Matched pairs case control study. Health information was obtained from a postal questionnaire, a daily symptom diary and GP records, these were compared between communities at different proximities to an open-cast mine.	4,860 children, aged 1-11 years, in Northern England. - 2,443 from five communities close to open-cast coal mine. - 2,417 in from five communities away from active open-cast coal mine.	<p>The cumulative and period prevalence (2 and 12 months) of wheeze, asthma, bronchitis and other respiratory symptoms.</p> <p>Prevalence and incidence of daily symptoms and GP consultations.</p> <p>Air pollution levels.</p>	<ul style="list-style-type: none"> Little evidence was found for associations between living near an open-cast site and an increased prevalence of respiratory illnesses, asthma severity, or daily diary symptoms. Children in four of the five open-cast communities had significantly more respiratory consultations than control communities. (1.5 v 1.1 per person-year; OR = 1.42, 95% CI: 1.13-1.79). Small but significant associations were found between daily respiratory symptoms and daily concentrations of PM. Particulate matter levels were higher in open-cast areas: mean ratio 1.14, 95% CI: 1.13-1.16. 	There was the level of variation between the communities and pairs, even though they were well matched for lifestyle and socioeconomic factors.

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Riva et al 2011 UK	Cross sectional study. Health surveys and geographical data were studied from 2004-2006 from the North East, West Midlands and South West of England.	Total of 26,097 adults aged > 18 years. - 4,733 lived in a former coalfield area.	Variation in health across former coalfield areas in England.	<ul style="list-style-type: none"> Living in coalfields areas was significantly associated with a greater likelihood of reporting a limited long term illness (OR = 1.39, 95% CI: 1.25-1.55) and less than good health (OR = 1.24, 95% CI: 1.12-1.37). Women were significantly less likely than men to report a limited long term illness and less than good health, but more likely to report common mental health problems. 	
Walker et al 2006 Russia	Cross sectional survey. Compared different social perceptions of environmental degradation through face to face interviews and environmental impact studies in the coal mining areas of Usinsk and Vorkuta in the sub-arctic region of Russia from 1998-2000.	Total of 175 individuals aged > 18 years. - 89 living in Usinsk. - 86 living in Vorkuta.	Levels of environmental pollution in the sub-arctic lowlands of north east European Russia.	<ul style="list-style-type: none"> Environmental issues were a low priority among the people of Usinsk and Vorkuta, compared with other social problems. People were concerned with the quality of their drinking water and with recreational activities such as swimming and fishing. 	Human and ecologic impacts of environmental change are not so much about mean changes but rather about extreme events. An extreme event poses a risk because people have to respond quickly.

Abbreviations: CI confidence interval, GP general practitioner, OR odds ratio, QLD Queensland, UK United Kingdom, US united States.

EVIDENCE TABLES FOR RESEARCH QUESTION 4

<p>Is there an association between coal mining and social injustice in the Hunter Region of NSW?</p>

Appendix C: Summary of Evidence for Research Question 4

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Brereton et al 2008 Australia	Cross sectional study. Face to face interviews, four focus group sessions and a literature review to determine the cumulative impacts of mining on the local community.	Total of 53 adults aged > 18 years in Muswellbrook, NSW. - 19 interviewed. - 34 in focus groups.	Impacts of mining on regional communities. Framework for coal mining operations to monitor and manage cumulative impacts of mining.	<ul style="list-style-type: none"> Broad agreement that mining had contributed significantly to economic development in Muswellbrook. Majority agreement that pollution has a negative impact on the lives of local people e.g. visual and social impacts of mining. 	
Connor et al 2004 Australia	Cross sectional survey. Perceptions of environmental change were investigated using interviews with key stakeholders, and in-depth semi-structured interviews with community residents.	Total of 55 people interviewed from the Upper Hunter Valley, NSW. - 13 key stakeholders. - 42 community residents.	Environmental change and the effect on human health.	Environmental change in the Upper Hunter is associated with considerable depth of feeling of personal distress about loss of, or damages to homes, farming properties, the landscape and community heritage.	Restructuring of rural industries and the decline of small farms was also a cause of distress to residents.
Connor et al 2008 Australia	Case study. The conflict over water during the Bickham coalmine proposal was investigated by analysing discourse.	Stakeholders of the Bickham coal mine, Upper Hunter Valley, NSW.	Asymmetry of power and control over water.	<ul style="list-style-type: none"> The contestation over water was increasing due its increasing scarcity and the conflicting demands of local communities and the mining industry. Policy changes to water rights reflected the advantage of political capital that the coal mining industry has over local communities. Inequalities in water rights and forced changes to the environment are issues of social injustice. 	
Connor et al 2009 Australia	Case study. Changing opposition practices of the local communities near the Anvil Hill mine site were investigated using available literature.	Local communities affected by the Anvil Hill open-cut mine, Wybong area, Upper Hunter Region, NSW.	Oppositional practices of local communities. Environmental knowledge.	<ul style="list-style-type: none"> The incorporation of global issues such as climate change has aided local communities in their opposition of coal mining projects. Local communities face barriers to accessing information, such as 'gag clauses' in settlements, causing social divisions. The mining industry has greater political privileges compared to local communities. 	

