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Estimating the Health Impact of Diesel Fuel Use from Road Based Transport

Horst (Oz) Kayak & Russell Thompson
The University of Melbourne
ozkayak@civenv.unimelb.edu.au

0419359299

ABSTRACT

Just as the risk of road trauma is a direct consequence of vehicles on the roads, so is the risk of cancer, diabetes and respiratory diseases, such as asthma. Fatality numbers due to road accidents are a dramatic newsbreak on most days. The tools available to measure the outcomes of the other road sector health risks are not so clear cut.

The disability adjusted life year (DALY) measurement is an indicator of the burden of disease (BoD) in the community. In this paper the DALY health measurement is used to indicate the difference in contribution to the BoD attributable to exposure to diesel engine emissions by people inside vehicles compared to those walking on footpaths along roadways used by the vehicles. The paper is in two sections. The first section quantifies the level of air pollution inside the vehicle cabin and compares it to that on the nearby footpath. The second section begins to set the scene for DALY health measurement to begin to estimate the differences in the BoD attributable to the different exposure rates to diesel engine emissions. The paper reports the conclusion that the possible contribution to the BoD for the population of the Melbourne Statistical Division (MSD) jurisdictions from exposure to diesel fuel emissions, by in-vehicle diesel engine environments is multiples greater than that to the population outside the vehicles. There is a need to build public health impact evaluation using tools such as the DALY health measurement for avoidable deaths into transport corridor planning policy

Keywords: Urban ecology, urban health, urban transport, diesel emissions, DALY, VATS

1 Background

In a world in which more than 50% of the population now lives in an urban environment, the application of the science of urban ecology to assist in management of the urban condition becomes an issue of ever increasing importance. The health of the urban population is affected by several factors which are unique to the urban environment. One of the factors determining the health of the urban population is air quality; in particular air quality affected by fuels used in the transport industry.

This paper is one in a series reporting on research in progress at The University of Melbourne to quantify the impact of transport activity on the wellbeing and health of urban communities

2 Introduction

In urban regions, such as Melbourne, emissions into the air are primarily a function of activities carried out by the population occupying the region. Of particular interest in this paper is the impact on a person's health of airborne emissions by the transport sector. The paper starts by describing the micro-environment air quality in the cabin of a diesel powered road vehicle as well as the air quality in the environment through which it is traveling, termed ambient conditions in this report.

The paper then begins to apply a simplified lifetime risk assessment methodology to quantify the potential health impact on people experiencing the two environments. This paper reports the results of a health impact model which compares the lifetime risk from the microenvironment of a truck cabin with that in the macro environment of a sub-region in the MSD. To illustrate the methodology the Municipality of Maribyrnong is used. Maribyrnong has some of the most heavy truck traffic in the MSD in its residential streets.

How much does the urban environment affect the mental and physical health of the urban dweller? How can the benefits to health from changes in the urban environment be measured?. When ever the word health is used in this paper, the term includes both mental and physical personal health.

2.1 The Study Area

The Melbourne Statistical Division (MSD) of 31 local government areas (LGAs) defines the study zone. ABS (2006) boundaries and populations define the population modelled. However only the Maribyrnong LGA is quantified for illustrative purposes.

SECTION 1 – Diesel Emission and Distribution

3.1 Diesel Engine Emissions

Diesel engine emissions include three health endangering compounds ultra-fine particles, gases including, nitrogen oxides and carbon monoxide, and volatile organic compounds (VOCs). Research into the composition and distribution of air pollutants from the engines of on-road vehicles continues in several research centres round the world. Engine generated air pollution enters the environment via the exhaust pipe and the engine crankcase vents. Crankcase vents can affect in-vehicle-pollution levels significantly.

