THE HEALTH OF NATIONS: THE VALUE OF A STATISTICAL LIFE

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Australian Government
Australian Safety and Compensation Council

The Health of Nations: The Value of a Statistical Life

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Glossary

AIHW	Australian Institute of Health and Welfare
ASA	Air Services Australia
CASA	Civil Aviation Safety Authority
CBA	cost benefit analysis
CEA	cost effectiveness analysis
CMA	cost minimisation analysis
COAG	Council of Australian Governments
CUA	cost utility analysis
CV	contingent valuation
DALYs	Disability Adjusted Life Years
DoHA	Department of Health and Ageing
DOTARS	Department of Transport and Regional Services
EPA	Environmental Protection Agency
GDP	gross domestic product
ICER	Incremental Cost Effectiveness Ratio
ITLS	Institute of Transport and Logistics Studies
LYG	Life Year Gained
LYS	Life Year Saved
MBS	Medicare Benefits Scheme
NPV	net present value
OBPR	Office of Best Practice Regulation
OHS	occupational health and safety
PBAC	Pharmaceutical Benefits Advisory Committee
PBS	Pharmaceutical Benefits Scheme
QALY	Quality Adjusted Life Years
QoL	quality of life
RIS	Regulatory Impact Statement
SES	socioeconomic status
VRR	Value of Risk Reduction

VSL	Value of a Statistical Life
VSLY	Value of a Statistical Life Year
WHO	World Health Organization
WTA	willingness to accept
WTP	willingness to pay
YLD	Years of healthy life Lost due to Disability
YLL	Years of Life Lost due to premature mortality

Executive Summary

Australians born today live more than 20 years longer than our counterparts a century ago[1]. This 38% gain in our longevity, together with other improvements in our health, has been achieved through a variety of incremental improvements in health and aged care expenditure, occupational safety, environmental interventions (in particular in relation to water and sanitation), and technological advances driven by research and innovation together with concern for public welfare and social justice. Such investments reflect the value we place on life, health and wellbeing.

Scope

This report is similarly motivated. The Office of the ASCC commissioned Access Economics on 30 May 2007 to conduct a comprehensive review of the available Australian and international literature, presenting the microeconomic framework and different methodologies for valuing life, with a view to deriving low, base and high values for the value of a statistical life (VSL) and the value of a statistical life year (VSLY) for use as inputs in cost effectiveness analysis (CEA) and cost benefit analysis (CBA). VSL is understood broadly as the marginal dollar value of a human life while VSLY is understood broadly as the marginal dollar value of a year of healthy human life. The latter is particularly important in practical applications, since most interventions and regulation are aimed at averting injuries and disease and most of these are not immediately fatal. In occupational health and safety (OHS), only around 0.2% of compensated injuries are fatal, and permanently disabling incidents are more substantially more costly than fatalities (NOHSC, 2004). The brief included a consultation process with stakeholders in other Australian Government portfolio areas that may have an interest in the calculation and use of the VSLY in public decision making processes.

Findings

Healthy life is a unique and exceptional commodity. It does not fit neatly into the traditional neoclassical framework because it is a prerequisite to deriving utility from all economic activities, including income from production and utility from consumption. Healthy life may, for certain periods, impart utility requiring neither income nor consumption. Healthy life can be measured in units that reflect mortality

– eg, 'fatalities averted' or 'life years saved (LYS)', but this is not the only aspect of healthy life that is valued. Quality of life (QoL) is also a source

1 http://www.aihw.gov.au/mortality/data/life_expectancy.cfm

of utility and attempts to measure this utility for different health states have resulted in the metrics of Quality Adjusted Life Years (QALYs) and Disability Adjusted Life Years (DALYs).

A QALY is derived by multiplying the utility of a health state by its duration, with 0 equivalent to death and 1 equivalent to perfect health. There can be difficulties converting utility values to QALYs across conditions and a standard approach is preferred here to an individually determined one due to the variability between individual and the policy implications of utility values less than zero. As such, the DALY approach is suggested, where international experts have agreed consistent weights for a broad range of health states (Appendix B). However, as well as the difference in who does the valuing, a DALY (where 0=perfect health and 1=death) is the reverse of a QALY. Hence, semantically, DALYs are averted while QALYs are sought in policy interventions. Like QALYs, DALYs comprise both mortality and morbidity components.

Healthy life (QALYs) is not generally tradeable between people or across time periods, due to physiological and technological limitations. To an individual, the price they would be willing to pay (WTP) to avoid imminent death is almost infinite. However, this dilemma is rarely faced. Rather, in the real world the value that people place on their own lives is largely reflected in decisions about how much they would be WTP to purchase small increases in health or reduced risk to their life or health, or how much they would be willing to accept (WTA) to compensate for increases in risk or loss of health. In many settings including OHS, people (or regulators on behalf of workers) may purchase units of safety.

However, the ability for people to accurately assess these commonly tiny risks or safety enhancements is limited by imperfect information and, at times and in particular for some groups (eg, the mentally ill, children or the frail aged), by irrational behaviour. Fear of particular situational threats, belief in abilities to beat the odds, the complications of addictive substances and other constraints mean that some of the fundamental tenets of the Walrasian general equilibrium world – perfect information now and in the future, rationality, and free competitive markets – are brought into question in relation to individual decisions to purchase safe, healthy life through various interventions.

Moreover, other positive and negative externalities exist which mean that resources invested in interventions to achieve health and safety are not optimally allocated by market forces alone. In this situation, principles of welfare economics suggest that social utility is optimised by government intervening to reallocate resources. Typically this is achieved by paying in part or in full for health interventions and by regulating safety requirements with which firms must comply.

