

2 Methodology

2.1 Overview

The DALY extends the concept of potential years of life lost due to premature death (PYLL) to include equivalent years of 'healthy' life lost by virtue of being in states other than good health. DALYs for a disease or health condition are calculated as the sum of the years of life lost due to premature mortality (YLL) in the population and the equivalent 'healthy' years lost due to disability for incident cases of the health condition:

$$\text{DALY} = \text{YLL} + \text{YLD}$$

The loss of healthy life due to non-fatal health conditions (YLD) requires estimation of the incidence of the health condition (disease or injury) in the specified time period. For each new case, the number of years of healthy life lost is obtained by multiplying the average duration of the condition (to remission or death) by a severity weight that measures the loss of healthy life using an average health state weight. The DALY is described in detail in Murray and Lopez (1996a).

The Australian study departs from the GBD methodology in the following five areas:

- The GBD uses a standard life table with a life expectancy at birth of 82.5 years for females and 80.0 years for males to calculate YLL. Australian cohort life expectancies that take projected future declines in mortality into account are higher than this: 85.7 years for females and 81.5 years for males. The Australian project uses Australian cohort life expectancies for 1996 to calculate YLL.
- The GBD discounted DALYs using a 3% time discount rate and applied age weights that gave higher weight to a year of life in young and mid-adult years, and lower weight to a year of life at very young and older years. The Australian project also uses a 3% discount rate but does not use age weights.
- The Australian study uses a set of Dutch weights for conditions common in developed countries, supplemented by weights used in the GBD study for other conditions. In general, the Dutch and GBD weights are reasonably consistent, but in the longer term it would be desirable to carry out weighting exercises in Australia to examine how appropriate the weights are in the Australian context.
- The Australian study includes a wider range of disease and injury categories than the GBD.
- The GBD did not attempt to deal with the effects of comorbidities on YLD estimates for individual diseases. The Australian study adjusts YLD estimates for comorbidities between mental disorders and between physical disorders at older ages.

2.2 Analysis categories

Estimates of burden of disease have been made for a comprehensive set of 176 disease and injury categories. Following the classification scheme used by the GBD study, disease and injury categories were grouped in three broad cause groups:

- Group I: Communicable, maternal, neonatal and nutritional conditions;
- Group II: Noncommunicable diseases; and
- Group III: Injuries.

Each of these groups is then subdivided into subcategories (22 in total), most of which correspond to chapter-level groups of ICD-9 codes. These are further divided into 176 individual disease and injury categories, such as hepatitis B infection, breast cancer, and accidental falls. Annex Table A lists these categories and defines them in terms of ICD-9 codes.

Estimates of burden of disease have been made for these condition categories using the following age groups:

0–4, 5–14, 15–24, 25–34, 35–44, 45–54, 55–64, 65–74, 75+.

Detailed estimates for YLL, YLD and DALYs in Annex Tables E–H are presented in terms of 20-year age groups for reasons of space. Full estimates by 10-year age groups are available on request. Analyses to be carried out for subpopulations below national level are limited at this stage to population quintiles of relative socioeconomic disadvantage (using a small-area-based index derived from census data).

2.3 Discounting and age weights

The main results reported here for the burden of disease and injury in Australia use DALYs calculated with a 3% discount rate (see Section 1.6). The effect of discounting on years of life lost due to mortality is shown in Figure 2.1 in the following section. The effect of discounting on the pattern and distribution of disease burden in Australia is examined in Section 5.5.

As discussed in Section 1.7, the DALY allows for non-uniform age weights. The particular age weights used in the GBD result in greater weight being given to all deaths below age 38 compared to deaths at older ages for Australia. The Steering Committees for both the Australian and Victorian burden of disease studies decided that uniform age weights should be used. All results in the Australian study reported here use uniform age weights ($K=0$ in the terminology of the GBD).

2.4 Years of life lost due to mortality

Years of life lost due to mortality (YLL) are the mortality component of DALYs. The GBD Study calculated the years of life lost due to a death at a given age using the life expectancy at that age in standard life tables (Coale and Demeny West Model Level 26) with life expectancy at birth fixed at 82.5 years for females and 80.0 years for males.²⁰ Murray (1996) argued that there is evidence for an intrinsic biological difference in life expectancy for males and females, but that it is much less than the approximately 5–7 years observed in

developed countries. Much of this excess is due to higher male exposure to various risks, e.g. alcohol, tobacco, occupational exposures – and arguably should not be allowed for in estimates of the burden of mortality.

The Steering Committee for the Australian Burden of Disease and Injury Study decided that cohort life expectancies for Australians alive in 1996 should be used to estimate the burden of premature mortality. Unlike the usually quoted ‘period’ life expectancies (ABS 1999c), which synthesise the currently observed mortality patterns across all age groups in the population, cohort life expectancies use projected trends in mortality rates to estimate the average life expectancies likely to be achieved by people currently alive.

