Costs of Negative Health Outcomes Arising from Air Pollution from Coal-Fired Power Stations

Prepared for Environmental Justice Australia

by Chris Johnson, Miing Pin Low, Abyn Scaria, Sheena Wong, Xiao Xu, Alan Yao, Yu Zhu

19 August 2020

Contents

1 Executive summary

This report was written and the underlying work performed by a team of actuarial volunteers. The work was performed for Environmental Justice Australia ("EJA").

The purpose of this report is to estimate the costs associated with the following negative health outcomes arising from air pollution from coal-fired power stations across Australia in 2019:

- 845 extra low birthweight live births;
- 14,434 extra person-days of asthma symptoms for 5-19 year olds; and
- 785 extra premature deaths.

Due to time and resource constraints, detailed calculations and in-depth analysis relating to the costs of the negative health outcomes was not possible. Instead, existing research papers and other publicly available information were heavily relied on to estimate the costs. The information sources used are documented as footnotes in this report.

The cost estimates required many explict and implicit assumptions which are described in this report. Where a choice between a conservative or non-conservative assumption or calculation was required, a conservative assumption or calculation was chosen.

The estimated total costs are $2,423m in 2019 Australian dollars, divided into economic costs and burden of disease costs as follows:

	Estimated Costs (2019 Australian dollars)		
Negative Health Outcome	**Economic**	**Burden of Disease**	**Total**
Extra Low Birthweight Live Births	$101m	$275m	$376m
Extra Person-Days of Asthma Symptoms	$1m	$10m	$11m
Extra Premature Deaths	$147m	$1,890m	$2,036m
Total	**$249m**	**$2,174m**	**$2,423m**

2 Background and context

2.1 The Actuarial Hackathon

The Actuarial Hackathon is organised by the Actuaries Institute, matching teams of actuarial volunteers with not-for-profit organisations so that their actuarial skills can be used to solve problems.

This report is provided to Environmental Justice Australia ("EJA") to detail the work performed by a team of actuarial volunteers participating in the 2020 Actuarial Hackathon, which ran from 1 June 2020 to 21 July 2020 inclusive. These volunteers ("Hackathon team members") are listed on the title page of this report. None of the Hackathon team members received payment of any kind from EJA or their campaign ally, Greenpeace, for the work performed or writing this report.

The work performed was based on an objective and scope of work agreed upon between the Actuarial Hackathon Organising Committee and EJA prior to the commencement of the work.

2.2 Objectives and scope of work

EJA is campaigning for government intervention to compel the installation of pollution controls to coal-fired power stations in New South Wales and Australia as part of the transition from coal to clean energy.

As part of this campaign, EJA has partnered with Greenpeace to release a report outlining the health burden from coal-fired power stations across Australia. A draft version of this report dated 18 December 2019 and a final version entitled "*Lethal Power: How Burning Coal Is Killing People in Australia*" ("the Greenpeace report") were made available to Hackathon team members for the purposes of the Actuarial Hackathon. In this report, the nature and extent of negative health outcomes arising from coal power stations were identified and estimated, with premature death, asthma and low birth weight being identified as some of the key impacts.

The objective of the work for EJA was to quantify the economic cost of the three key health burdens, using the estimated outcomes as outlined in the Greenpeace report as a basis of the work. These outcomes are summarised in the subsections below.

2.2.1 Health outcomes arising from coal power stations

In the Greenpeace report, the following negative health outcomes have been estimated to arise from pollution from coal-fired power stations over an annual period:

- 845 extra low birthweight live births;
- 14,434 extra person-days of asthma symptoms for 5-19 year olds; and
- 785 extra premature deaths.

The 785 extra premature deaths caused by air pollution from coal-fired power stations was further broken down by population and negative health outcome combination by EJA/Greenpeace as follows:

Table 2.1
Breakdown of # Extra Premature Deaths
by Population and Negative Health Outcome Combination

Pollutant	Negative Health Outcome (Cause)	Population	ICD-10 Codes	# Extra Premature Deaths
NO_2	death (all causes)	Aged 30+	All	424
$PM_{2.5}$	death (ischaemic heart disease)	All Ages	I20-I25	132
$PM_{2.5}$	death (heart failure)	All Ages	I50	19
$PM_{2.5}$	death (lung cancer)	All Ages	C33-C34	66
$PM_{2.5}$	death (stroke)	All Ages	I60-I64	60
$PM_{2.5}$	death (ALRI)	All Ages	J09-J22	52
$PM_{2.5}$	death (diabetes)	All Ages	E10-E14	33
Total				**785**

2.2.2 Assumed Year of Occurrence

The negative health outcomes were calculated by EJA/Greenpeace with:

- pollution analysis relating to 2018;
- a spatial population distribution from 2010.

For simplicity, this report assumes that these negative health outcomes arose in 2019. We note that the population of Australia has increased since 2010, and thus, this assumption leads to conservative estimates.

2.3 Reliances and limitations

As mentioned above, the negative health outcomes listed in Section 2.2 were provided by Greenpeace and have been relied upon throughout this work and the report. The negative health outcomes were not independently reviewed because this was outside the scope of the Actuarial Hackathon project. However, a high-level understanding of how they were derived was established to estimate their associated costs appropriately.

Due to the time and resource constraints involved in the Actuarial Hackathon, detailed calculations and in-depth or more granular analysis relating to the costs of the negative health outcomes was not possible. Instead, the Greenpeace report, existing research papers and other publicly available information were heavily relied on to estimate the costs. The information sources used are all documented as footnotes throughout this report.

Judgement regarding the information contained in this report should only be made after reading the report in its entirety, as the conclusions reached by reviewing a section or sections in isolation may be incorrect. Any use of the findings, including in further reports, analyses and public releases, should be made with consideration towards the underlying assumptions and limitations of this work.

Hackathon team members, Hackathon Organising Committee members and the Actuaries Institute:

- are not liable for any loss or damages caused by any use of the analysis or findings in this report or the work underlying it; and
- accept no responsibility for any action taken in respect of this report or the work underlying it.

Any views and opinions expressed in this report are those of the authors and do not reflect the views and opinions of their employers, the Actuarial Hackathon Organising Committee or the Actuaries Institute.

2.3.1 Conservatism

Where a choice between a conservative or non-conservative assumption or calculation was required in the work underlying this report, a conservative assumption or calculation was chosen. The conservative assumptions and calculations adopted are described in this report.

2.4 How to read this report

Within each section of this report, the same numbers (or groups of numbers) may be referred to multiple times. To make it easier for the calculations to be seen and understood, these numbers (or groups of numbers) have been shaded the same colour each time they appear within a particular section.

To avoid confusion, this colour coding does not apply across sections.

3 Overall approach

The approach taken was to estimate the cost of each of the health outcomes (premature death, low birthweight and asthma) separately, each with two separate components: economic costs and burden of disease costs.

Economic costs represent the financial costs incurred in areas such as the health system and productivity costs. On the other hand, the burden of disease cost represents the loss of wellbeing of the individual through pain, suffering, morbidity or mortality in monetary terms.

A combination of the widely used burden of disease methodology and existing research in Australia and the United States ("US") was relied upon to arrive at cost estimates for each component. As such, the approach undertaken for each component is dependent on the availability of reliable external research papers. Each of these research papers, the way in which they have been utilised and associated limitations are discussed in each of the subsections of this report.

4 Burden of disease costs concept

4.1 Methodology

The approach adopted was consistent with the “burden of disease” methodology used by the World Health Organisation, the Institute for Health Metrics and Evaluation and the Australian Institute of Health and Welfare.

To estimate the burden of disease costs, each of the negative health impacts outlined in Section 2.2 above was converted into an overall “burden” of pain, suffering and premature mortality measured as a number of life years multiplied by a dollar value for each life year.