A final complexity is that decisions about healthy life outcomes are made over the entire lifespan, rather than over short periods such as a year. Time is optimally allocated in a way that, for most people, places most leisure in the early and late stages of life, and most labour in the middle. This means that utility or value to the individual does not reflect productivity age patterns. This and other factors have led to the discrediting of the traditional productivity approaches to valuing human life.

Measurement approaches

The literature refers to the 'value of a statistical life' (VSL) and, while this is a somewhat flawed concept to capture measurement of the value of healthy life, the terminology is retained in this report due to its widespread use.

Productivity approaches to measuring the VSL or the value of a statistical life year (VSLY) are based on the expected earnings of the individual (a measure of lost production). Frictional approaches are appropriate to measure productivity losses in the short term or in situations of a relatively large unemployment pool. Human capital approaches are appropriate in the longer term in economies like Australia operating at near full employment. Although both approaches have their place in measuring productivity losses, the loss of human life is viewed as more than earnings, incorporating both the value of unpaid work and the utility value of leisure. As such, the human capital valuation could be considered to be an absolute lower bound on the VSLY.

- In attempting to take account of the value of unpaid work and leisure, a hybrid or markup approach has been adopted in some cases where the value is estimated typically as 30% or 40% of the value of earnings. Other early approaches to valuing life included the discounted consumption approach, the implicit value approach (based on past investments by public policy makers), the insurance value approach and the court award approach.
- A hybrid approach is currently used in the Australian transport sector, although this was acknowledged by DOTARS as sub-optimal conceptually.

Willingness to pay (WTP) approaches to valuing human life have been the focus of the literature on the economics of life saving since the 1960s. WTP assumes that a person's utility depends on their income and their health, although the complexities of the interactions are not always taken into account. The person's WTP, with their available income, to avoid a risk to their health is then able to be translated mathematically into an estimate of their VSL. A criticism of the approach is the observation that at some critical level of risk individuals are not willing to trade off any more health and the VSLY approaches infinity; moreover, this suggests that the WTP changes depending on the base level of risk/safety or wellbeing. This helps explain why people tend to value specific lives under threat (eg, Beaconsfield miners) as more valuable than incremental risks to anonymous lives. It also helps explain why people may have more concern about losing more health if they are already very unwell, compared to moving from perfect health to mild sickness for a period.

There are two empirical methods of determining VSL using WTP:

> stated preference valuation methods; and

> revealed preference valuation methods.

The terminology in this field is ambiguous but, essentially, stated preference and contingent valuation are fairly synonymous, while noting that some people prefer to distinguish stated choice methods as more sophisticated and valid. There are many stated preference methods, which include methods used in measuring utility values – rating scales, standard gambles, time trade-offs and person trade-offs. Most methods involve surveys, which can be ex-post, ex-ante or ex-ante (insurance based) and may use open-ended or closed-ended scales (eg, discrete choice, bidding games, paired rating and contingent ranking).

The defining characteristic of stated preference methods is that they do not infer values from actual real world decisions, but are either hypothetical or use referencing to enhance realism. This is both their greatest strength and their greatest weakness. Although stated reference models have the potential to generate highly stratified granular results – by virtually any attribute one can desire including age, gender, socioeconomic status (SES), time, location, situation – their findings are not believed by many people. Caution is suggested in relation to spending often large sums to obtain results that may vary greatly depending on the framing of the survey questions, the context, the level of risk and other factors such as whether the person is asked about their own life or someone else's. Stated preference approaches may also (sample) bias upwards the VSL(Y) of working age people and may also suffer from information, non-response and strategic biases, 'embedding' effects, 'warm glow' effects and the 'ordering problem'. However, well designed and implemented surveys may eliminate these biases.

In contrast, revealed preference studies are generally considered superior to measure individual WTP as they are based on real world empirical, binding market transactions. They are self-validating since the WTP is derived from actual risk-taking behaviours – most commonly compensating wage differentials, but also product market studies, housing decisions, compensation decisions and public sector decisions. Compensating (hedonic) wage studies use information on people's job choices to estimate WTP for job risk changes. However, their limitations include potential asymmetries and imperfect information in labour markets and variability with the base level of risk. The latter may be able to be controlled for in multiple regression analysis, although the econometric interpretation of revealed preference studies may then suffer the identification problem due to selection bias. A weakness and strength of revealed preference is that people are subject to budget constraints, so correlation of VSL with SES is strong (although this also can be controlled econometrically). Moreover, revealed preference studies can only reflect an individual's value for their own life.

A mixture of revealed preference and stated choice studies, as well as other studies valuing life, was considered the best way to proceed in estimation of the VSL and VSLY (in accord with Rose et al, in press 2008).

VSL and VSLY estimates in the literature

The literature review was undertaken in conjunction with the DEEWR library. The search protocol included all journal articles and reports in the period 2005 to June 2007 with 'value of a statistical life' in the title of the document, and an internet search. Seminal studies from earlier periods were also retrieved and reviewed, and stakeholders provided other relevant material.

VSL estimates were identified from 244 'western' studies (17 Australian and 227 international studies) between 1973 and June 2007, although these contained only 19 explicit VSLY estimates (nine Australian and ten international studies). Estimates were converted to 2006 Australian dollars and analysed by:

> sector – health, occupational safety, transport, environment, 'other';

> country – Australia's VSL was 5th (lowest) of 14 economies included;

> broad methodology – stated preference, revealed preference, mixed, other/unknown;

> age of the study.

Where needed, a discount rate of 3% was considered appropriate for healthy life years, which aligns generally with the literature and the current practice of the Australian Institute of Health and Welfare (AIHW).