Projections of Australian mortality rates to the year 2051 (ABS 1998a) were used to estimate cohort life expectancies by age and sex for Australians alive in 1996.²¹ The projected cohort life expectancy for infants born in 1996 is 81.5 for males and 85.7 for females, compared to period life expectancies at birth in 1996 of 75.6 and 81.3 respectively. The male–female difference is around 4.2 years compared to 5.7 for the period life expectancies and 2.5 for the GBD.

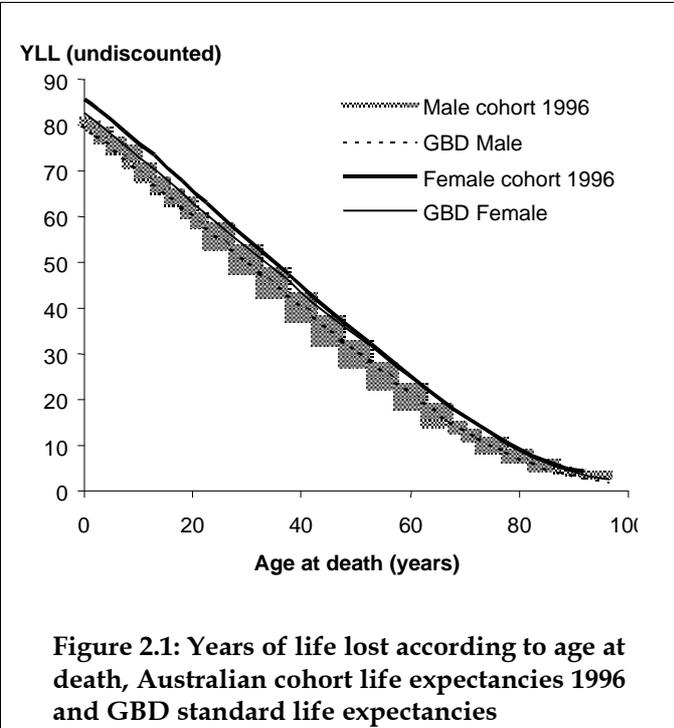


Figure 2.1 compares the 1996 Australian cohort life expectancies with the GBD standards. There is very little difference (and if discounting is applied this almost completely disappears).

If Australian YLL are calculated using the GBD standard life tables rather than the cohort life tables, the differences are small. At 3% discounting, they become negligible.

For each age category used in this study, mean cohort life expectancy was calculated from the observed mean age at death in the age interval and interpolation between the cohort life expectancy estimates at the exact ages defining the age interval.

The mean life expectancy in each age interval was then discounted using the formula:

$$YLL = (1 - \exp(-0.03L)) / 0.03$$

where L is the life expectancy. The effect of discounting on years of life lost due to mortality is shown in Figure 2.2. Cohort life expectancies for cohorts alive at various ages in 1996 and YLLs due to a death at each of these ages are shown in Table 2.1. Note that YLLs are lost due to deaths at every age. A death at age 95 results in a loss of YLLs. Unlike most potential years of life lost (PYLL) measures, YLLs do not exclude deaths above a certain age level, or give zero value to years of life lost above that age level.

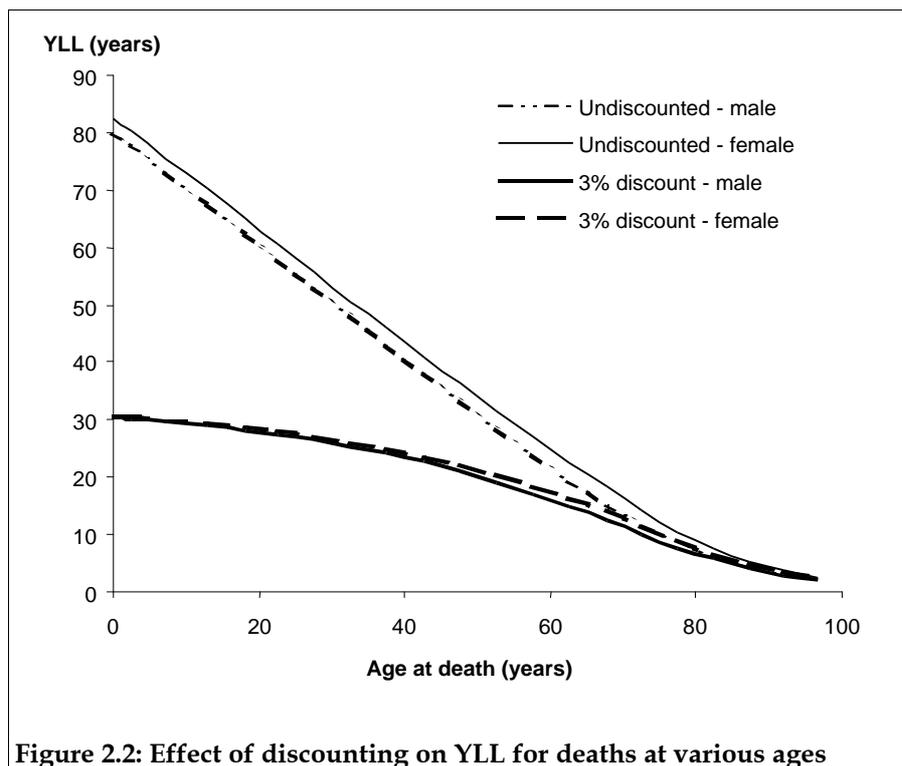


Figure 2.2: Effect of discounting on YLL for deaths at various ages

Table 2.1: Projected cohort life expectancies at selected exact ages and discounted YLL due to a death at each age used in the Australian Burden of Disease and Injury Study