3.1.1 Ultra-Fine Particles

The ultra-fine particle standards to be applied to in-cabin air quality management are not yet finalized by legislation in Australia, nor the USA. An example of the state of flux in the topic is demonstrated by the USA legislators over the years 1998-2001 having the ultra fine 2.5 standards challenged and blocked in the federal appeals court, but ultimately upheld by the Supreme Court. Emission standards for new diesel engines exist in the EU. The paper by Int Panis et al. (2001) is one of many research summary reports stating that diesel engines generate more ultra-fine particles than petrol engines. The ultra-fine particles (respirable particulates less than 10 microns, particularly particles less than 2.5 microns) in diesel fuel emissions are a health problem in themselves, as well as magnifying the adverse health impact of BTEX exposure. This paper focuses in the adverse impact on health from particulates, because there is consistent

evidence that the levels of fine particulate matter in the air are associated with the risk of death from all causes and from cardiovascular and respiratory illnesses.

Samet et al. (2000) is cited on 98 occasions in refereed journals which in various forms support the seriousness of the impact of ultra fine particulates on health.

Future research papers will quantify the impact on health from the other air pollution components. The four VOCs, benzene, toluene, ethylbenzene and xylene (BTEX) are generally regarded as chemical compounds associated with a range of adverse human health effects, from headaches and eye irritation to cancer.

3.1.2 In-Cabin Diesel Pollution

As Cheng et al. (2006a) reported there were no studies of the level of air pollution in diesel powered truck cabins available to the public in 2006. Cheng et al. (2006b) subsequently reported, that “readings for PM_{2.5} were within the range of 66-835 µg/m³ which were 1-13 times the recommended value”.

Using fingerprint identification for the PM_{2.5} fraction, Tana et al. (2007) support the conclusion “that *engine (sic)* vehicle emission is a major contributor to the presence of PM_{2.5} in the truck cabin” This is given additional support by Cheng et al. (2006b) who found that “the particle numbers increased when the truck was idling and decreased when the truck was off-duty as compared to the moving state.”

Research programs demonstrating higher air pollution inside many types of road vehicles compared to ambient air quality include, Chertok (2004), Fruin (2004) and Rodes C et al. (1998).

4.1 In-Cabin Air Pollution Exposure Rates

The level of in-cabin exposure to air pollutants is a direct function of the time a person spends in the cabin with the engine running. It is acknowledged that differences in the mixture and quantity of air pollution are generated by a diesel engine with variations in engine operation. This paper assumes a constant rate of air pollution based on a constant rate of fuel consumption per unit of time. In other words, it is assumed that two hours of driving expose the driver to twice the amount of air pollution compared to one hour of driving. Of relevance is the observation for “commute” vehicles by Rodes C et al. (1998) that:

“Elevated levels of both fine particles and black carbon were measured inside the test vehicle when it followed diesel-powered vehicles”

No literature was found that stated in cabin air quality was better than ambient air quality on the footpaths nearby.

Discussion on whether the in-vehicle air quality may be at a concentration and composition detrimental to the vehicle occupant’s health follows later in the paper.

4.2 Comparing Roadway, Footpath and Front Yard Exposure Rates

The dispersion of exhaust generated air pollution VOCs is one of rapid dilution. Vo Thi Quynh Truca et al. (2007) Figure 1, is one of the many recent confirmation studies.

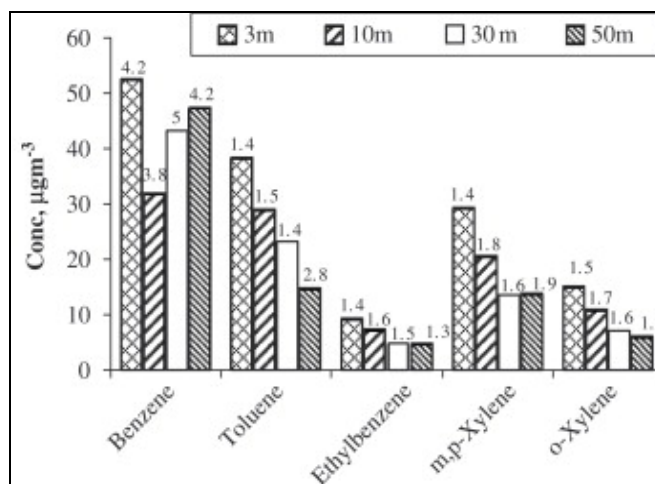


Fig. 1: Geometric mean concentration and its geometric standard deviation of BTEX

Note: (shown values) at distances of 3, 10, 30, and 50 m downwind from TC—each data point is the mean of 14 measurements.