Simple analysis of all these data (regardless of study quality) showed:

> a mean VSL of $9.4 million for all countries and a median of $6.6 million;

> a mean VSL for Australia of $5.7 million and a median (taking into account a large number of implicit valuation estimates based on past policy decisions) of $2.9 million;

> a mean VSLY of A$433,437 and a median of A$119,589 (also influenced by the skew towards Australian estimates used in previous policy-making);

- revealed preference estimates were slightly lower than stated preference estimates[2]; but
- lower estimates for older studies; and
- significant differences by sector in means/medians: health ($4.0/$3.7 million), transport ($7.9/$5.4 million), 'other' (consumer choice, crime and fire safety – $8.5/$6.0 million), environment ($11.2/$8.1 million) and occupational safety ($11.1/$7.4 million).

A random effects meta-analysis was performed, using MIX software, of the higher quality studies (ie, studies from 1980 on that had either a midpoint and standard deviation or other minimum-maximum range, and were not outliers). This eliminated many of the implicit evaluation studies (which helps to remove the circularity effect of future policy being based on speculative past policy).

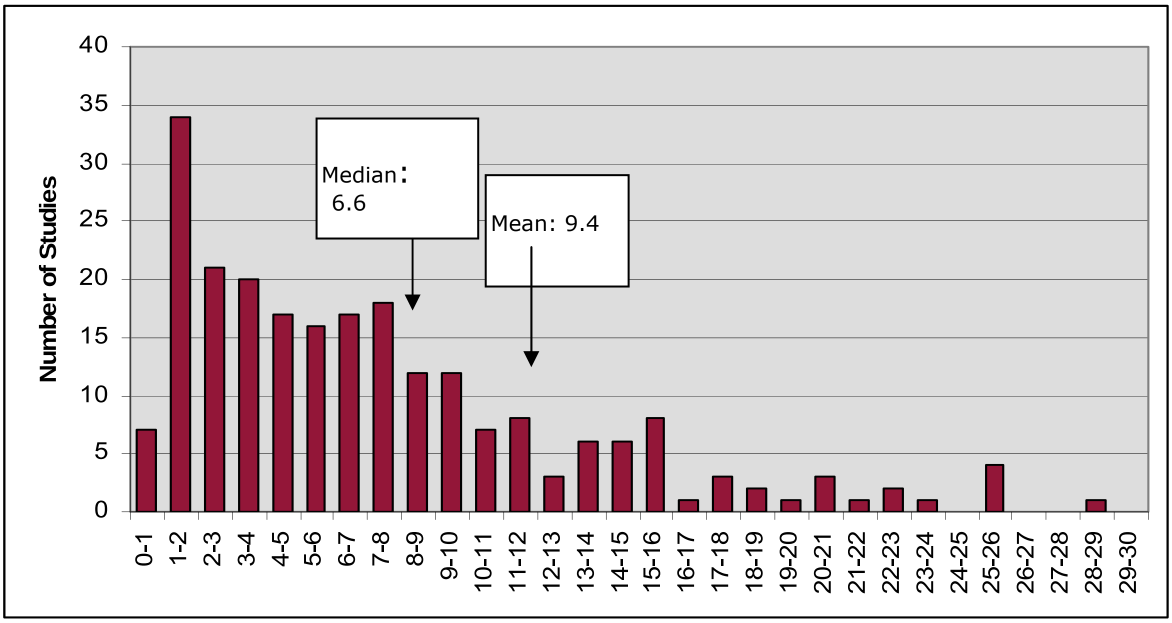
- The meta-analysis yielded an average VSL of $6.0 million in 2006 Australian dollars with a range of $5.0 million to $7.1 million based on exclusion sensitivity analysis.
- No publication bias was evident from the funnel plot and the meta-analysis was also robust in relation to exclusion sensitivity analysis.
- However, because of the greater variability shown across all the source studies, particularly across sectors, the suggested range for sensitivity analysis is based on the 'raw' study median values, which ranged from $3.7 million in the health sector to $8.1 million in the environment sector.

Data constraints prevented analysis of some items of interest such as the average age of the study group (which it is expected may account for a great deal of variation in VSL estimates), the base level of risk/wellbeing and whether the individual's valuation is for their own or another's life. However, these factors were accounted for by using a random effects meta-analysis technique, which is designed to allow for other underlying variables.

The literature review concluded that attempts to empirically determine the relationship between VSL and age have been inconclusive. The 'n-curve' relationship found in some studies may result from sample bias or from the exclusion of non-income, non-consumption aspects of utility. Moreover, the early implied curvature may be very slight, suggesting that the VSLY is likely to be fairly constant by year of age. There was correlation found with income, wealth and ethnicity but no correlation with baseline health status. A plethora of attributes are available from stated preference models, although these may have more application in the private sector than for public policy making.

2 We suspect that higher revealed preference estimates are masked by the 'other' category being clustered as low (implicit) valuation estimates and high (revealed) preference estimates; further research is indicated here.

Histogram of VSL Estimates (Excluding Far Right Tail)



Note: This figure excludes 18 studies with a VSL of over A$30 million, and does not control for the age of the person or study population at the time of the study, which would account for some of the variability.

Social utility preferences were expressed to: avoid severe health states and catastrophes; protect children and disadvantaged groups; and protect more when private costs of risk aversion are high.

The literature suggests that the VSLY should be adjusted if necessary for any benefits (and costs) to third parties. It is also important, in a cost effectiveness application, to net out any other costs or benefits to the individual to avoid double counting.