Age (years)	Life expectancy (years)		YLLs due to a death at each age (discounted at 3%)	
	Males	Females	Males	Females
0	81.45	85.69	30.44	30.78
5	76.88	81.20	30.01	30.42
15	66.22	70.87	28.76	29.36
25	55.92	60.55	27.11	27.91
35	45.65	50.16	24.86	25.93
45	35.43	39.82	21.82	23.24
66	25.50	29.85	17.82	19.72
65	16.75	20.56	13.17	15.34
75	9.89	12.50	8.55	10.42
85	5.39	6.64	4.97	6.02
95	3.30	3.49	3.14	3.32

2.5 Disability weights

The DALY uses explicit preference weights for health states derived using a deliberative person trade-off (PTO) method (see Section 1.5). No comprehensive Australian measurements of disability weights have yet been undertaken. The Netherlands has carried out a project to measure weights for 53 diseases of public health importance, involving the

estimation of weights for 175 disease stages, sequelae and severity levels (Stouthard et al. 1997).

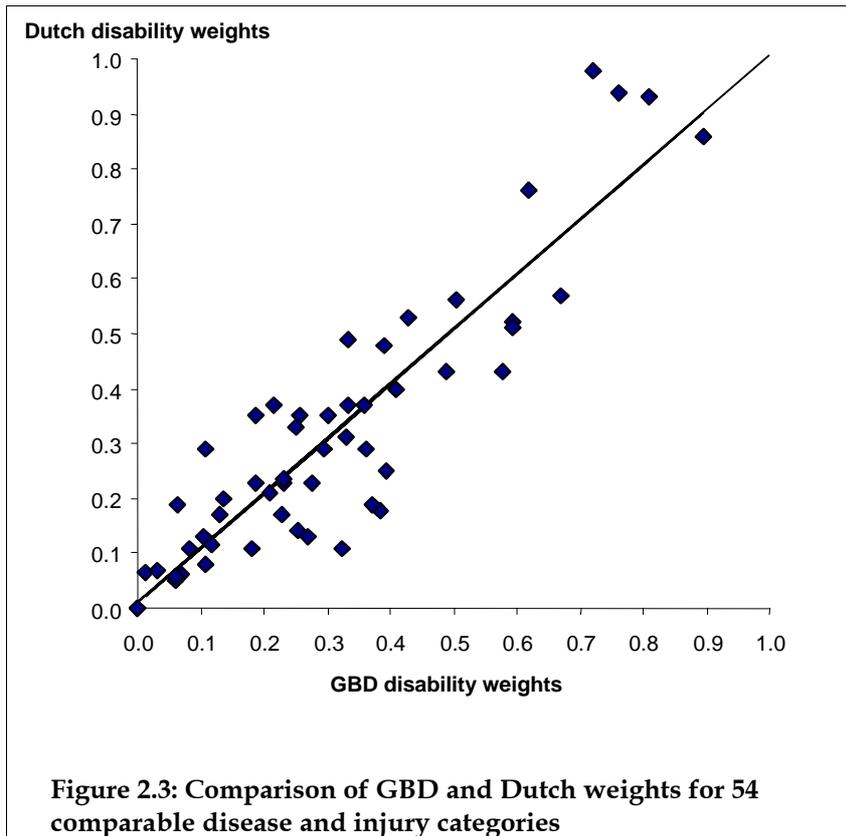
The Dutch weights only cover a restricted range of conditions, but they differentiate between different condition stages and severities. Hence they can be applied more directly to detailed disease models in estimating YLD and allow Australian information on the severity distribution of each disease to be taken into account. Further the conditions they focus on are also those of most relevance to the health of the Australian population.

The Dutch weights also have the great advantage that they define each disease stage or sequela in terms of a standardised health state description using a variant of the EuroQol 5D classification, the EQ-5D+, which includes a sixth dimension for cognitive functioning (see Box 2.1). For many conditions, either there are no standard clinical definitions of severity or stages, or available Australian population data do not use these definitions. The availability of standardised health state descriptions in the Dutch study has greatly assisted in defining and estimating distributions of severity levels from Australian population data. The estimation of the burden of mental disorders from the 1997 National Mental Health Survey provides an example of this (see Section 5.2).

The GBD weights cover a wider range of conditions, but generally for less specific disease and sequelae categories. The exception is injury, where the GBD has a much more comprehensive set of weights for the short-term and long-term sequelae of 39 types of injury. For this first Australian Burden of Disease and Injury Study, we have used Dutch weights where possible. For disease and injury categories where Dutch weights are not available, we have generally used the GBD weights if these are available.