4.3 Comparison of In-cabin and out of cabin pollution

Pollutant	Sacramento In-Vehicle	Sacramento Ambient	Los Angeles In-Vehicle	Los Angeles Ambient
MTBE, µg/m ³	3 to 6	2 to 7	20 to 90	10 to 26
Benzene, µg/m ³	3 to 15	1 to 3	10 to 22	3 to 7
Toluene, µg/m ³	7 to 46	4 to 8	22 to 54	10 to 40
PM _{2.5} , µg/m ³	6 to 22	6 to 11	29 to 107	32 to 64
PM ₁₀ , µg/m ³	5 to 14	2 to 4	<MQL to 22	<7 to 19
CO, ppm	<MQL to 3	<MQL	3 to 6	<MQL
Black Carbon, µg/m ³	<MQL to 10	na	3 to 40	na

Table 2: Selected In-Vehicle Pollutants in Los Angeles & Sacramento, California

Source: Adapted from: Rodes C et al. (1998)

Notes:

- 1) Abbreviations: <MQL, below quantification limit
- 2) min–max value ranges for all driving scenarios

Fruin (2004) aggregated the exposure rates shown in, Table 3: In-Vehicle Fraction of Total Ultra-fine Particle Exposure, and showed that exposure in vehicles is more than 50% for a person driving in LA.

Ultra-fine particle number and time spent

Location	Time (Hours)	Concentration ($\mu\text{g}/\text{m}^3$)
Residential	9	2 (night)
Residential	5.5	5 (evening)
Workplace	7	5
Outdoors	1	20
In-vehicle arterial	1	50
In-vehicle freeway	0.5	150

Table 3: In-Vehicle Fraction of Total Ultra-fine Particle Exposure

SECTION 2 – The Effect of Diesel on Public Health

5 General

There is abundant medical research literature reporting that the burning of diesel fuel may generate several potentially health damaging air born pollutants. The report *An Analysis of Diesel Air Pollution and Public Health in America* by the Clean Air Task Force (2005) is one of the many available comprehensive summaries of the topic. Modelling the impact of pollutants on health is complex and uncertain. Isolating and quantifying the effect of diesel generated carcinogenic compounds in population level morbidity and mortality rates requires debatable assumptions and approximations. This report uses only mortality rates to simplify comparisons.

5.1 Mortality Rates

One indicator of public health and public health trend is the mortality rate of the population being studied. Modelling the effect of urban population activity scenarios that may lead to premature death, requires a “normal” death age to be defined to be able to quantify years of possible life not lived. The accepted normal age at death is described as life expectancy (LE). However life expectancy is a “moving target” and dependent on when in the life cycle of a person or population cohort the estimate is made.

In preparation for evaluating the impact of various life shortening scenarios attributable to diesel exposure rates, the following mortality scene is set.

- 1) The oldest person living in the MSD on census night 2006 was of age 104. There were 573 people (0.016% of the total population), 100 years and over. For the purpose of this paper, 573 people are statistically insignificant in discussion of LE.
- 2) People born in 1906 in the Melbourne region would have had a LE of 55.6 years if the currently available mortality rates for the MSD for people born in 1906 are applied. Refer, Australian Institute of Health and Welfare (2007)
- 3) In 2005 there were 490.2 deaths per 100,000 population; subsequent discussion in this report aims to estimate the deaths per 100,000 population, possibly attributable to diesel generated emissions.
- 4) For males born in the years 2003-2005, their life expectancy is estimated to be 78.5 years, and for females born in the years 2003-2005, their life expectancy is estimated to be 83.3 years. However the following trends should be noted:

Males aged 30 in 2003-05 could expect to live to 79.7 years.