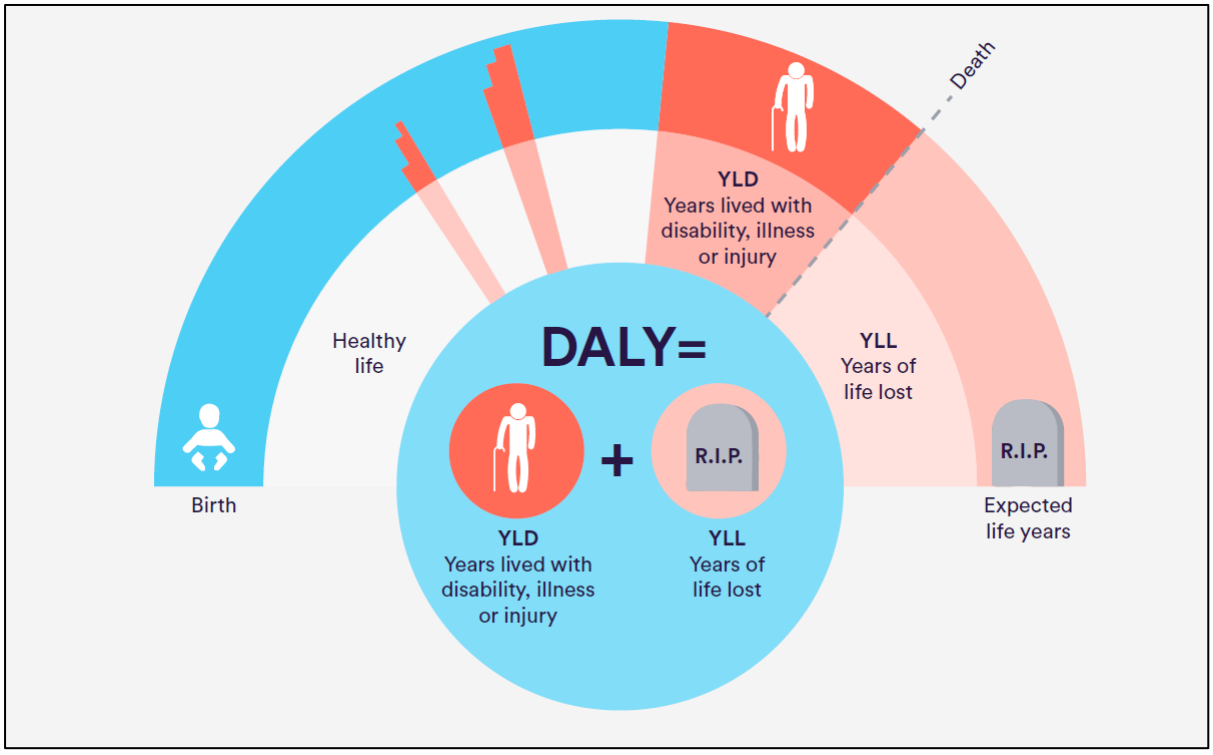
i.e. $ Burden of Disease Costs

= Disability-Adjusted Life Years (DALYs) x $ Value of a Statistical Life Year (VLY).

4.2 Disability-adjusted life years (DALYs)

The concept of a DALY is shown diagramatically below[1]:

Figure 4.1
Illustration of Disability Adjusted Life Years



[1] Public Health England (2015). Reproduced under Open Government Licence.

Formulaically, DALYs are expressed as the cumulative number of years lost due to early death, disability or ill-health, as follows:

DALYs = YLLs + YLDs

where:

- **YLL** is the years of life lost due to premature death and, where applicable, is calculated as

  YLL = N x L

  where:
  - N = number of deaths due to condition
  - L = life expectancy at age of death

- **YLD** is the years of life lost due to morbidity or disability and, where applicable, is calculated as

  YLD = I x DW x L

  where:
  - I = number of disability incidence cases
  - DW = degree of disability (weight) of a specific condition
  - L = average duration until remission or death (years)

4.2.1 Benefits and limitations

There are benefits and limitations of using this approach[2,3].

The benefits are:

- it relies on expert valuations and person trade-off techniques, not on self-reported health reports, which have the potential for causing counter-intuitive results;
- it considers both the mortality and morbidity and effects of a disease into a single measure; and
- it is easy measure to calculate and aggregate different diseases and regions.

The limitations are:

- it provides only general regional estimates of the burden, but not tailored to the specific conditions in different countries across the world;
- it ignores the impact of social, cultural or economic contexts on the severity of the disability; and
- it does not take psychological distress of the disability into consideration.

[2] Public Health Notes, *DALY (Disability Adjusted Life Years),* www.publichealthnotes.com (2020). Available online: https://www.publichealthnotes.com/daly-disability-adjusted-life-years (accessed 11 July 2020)

[3] AbouZahr, C.,*Global burden of maternal death and disability*. British Medical Bulletin (2003), 67(1), pp.1-11.

4.3 Value of a statistical life year

The value of a statistical life is an estimate of the value society places on reducing the risk of dying. It is not based on the life of a particular person but a young adult with at least 40 years of life ahead.

It is measured by how much society is willing to pay to reduce the risk of death. There are a number of ways of determining this:

- survey people and ask how much they are willing to pay;
- how much do consumers pay for safety items; or
- how much are workers willing to pay for increased work safety.

It is defined in *Best Practice Regulation Guidance Notes* released by the Australian Government - Department of the Prime Minister and Cabinet - Office of Best Practice Regulation every few years, based on international and Australian research. In the August 2019 version[4], the following estimates are provided:

- Value of a Statistical Life (VSL) = $4.9m in 2019 dollars
- Value of a Statistical Life Year (VLY) = **$213,000 in 2019 dollars**
- based on a private time preference discount rate of 3 per cent

This objective value of **$213,000 in 2019 dollars** has been used in this report to estimate burden of disease costs.

[4] Australian Government - Department of the Prime Minister and Cabinet - Office of Best Practice Regulation, *Best Practice Regulation Guidance Note: Value of statistical life*. August 2019. Available online: https://www.pmc.gov.au/sites/default/files/publications/value-of-statistical-life-guidance-note_0_0.pdf Refer to 2

5 Extra low birthweight live births – economic costs

In this section we refer to economic costs as the societal costs that materialise as a result of the health condition. This includes, for example, medical costs, and reduced working capacity and hence productivity.

5.1 Methodology

We have drawn on two research papers which were conducted in the United States to estimate the economic costs of pre-term and low birthweight (LBW) live births: (1) *Preterm birth causes, consequences and prevention*[5] ("Paper 1"); and (2) *Estimates of healthcare spending for preterm and low-birthweight infants in a commercially insured population: 2008–2016*[6] ("Paper 2"). These were converted into an average extra cost per low birthweight live birth relating to the Australian population and Australian Dollars (AUD) as at 2019 in the following steps:

Step	Description	Cost basis			
		Population base	**Birth types**	**LBW distribution**	**Currency**
	Findings from research papers:				
	Paper 1	Total US	Pre-term	US 2005	2005 USD
	Paper 2	an Insured US	Pre-term and LBW	US 2008-2016	2008-2016 USD
1	Convert to Australian low birthweight distribution	an Insured US	Low birthweight	Australia 2017	2008-2016 USD
2	Convert to total population	Total US	Low birthweight	Australia 2017	2008-2016 USD
3	Convert to Australian dollars in 2019	Total US	Low birthweight	Australia 2017	2019 AUD

These steps and the underlying assumptions are described in the following sections.

Note that throughout Section 5, the same numbers (or groups of numbers) are referred to multiple times. These numbers (or groups of numbers) have been shaded the same colour each time they appear so their flow through the calculations can be more easily seen and understood.

[5] Behrman RE, Butler AS, *Preterm birth: causes, consequences, and Prevention - Chapter 12 Societal Costs of Preterm Birth*, The National Academies Press (2007). Available online: https://www.nap.edu/read/11622/chapter/17

[6] Beam, A.L., Fried, I., Palmer, N. et al. *Estimates of healthcare spending for preterm and low-birthweight infants in a commercially insured population: 2008–2016*. Journal of Perinatology 40, 1091–1099 (2020). Available online: https://doi.org/10.1038/s41372-020-0635-z

5.2 Summary of findings from research papers

Paper 1 estimates average extra costs for pre-term births as follows:

Table 5.1
Estimated Average Extra Cost of Pre-Term Live Birth Per Case
Total United States Population

Cost Type	**Average Extra Cost (2005 USD)**
Medical Care – Birth to Age 5 Years	$31,290
Medical Care – 6 years and older (4 DDs)	$1,920
Maternal Delivery Costs	$3,812
Early Intervention Costs	$1,203
Special Education Costs (4 DDs)	$2,150
Lost Productivity Costs (4 DDs)	$11,214
Total	**$51,589**

These costs are above and beyond what would have been expended had these infants been born at term. They are based on overall medical care costs, not just the costs of the insured or uninsured population.

This estimate is conservative because:

- it does not include all costs such as:
    - caregiver costs; and
    - medical costs beyond early childhood.
- certain costs are only included for the four main developmental disabilities (4 DDs) associated with pre-term birth:
    - cerebral palsy;
    - mental retardation;
    - vision impairment; and
    - hearing loss

Paper 2 estimates costs of both pre-term and low birthweight live births based on an insured population over a period from 2008 to 2016.

Table 5.2 Estimated Average Costs of Pre-Term and Low Birth Weight Live Births
A Specific United States Insured Population

Birth Type	n	Average Cost (2008-2016 USD)
Full Term	713,253	$6,370
All Pre-Term	50,512	$76,153
Normal Birthweight	727,538	$6,743
All Low Birthweight	32,508	$114,437
<1000g	2,857	$442,091
1000–1499g	4,273	$220,133
1500–1999g	8,895	$90,805
2000–2499g	16,483	$42,998

It was unclear whether these costs included maternal delivery costs, so it was conservatively assumed that they do.