The role of VSLY in decision-making

The VSLY estimated from the meta-analysis reflects what individuals and society on average will currently pay for any life-enhancing opportunities currently available, based on various risk and wellbeing scenarios. Since many of the source studies reflected changes at the margin, it thus may become less appropriate to apply this relatively high price to very large changes in health states for large populations, since such changes (if they were technologically possible) may challenge the budget constraint imposed by current income and wealth and may alter general equilibrium optimal pricing. However, since most public policy interventions are also incremental, the VSLY estimates derived from the literature are appropriate to use in public decision making.

It is important to emphasise that the decision about whether an intervention should be publicly financed is separate from the decision about whether *any* resource investment (public or private) is justified.

The latter decision is based on the cost effectiveness of the intervention and the valuation of human life and wellbeing, while the former decision is based on views about the extent to which governments should intervene in the particular market under consideration. Many factors enter into that consideration process, including the overall government budget constraint and the relative strength of social utility impacts in relation to different externalities. Indeed, analysis of public financing decision making revealed the tension between the incremental cost effectiveness ratio (ICER), budget constraints and other considerations, with an econometric analysis showing that the probability of pharmaceutical subsidisation in Australia gradually falls, for example, as ICER rises, rather than a simple threshold being evident.

Best practice principles and next steps

In designing analyses for public decision making purposes regarding regulation and financing interventions to enhance safety and wellbeing in Australia going forward, the following principles are suggested.

1. Be aware that any attempt to value life in dollar terms is limited by the unique nature of healthy life and that neoclassical assumptions of perfect information and rationality may not apply. It is the extent of these market failures and externalities that is the *raison d'etre* for the government intervention, rather than the value of human life per se.

2. Measuring changes in risks to life provides a value for safety while valuing the utility of different health states provides estimates of wellbeing. Estimate safety/wellbeing in QALYs or DALYs, preferably with separate estimates of life years saved (LYS) and morbidity avoided as per Begg et al (2007).

3. For health states other than mortality, use disability weights from DALY tables (Appendix B) to allocate utility associated with various health states. If a disability weight is required that is not available in the table, use the most robust utility value available from the literature (or expert opinion in the worst case) and triangulate it against similar health states that have weights in the table; conduct sensitivity analysis around the disability weight. (Use the metric '$/QALY' rather than '$/DALY averted' for simplicity of terminology.

4. Calculate all of the costs and benefits associated with the intervention by who bears them – individuals (if families are included use the term 'households'), Federal and State governments, employers, and other relevant entities in society. The net costs to the individual must be netted out of from the gross value of wellbeing.

5. A variety of techniques may be used to evaluate the efficiency of an intervention, including:

> cost benefit analysis (CBA), which measures the net present value (NPV) of dollar costs compared to the net present value of dollars saved;

> cost efficacy analysis, which measures the net costs (excluding the dollar value of QALYs) per LYS (or another outcome measure); and

> cost utility analysis (CUA), which measures the net costs (excluding the dollar value of QALYs) per QALY gained. If the net cost is negative (ie, if there is a net benefit excluding the dollar value of QALYs), the intervention's CUA could be described as cost saving rather than cost effective.

6. Because the dollar value for the VSLY estimate is likely to be large and associated with a higher level of uncertainty than most financial estimates, it is suggested that:

> sensitivity analysis accompanies the estimates, for example using high and low levels of a VSLY; and

> cost utility analysis (CUA), and potentially also $/LYS, is used alongside cost benefit analysis (CBA) in public decision making so that the dollar value of the QALY benefit is transparently reported.

7. Avoid productivity or hybrid approaches to value safety/wellbeing, although the productivity impacts may still need to be calculated as part of the analysis.

> In general, if the goal is to measure individual utility, and revealed preference data are available, they should be used, reflecting consumer sovereignty.

> If no revealed preference data are available, or if the goal is to measure social or private utility in specific situations, stated preference approaches may be more appropriate.

8. A suggested ballpark average VSL is $6.0 million in 2006 Australian dollars with sensitivity analysis suggested at $3.7 million and $8.1 million.

> This equates to an average VSLY of $252,014 ($155,409 to $340,219), using a discount rate of 3% over an estimated 40 years remaining life expectancy.

9. The empirical evidence appears inadequate currently to robustly stratify the average VSLY on the basis of age.

10. The externalities that provide the *raison d'etre* for government interventions are based largely on social utility from enhancing socioeconomic equity and health equity, so it would seem self-defeating to stratify VSLY on the basis of income, wealth, ethnicity, or other criteria that correlate strongly with SES, in public policy making.

11. Naturally policy makers are still able to take factors other than the social utility into account in their decisions. An important consideration is the budget constraint, which may vary across different portfolios of interventions given different types of externalities in different sectors (eg, some sectors may have more ‘public good’ characteristics than others) and given imperfect historical budget allocation mechanisms. Thus the value of the marginal intervention displaced may not equate across portfolios.

12. While the VSLY should be used in public decision making, as needed, to apply to individual’s own valuation of healthy life, social valuations for public financing decisions should be based on thresholds reflecting the extent of externalities and budget constraints.

13. The decision rule to approve an intervention should be (CUA):

$$\Delta C / \Delta Q < \lambda i$$

Where ΔC is the change in costs of the intervention, ΔQ is the change in the QALYs and λi is the ICER threshold for portfolio $_i$. Rearranging, the CBA decision rule is:

$$\lambda i * \Delta Q\$ - \Delta C > 0$$

where $\Delta Q\$ = \Delta Q * VSLY$.

14. It will therefore be important to determine financing thresholds in different sectors/portfolios. Further carefully designed research may be desirable to this end, using specialists capable in experimental design theory and practice.

   > Portfolio thresholds should also be surrounded with sensitivity analysis based on high and low bounds, as with VSLY.