Males aged 65 in 2003-05 could expect to live to 83.1 years.

Females aged 30 in 2003-05 could expect to live to 84.1 years.

Females aged 65 in 2003-05 could expect to live to 86.4 years

- 5) Table 4 shows the leading causes of death in 2005. The dominance of cancer as a cause of death in the 45 to 84 age cohort is clear. How avoidable and amenable is early death by cancer?

	Males		Females	
Age group	Cause of death	% deaths*	Cause of death	% deaths*
15-24	Injury and poisoning	75	Injury and poisoning	57.1
	Cancer	6.3	Cancer	16
	Nervous system diseases	5.1	Nervous system disease	5.4
	Cardiovascular disease	4.2	Cardiovascular disease	4.3
25-44	Injury and poisoning	51.9	Cancer	35.5
	Cancer	14.1	Injury and poisoning	27
	Cardiovascular disease	13.9	Cardiovascular disease	13.5
	Digestive disorders	4.3	Digestive disorders	4.4

45-64	Cancer	42.5	Cancer	57.3
	Cardiovascular disease	26.4	Cardiovascular disease	15.1
	Injury and poisoning	10.5	Injury and poisoning	6.3
	Digestive disorders	5.6	Respiratory system disease	5.3
65-84	Cancer	38.1	Cardiovascular disease	34.3
	Cardiovascular disease	33.5	Cancer	33.8
	Respiratory system disease	9.6	Respiratory system disease	8.6
	Endocrine	4	Endocrine	4.7
85+	Cardiovascular disease	44.2	Cardiovascular disease	51.2
	Cancer	20.5	Cancer	12.6
	Respiratory system disease	12	Respiratory system diseases	8.8
	Genitourinary diseases	3.5	Mental disorders	5.2

Table 4: Leading causes of death by age and sex, 2005

* Percent of deaths within each age and sex group.

Source: AIHW National Mortality Database

4) Table 5 show the national death numbers by age group

Age (years)	Males		Females	
	Number	%	Number	%
<1	714	1.1	588	0.9
1-14	306	0.5	223	0.4
15-24	959	1.4	410	0.7
25-44	3,666	5.5	1,762	2.8
45-64	11,663	17.3	6,971	11
65-84	35,199	52.3	26,990	42.5
85+	14,721	21.9	26,576	41.9
Missing age	13		13	
Total	67,241	100	63,473	100

Table 5: Numbers of deaths by age group and sex, 2005

5.2 Aging of the MSD Population

An ever increasing percentage of the total urban population is in the 60 year and over age group. Table 6 shows this steady increase of 2.7 % from 1991 to 2006 for the MSD.

Count on Census Night	1991 (1)	1996 (1)	2001 (1)	2006 (2)
Total Population	3022439	3138147	3366542	3,592,592
Population 60 & over	442738	477924	536283	622,858
60 & over as a % of total population	14.65	15.23	15.93	17.34
60 & over per 1000 population	146.48	152.29	159.30	173.37
Increase over pervious 5 years	-	35186	58359	86575

Table 6: MSD population on census night

Sources: ABS (2006b, ABS (2007

5.3 DALY Definition

One DALY represents one lost year of 'healthy' life and is a combination of years of life lost (YLL) as a result of premature mortality plus an equivalent number of 'healthy' years of life lost as a result of disability (YLD).

“The burden of disease, therefore, measures the gap between current health status and an ideal situation in which everyone lives into old age free of disease and disability. As such, it indicates the ‘unfinished’ health agenda, identifying areas in which additional health gains can be made. The study uses the methods developed for the Global Burden of Disease Study, adapted to the Victorian context and drawing extensively on Victorian sources of population health data.”