5.3 Step 1 - Converting costs to an Australian 2017 low birthweight distribution

The average USD$114,437 per case from the Paper 2 was converted to an average for the Australian 2017 population distribution using the low birthweight breakdown for 2017 as follows:

Table 5.3 Estimated Average Cost of a Low Birthweight Live Birth
A Specific United States Insured Population
Using Australia 2017 Low Birthweight Distribution[7]

Birth Type	i	Average Cost (2008-2016 USD) (A)	Australia 2017 n (B)	$\frac{\sum A_i \times B_i}{\sum B_i}$
All Low Birthweight		$114,437	20,271	$93,236
<1000g	1	$442,091	1,341	
1000–1499g	2	$220,133	1,655	
1500–1999g	3	$90,805	3,975	
2000–2499g	4	$42,998	13,300	

5.4 Step 2 - Converting average costs from an insured population to total population

The average costs from the two papers above were then blended to give a conservative estimate of low birthweight costs.

To estimate the impact of moving from an insured population to an overall population a ratio was calculated based on the average pre-term live birth costs in both papers.

Component	Calculation Step
2005 “Medical Care – Birth to Age 5 Years” average extra costs from Paper 1	$31,290
2005 “Medical Care – Birth to Age 5 Years” average extra costs from Paper 1 in 2012 USD (inflated from 2005 to 2012 using PPI index[8])	$31,290 x 107.8 / 87.3 = $38,638
2012 (on average) extra costs from Paper 2	$76,153 - $6,370 = $69,783
Average Costs for Total Population/Average Costs for an Insured Population Ratio	$38,638 / $69,783 = 55.37%

Applying this same ratio to the Australia 2017 weighted low birthweight excess average cost from Paper 2 gives:

55.37% x ($93,236 - $6,743) = $47,890

[7] Australian Institute of Health and Welfare. *Australia's mothers and babies 2017—in brief - Data tables - Table 3.9*. AIHW, 2019. Available online: https://www.aihw.gov.au/getmedia/233c91fd-4b0c-49d6-b98d-3b86686034dc/aihw-per-100-data-tables.xlsx.aspx

[8] Refer to Table A.1 in the Appendix

In these calculations, we have assumed that the average costs related to pre-term births have been estimated on a consistent basis, and, as such, are comparable.

Using the rest of the figures from Paper 1 produced the following table.

Table 5.4
Estimated Average Extra Cost of a Low Birthweight Live Birth
Total United States Population

Cost Type	Average Extra Cost (USD)	Year
Medical Care – Birth to Age 5 Years*	$47,890	2008-2016
Medical Care – 6 years and older^	$1,920	2005
Maternal Delivery Costs	$3,812	2005
Early Intervention Costs^	$1,203	2005
Special Education Costs^	$2,150	2005
Lost Productivity Costs^	$11,214	2005

* excluding maternal delivery costs
^ these figures are conservative because the average extra cost for low birthweight births is higher than for pre-term births, but the pre-term birth figures have been used unadjusted.

5.5 Step 3 - Converting from US costs above to Australian 2019 costs

The following information was used to convert from US costs to Australian costs:

- average USD/AUD exchange rates for 2005, 2008-2016 and 2017
- purchasing power parities for 2017
- Australian health costs inflation from 2005-2019 and 2012-2019
- Australian costs inflation from 2005-2019

These factors are all summarised in the following table.

Table 5.5
Estimated Average Extra Cost of a Low Birthweight Live Birth
Converting from US Costs for Particular Years to Australian 2019 Costs

Cost Type	Average Extra Cost (USD) (A)	Year	Purchasing Power Parities[9]		Australian Inflation[10]			Average Extra Cost (2019 AUD) (D)*
			Category	(B)	Category	Period	Rate (C)	
Medical Care – Birth to Age 5 Years	$47,890	2008-16	Hospital	1.278[11]	Health	1 Jul 2012 - 30 Jun 2019	34.54%	$82,312
Medical Care – 6 years and older	$1,920	2005	Health	1.040	Health	1 Jul 2005 - 30 Jun 2019	83.03%	$3,655
Maternal Delivery Costs	$3,812	2005	Health	1.040	Health	1 Jul 2005 - 30 Jun 2019	83.03%	$7,256
Early Intervention Costs	$1,203	2005	Health	1.040	Health	1 Jul 2005 - 30 Jun 2019	83.03%	$2,290
Special Education Costs	$2,150	2005	Education	0.834	All	1 Jul 2005 - 30 Jun 2019	39.03%	$2,493
Lost Productivity Costs	$11,214	2005	GDP	1.390	All	1 Jul 2005 - 30 Jun 2019	39.03%	$21,671
*(D) = (A) x (B) x [1 + (F)]							**Total**	**$119,676**

A conservative estimate of the economic costs of the 845 extra low birthweight live births due to air pollution from coal-fired power stations in 2019 Australian dollars is therefore:

845 x $119,676 = $101m

[9] Organisation for Economic Co-operation and Development (OECD), *2005/2008/2011/2014/2017 PPP Benchmark results - Table 1.12: Purchasing power parities in national currencies per US dollar (United States=1.00)*. OECD (2020). Available online: https://stats.oecd.org/Index.aspx?DataSetCode=PPP2017 (accessed on 13 July 2020)

[10] Refer to Table A.2 in the Appendix. The rate shown is calculated by compounding the relevant quarterly rates.

[11] Average of 2008, 2011, 2014 and 2017 Purchasing Power Parities to reflect that the $47,890 costs relate to the years 2008-2016

5.6 Implicit assumptions

The assumptions implicit in the calculations described above are:

- The weight distribution of extra low birthweight live births due to air pollution from coal-fired power stations is the same as the weight distribution of low birthweight live births for Australia in 2017.
- Apart from the exchange rates and purchasing power parities incorporated above, there are no differences in the costs for the cost types listed above relating to low birthweight and pre-term births between the United States and Australia. We have also assumed that the costs for the US insured population relative to the overall population is consistent with that for Australia.
- Furthermore, the differences in the quality, structure and provision of health and special education services between the US and Australia have not been incorporated in this analysis, and thus, are assumed to be consistent.

6 Extra low birthweight live births – burden of disease costs

6.1 Methodology

We have used the Burden of Disease and VSLYs methodology as described in Section 4 to estimate the burden of disease costs associated with the extra low birthweight live births as estimated by Greenpeace. This involves using global health data on DALYs for pre-term births and scaling these numbers to apply to the low birthweight population in Australia, and then applying VSLYs. This is described below.

6.2 DALYs for low birthweight live births in 2018

We have used the information in Table 6.1 and Table 6.2 to scale the DALYs for pre-term births to using birthweight bandings.

Table 6.1
Breakdown of Total Live Births in Australia in 2018 by Birthweight[12]

Birthweight		Live Births in Australia in 2018				
		Pre-Term*	**Term**	**Post-Term**	**Unknown**	**Total**
Low	< 2,500g	13,912	6,224	4	5	20,145
Normal	2,500 – 3,999g	10,591	265,355	1,207	65	277,218
High	>= 4,000g	28	3,265	82	0	3,375
Unknown		49	115	0	0	164
Total		24,580	274,959	1,293	70	300,902

*any birth before 37 weeks completed weeks of gestation

[12] Australian Institute of Health and Welfare (AIHW), *Australia's mothers and babies in 2018 – in brief report: Australia's mothers and babies data visualisations*. AIHW, 29 May 2020.
Available online: https://www.aihw.gov.au/getmedia/475b6918-c2c9-40d1-b4c2-a39f92d6bc88/per-101-data-tables.xlsx.aspx (accessed on 16 June 2020)

Table 6.2
DALYs (Disability-Adjusted Life Years) for Australia 2013-2017 for the "Neonatal Pre-Term Birth" Cause[13]

Year	YLLs (Years of Life Lost)	YLDs (Years Lived with Disability)	DALYs (Disability-Adjusted Life Years)
2013	19,613	33,248	52,861
2014	18,918	33,754	52,672
2015	19,128	34,266	53,394
2016	19,028	34,838	53,865
2017	19,028	35,355	54,383

The above DALYs are on a prevalence basis and do not include any discounting or age weighting factors.

A conservative estimate of the DALYs associated with low birthweight for live births in 2018 is:

= DALYs for Australia for the "neonatal pre-tem birth" cause in 2017

x $\frac{\text{\# pre-term low birthweight births in 2018}}{\text{\# pre-term births in 2018}}$

= 54,383 years x 13,912 / 24,580

= 30,780 years

The following assumptions have been made in this calculation, leading to an overall conservative estimation:

- We have not incorporated the upwards trends in YLDs over time, which means:
  - using the 2017 figure for 2018 is a conservative approach; and
  - assuming the age distribution of the YLDs is relatively consistent over time, using the prevalence YLDs from Table 6.2 as incidence YLDs in the calculation above is also conservative.
- Incidence YLLs are almost identical to prevalence YLLs for the "neonatal pre-term birth" cause because <1% of the YLLs relate to ages greater than 1[14], so using prevalence YLDs from Table 6.2 as incidence YLDs in the calculation above is an acceptable approximation.
- YLLs have been trending gradually downwards over time, so using the 2017 figure for 2018 is not conservative, but this is outweighed by the conservative treatment of

[13] Institute for Health Metrics and Evaluation (IHME), *Global Burden of Disease Study 2017 (GBD 2017) Disability-Adjusted Life Years 1990-2017*. Seattle, WA: IHME, University of Washington, 2018. Available online: http://ghdx.healthdata.org/gbd-results-tool (accessed on 16 June 2020)

[14] Refer to Table A.3 in the Appendix

the YLDs because YLDs are higher and trending upwards at a greater rate than the YLLs are trending downwards.