15. Since the VSLY and portfolio thresholds are expressed in dollar terms, they should be indexed over time to inflation (CPI is suggested here), reviewing λ_i/VSLY over time for each portfolio to reflect potential changes in technology and preferences.
Access Economics
14 January 2008

Chapter 1: Introduction

Access Economics was commissioned on 30 May 2007 by the Office of the ASCC, DEEWR[3], to conduct a comprehensive review of the available Australian and international literature, presenting the microeconomic framework and different methodologies for valuing life, with a view to deriving low, base and high values for the value of a statistical life (VSL) and the value of a statistical life year (VSLY) for use as inputs in cost effectiveness analysis (CEA) and cost benefit analysis (CBA). VSL is understood broadly as the marginal dollar value of a human life while VSLY is understood broadly as the marginal dollar value of a year of healthy human life. The latter is particularly important in practical applications, since most interventions and regulation are aimed at averting injuries and disease and most of these are not immediately fatal. In occupational health and safety (OHS), only around 0.2% of compensated injuries are fatal, and permanently disabling incidents are more substantially more costly than fatalities (NOHSC, 2004). The brief included a consultation process with stakeholders in other Australian Government portfolio areas that may have an interest in the calculation and use of the VSLY in public decision making processes.

The brief included addressing complex issues in the economics of life saving, such as the treatment of the productivity component of the VSL, irrational behaviour, imperfect information and inter-temporal (lifetime or even intergenerational) allocation of labour-leisure choices, which may lead, among other factors, to potential variation in VSLY estimates by age and gender, health and socioeconomic status. In addition, the brief included a discussion of the role of the VSLY and its appropriate application in public financing decisions across different interventions and even different sectors, including distinguishing the dollar estimate of the VSLY from 'threshold' views regarding reimbursement decisions.

A final aspect of the brief was to conduct a brief consultation process to ascertain the views of other key stakeholders, including in the transport sector and other national portfolio areas that may have an interest in the calculation and use of the VSLY in public decision making processes.

3 The Office of the ASCC leads and coordinates Australia's national effort to promote best practice in OHS, improve workers' compensation arrangements and improve rehabilitation and return to work of injured workers. The role of the Office of the ASCC is to develop national OHS and workers' compensation policy, to encourage policy discussion and research and to promote consistency in legislation developed by states and territories.

One of the stakeholders in the consultation process was the Office of Best Practice Regulation (OBPR), part of the Productivity Commission[4], who is keen to encourage more consistency and comparability of VSL estimates

across government. For regulations that might reduce the risk of fatalities, OBPR's guidance material currently encourages agencies to include the value of a risk reduction as a benefit of the regulatory proposal. However, OBPR does not explicitly require this assessment nor provide guidance on a generally accepted value (or values) of a statistical life to use to estimate this benefit. As a result, agencies' regulation impact analyses often do not value these benefits in dollars or, when they do, the estimate of the benefits may be based on different VSLs. Such differences create difficulty in comparing regulatory proposals across agencies. Moreover, in many cases, the benefits reduce the risk of *non-fatal* injury, which appears less of a focus for OBPR despite the fact that the overwhelming proportion of OHS incidents (over 99%) and costs (89%) are non-fatal (NOHSC, 2004).

Methods

The review focused primarily on a review of the literature, together with a summary of the theoretical underpinnings of the economics of life-saving and a brief consultation process with key stakeholders.

Literature Review

The literature review was undertaken in conjunction with the Office of the DEEWR library. Access Economics specified the initial search protocol as all journal articles or reports in the period 2005 to 2007 with 'value of a statistical life' in the title of the document (which also captured documents with 'value of a statistical life year' in the title).

The library prepared a bibliography based on this protocol, as well as a list of documents available from an internet search. Access Economics reviewed the list, identified relevant items – with an emphasis on Australian literature and on meta-analyses – and reviewed these articles as retrieved from electronic journals and databases. Seminal studies from earlier periods (based on citation reoccurrence) were also retrieved and reviewed, identified from the bibliographies of the most recent literature.

In addition, articles, reports and books were provided by stakeholders in the course of the consultation processes, which were also included in the literature review.

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4 OBPR shares the PC's statutory independence, with a central role in assisting departments and agencies to meet the Australian Government's regulatory impact analysis requirements and in monitoring and reporting on their performance. It also serves a similar role for the Council of Australian Governments (COAG) in relation to national regulatory proposals.

The results of the literature review are woven throughout this report, in relation to the different chapters and issues as they arise. A list of references is provided at the end of the report.

Access Economics would like to acknowledge with appreciation the role of Ms Thea Moyes (Library and Information Services, DEEWR) and Dr Anthony Hogan (Research Section, the Office of the ASCC, DEEWR) in expediting and assisting with the literature review process.

Consultation Processes

An important part of the review, identified early on, is the need for general consensus among key stakeholders in relation to the methodologies adopted to value the quantity and quality of life, the resulting estimates, and the application of such estimates in public reimbursement, regulation or other policy decision making processes.

There were two steps in the consultation process.

First, a group of key stakeholders were identified who were known to be familiar with this issue or who were considered may have an interest in the calculation and use of the VSLY in their portfolio decision making processes. These stakeholders were provided with a draft report structure outlining the issues to be covered in the report, and meetings were held with each stakeholder over June 2007 where their views and inputs were sought on each aspect of the report – namely:

- the background, context, processes and methods (literature search, consultation, report);
- the microeconomics of valuing life, including metrics of wellbeing (ie, valuing healthy life lost from disability as well as from fatality) and the applicability of classical microeconomic assumptions;
- measurement approaches including human capital and the different types of willingness to pay (WTP) approaches;
- VSL and VSLY estimates used in their portfolio area, with rationale (including for the discount rate), 'netting' processes and sensitivity analysis;
- consideration of the policy implications of stratification of the VSLY by age, gender and other factors; and
- the role of the VSLY in policy decision making more generally through CEAs and CBAs across sectors, including the appropriateness of thresholds or benchmarks, indexation and the need for best practice guidelines.