Box 2.1 The EuroQol 5D+ classification for health status (Stouthard et al. 1997)

<i>Dimension</i>	<i>Level</i>	<i>Code</i>
<i>Mobility</i>	<i>No problems in walking about</i>	1
	<i>Some problems in walking about</i>	2
	<i>Confined to bed</i>	3
<i>Self-care</i>	<i>No problems with washing or dressing self</i>	1
	<i>Some problems with washing or dressing self</i>	2
	<i>Unable to wash or dress self</i>	3
<i>Usual activities</i>	<i>No problems performing usual activities (e.g. work, study, housework, family, leisure)</i>	1
	<i>Some problems with performing usual activities</i>	2
	<i>Unable to perform daily activities</i>	3
<i>Pain/discomfort</i>	<i>No pain or discomfort</i>	1
	<i>Moderate pain or discomfort</i>	2
	<i>Extreme pain or discomfort</i>	3
<i>Anxiety/depression</i>	<i>Not anxious or depressed</i>	1
	<i>Moderately anxious or depressed</i>	2
	<i>Extremely anxious or depressed</i>	3
<i>Cognition</i>	<i>No problems in cognitive functioning (e.g. memory, concentration, coherence, IQ)</i>	1
	<i>Some problems in cognitive functioning</i>	2
	<i>Extreme problems in cognitive functioning</i>	3

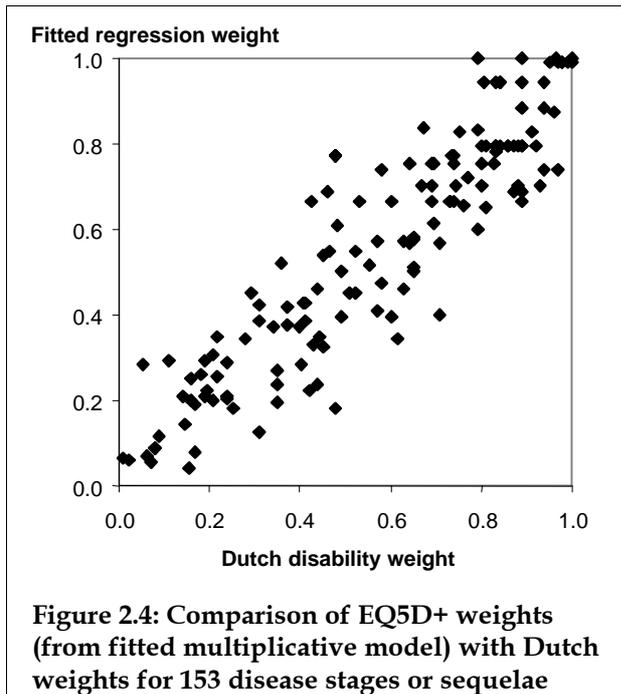


The two sets of disability weights cannot be directly compared for most conditions because the disease categories in the Dutch study are more specific.²² There are 54 disease and injury categories in the Australian study where Dutch weights were used and GBD weights are also available. Figure 2.2 compares the Dutch and GBD disability weights for these 54 conditions. In some cases, the GBD weight for a disease category has been compared with the average Dutch weight across a range of disease stages or sequelae using Australian information on stage/sequelae distributions.

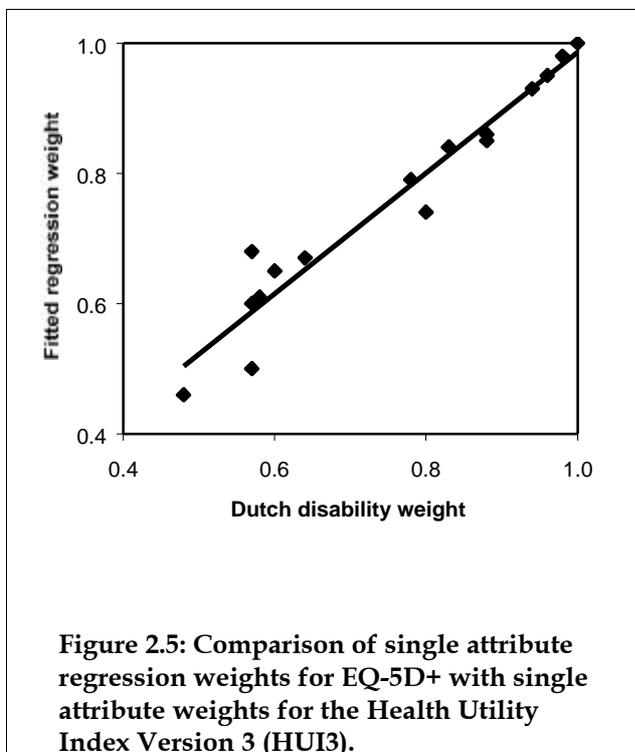
The correlation coefficient for these two sets of disability weights is 0.91 and the line of best fit (shown in Figure 2.3) has a slope of 0.998 and an intercept of 0.009. This suggests that the two studies generally valued the same conditions in a similar way, and that it is reasonably valid to use GBD and Dutch weights in the same study.