- Applying the 13,912 / 24,580 ratio in this calculation assumes that the DALYs arising from each low birthweight pre-term live birth is equal to DALYs arising from each pre-term live birth, which is conservative given an average low birthweight live birth is subject to a higher probability of disability and mortality than an average pre-term live birth.
- This calculation is additionally conservative because it ignores DALYs arising from full-term low birthweight live births, which accounted for 31% of all low birthweight live births in 2018.

6.3 Burden of disease costs in 2019

Estimate of the burden of disease costs from 845 extra low birthweight live births in 2019 due to air pollution from coal-fired power stations in 2019 Australian dollars:

= 845 / # low birthweight live births in Australia in 2019

x DALYs for Australia for the “low birthweight” cause in 2019

x VLY in 2019 dollars from Section 4.3 above

= 845 / 20,145 x 30,780 x $213,000

= $275m

This calculation assumes that

- the DALYs for low birthweight live births in 2019 are equal to the DALYs for low birthweight live birth in 2018, which is conservative because the DALYs for the “neonatal pre-term birth cause” have been increasing gradually over time based on a flat number of pre-term live births and the number of low birthweight live births has been increasing gradually over time[15].
- the population exposed to the risk of extra low birthweight live births due to pollution from coal-fired power stations and the population of Australia to which the number of live births breakdowns in Table 6.1 and the DALYs in Table 6.2 relate , are homogeneous.

[15] Refer to Table A.4 in the Appendix

7 Extra asthma – total costs

7.1 Methodology

To estimate the economic costs and burden of disease costs of the extra person-days of asthma symptoms arising from the pollution from coal-fired power stations, we have drawn on a report by Deloitte Access Economics entitled "*The Hidden Cost of Asthma*"[16] (the "Deloitte report"). This provides an estimate of the economic costs and burden of disease costs of asthma in Australia in 2015, which we have used to arrive at a background cost estimate of asthma in Australia in 2019. We have then used the extra and background person-days of asthma symptoms in the Greenpeace report to attribute the costs to pollution from coal-fired power station.

7.2 Background costs of asthma for Australia in 2019

The **economic costs** of asthma for 5-19 year olds in 2015 from the Deloitte report was estimated to be $350m in 2015 Australian dollars.

Converting this to a 2019 figure by applying the change in the Australian population aged 5-19 years old[17] and CPI inflation[18] from 1 Jul 2015 to 30 Jun 2019 gives:

Economic costs of asthma for 5-19 year olds in 2019

$$= \$350m \times \frac{\text{\# Australian 5-19 year olds @ 30 June 2019}}{\text{\# Australian 5-19 year olds @ 30 June 2015}} \times (1 + 6.70\%)$$

$$= \$350m \times 4{,}674{,}105 / 4{,}416{,}806 \times (1 + 6.70\%)$$

= $395m in 2019 Australian dollars

The **burden of disease costs** of asthma for 5-19 year olds from the Deloitte report was estimated to be $5,021m in 2015 Australian dollars. This used a VLY in 2015 dollars of $184,730.

Converting this to a 2019 figure by applying the change in the Australian population aged 5-19 years old[15] and inflating this from 2015 to 2019 using the VLY in 2019 dollars of $213,000 (described in Section 4.3 above) instead of the VLY in 2015 dollars gives:

Burden of disease costs of asthma for 5-19 year olds in 2019

$$= \$5{,}021m \times \frac{\text{\# Australian 5-19 year olds @ 30 June 2019}}{\text{\# Australian 5-19 year olds @ 30 June 2015}} \times \frac{VLY_{2019}}{VLY_{2015}}$$

$$= \$5{,}021m \times 4{,}674{,}105 / 4{,}416{,}806 \times \$213{,}000 / \$184{,}730$$

[16] Deloitte Access Economics, *The Hidden Cost of Asthma - Asthma Australia and National Asthma Council Australia*. November 2015. Available online: https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-hidden-cost-asthma-241115.pdf

[17] Refer to Table A.6 in the Appendix.

[18] Refer to Table A.2 in the Appendix. The rate shown is calculated by compounding the relevant quarterly rates.

= $6,126m in 2019 Australian dollars

7.3 Extra costs of asthma for Australia attributed to coal-fired power stations

Both the extra person-days of asthma symptoms due to air pollution from coal-fired power stations and background person-days of asthma symptoms was provided by EJA as follows:

- extra person-days of asthma symptoms = 14,434 per annum
- background person-days of asthma symptoms = 8,907,837 per annum

These extra person-days of asthma symptoms are for 5-19 year olds only.

As per Section 2.2.2, it was assumed these relate to the 2019 calendar year.

An estimate of the **economic costs** of 14,434 extra person-days of asthma symptoms in 2019 due to air pollution from coal-fired power stations in 2019 Australian dollars:

$$= \$395\text{m} \times \frac{\text{extra person-days of asthma symptoms}}{\text{background person-days of asthma symptoms}}$$

$$= \$395\text{m} \times 14{,}434 / 8{,}907{,}837$$

$$= \$1\text{m}$$

An estimate of the **burden of disease** costs of 14,434 extra person-days of asthma symptoms in 2019 due to air pollution from coal-fired power stations in 2019 Australian dollars:

$$= \$6{,}126\text{m} \times \frac{\text{extra person-days of asthma symptoms}}{\text{background person-days of asthma symptoms}}$$

$$= \$6{,}126\text{m} \times 14{,}434 / 8{,}907{,}837$$

$$= \$10\text{m}$$

7.4 Implicit assumptions and limitations

The estimates above assume:

- that additional person-days of asthma symptoms caused by air pollution from coal-fired power stations is equivalent to additional asthma sufferers distributed evenly across the age 5-19 age bands in proportion to their existing distribution in the Deloitte report;
- that the population aged 5-19 exposed to the risk of asthma in the calculations underlying the 14,434 extra person-days of asthma symptoms and the Australian population aged 5-19 are homogeneous;
- that the change in the cost of asthma in Australia from 2015 to 2019 is proportionate to the change in the size of the population and cost indexation as per the calculation above without any change in the underlying gender/age distribution of the cost or the overall cost (due to improved asthma diagnosis and/or treatment, for example)

The estimates above are subject to all the limitations of the estimates in the Deloitte report from which they have been extrapolated.

7.5 Double counting

There will be some overlap between the extra person-days of asthma symptoms burden of disease costs above and the YLD component of the extra low birthweight live births burden of disease costs estimated in Section 6. However, this overlap is likely to be small so has been ignored.

There is no overlap between the cost of asthma and cost of premature deaths in this report because the cost of premature deaths does not include any premature deaths due to asthma for 5-19 year olds.

8 Extra premature deaths – economic costs

8.1 Methodology

A paper by Carter, Schofield and Shrestha (2017)[19] analyses the economic costs arising from the extra premature deaths in Australia in 2003, inflated to 2015. To estimate the economic costs of extra premature deaths arising from air pollution from coal-fired power stations, the extra premature deaths by cause from Table 2.1 above were mapped to the causes from Carter, Schofield and Shrestha (2017).

8.2 Results

The paper adopts a human capital approach to estimate the long-term productivity impacts of all-cause premature mortality, estimating:

- the working years; and
- present value of lifetime income (PVLI) lost,

as per the following table:

Table 8.1
Results from Carter, Schofield and Shrestha (2017) Paper

Cause of Death	Working Years Lost	PVLI Lost ($m)	# Deaths	PVLI Per Death ($m)
Cancer	87,653	4,200	25,733	0.163
Cardiovascular disease	51,659	2,582	18,450	0.140
Unintentional injuries	40,942	2,017	3,387	0.595
Intentional injuries	35,056	1,815	2,371	0.765
Diseases of the digestive system	11,633	588	2,466	0.238
Nervous system and sense organ disorders	9,206	439	2,343	0.187
Chronic respiratory disease	8,110	377	4,273	0.088
Mental disorders	7,280	376	575	0.654
Congenital anomalies	5,160	201	570	0.352
Infectious and parasitic diseases	5,064	261	695	0.375
Neonatal causes	4,972	150	600	0.250
Endocrine and metabolic disorders	4,369	209	899	0.232
Diabetes mellitus	4,221	205	1,732	0.118
Genitourinary diseases	2,936	141	1,387	0.102
Acute respiratory infections	2,515	121	932	0.130

[19] Carter, H.E., Schofield, D. and Shrestha, R., *The long-term productivity impacts of all cause premature mortality in Australia*. Australian and New Zealand Journal of Public Health (2017), 41: 137-143. Available online: https://doi.org/10.1111/1753-6405.12604