The eight stakeholders with whom consultation was sought comprised:

1. Office of the ASCC;
2. Office of Best Practice Regulation (OBPR);

3 Civil Aviation Safety Authority (CASA);

4 Department of Transport and Regional Services (DOTARS);

5 Institute of Transport and Logistics Studies (ITLS);

6 Department of Health and Ageing (DoHA);

7 Attorney General's Department; and

8 Department of Defence.

Contact officers were identified in each of the first five organisations and interviews were conducted; for the other three stakeholder bodies, difficulties in locating relevant contact officers precluded consultation processes in June.

The second phase of consultation occurred between July and December 2007 and involved the circulation of the draft report to other stakeholders (including jurisdictional stakeholders) by the Office of the ASCC.

A brief summary of the reasons for selecting the eight key stakeholders chosen is provided below.

1. The Office of the ASCC commissioned the report and use VSL and VSLY in their assessment of benefits from reducing the risk of workplace incidents, either through injury or disease OHS exposures. The Office of the ASCC includes the value of the potential healthy life saved in their CBAs for Regulatory Impact Statements that, in turn, are also assessed by OBPR.

2. OBPR were keen that the study explain the various strengths and weaknesses of each approach and suggest which approach, and importantly which value, is most appropriate in various circumstances. OBPR considered that it would be useful from a pragmatic policy perspective if, at some point in the future, a best practice standard for valuing risk reduction benefits were developed, so that the same life-saving benefits are given the same value for different regulations, allowing resources to be directed to where they save the most lives. OBPR suggested that the review by Access Economics could be a useful 'first step' along this path. Appendix C has been included in this report subsequently to this end, as an example of application in an OHS setting.

3. CASA have taken on the role previously undertaken by Air Services Australia (ASA) of regulating airspace, and use VSL and VSLY in their CBA calculations of the impacts of airspace regulation. Access Economics has previously worked with ASA in providing such CBAs. CASA have a well-developed understanding of the different methodological approaches to valuing life, as well as the parameters for VSL and VSLY utilised in Australia and by their counterpart air safety organisations overseas, due to the particular need in their case to be cognisant of international air safety protocols and obligations.

4. DOTARS also have a well-developed understanding of the 'state of play' in relation to use of willingness to pay methodologies, which is balanced against their need to consult widely (including at jurisdictional level) if there were to be any consideration of changing their sector's current 'hybrid' approach to measurement of VSL and VSLY in road and rail transport policy processes. Their current (Austroads) VSL estimates are widely used for cost benefit analyses of road infrastructure projects to measure safety benefits. For major road infrastructure projects, the safety benefits are a small percentage of the total – savings in time and vehicle operating costs predominate. 'Black Spot' projects are at the other extreme, being small projects with safety benefits predominating. Then there are a range of projects in between, for which benefit cost rates would have varying degrees of sensitivity to the VSL. Road agencies tend to use technical criteria to determine speed limits on individual roads rather than cost benefit analysis. For example, DOTARS commented that it is not known whether school zones have proven safety benefits, but they may create a perception of safety, which gives parents greater confidence to allow their children to walk to school, rather than take them by car. The Bureau of Transport and Road Economics (BTRE, 2003) has produced a short paper on trade-offs between speed, safety and other factors.

5. ITLS has been active in the area of measurement of VSL and VSLY eg, in relation to valuing the time element of travel for toll road users using stated choice methods. ITLS have recently completed a large survey in NSW relating to safety in the road environment, applying random utility theory to develop sophisticated stated choice WTP methodology, the findings of which may become available later in 2008. In road safety the term 'Value of Risk Reduction' (VRR) is sometimes used rather than VSL.

6. DOHA has a long history of assessing the value for money of health and aged care interventions, including in order to list pharmaceuticals on the Pharmaceutical Benefits Scheme (PBS) through the Pharmaceutical Benefits Advisory Committee (PBAC) processes and to provide services under the Medicare Benefits Scheme (MBS) and under special program funding arrangements.

7. The Attorney General's Department provides expert support to the Government in the maintenance and improvement of Australia's system of law and justice and its national security and emergency management systems, including through the National Security and Criminal Justice Group. In cases of crime prevention, protective security and emergency management, the decision to incur government expenditure in order to reduce risks to human life is evident.

8. Similarly, in cases of national Defence and anti-terrorism initiatives, Australian Government expenditure is directed primarily to the reduction in risk to the life and health of Australians.

A number of other organisations might also be interested in this analysis. For example, the Department of the Environment and Water Resources may use CBAs to assess potential expenditures on initiatives to reduce toxins into the environment that impose risks to human life, and hence may potentially call on the use of VSLYs to assess benefits. DOTARS noted that state jurisdictions in the road and rail transport sector may also be interested, as may the Australian Institute of Health and Welfare (AIHW).

Structure of this Report

The remainder of this report addresses the findings from the literature analysis and consultation processes.

Chapter 2 addresses first principles by briefly summarising microeconomic frameworks for valuing (and saving) life and the metrics of wellbeing that have been developed to measure the quantity and quality of life. Two common metrics, Disability Adjusted Life Years (DALYs) and Quality Adjusted Life Years (QALYs) are compared and contrasted. The applicability of classical (Walrasian) theoretical assumptions are discussed, such as rationality of consumers, perfect information and externalities, to ascertain: the confidence that might be placed in the methods of valuation; and the extent that imperfect information, irrationality and market failure form a basis for government intervention and the provision of public goods. The constraints to market tradability in human life are noted, as are the complex intertemporal aspects of the labour-leisure choice and the relationship between consumption and utility.