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Dalton 2003 Australia	Cross sectional survey. Environmental health issues were identified using surveys of residents, government council members and Hunter Health Council members.	894 people > 15 years residing in the Hunter Valley, NSW. - 11 local government members. - 719 local residents. - 164 Hunter Health Council members.	Environmental health concerns in the Hunter Valley.	<ul style="list-style-type: none"> 88% of respondents named air pollution as an environmental health concern followed by water pollution. There were no differences by gender. 	There was a trend for respondents of higher socioeconomic status (by postcode SEIFA) score to name an environmental concern compared to those of lower status.
Harris et al 2009 Australia	Qualitative descriptive analysis. Environmental impact assessments were analysed by developing an audit tool that then was applied to a stratified randomised sample.	22 environmental impact assessment reports from July 2006 to December 2007, taken from the NSW Department of Planning.	Inclusion of health in environmental impact assessments.	Health and well-being impacts are not considered explicitly in environmental impact assessments within major environmental projects in NSW. This is despite the likelihood of a range of health impacts occurring due to size and nature of the developments.	Small sample size meant descriptive statistics were unable to be used.
Higginbotham et al 2007 Australia	Cross sectional survey. Fieldwork was used to validate an EDS which was then used to analyse results of postal surveys.	203 residents of Singleton (high disturbance area from mining) and Dungog (low disturbance area from mining) in the Upper Hunter, NSW.	Validation of EDS. Environmental distress relative to location of coal mines.	<ul style="list-style-type: none"> The EDS was validated, subscales were intercorrelated ($r = 0.67-0.73$) and had internal consistency reliability (Cronbach's $\alpha = 0.79-0.96$) and test-retest reliability ($ICC = 0.67-0.73$). Communities affected by mining have higher levels of environmental distress than communities not affected by mining. 	
Higginbotham et al 2010 Australia	Literature review. Available literature was reviewed to determine environmental injustices in local communities caused by coal mining.	Hunter Valley, NSW.	Environmental injustice and air pollution in local communities.	<ul style="list-style-type: none"> Coal mining is associated with intergenerational injustices through health inequity and environmental injustice. Coal mining has dramatically changed the local environment. Technical and methodological barriers are used by relevant authorities to prevent conducting a cumulative health study on the local populations. 	

Author, year country	Study type & method	Study population	Outcomes	Relevant Results	Comments
Richardson & Denniss 2011 Australia	Literature review. Effects of the commodities boom in Australia were reviewed using available literature and data.	Australia	Social and economic effects of the mining industry in Australia.	<ul style="list-style-type: none"> • The government spends \$10 billion annually in subsidies to support fossil fuel extraction. • The mining industry contributes 9% of Australia's total GDP. • State governments provide assistance to the mining industry through the Productivity Commission in many ways, e.g. through the provision of cheap water and power. 	

Abbreviations: EDS environmental distress scale, GDP gross domestic product, ICC intraclass correlation coefficient, NSW New South Wales, SEIFA socio-economic indexes for areas