Cause of Death	Working Years Lost	PVLI Lost ($m)	# Deaths	PVLI Per Death ($m)
Other	3,296	140	1,001	0.140
Total (All Causes)	**284,072**	**13,821**	**67,414**	**0.205**

Table 8.2
Mapping Extra Premature Deaths to These Causes Applying the Same PVLIs

Cause of Death	PVLI Per Death ($m)	# Extra Premature Deaths	Estimated Economic Cost ($m)
Cancer	0.163	66	11
Cardiovascular disease	0.140	211	30
Diabetes mellitus	0.118	33	4
Acute respiratory infections	0.130	52	7
All Causes	**0.205**	424	87
Total		**785**	**138**

Inflating the $138m above from Sep 2015 to Jun 2019 inclusive[20] gives an estimate of the economic costs of the 785 extra premature deaths in 2019 due to air pollution from coal-fired power stations in 2019 Australian dollars of:

$138m x (1+ 6.70%) = $147m

8.3 Implicit assumptions

The assumptions implicit in the calculations described in this section are:

- For each negative health outcome, the gender, age and occupation distribution of extra premature deaths due to air pollution from coal-fired power stations in 2019 is the same as the gender, age and occupation distribution of deaths in Australia in 2003 for that negative health outcome (or a similar negative health outcome if a distribution for that negative health outcome was not available).

[20] Refer to Table A.2 in the Appendix

9 Extra premature deaths – burden of disease costs

9.1 Methodology

For each of the population and negative health outcome combinations listed in Table 2.1 above, the following methodology was adopted to calculate the YLLs (Years of Life Lost):

1) Split the extra premature deaths by gender and age bands using the latest available splits of the same negative health outcome combination of the Australian population.

2) For each gender and age band, calculate a weighted average life expectancy at the age of death based on:
   - averaging "$(e_x + e_{x+1}) / 2$" included in the age band from the latest available Australian Life Table[21];
   - using d_x from the latest available Australian Life Table[21] as weights.

3) Calculate the Years of Life Lost (YLLs) for each gender/age band combination by multiplying the # extra premature deaths from Step 1) above by the weighted average life expectancy at death from Step 2) above.

4) For the ischaemic heart disease, heart failure, stroke and ALRI negative health outcomes only, exclude YLLs for the age band including the 0-4 ages[22] from the total to remove any double-counting between the extra LBW births burden of disease costs and the extra premature deaths burden of disease costs. Excluding the entire age band including the 0-4 ages is a conservative approach.

Table 9.1
Generic YLL Calculation Table

Age Band	**# Extra Premature Deaths**			**Average Life Expectancy at Death**		**YLL (Years of Life Lost) [= $EPD_{M/Fn}$ x $LED_{M/Fn}$]**		
	Male	**Female**	**Total**	**Male**	**Female**	**Male**	**Female**	**Total**
AB_1	EPD_{M1}	EPD_{F1}	∑row	LED_{M1}	LED_{F1}	YLL_{M1}	YLL_{F1}	∑row
AB_2	EPD_{M2}	EPD_{F2}	∑row	LED_{M2}	LED_{F2}	YLL_{M2}	YLL_{F2}	∑row
AB_3	EPD_{M3}	EPD_{F3}	∑row	LED_{M3}	LED_{F3}	YLL_{M3}	YLL_{F3}	∑row
…	…	…	∑row	…	…	…	…	∑row
AB_n	EPD_{Mn}	EPD_{Fn}	∑row	LED_{Mn}	LED_{Fn}	YLL_{Mn}	YLL_{Fn}	∑row
All Ages	∑col	∑col	provided			∑col	∑col	∑col

[21] Refer to Table A.5 in the Appendix

[22] The YLLs used for the Burden of Disease "Neonatal Pre-Term Birth" cause in the Extra LBW Live Births Burden of Disease calculations in Section 6 do not extend beyond the 0-4 age band

9.2 Results by population and negative health outcome combination

9.2.1 Age 30+; death (all causes)

Table 9.2
Distribution of All Deaths by Gender and Age Band

Age Band	All Causes Deaths 2017[23]		
	Male	Female	Total
30–34	748	341	1,089
35–39	919	476	1,395
40–44	1,246	712	1,958
45–49	1,856	1,124	2,980
50–54	2,398	1,610	4,008
55–59	3,603	2,262	5,865
60–64	4,834	2,972	7,806
65–69	6,768	4,239	11,007
70–74	8,793	5,742	14,535
75–79	10,440	7,577	18,017
80–84	12,340	10,689	23,029
85–89	13,879	15,305	29,184
90–94	9,514	15,169	24,683
95–99	2,920	7,034	9,954
100+	381	1,577	1,958
Age 30+	80,639	76,829	157,468

[23] Australian Institute of Health and Welfare (AIHW), *Deaths in Australia - Data tables: Deaths in Australia 2019 - Table S2.1: Deaths by sex and age group, 2017,* AIHW (2019). Available online: https://www.aihw.gov.au/reports/life-expectancy-death/deaths-in-australia/data https://www.aihw.gov.au/getmedia/b7168df5-4678-42fd-afc3-6a0fc7fddf88/phe-229-data-tables.xlsx.aspx

Table 9.3
YLL Calculations for All Ages; Death (all causes)

Age Band	# Extra Premature Deaths			Average Life Expectancy at Death		YLL (Years of Life Lost)		
	Male	Female	Total	Male	Female	Male	Female	Total
30–34	2	1	3	49.1	52.8	99	48	147
35–39	2	1	4	44.3	48.0	110	61	171
40–44	3	2	5	39.6	43.1	133	83	216
45–49	5	3	8	35.0	38.4	175	116	291
50–54	6	4	11	30.4	33.7	196	146	342
55–59	10	6	16	26.0	29.1	252	177	430
60–64	13	8	21	21.8	24.7	284	197	481
65–69	18	11	30	17.8	20.2	324	231	555
70–74	24	15	39	14.0	16.1	331	249	580
75–79	28	20	49	10.5	12.3	296	250	546
80–84	33	29	62	7.6	8.9	253	255	508
85–89	37	41	79	5.3	6.1	199	252	451
90–94	26	41	66	3.8	4.2	97	170	267
95–99	8	19	27	2.7	2.8	22	53	75
100+	1	4	5	2.1	2.2	2	9	11
Age 30+	217	207	424			2,772	2,299	5,071

9.2.2 All ages; death (ischaemic heart disease & heart failure)

Table 9.4
Distribution of Coronary Heart Disease Deaths by Gender and Age Band

Age Band	Coronary Heart Disease Deaths 2017 (per 100,000)[24]		Population @ 30 June 2007[25]		# Deaths Due to Coronary Heart Disease 2017[26]		
	Male (A)	Female (B)	Male (C)	Female (D)	Male (E) = (A)/10^5 x (C)	Female (F) = (B)/10^5 x (D)	Total (E)+(F)
0–34	1	0	5,854,428	5,668,658	59	0	59
35–44	9	2	1,625,906	1,639,343	146	33	179
45–54	35	7	1,561,820	1,622,397	547	114	660
55–64	79	18	1,387,916	1,450,550	1,096	261	1,358
65–74	178	62	1,057,029	1,094,545	1,882	679	2,560
75–84	532	273	531,605	614,740	2,828	1,678	4,506
85+	2,147	1,719	185,066	307,857	3,973	5,292	9,265
All Ages			12,203,770	12,398,090	10,531	8,056	18,587

For the purposes of allocating the # extra premature deaths due to heart failure in Table 9.5 below, it was assumed that the distribution of heart failure deaths by gender and age bands was the same as the distribution of coronary heart disease deaths from the table above.