Chapter 3 summarises measurement approaches to valuing healthy life, as they emerged historically, starting with productivity approaches, including 'human capital' and 'frictional' approaches as well as 'mark-ups' for leisure that can lead to hybrid valuations. Willingness to pay (WTP) approaches are summarised, including stated and revealed preference approaches, covering issues such as contingent valuation, hedonic wage pricing and the conversion of a VSL to VSLY (and vice versa), including appropriate discount rates.

Chapter 4 summarises VSL and VSLY estimates from the literature review, stratified by the type of study, the country and sector. The range of outcomes is discussed, particularly in the context of the nature and limitations of the source studies. Conclusions are drawn from meta-analysis of higher quality studies for the feasible range of the VSL and its applications, noting that the metric of more interest appears to be the VSLY. Stratification in the VSLY by age, gender, socioeconomic status (SES) and other factors are discussed; sensitivity analysis around the VSLY is also based on the literature and the issue of 'net' values is discussed to avoid double counting in CBAs.

Finally, Chapter 5 discusses the role of using the VSLY in decision making in various types of analysis – cost benefit analysis (CBA), cost utility analysis (CUA), cost efficacy analysis and cost minimisation analysis –

see Box below (based on Drummond, 2005). Decision making is discussed in the context of the occupational health and safety (OHS) sector as well as other sectors, where different and various public financing considerations come into play. Thresholds and benchmarks are discussed that have been or might be adopted. The issue of whether and how the VSLY and thresholds should be indexed over time is also addressed. Suggestions for consideration in the development of best practice guidelines are presented in the final section.

Cost benefit analysis – net present value (NPV) of dollar costs compared with the NPV of benefits.

Cost utility analysis – dollar costs per disability adjusted life year (DALY) averted or quality adjusted life year gained (QALY).

Cost efficacy analysis – dollar costs per outcome measure, such as $ per life years saved (LYS).

Cost minimisation analysis – the achievement of the same value of benefits at the same or lower cost, compared to an alternative.

Chapter 2: Microeconomics and Valuing Life

This chapter starts by describing and contrasting two common metrics of wellbeing – Disability Adjusted Life Years (DALYs) and Quality Adjusted Life Years (QALYs). The rest of the chapter looks at pricing issues using a neoclassical microeconomic framework and notes the constraints in relation to this framework in real world applications that value life in dollars. The economic basis for government intervention is also presented (with discussion of externalities and public goods). The final section notes different views on the allocation of choices over time in relation to labour, leisure, consumption and utility.

Metrics of Wellbeing

Wellbeing comprises the quantity and quality of life. The starting point for valuing human life is to define a 'unit' of human life.

Dead Or Alive

Early and fairly non-controversial metrics were based on mortality alone, effectively distinguishing only two health states – dead or alive. In early studies in OHS, a common metric was the 'fatality avoided' and this remains the case in current applications in other sectors where actuarial risk trees essentially have only two probable paths – death or healthy survival. In other words, the risk of survival in another health state is insignificantly small (eg, an aeroplane crash).

A refinement to the simple 'dead or alive' metric is the concept of 'life years saved' (LYS). While mortality remains the only outcome measure, age at death and life expectancy are taken into account as well in this metric as is, in some cases, a discounting process such that immediate years of life saved are valued more highly than distant years, reflecting the common principle of positive time preference (ie, people prefer to enjoy utility and consumption now rather than in the future).

Outcome measures such as fatalities avoided or LYS are commonly used as the denominator in cost efficacy analysis in public decision making processes.

However, longevity is not the only aspect valued in life. QoL is also valued, and this arises in public decision making in interventions that avoid non-fatal but disabling incidents or that enhance people's functionality and wellbeing. The ability to distinguish different health states has been addressed in two different ways – Quality Adjusted Life Years (QALYs) and Disability Adjusted Life Years (DALYs).

Quality Adjusted Life Years (QALYS)

The QALY was developed as an attempt to reflect that health is a function of length and QoL, by multiplying the value assigned to different health states by their duration. QALYs value a year of perfect health as unity (1), a year of less than perfect health as less than unity and death as zero. They provide a standard unit for measuring health gain across diseases and population groups.

QALYs had their origins in disease specific measures of utility states and were designed to compare treatments for a particular disease, especially in the context of different arms of randomised controlled clinical trials, rather than using a plethora of (efficacy) outcome measures whose comparability was varied – eg, blood pressure level, visual acuity, functionality score in activities of daily living, Mini-Mental State Examination (cognitive) score, score on a depression-anxiety scale, bone mineral density measure, and so on.

Utility states are cardinal values representing the strength of an individual's preferences for specific health states under conditions of uncertainty (Petrou, 2001). Utility studies address very similar methodological issues to studies that value life, so this section addresses them in some detail. However, it should be remembered that a key aspect of consumer theory is that utility (even if measured cardinally) is not necessarily comparable or able to be aggregated across individuals. Measuring utilities involves four steps.

1. Defining the health states of interest. The measurement instrument should include appropriate health attributes eg, physical, social and cognitive function, psychological wellbeing, symptoms and pain. The number of attributes in a health state should be less than nine since humans cannot simultaneously process more than nine pieces of information (Miller, 1956).