There are some disease categories included in the Australian study for which there are no weights in either the Dutch or GBD studies. To assist in estimating provisional weights for these, we have fitted a multiplicative regression model²³ for the single attribute states defined by the six dimensions of the EQ-5D+ (see Box 2.1). Figure 2.4 shows the fitted regression weights plotted against the weights estimated in the Dutch study. The model explains 92% of the variation in the Dutch weights. Unexplained variance may reflect the limitations of the EQ-5D+ in fully describing important variations in health status associated with different diseases or perhaps inconsistencies in the valuations of similar health states.

The EQ-5D+ regression model has been used to estimate disability weights for 33 disease stages, severity levels or sequelae where empirical evidence or expert opinion could be used to specify the distribution using the EQ-5D+. The validity of the estimated weights depends on the accuracy of the EQ-5D+ descriptions and the validity of the fitted regression model.



of the very different methods used to obtain these weights.²⁵ The Dutch weights were for specific disease states and derived using PTO, a deliberative approach, small expert panels and one lay panel; whereas the HUI3 study used generic health state descriptions, the standard gamble approach, no deliberation, and 500 members of the general population.



Apart from the internal validity of the model in fitting the Dutch weights, we have also validated the regression model by comparing it with a multiplicative regression model for the Health Utility Index Version 3 (HUI3).

Furlong et al. (1998) have fitted a multiplicative function to measured utility weights for the HUI3. The HUI3 has more dimensions and more levels than the EQ-5D+ but there is reasonable correspondence between most of these. Figure 2.5 compares the single attribute weights for the HUI3 and the EQ-5D+ regression model.²⁴ The correlation coefficient for the two sets of weights is 0.94. Although the mapping carried out between HUI3 and EQ-5D+ may overstate the consistency between the single attribute weights, there is still a remarkable level of concordance in view

Annex Table B lists all the disability weights used in the Australian Burden of Disease Study and their sources. Where Dutch or GBD weights were not available, and it was not feasible to use the EQ-5D+ regression model, a Dutch or GBD weight for a similar condition was used on a provisional basis. For a few mental disorders, Australian experts were asked to assess weights using a value rating scale to compare them with Dutch weights for other mental disorders. In any further Australian burden of disease studies, it would be useful to do this on a more systematic basis for a wider range of conditions where provisional weights have been used. In the longer term, it may be appropriate to carry out a full Australian disability weight study.

Table 2.2 summarises the sources of weights for the 1260 disease sequelae, stages and severity levels used in the

Australian Burden of Disease and Injury Study. These 1260 categories are listed in Annex Table B, together with disability weights and sources. GBD weights were used for 40 different types of injury. These were used as sequelae for each of the 18 external causes of injury, so that there were 720 injury categories in total. Dutch weights or the EQ-D5+ were used for over 75% of the 536 non-injury sequelae. The weights used in this study must be regarded as provisional pending either the development of internationally accepted standard weights or suitable Australian weights.

Table 2.2: Sources of disability weights used in the Australian Burden of Disease and Injury Study

Source of weights	Diseases (Groups I and II)	Injuries (Group III)	Total
Dutch weights ^(a)	370	—	370
EQ-5D+ regression model	46	—	46
GBD weights ^(b)	118	720	838
Australian weights	6	—	6
Total	540	720	1,260

(a) Stouthard et al. (1997).

(b) Murray and Lopez (1996a).

2.6 Years lost due to disability

Years lost due to disability are essentially calculated as follows (ignoring the complications of discounting):

$$YLD = I \times D \times L$$

where I is the number of incident cases in the reference period, D is the disability weight (in the range 0–1) and L is the average duration of disability (measured in years). With discounting at rate r, the formula for calculating YLD becomes:

$$YLD = I \times D \times [1 - \exp(-rL)] / r$$

In order to make a consistent and meaningful estimate of YLD for a condition, it is crucial to clearly define the condition under consideration in terms of case or episode, and severity level or disease stage. It is then necessary to ensure that the disability weight and the population incidence/prevalence data relate to the same case definition. The most difficult step in estimating YLD for most diseases is matching existing population data to the disease stage/severity categories for which the weights are available. Getting this wrong can result in substantial error in the YLD estimate. Disability weights are discussed further below.

For some conditions, numbers of incident cases are available directly from disease registers or epidemiological studies but for most conditions, only prevalence data are available. In these cases, a software program called DISMOD[®] is used to model incidence and duration from estimates of prevalence, remission, case fatality and background mortality.²⁶ The underlying model is shown in Figure 2.6.