[24] Australian Institute of Health and Welfare (AIHW), *Cardiovascular disease - Data Tables - Table 3.7: CHD deaths, by age and sex, 2017,* AIHW (2019). Available online: https://www.aihw.gov.au/reports/heart-stroke-vascular-diseases/cardiovascular-health-compendium https://www.aihw.gov.au/getmedia/4a758db2-37c6-49b6-9f9e-578213fb42ed/aihw-cvd-83-data-tables.xlsx.aspx

[25] Refer to Table A.6 in the Appendix

[26] Used to allocate # extra deaths to gender and age bands in Table 9**9**.5

Table 9.5
YLL Calculations for All Ages; Death (ischaemic heart disease & heart failure)

Age Band	# Extra Premature Deaths			Average Life Expectancy at Death		YLL (Years of Life Lost)		
	Male	Female	Total	Male	Female	Male	Female	Total
0–34	0	-	0	61.7	69.3	removed to avoid double counting		
35–44	1	0	1	41.6	45.0	50	12	62
45–54	4	1	5	32.3	35.6	144	33	176
55–64	9	2	11	23.5	26.5	210	56	266
65–74	15	6	21	15.5	17.7	237	98	335
75–84	23	14	37	8.8	10.1	203	138	341
85+	32	43	75	4.2	4.4	136	190	326
All Ages	86	65	151			979	527	1,506

9.2.3 All ages; death (lung cancer)

Table 9.6
Distribution of Lung Cancer Deaths by Gender and Age Band

Age Band	Lung Cancer Deaths 2017[27]		
	Male	Female	Total
0–4	0	0	0
5–9	0	0	0
10–14	0	1	1
15–19	0	0	0
20–24	0	0	0
25–29	0	0	0
30–34	3	4	7
35–39	10	9	19
40–44	30	19	49
45–49	59	61	120
50–54	159	119	278
55–59	284	240	524

[27] Australian Institute of Health and Welfare (AIHW), *Cancer Data in Australia - Data tables: Cancer data in Australia - Book 2: Mortality supplementary tables - Table 2: Cancer mortality counts, age-specific rates, age-standardised rates, and mean and median ages of death, by sex and age group, actual data from 1982 to 2018 and projections to 2020*, AIHW (2020). Available online: https://www.aihw.gov.au/reports/cancer/cancer-data-in-australia/data https://www.aihw.gov.au/getmedia/26958c33-29fe-4e44-a950-21a903d7a0de/aihw-can-122-cancer_mortality.xlsx.aspx

Age Band	Lung Cancer Deaths 2017[27]		
	Male	Female	Total
60–64	527	347	874
65–69	735	473	1,208
70–74	878	630	1,508
75–79	854	501	1,355
80–84	666	428	1,094
85–89	521	366	887
90+	269	214	483
All Ages	4,995	3,412	8,407

Table 9.7
YLL Calculations for All Ages; Death (lung cancer)

Age Band	# Extra Premature Deaths			Average Life Expectancy at Death		YLL (Years of Life Lost)		
	Male	Female	Total	Male	Female	Male	Female	Total
0–4	-	-	-	80.1	84.2	-	-	-
5–9	-	-	-	73.6	77.9	-	-	-
10–14	-	0	0	68.1	72.3	-	1	1
15–19	-	-	-	63.3	67.6	-	-	-
20–24	-	-	-	58.8	62.8	-	-	-
25–29	-	-	-	54.0	57.8	-	-	-
30–34	0	0	0	49.1	52.8	1	2	3
35–39	0	0	0	44.3	48.0	3	3	7
40–44	0	0	0	39.6	43.1	9	6	16
45–49	0	0	1	35.0	38.4	16	18	34
50–54	1	1	2	30.4	33.7	38	31	69
55–59	2	2	4	26.0	29.1	58	55	113
60–64	4	3	7	21.8	24.7	90	67	157
65–69	6	4	9	17.8	20.2	102	75	177
70–74	7	5	12	14.0	16.1	96	79	175
75–79	7	4	11	10.5	12.3	70	48	119
80–84	5	3	9	7.6	8.9	40	30	69
85–89	4	3	7	5.3	6.1	22	18	39
90+	2	2	4	3.4	3.5	7	6	13
All Ages	39	27	66			553	439	991

9.2.4 All ages; death (stroke)

Table 9.8
Distribution of Stroke Deaths by Gender and Age Band

Age Band	Stroke Deaths 2017 (per 100,000)[28]		Population @ 30 June 2007[29]		# Deaths Due to Stroke 2017[30]		
	Male (A)	Female (B)	Male (C)	Female (D)	Male (E) = (A)/10^5 x (C)	Female (F) = (B)/10^5 x (D)	Total (E)+(F)
0–34	0	0	5,854,428	5,668,658	0	0	0
35–44	2	2	1,625,906	1,639,343	33	33	65
45–54	7	6	1,561,820	1,622,397	109	97	207
55–64	15	9	1,387,916	1,450,550	208	131	339
65–74	46	35	1,057,029	1,094,545	486	383	869
75–84	202	187	531,605	614,740	1,074	1,150	2,223
85+	809	936	185,066	307,857	1,497	2,882	4,379
All Ages			12,203,770	12,398,090	3,407	4,675	8,082

Table 9.9
YLL Calculations for All Ages; Death (stroke)

Age Band	# Extra Premature Deaths			Average Life Expectancy at Death		YLL (Years of Life Lost)		
	Male	Female	Total	Male	Female	Male	Female	Total
0–34	-	-	-	61.7	69.3	removed to avoid double counting		
35–44	0	0	0	41.6	45.0	10	11	21
45–54	1	1	2	32.3	35.6	26	26	52
55–64	2	1	3	23.5	26.5	36	26	62
65–74	4	3	6	15.5	17.7	56	50	106
75–84	8	9	17	8.8	10.1	70	86	156
85+	11	21	33	4.2	4.4	47	94	141
All Ages	25	35	60			244	292	536

[28] Australian Institute of Health and Welfare (AIHW), *Cardiovascular disease - Data Tables - Table 3.9: Stroke deaths, by age and sex, 2017,* AIHW (2019). Available online: https://www.aihw.gov.au/reports/heart-stroke-vascular-diseases/cardiovascular-health-compendium https://www.aihw.gov.au/getmedia/4a758db2-37c6-49b6-9f9e-578213fb42ed/aihw-cvd-83-data-tables.xlsx.aspx

[29] Refer to Table A.6 in the Appendix

[30] Used to allocate # extra premature deaths to gender and age bands in Table 9.9

9.2.5 All ages; death (ALRI)

Table 9.10
Distribution of Influenza Deaths by Gender and Age Band

Age Band	# Influenza Deaths 2017 (per 100,000)[31]		
	Male	**Female**	**Total**
0–44	10	11	21
45-64	33	25	58
65-69	30	24	54
70-74	39	25	64
75-79	45	55	100
80-84	93	105	198
85-89	111	161	272
90-94	97	215	312
95+	53	123	176
All Ages	511	744	1,255

For the purposes of allocating the # extra premature ALRI deaths in Table 9.11 below, it was assumed that the distribution of ALRI deaths by gender and age bands was the same as the distribution of influenza deaths from the table above.

[31] Australian Bureau of Statistics (ABS), *3303.0 - Causes of Death, Australia, 2017 - Deaths Due to Influenza, 2017 - Influenza deaths (J09-J11) - number and age-specific death rate by sex, 2017*, ABS (2018). Available online: https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/3303.0~2017~Main%20Features~Deaths%20due%20to%20influenza~5

Table 9.11
YLL Calculations for All Ages; Death (ALRI)

Age Band	# Extra Premature Deaths			Average Life Expectancy at Death		YLL (Years of Life Lost)		
	Male	Female	Total	Male	Female	Male	Female	Total
0–44	0	0	1	53.0	58.7	removed to avoid double counting		
45-64	1	1	2	26.3	29.4	36	30	66
65-69	1	1	2	17.8	20.2	22	20	42
70-74	2	1	3	14.0	16.1	22	17	39
75-79	2	2	4	10.5	12.3	19	28	47
80-84	4	4	8	7.6	8.9	29	38	67
85-89	5	7	11	5.3	6.1	24	40	65
90-94	4	9	13	3.4	3.5	13	31	44
95+	2	5	7	2.6	2.7	6	13	19
All Ages	21	31	52			172	218	389

9.2.6 All ages; death (diabetes)

Table 9.12
Distribution of Diabetes Deaths by Gender and Age Band

Age Band	Diabetes Deaths 2017 (per 100,000)[32]		Population @ 30 June 2007[33]		# Deaths Due to Diabetes 2017[34]		
	Male (A)	Female (B)	Male (C)	Female (D)	Male (E) = (A)/10^5 x (C)	Female (F) = (B)/10^5 x (D)	Total (E)+(F)
0–55	5	3	9,042,154	8,930,398	452	268	720
55–64	66	34	1,387,916	1,450,550	916	493	1,409
65–74	196	103	1,057,029	1,094,545	2,072	1,127	3,199
75–84	588	359	531,605	614,740	3,126	2,207	5,333
85+	1,538	1,133	185,066	307,857	2,846	3,488	6,334
All Ages			12,203,770	12,398,090	9,412	7,583	16,995

Table 9.13
YLL Calculations for All Ages; Death (diabetes)

Age Band	# Extra Premature Deaths			Average Life Expectancy at Death		YLL (Years of Life Lost)		
	Male	Female	Total	Male	Female	Male	Female	Total
0–54	1	1	1	43.3	47.2	38	24	62
55–64	2	1	3	23.5	26.5	41	25	67
65–74	4	2	6	15.5	17.7	62	38	100
75–84	6	4	10	8.8	10.1	53	43	96
85+	6	7	12	4.2	4.4	23	30	53
All Ages	18	15	33			217	160	377

[32] Australian Institute of Health and Welfare (AIHW), *Diabetes - Data Tables - Table 3.2: Diabetes deaths (underlying and/or associated cause), by age and sex, 2017*, AIHW (2019). Available online: https://www.aihw.gov.au/reports/diabetes/diabetes-snapshot/contents/deaths-from-diabetes; https://www.aihw.gov.au/getmedia/162cdeca-e7a1-4739-abaa-eab8146969e1/aihw-cvd-82-diabetes-2019.xls.aspx