Department of Human Services-Public Health Group (2005), page 1

5.4 Dose-Response Modelling (DRM)

Many studies aim at hazard identification and not DRM. “The DRM is important for quantifying mortality and morbidity associated with the respective air pollutants on a population level in the risk characterisation procedure”.

Twice the dose, twice the risk?

5.5 Which Bio-marker?

This paper limits its health modelling to a single illustrative case which is the application of the role of the DALY health measurement in evaluating transport policy options. It uses the bio-marker of cancer outcomes that are possibly attributable to compounds in diesel. The State of California (USA), places several hundred compounds on a Proposition 65 list of chemicals "known to the state of California to cause cancer". Victoria has no equivalent list of carcinogens.

Several of the most carcinogenic are found in diesel, These compounds include, benzene, toluol or toluene, and xylene Benzene is an extremely carcinogenic chemical, and has been declared unsafe by the World Health Organisation in any concentration.

5.6 Cohorts for which the DALY is Modeled

The simplifying assumptions made include:

- 1) The in-cabin DALY is calculated for diesel fuelled trucks driven by males of age 18 to 65 traveling in the MSD.
- 2) The footpath DALY for the total urban population is calculated using occupancy rates derived from the Victorian Activity and Travel Survey (VATS) for the MSD

6 Discussion

For the purpose of this discussion to attempt to set quantifiable health evaluation criteria to enable transport sector activity evaluation several arguable assumption are made.

- 1) Truck drivers are male with an overall normal life expectancy of 78
- 2) In-Cabin time of drivers while in the Maribyrnong LGA averages out at 1 hour.
- 3) Only a work week day, is modelled.
- 4) 20,000 truck trips occur in the LGA on a work week day

- 5) The overall Maribyrnong population LE approximation for modelling purposes is 80
- 6) There are 50 km of residential streets with significant truck traffic where truck traffic impacts directly on local air pollution..
- 7) Streets that generate predominantly retail and service activity are not included in the residential exposure model
- 8) The residential population of Maribyrnong is 64,000
- 9) Population inflow and outflow are approximately in balance over 24 hours on a week day.
- 10) The population of people traveling through the LGA without stopping in other than diesel trucks has not been modelled.

6.1 Exposure Rates

Table 6: Maribyrnong LGA Location Exposure Rates

Drivers	Truck Drivers	Time	Per Day	Exposure Rate	Aggregate Exposure	Source
	(number)	(hours/driver)	(driver hours)	($\mu\text{g}/\text{m}^3$)	Index	
In Maribyrnong	20,000	1	20,000	150	3000000	VicRoads
Residential Population	Resident	Time (hours/person)	Location Exposure	Exposure Rate ($\mu\text{g}/\text{m}^3$)		
In Maribyrnong LGA						
At home evening	64000	4	256000	5	1280000	VATS
At home night	64000	12	768000	2	1536000	VATS
Out-of Home	64000	8	512000	5	2560000	VATS
Travel	20,000	1	20000	50	1000000	VATS

6.2 Estimating Mortality Rate Reductions

In the USA, The Clean Air Task Force (2005), (CATF) estimates that a feasible and practical program to retrofit existing diesels would cumulatively avoid approximately 100,000 premature deaths between 2005 and 2030. In generating this estimate, the CATF followed a methodology developed by EPA during its analysis of the benefits of the heavy-duty diesel rule to predict the future benefits of a hypothetical emission reduction initiative. The method is not sufficiently rigorous for a full regulatory impact analyses, but provides a first-order approximation in the absence of time-consuming and prohibitively costly air quality modeling. The EPA approach determines a health damage transfer factor from pre-existing modeling (expressed in population-adjusted damages/ton emissions/person) and applies it to the number of tons reduced from a new emissions reduction scenario.