Where remission rates and/or case fatality rates are not known, they are usually estimated from available evidence. While this affects the age distribution of incident cases and YLD, total YLD are quite insensitive to these assumptions. This is because YLD are proportional to incidence multiplied by duration, which approximately equals the prevalence of the condition. In other words, the combination of incidence and remission rates chosen (and

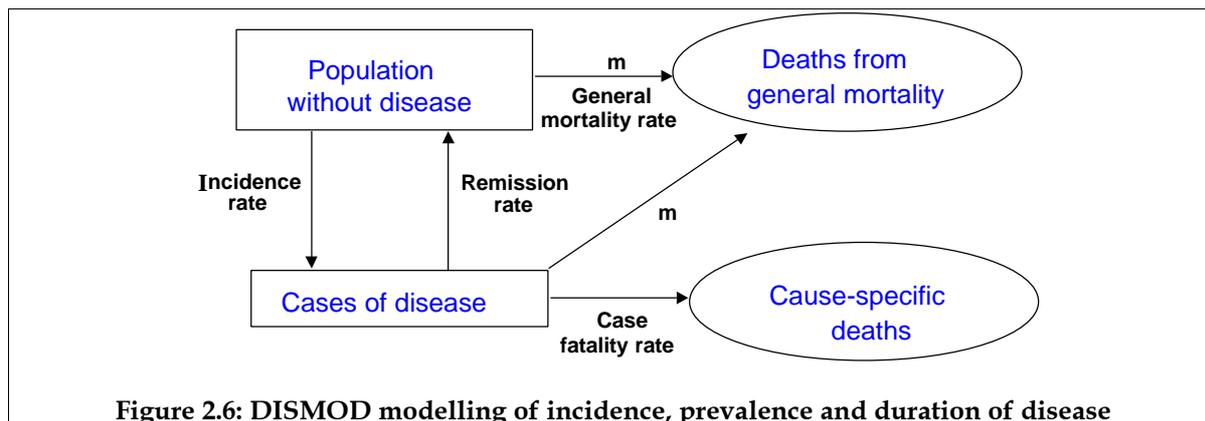


Figure 2.6: DISMOD modelling of incidence, prevalence and duration of disease

thus derived durations) does not make a lot of difference to total YLD added across all ages, if the incidence and duration estimates are being matched to the same prevalence figures.

Locating or modelling information on the incidence (the number of new cases arising in 1996), average duration, and, in some cases severity distribution of 1260 disease and injury stages and sequelae in the Australian population requires considerable work and creativity. The sources of data and methods used for each of the major disease and injury groups are summarised in Section 5.2 in more detail. Due to the large number of categories analysed, and the paucity of even basic epidemiological information for many of them, many of the disease models are necessarily simple and approximate. Many different sources of information were used to calculate YLD. Where no data were available and estimates could not be found in Australian or international epidemiological and medical literature, expert judgement was relied on. The resulting YLD estimates should be seen as a first step in a developmental process. It is hoped that many of these models can be refined and improved by relevant disease experts and that the data gaps and deficiencies identified by the YLD analyses carried out for this project will contribute to setting priorities for improving Australian health information (see Section 8.3).

For most disease and injury groups, Australian experts were consulted during the development and revision of YLD estimates. Complete worksheets for each disease group were given to selected experts for comment and assumptions, models and estimates were revised where necessary.

Worksheets for each disease and injury category detailing data sources, assumptions and methods used to calculate YLD are available on request as Excel 97 spreadsheets.

2.7 Adjustments for comorbidity

Comorbidity is common between mental disorders and has been taken into account in analysis of YLD for mental disorders, but not for comorbidity between physical and mental disorders. In addition, there are significant proportions of older people who will have comorbidities for some of the common non-fatal conditions of older age (e.g. hearing loss, osteoarthritis, heart conditions, diabetes etc.). The GBD and Dutch disability weights were estimated for each condition in isolation and no attempt was made to estimate weights for comorbid conditions. It is not always sensible to add the weights for such conditions, as it is then possible to have very severe weights and weights exceeding 1.0. It is unlikely that for

someone with a severe condition, such as Alzheimer's disease or cancer, that the additional weight of 0.02 for mild vision loss is still appropriate.

Weights for prevalent low-severity conditions have been adjusted to take account of comorbidities. A multiplicative model was used to estimate weights for comorbid conditions and the change in total weight attributed back to the weight for the milder of the conditions.²⁷ The most prevalent physical conditions at older ages together with the comorbidity adjustment factors for weights at ages 65–74 and 75+ are listed in Appendix A.²⁸

Mental health problems are less prevalent at older ages, apart from dementia, and no attempt has been at this stage to also adjust for mental-physical comorbidities. The National Mental Health Survey data could allow this to be done, since it identifies mental-physical comorbidity (through self-report).

2.8 Socioeconomic inequalities

One of the longer term aims of this study is to develop estimates of the burden of disease for different groups within the Australian population, including groups defined in terms of relative socioeconomic status. For this initial report, we have undertaken analyses of inequalities in the burden of mortality by level of socioeconomic disadvantage, using an index classifying people according to the average disadvantage of their statistical local area (SLA) of usual residence.

In keeping with earlier work (Mathers 1994a, 1994b, 1995, 1996), this study uses a small-area based measure known as the Index of Relative Socioeconomic Disadvantage (IRSD). The IRSD is one of the socioeconomic indexes for areas (SEIFA indexes) developed by the Australian Bureau of Statistics (ABS) using data collected in the 1986, 1991 and 1996 population censuses to categorise areas on the basis of their social and economic characteristics (ABS 1998c). It is constructed using principal components analysis and is derived from attributes such as low income, low educational attainment, high levels of public sector housing, high unemployment, and jobs in relatively unskilled occupations.