[33] Refer to Table A.6 in the Appendix

[34] Used to allocate # extra deaths to gender and age bands in Table .13

9.3 Results summary

Table 9.14
YLLs for All Population and Negative Health Outcome Combinations

Pollutant	Population	Negative Health Outcome	# Extra Premature Deaths			YLL (Years of Life Lost)			Burden of Disease Cost (2019 AUD)
			Male	Female	Total	Male	Female	Total	
NO_2	Aged 30+	death (all causes)	217	207	424	2,772	2,299	5,071	$1,080m
$PM_{2.5}$	All Ages	death (ischaemic heart disease & heart failure)	86	66	151	979	527	1,506	$321m
$PM_{2.5}$	All Ages	death (lung cancer)	39	27	66	553	439	991	$211m
$PM_{2.5}$	All Ages	death (stroke)	25	35	60	244	292	536	$114m
$PM_{2.5}$	All Ages	death (ALRI)	21	31	52	172	218	389	$83m
$PM_{2.5}$	All Ages	death (diabetes)	18	15	33	217	160	377	$80m
Total			**406**	**379**	**785**	**4,937**	**3,934**	**8,871**	**$1,890m**

An estimate of the burden of disease costs of the 785 extra premature deaths in 2019 due to air pollution from coal-fired power stations in 2019 Australian dollars is therefore:

= 8,871 x 2019 VLY described in Section 4.3 above

= 8,871 x $213,000

= $1,890m

9.4 Implicit assumptions

The assumptions implicit in the calculations described above are:

- For each negative health outcome, the gender and age distribution of extra premature deaths due to air pollution from coal-fired power stations in 2019 is the same as the gender and age distribution of deaths in Australia in 2017 for that negative health outcome (or a similar negative health outcome if a distribution for that negative health outcome was not available).

10 Conclusion

The estimated costs of the negative health outcomes arising from air pollution from coal-fired power stations in Australia in 2019 are $2,423m in 2019 Australian dollars, divided into economic costs and burden of disease costs as follows:

	Estimated Costs (2019 Australian dollars)		
Negative Health Outcome	**Economic**	**Burden of Disease**	**Total**
Extra Low Birthweight Live Births	$101m	$275m	$376m
Extra Person-Days of Asthma Symptoms	$1m	$10m	$11m
Extra Premature Deaths	$147m	$1,890m	$2,036m
Total	**$249m**	**$2,174m**	**$2,423m**

Appendix

Table A.1
United States Hospital PPI Indexes and Hospital CPI Indexes, (2009=100)[35]

Year	Medicare PPI	Medicaid PPI	Private PPI	Overall PPI	Overall CPI
1997	71.0	80.3	60.4	67.3	48.3
1998	70.6	79.8	61.6	67.9	49.8
1999	71.0	80.4	63.1	69.1	51.9
2000	72.0	82.8	65.2	71.0	55.0
2001	73.8	84.9	67.6	73.1	58.7
2002	75.8	87.6	71.1	75.8	63.9
2003	79.7	90.9	76.8	80.2	68.7
2004	82.6	93.0	82.3	84.1	72.8
2005	85.6	94.4	85.8	87.3	76.7
2006	89.5	96.3	89.5	90.9	81.7
2007	93.2	98.0	93.0	94.1	87.1
2008	96.5	99.6	96.2	97.0	93.6
2009	100.0	100.0	100.0	100.0	100.0
2010	102.8	99.6	104.7	102.9	107.8
2011	104.4	100.9	108.2	105.1	114.5
2012	106.5	102.5	112.3	107.8	120.3
2013	107.1	101.3	118.1	110.2	126.0
2014	107.2	101.2	121.2	111.4	132.3
2015	106.0	100.2	124.4	112.3	137.7

Data Sources:

- PPI indexes for hospitals and CPI indexes taken from BLS data sources www.bls.gov

Abbreviations:

- PPI – Producer Price Index
- CPI – Consumer Price Index
- PPI – Producer Price Index

[35] Dunn, A., Grosse, S.D. and Zuvekas, S.H., *Adjusting Health Expenditures for Inflation: A Review of Measures for Health Services Research in the United States – Appendix Table 2*. Health Serv Res, 53: 175-196 (2018). Available online: https://doi.org/10.1111/1475-6773.12612

Table A.2
Australia Quarterly Health Care and CPI Inflation Rates – 2005 to 2019[36,37]

Year	Quarter	Health Care	CPI
2005	Mar	4.00%	0.70%
2005	Jun	2.40%	0.60%
2005	Sep	-1.10%	1.00%
2005	Dec	-1.10%	0.50%
2006	Mar	4.40%	0.80%
2006	Jun	2.40%	1.70%
2006	Sep	-0.70%	0.90%
2006	Dec	-0.80%	-0.10%
2007	Mar	3.50%	0.00%
2007	Jun	2.10%	1.30%
2007	Sep	-0.50%	0.70%
2007	Dec	-1.00%	0.90%
2008	Mar	4.00%	1.30%
2008	Jun	2.40%	1.40%
2008	Sep	-0.20%	1.20%
2008	Dec	-1.20%	-0.30%
2009	Mar	4.40%	0.10%
2009	Jun	2.30%	0.40%
2009	Sep	-1.00%	1.00%
2009	Dec	-0.90%	0.50%
2010	Mar	4.70%	1.00%
2010	Jun	2.20%	0.60%
2010	Sep	-0.70%	0.70%
2010	Dec	-1.20%	0.40%
2011	Mar	3.90%	1.40%
2011	Jun	2.00%	0.90%
2011	Sep	-1.00%	0.60%
2011	Dec	-1.20%	0.00%
2012	Mar	4.40%	0.10%
2012	Jun	1.50%	0.50%
2012	Sep	2.40%	1.40%
2012	Dec	-0.90%	0.20%
2013	Mar	3.00%	0.40%
2013	Jun	1.90%	0.40%
2013	Sep	0.00%	1.20%
2013	Dec	-0.50%	0.80%
2014	Mar	2.60%	0.60%
2014	Jun	2.90%	0.50%
2014	Sep	-0.20%	0.50%
2014	Dec	-0.90%	0.20%
2015	Mar	2.50%	0.20%
2015	Jun	2.70%	0.70%
2015	Sep	0.30%	0.50%
2015	Dec	-0.40%	0.40%
2016	Mar	1.90%	-0.20%
2016	Jun	2.60%	0.40%
2016	Sep	-0.20%	0.70%
2016	Dec	-0.60%	0.50%
2017	Mar	2.00%	0.50%
2017	Jun	2.70%	0.20%
2017	Sep	-0.20%	0.60%
2017	Dec	-0.50%	0.60%
2018	Mar	2.20%	0.40%
2018	Jun	1.90%	0.40%
2018	Sep	-0.40%	0.40%
2018	Dec	-0.40%	0.50%
2019	Mar	1.90%	0.00%
2019	Jun	1.80%	0.60%
2019	Sep	-0.20%	0.50%
2019	Dec	-0.30%	0.70%

[36] Australian Bureau of Statistics (ABS), *6401.0 - Consumer Price Index, Australia*, ABS (2005-2019). Available online: https://www.abs.gov.au/AUSSTATS/abs@.nsf/second+level+view?ReadForm&prodno=6401.0&viewtitle=Consumer%20Price%20Index,%20Australia~March%202020~Latest~29/04/2020&&tabname=Past%20Future%20Issues&prodno=6401.0&issue=March%202020&num=&view=& (accessed on 11 July 2020)

[37] Reserve Bank of Australia (RBA), *Statistical Tables - Inflation and Inflation Expectations*. RBA (2005-2019). Available online: https://www.rba.gov.au/statistics/tables/xls/g01hist.xls (accessed on 11 July 2020)

Table A.3
DALYs (Disability-Adjusted Life Years) for Australia 2017 for the "Neonatal Pre-Term Birth" Cause by Age Band[38]

Age Band	YLLs (Years of Life Lost)	YLDs (Years Lived with Disability)	DALYs (Disability-Adjusted Life Years)
Early Neonatal	15,008	10	15,018
Late Neonatal	1,592	29	1,621
Post Neonatal	2,342	471	2,813
1–4	87	2,232	2,319
5–9	-	2,921	2,921
10–14	-	2,719	2,719
15–19	-	2,606	2,606
20–24	-	2,794	2,794
25–29	-	2,960	2,960
30–34	-	2,986	2,986
35–39	-	2,726	2,726
40–44	-	2,557	2,557
45–49	-	2,562	2,562
50–54	-	2,244	2,244
55–59	-	1,986	1,986
60–64	-	1,519	1,519
65–69	-	1,071	1,071
70–74	-	612	612
75–79	-	257	257
80–84	-	66	66
85–89	-	18	18
90–94	-	7	7
95+	-	2	2
Total	**19,028**	**35,355**	**54,383**