The USA EPA after extensive research state that ASPEN 1999 ambient diesel fine particle concentration is 1.3822 $\mu\text{g}/\text{m}^3$ in urban areas and converts to cancer risks of 415

per million in urban areas. That is 41 per 100,000 population of extra deaths above the base cancer rates. Ambient, in this scenario, means that the population is exposed to the particles 24 hours a day. Appendix A provides a fuller explanation.

6.3 Australian Legislation

Australia lacks a nationally agreed to comprehensive set of air pollution standards. However the National Environmental Protection Council Act (1994) Section 14(1) includes reference to ambient air quality. The Act refers to National Environment Protection Measures (NEPM). Limited action was taken by the NEPC in 1998, to initiate the Ambient Air Quality National Environment Protection Measure (AAQ NEPM) that set national ambient air quality standards to apply Australia wide. These standards cover six pollutants – particles (PM10), ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and lead. The NEPM provides a nationally consistent framework for the monitoring and reporting of these six pollutants. The NEPM was varied in 2003 to incorporate advisory reporting standards for fine particles (PM2.5)

The AAQ NEPM was adopted into Victorian legislation by the creation of the State Environment Protection Policy (Ambient Air Quality) [SEPP (AAQ)] which adopted all provisions of the NEPM. The NEPM may also relate to motor vehicle emissions

*“The emissions of most interest in relation to diesel vehicles are oxides of nitrogen (NOx) and fine particles, (also known as fine particulates). NOx is a precursor to the formation of photochemical smog. There is also evidence that NOx reacts with other pollutants to form particles. **Fine particles have been identified as a major health risk. The smaller the particle the greater the risk.**”*

Source: http://www.ephc.gov.au/nepms/diesel/diesel_intro.html

The goals, standards, protocols, and guidelines determining National Environment Protection Measures (NEPM) are prescribed in the NEPC Act (1994) which includes reference to ambient air quality.

Air pollution for comparison purposes is generally measured in micro-grams per 1000 cc. Each diesel compound has a different severity of impact on health. Concentration of pollution variation must there for be compared within each category of polluting compound.

Diesel fuel quality improvements are underway as indicated in:

http://www.ephc.gov.au/nepc/annual_report06.html#nepm_imp

http://www.ephc.gov.au/pdf/annrep_05_06/AR_Jur_DVE_05-06.pdf

http://www.ephc.gov.au/pdf/annrep_05_06/AR_Nat_Rep_AAQ_05-06.pdf

6 4 Estimating Intervention Strategies that Reduce YLL or conversely increase LE

The DALY health measurement is the combination of YLL and YLD.

As part of the measure of overall life expectancy, healthy life expectancy (HALE) is a measure of the expected number of years to be lived in what might be termed the equivalent of 'full health'. HALE calculations adjust the overall life expectancy by the years of ill health according to their severity.

In 2002, Australian males could expect to live 70.9 years of healthy life, and females 74.3 years. This means that Australian males can expect to live 90% of their lives in good health.

This paper has only taken a small step toward quantifying the DALY, your comment will be appreciated.

7 Conclusion

- 1) Even a limited search of refereed research literature clearly shows that the in-vehicle microenvironment contains higher than ambient levels of engine generated health endangering air pollution.
- 2) A simplified and approximate DALY analysis will be able to show that the impact on the health of vehicle drivers from diesel use is far greater than the roadside or general population.
- 3) Government programs that reduce the risk of premature death from diesel fuel to truck drivers rather than reducing the health risk to the general residential population would be the most cost effective.
- 4) An epidemiological study is required to quantify mortality and morbidity patterns for the drivers of diesel powered vehicle. Premature and preventable deaths of truck drivers due to in-cabin pollution should be a serious occupational health and safety issue.