For the years 1995–97 deceased persons were classified into quintiles of socioeconomic disadvantage according to the IRSD for their SLA of usual residence²⁹, with the 1st quintile corresponding to the highest socioeconomic group and the 5th quintile the lowest. SLAs were grouped into quintiles so that each quintile contained approximately 20% of the total Australian population.

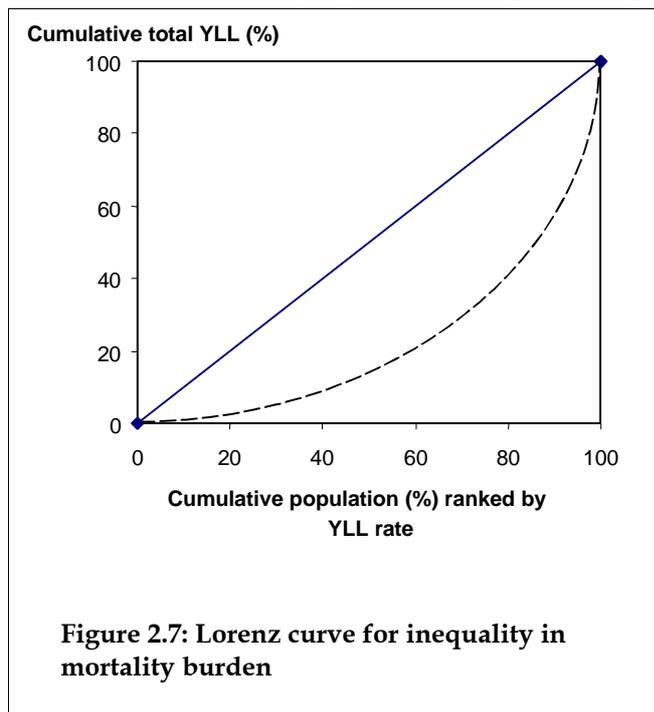
YLL inequalities

Inequality in mortality burden across the quintiles of socioeconomic disadvantage was assessed using three measures: the rate ratio, the Gini coefficient, and excess mortality burden.

Rate ratios. The age standardised YLL rate per 1,000 population for the most socioeconomically disadvantaged quintile (Q₅) is expressed as a multiple of the standardised rate for the least disadvantaged quintile (Q₁). Thus, for example, the rate ratio for all cause mortality burden in males is 1.41 (YLL Rate_{Q1}/YLL Rate_{Q5} = 9598/6802).

Gini coefficient. In recent years, studies examining socioeconomic health inequalities have made increasing use of the Gini coefficient (Leclerc et al. 1990, Carr-Hill 1990, Kennedy et al. 1996). The Gini coefficient is a summary measure of the degree of inequality in some

characteristic (such as income) within the population. It is derived from the Lorenz curve and takes values ranging between 0 (perfect equality) to 1 (complete inequality).³⁰



In this study, we use a form of the Lorenz curve in which cumulative YLL are plotted against cumulative population across the five quintiles of socioeconomic disadvantage (ranked in terms of decreasing disadvantage). This is illustrated in Figure 2.7, where the dashed line represents to cumulative YLL plotted according to cumulative population. The straight line is the line of perfect equality (every quintile has the same YLL rate) and the area between the two curves expressed as a proportion of the area below the diagonal line gives the Gini coefficient.

Even if age-specific rates of mortality burden were equal across all quintiles, there would still be inequality if population age structures differ across the quintiles (since there will be more deaths in older populations). To remove the effects of population age structure

on the Lorenz curve we have plotted cumulative numbers of age-standardised YLL across quintiles. The corresponding Gini index measures the degree of mortality inequality across the quintiles of socioeconomic disadvantage, excluding inequality due purely to population age structure differences.

The term 'Gini coefficient' is used here to refer to a measure of mortality inequality based on population groups ranked by socioeconomic status rather than health status. Wagstaff et al. (1991) have referred to these as health or ill-health concentration indices.

Excess mortality. Kunst (1997) has proposed mortality inequality measures that are not only sensitive to relative differences between groups but, in addition, take into account the size of the socioeconomic groups that are compared. These measures address the total impact that socioeconomic differences have on the mortality level of the general population. We also present an excess mortality measure which estimates the percentage of YLL that potentially could be avoided if all quintiles had the same age-standardised YLL rate as the least disadvantaged quintile.

In effect, the measure identifies the burden of mortality in the Australian population that may be attributable to socioeconomic disadvantage.³¹ Note that this measure is only indicative. Different estimates would be obtained using different reference groups (eg. top decile rather than top quintile) or using a different measure of socioeconomic disadvantage (eg. education level or family income).

YLD inequalities

Inequality in disability burden was assessed for selected mental disorders using data from the 1997 National Survey of Mental Health and Wellbeing (MHS'97). Survey respondents were classified into quintiles of socioeconomic disadvantage using the IRSD to classify place

of usual residence. The Victorian Burden of Disease project estimated incidence rates for substance abuse disorders (except heroin), affective disorders, anxiety disorders and borderline personality disorders. These were modelled by age, sex and quintile of socioeconomic disadvantage by fitting a logistic regression model to the unit record data from the MHS'97. Socioeconomic variations in YLD for heroin dependence were assumed to follow the same pattern as YLL.