[38] Institute for Health Metrics and Evaluation (IHME), *Global Burden of Disease Study 2017 (GBD 2017) Disability-Adjusted Life Years 1990-2017*. Seattle, WA: IHME, University of Washington, 2018. Available online: http://ghdx.healthdata.org/gbd-results-tool (accessed on 16 June 2020)

Table A.4
Australian Birth Data 2013-2018[39]

Year	Australian Live Births	
	Low Birthweight	Pre-Term
2013	19,597	24,643
2014	19,833	25,011
2015	19,852	24,954
2016	20,430	24,994
2017	20,271	24,862
2018	20,145	24,580

[39] Australian Institute of Health and Welfare (AIHW), *Australia's mothers and babies in 2013-2018 - Supplementary Tables and Data*. AIHW (2015-2020)
Available online:
2013 https://www.aihw.gov.au/getmedia/6b7f5e2b-6c91-4cbf-8795-a41d1218f1d4/19580-supp-data-tables.xls.aspx
2014 https://www.aihw.gov.au/getmedia/ae41bc6a-1ef5-49fd-8dd9-06baf696bf46/20210-supplementary-tables.xls.aspx
2015 https://www.aihw.gov.au/getmedia/d91df4b8-4e95-4f3e-aa57-caedf4db879e/aihw-per-91-supplementary-data-tables.xls.aspx
2016 https://www.aihw.gov.au/getmedia/fa6bada2-77db-42ff-8b6e-07b46b0621ac/aihw-per-97-australias-mothers-and-babies-data-tables.xlsx.aspx
2017 https://www.aihw.gov.au/getmedia/233c91fd-4b0c-49d6-b98d-3b86686034dc/aihw-per-100-data-tables.xlsx.aspx
2018 https://www.aihw.gov.au/getmedia/475b6918-c2c9-40d1-b4c2-a39f92d6bc88/per-101-data-tables.xlsx.aspx

Table A.5
Australian Life Tables 2016-2018[40]

Age	Males		Females	
	d_x	e_x	d_x	e_x
0	351	80.72958	303	84.87291
1	28	80.01323	23	84.13051
2	15	79.03599	12	83.15013
3	12	78.04741	11	82.16008
4	10	77.05699	8	81.16853
5	9	76.06484	8	80.17567
6	7	75.07128	7	79.18172
7	7	74.07688	5	78.18692
8	7	73.08217	6	77.19150
9	8	72.08738	5	76.19573
10	7	71.09261	6	75.19990
11	9	70.09801	7	74.20430
12	10	69.10403	8	73.20932
13	14	68.11134	11	72.21541
14	18	67.12059	13	71.22288
15	24	66.13258	15	70.23190
16	30	65.14818	17	69.24254
17	39	64.16823	20	68.25470
18	47	63.19318	21	67.26811
19	54	62.22288	22	66.28236
20	57	61.25592	23	65.29705
21	59	60.29083	23	64.31181
22	60	59.32649	23	63.32641
23	62	58.36248	23	62.34083
24	62	57.39851	23	61.35512
25	63	56.43432	24	60.36946
26	64	55.46978	26	59.38411
27	66	54.50514	27	58.39919
28	68	53.54110	28	57.41483
29	73	52.57809	30	56.43089
30	76	51.61628	32	55.44775
31	79	50.65564	37	54.46596
32	83	49.69591	39	53.48568
33	88	48.73751	43	52.50679
34	93	47.78054	48	51.52925
35	99	46.82530	51	50.55383
36	106	45.87213	55	49.57998

Age	Males		Females	
	d_x	e_x	d_x	e_x
51	295	31.89614	192	35.23309
52	320	30.99338	207	34.30154
53	349	30.09626	223	33.37362
54	381	29.20552	242	32.44962
55	413	28.32155	260	31.52957
56	446	27.44401	277	30.61333
57	481	26.57281	298	29.70033
58	522	25.70801	324	28.79122
59	566	24.85036	348	27.88709
60	613	24.00064	380	26.98757
61	662	23.15882	408	26.09374
62	713	22.32464	437	25.20470
63	764	21.49791	463	24.31963
64	820	20.67819	494	23.43781
65	879	19.86564	535	22.55970
66	947	19.06079	587	21.68748
67	1020	18.26430	651	20.82300
68	1102	17.47655	722	19.96819
69	1197	16.69867	792	19.12372
70	1303	15.93212	865	18.28832
71	1419	15.17807	951	17.46189
72	1544	14.43738	1050	16.64558
73	1679	13.71049	1163	15.84092
74	1817	12.99813	1282	15.04948
75	1966	12.29974	1413	14.27080
76	2134	11.61609	1555	13.50553
77	2320	10.94920	1720	12.75416
78	2520	10.30112	1910	12.01885
79	2727	9.67332	2108	11.30200
80	2945	9.06646	2330	10.60308
81	3165	8.48215	2580	9.92428
82	3377	7.92127	2849	9.26827
83	3579	7.38419	3126	8.63635
84	3779	6.87147	3434	8.02922
85	3957	6.38609	3730	7.45103
86	4090	5.93001	4005	6.90147
87	4167	5.50364	4281	6.38030

[40] Australian Bureau of Statistics (ABS), *3302.0.55.001 - Life Tables, States, Territories and Australia, 2016-2018 - Table 1.9 Life Tables, Australia, 2016-2018*, ABS (2019). Available online: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3302.0.55.001Main+Features12016-2018 https://www.abs.gov.au/ausstats/subscriber.nsf/log?openagent&3302055001do001_20162018.xls&3302.0.55.001&Data%20Cubes&17BF5F952115F2AACA2584A20012C328&0&2016-2018&30.10.2019&Latest

Age	Males		Females	
	d_x	e_x	d_x	e_x
37	113	44.92126	58	48.60696
38	120	43.97257	64	47.63541
39	127	43.02583	69	46.66589
40	134	42.08104	75	45.69825
41	143	41.13827	82	44.73266
42	154	40.19803	91	43.76928
43	164	39.26054	101	42.80918
44	179	38.32619	112	41.85275
45	193	37.39585	119	40.89968
46	210	36.46980	126	39.94870
47	225	35.54786	134	38.99930
48	240	34.62977	148	38.05222
49	255	33.71503	160	37.10887
50	274	32.80367	175	36.16914

Age	Males		Females	
	d_x	e_x	d_x	e_x
88	4179	5.10729	4510	5.89119
89	4116	4.74155	4682	5.43460
90	3961	4.40714	4777	5.01145
91	3728	4.10263	4756	4.62258
92	3424	3.82797	4614	4.26565
93	3060	3.58348	4365	3.93769
94	2648	3.36855	4031	3.63617
95	2164	3.18048	3497	3.36193
96	1726	2.98761	3157	3.08034
97	1387	2.77292	2649	2.83649
98	1121	2.54240	2202	2.59947
99	913	2.30889	1789	2.38002
100	2100	2.10433	4182	2.19424

Table A.6
Australian Population by 5-Year Age Band[41]

Age Band	30 June 2015		30 June 2017		30 June 2019	
	Males	Females	Males	Females	Males	Females
0–4	797,038	755,529	811,093	767,901	805,842	761,430
5–9	788,647	747,615	814,019	772,832	830,229	788,283
10–14	724,624	686,064	757,231	716,032	799,114	756,658
15–19	752,497	717,359	760,068	722,532	771,082	728,739
20–24	856,374	819,905	878,560	840,528	900,019	851,565
25–29	895,666	890,360	924,848	924,383	957,995	949,230
30–34	874,867	877,424	908,609	924,450	933,624	959,204
35–39	785,317	787,641	828,146	833,090	885,272	896,729
40–44	819,248	835,962	797,760	806,253	793,394	802,482
45–49	767,682	794,148	807,186	841,317	825,317	853,681
50–54	769,616	790,311	754,634	781,080	750,346	784,254
55–59	710,341	735,291	738,626	767,806	757,317	788,474
60–64	628,448	653,717	649,290	682,744	676,189	712,953
65–69	573,231	583,148	586,613	606,859	595,438	629,862
70–74	416,272	434,039	470,416	487,686	518,729	539,104
75–79	298,086	332,446	321,691	355,451	351,149	383,044
80–84	197,816	250,321	209,914	259,289	228,249	277,253
85–89	119,313	181,531	124,791	182,945	129,129	184,001
90–94	43,802	90,705	49,115	95,436	54,387	98,882
95–99	8,018	21,898	10,274	26,506	12,812	31,127
100+	749	2,929	886	2,970	1,422	3,543
Total	11,827,652	11,988,343	12,203,770	12,398,090	12,577,055	12,780,498

[41] Australian Bureau of Statistics (ABS), *3101.0 - Australian Demographic Statistics, Dec 2019 - TABLE 59. Estimated Resident Population By Single Year Of Age, Australia*, ABS (2020). Available online:
https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3101.0Dec%202019?OpenDocument
https://www.abs.gov.au/ausstats/abs@archive.nsf/log?openagent&3101059.xls&3101.0&Time%20Series%20Spreadsheet&2B19F51532210518CA25858A00260D02&0&Dec%202019&18.06.2020&Latest