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Appendix A: Cancer Risk from Diesel Particles

Source: [http://www.catf.us/publications/reports/Diesel in America Technical Paper.pdf](http://www.catf.us/publications/reports/Diesel_in_America_Technical_Paper.pdf)

“1) The number per million is the chance in a population of a million people who might be expected to get cancer over a 70-year lifetime. A potential cancer risk of 10 in a million means if one million people were exposed to a certain level of a pollutant or chemical there is a chance that 10 of them may develop cancer over their 70-year lifetime. This would be 10 new cases of cancer above the expected rate of cancer in the population.

2) For 1999 NATA national excess cancer risk from air toxics other than diesel see: Inside EPA, Inside Washington Publishers, (December 15, 2004) <http://www.insideepa.com/>

3) This finding is based on inhalation as the only exposure path and is limited to the thirty-three air toxics included in EPA’s 1996 National Air Toxics Assessment (NATA). The relative cancer risk of diesel particulate matter is calculated as a ratio of the cancer risk of all air toxics tracked by EPA in the NATA divided by the risk of diesel particulate. We calculated the cancer risk for diesel PM in the U.S. based by applying the CARB cancer unit risk factor for diesel particulate matter to 1999 ASPEN model average national ambient concentration results for diesel PM. (Source for national toxic risk: Inside EPA, Inside Washington Publishers, December 15, 2004.)

4) The national average ambient diesel particulate matter concentration from 1999 ASPEN modeling (1.21 ug/m³) was multiplied times the CARB diesel particulate matter unit risk of 3 in 10,000 per 1.0 ug/m³ and distributed over the 2005 U.S. population to get total of 107,000 lifetime cancers assuming a 70-year lifetime of exposure to the national average ambient concentration. The annual estimated impact is calculated by dividing the 107,000 lifetime cancers by 70 years, arriving at 1,530 annual cancers attributable to diesels per year. This estimate is likely very conservative (low) because urban areas where larger populations dwell, are characterized by concentrations that are much higher than the national average.

5) According to the EPA’s categorization of counties as urban or rural, the average ASPEN 1999 ambient diesel fine particle concentration is 1.3822 ug/m³ for urban counties and 0.4730 ug/m³ for rural counties. The overall national average is 1.2096 ug/m³. These averages are population weighted. These averages convert (using the 0.0003 factor) to cancer risks of 415 per million urban, 142 per million rural, and 363 per million average.

Appendix B: LE Tables

	At birth		At age 15		At age 65	
Year	Males	Females	Males	Females	Males	Females
Annual average						
1901-10	55.2	58.8	49	51.9	11.3	12.9
1920-22	59.2	63.3	51.4	54.6	12	13.6
1946-48	66.1	70.6	54.3	58.3	12.3	14.4
1960-62	67.9	74.2	55.1	61	12.5	15.7
1980-82	71.2	78.3	57.4	64.3	13.8	18
Annual rates						
1990	73.9	80.1	59.8	65.8	15.2	19
1991	74.4	80.4	60.2	66	15.4	19.1
1992	74.5	80.4	60.3	66.1	15.4	19.2
1993	75	80.9	60.8	66.5	15.7	19.5
1994	75	80.9	60.8	67	15.7	19.7
1994-1996(a)	75.2	81.1	60.9	66.7	15.8	19.6
1995-1997(a)	75.6	81.3	61.3	66.9	16.1	19.8
1996-1998(a)	75.9	81.5	61.5	67.1	16.3	20
1998-2000(a)	76.6	82	62.2	67.6	16.8	20.4
2000-2002(a)	77.4	82.6	63	68.1	17.4	20.8
2003-2005(a)	78.5	83.3	64.1	68.9	18.1	21.4

Table 5: Life expectancy (years) at selected ages, 1901-10 to 2003-2005

(a) The methodology used to calculate this table has changed since 1995. Data on population and deaths averaged over 3 years are now used to minimise year to year statistical variations.

Sources: ABS Cat. No. 3302.0; ABS unpublished data.

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