Confidence intervals for YLD rate ratios, Gini coefficients and excess burden were estimated using the @RISK statistical software package (see Section 2.10) based on the standard error estimates for the incidence rate ratios estimated from logistic models.

DALY inequalities

It has not been possible to complete comprehensive analyses of YLD by quintile of socioeconomic disadvantage for all disease and injury categories for this first report on the burden of disease and injury in Australia. Provisional estimates of differentials in burden of disease measured in DALYs for the main disease and injury groups are included in Section 5.6. These are based on provisional YLD estimates for main disease groups derived as follows:

- Data from the 1997 National Survey of Mental Health and Wellbeing were used to model incidence of selected mental disorders by quintile of socioeconomic disadvantage (see above).
- Data from the 1995 National Health Survey were used to model prevalence of a number of low-fatality conditions by quintile of socioeconomic disadvantage. These included low-fatality infectious diseases, acute respiratory infections, anaemia, childhood mental disorders, sense organ disorders, ischaemic heart disease, stroke, peripheral vascular disease, chronic obstructive pulmonary disease (COPD), asthma, digestive system disorders, genitourinary conditions, skin disorders and musculoskeletal disorders. YLD differentials by age and sex were modelled from these differentials.
- Oral health problems were modelled from Australian data collected by the AIHW Dental Statistics Research Unit (AIHW 1992).
- For the remaining conditions, with significant case fatality levels, incidence rates were assumed to follow the same pattern as mortality rates by level of socioeconomic disadvantage. YLD differentials for each age-sex group were modelled from death rate differentials for the corresponding age-sex group.

Confidence intervals for DALY rate ratios were estimated using the @RISK statistical software package (see Section 2.10). Uncertainties in YLL differentials were modelled assuming observed deaths followed Poisson distributions. Uncertainties in mental health YLD differentials were modelled as described above. Uncertainties in other YLD differentials were estimated based on sampling errors for the 1995 National Health Survey, where relevant, and uncertainties in YLL differentials.

2.9 Burden attributable to risk factors

The proportions of the burden of disease and injury attributable to various risk factors to health are estimated in Chapter 7 for ten selected risk factors. Population attributable fractions (PAF) are calculated for each risk factor from available information on the prevalence of the risk factor and the relative risks (RR) of incidence or mortality for each

health condition causally associated with exposure to the risk factor. For some conditions, direct estimates for PAFs are directly available from surveillance systems or epidemiological studies (e.g. HIV/AIDS and unsafe sex, motor vehicle accidents and alcohol consumption).

The population attributable fraction is the proportion of the total risk (incidence rate, mortality rate or burden) in the whole population (including the subpopulations exposed and unexposed to the risk factor) that is causally attributable to the exposure to the risk factor. It is derived by comparing the risk (or burden) in the whole population to the risk in the unexposed group English et al. (1995).

For a risk factor with k exposure categories, the aetiologic fraction for exposure category i is calculated as follows:

$$PAF_i = \frac{p_i (RR_i - 1)}{\sum_{i=0}^k p_i (RR_i - 1) + 1}$$

where p_i is the prevalence of exposure to category i of the risk factor,
 RR_i is the corresponding relative risk for category i of the risk factor relative to the reference category, and
 $i=0$ is the reference (non-exposed) category.

The attributable fraction is conventionally interpreted as the proportion of current disease (or mortality) attributable to the risk factor concerned. This is only strictly correct if the prevalences used to calculate the PAFs reflect the prevalence of the risk factor at an appropriate period in the past. For some chronic diseases, current disease may be associated with exposure many years in the past (e.g. occupational asbestos exposure and mesothelioma) or with cumulative exposure over a considerable period. For tobacco smoking, there is a long timelag between exposure to tobacco smoke and some diseases, particularly cancers and chronic obstructive pulmonary disease. For these diseases, the Peto-Lopez method was used to calculate PAFs for tobacco smoking (Peto and Lopez 1993). This method derives an artificial prevalence measure of cumulative tobacco exposure derived from a comparison between overall lung cancer rates in Australia and lung cancer rates among non-smokers derived from a large long-term follow-up study in the USA.

2.10 Uncertainty analyses

For a number of comparisons of life expectancy and socioeconomic inequalities, we have estimated 95% confidence intervals. Although analytical solutions for the confidence intervals for these measures can be constructed, we used a simulation approach to estimate 95% confidence intervals. Latin hypercube sampling was carried out using the @RISK software program (Palisade 1996). Observed deaths were assumed to follow Poisson distributions. Confidence intervals for survey-based estimates were used to estimate uncertainty in YLD differentials.

This software is also being used to calculate ‘uncertainty’ intervals for some YLD and DALY estimates based on estimated ranges of uncertainty for various key parameters and assumptions built into the relevant disease models. It is intended to carry out a more detailed sensitivity analysis of the DALY estimates in relation to the underlying epidemiological parameters using simulation methods. The first report examines only the sensitivity of the results to some of the key value assumptions such as the discount rate.