2. Identifying individuals to provide judgements of the desirability of each health state. Utilities are usually obtained from: clinicians or other experts – who tend to be knowledgeable and accessible; patients – since they are the ones impacted; and the general public – since decisions pertinent to public policy should be based on public opinion (Drummond et al, 1987). There is some evidence that utilities differ among different population groups. In general, the correlation between patient and proxy responses varied by health dimension, but proxy ratings tended to be lower than patient ratings, especially for older people (Sackett and Torrance, 1978; Llewellyn-Thomas et al, 1991; Carter et al, 1976; Rothman et al, 1991).

3. Determining the appropriate preference scaling method to elicit utilities. The methods that have been used to collect data on utilities include the standard gamble approach, the time trade-off approach and rating scales (see sections below).

4. Aggregating across individuals to determine scaled values for each health state (Torrance et al, 1982), **minimising the impact of 'context effects'**. Most inconsistencies result from differences in perspective that can arise from the way a health state or treatment is presented to the respondent. Preference ratings have been shown (Kaplan and Ernst, 1983; Froberg and Kane, 1989) to be affected by: 'labelling effects' ie, using specific terms); 'anchor effects' e.g., if the anchor (see Section 2.1.2.3) is 'death' or 'worst possible health'; and prognosis/duration of the health state (little is known about the impact of culture). Context effects can be minimised by careful attention to construction and presentation of the health states including: using states of the same duration; avoiding inclusion of diagnosis, disease labels, laboratory test results and prognosis in health-state descriptions; using trained personnel to collect data; posing questions to the respondent in an unbiased manner to reduce framing effects; using a variety of administration techniques to reduce cognitive burden (for example, props that allow presentation of the task in a clear and concise manner and presentation of subsets where the total number of health states is large).

Standard Gamble

The standard gamble approach is the classic method of measuring preferences in economics, first presented by von Neumann and Morgenstern (1953). It uses hypothetical lotteries as a means of measuring people's preferences. These lotteries involve a choice between two alternatives: the certainty of one outcome and a gamble with two possible outcomes (see Box).

The standard gamble approach in practice: An individual might be asked to choose between the certainty of surviving for a fixed period in a particular state of ill health and a gamble between surviving for the same period without disability on the one hand and immediate death on the other. The probability of surviving without disability, as opposed to dying, is then varied until the person shows no preference between the certain option and the gamble. This probability then defines the utility of an individual for the disabled state on a scale between 0 and 1, whose end-points are death and perfect health (Petrou, 2001).

Breyer and Fuchs (1982) used the standard gamble approach to investigate two alternative treatments where one offered a fixed health effect and the other offered two possible outcomes – a more favourable and a less favourable health effect. The individuals exhibited risk-averse behaviour towards positive health outcomes (opting for the certain and intermediate outcome) and risk-seeking behaviour towards negative health outcomes (they are willing to take more of a risk in order to have a chance of experiencing the most positive outcome on offer).

Time Trade-Off

The time trade-off approach involves asking subjects to consider the relative amounts of time they would be willing to trade in order to survive in various health states. The choice is often between continuing in a present defined state of ill health and moving to a shorter but healthier life. The duration of survival in the healthier state is varied until the subject indicates no preference between the two alternatives (similar to the standard gamble).

Rating Scale

The rating scale is based on psychometric theory. It consists of a single line with anchors representing best possible health and death (or some alternative). Respondents are asked to place each health state on the line such that the intervals between the placements reflect their perceived differences between the health states. Rating scale estimates are consistently lower than those obtained via the standard gamble or time trade-off methods. Rating scales are often used to introduce the standard gamble exercise because they allow the respondent to become familiar with the health states and with ranking.[5]

5 Two additional techniques, equivalence technique and ratio scaling, have also occasionally been used to measure health state utilities, but they are not widely used and will not be discussed here.

Comparing preference-scaling methods (Petrou, 2001): While each scaling method has its advocates, none has been proven superior. The advantage of the rating scale approach is its efficiency, straightforwardness, wide applicability and the fact that it is quick and inexpensive to employ. However, there is a temptation for subjects to spread their responses evenly across categories.

The standard gamble remains the gold standard for many health economists because it is based on decision-making under conditions of uncertainty, a component of most studies in healthcare. However, this approach is relatively time-consuming and people often have difficulties understanding the concept of probabilities. Moreover, utilities or preference values can be strongly influenced by the way questions are framed (Read et al, 1984).

Despite the fact that the time trade-off approach has advantages over standard gamble and is reliable, practicable, and a reliable measure of utility, it does have some drawbacks. As Rosser and Kind (1978) point out, the approach is based on the assumptions that the perception of time is linear and that the perception of the severity of illness is independent of the time spent in this state. In addition, the trade-off concept is difficult for many people to understand.

The standard gamble approach reflects risk aversion, while the time-trade off reflects discounting. Commonly used value matrices of different health states in practice include the SF-36 (standard gamble) and the EQ-5D (time trade off).

Converting Utilities To QALYs

All these approaches yield utilities that range from 0-1, where a higher score represents better health-related QoL. These utilities have been widely used as the preference weights (quality levels) for QALYs, noting that a utility-weighted QALY is not in itself a utility (Torrance and Feeny, 1989:569). QALYs can then be used in cost utility analysis or converted, using VSLY from WTP analysis, to a monetary input to CBAs.

The major disadvantage of QALY measures is that they remain, in general, a conversion metric from outcome measures based on the views of individuals in a sample who are assessing their own (or others') relative utility from different health states. As such, there can be substantial variation in QALY scores for health states and there is a need to account for a variety of effects.

Response shift: As people's health status changes, their emotions may change or settle as may their perspective on the problem. With a simple 'before and after' analysis there is not necessarily an ability to separate the impacts of the health state with those of response shift. For example, if a person loses their finger in a workplace accident, they may initially be devastated by the injury and rank their health state very low. Over time, they may adjust to the loss of the finger and their health state ranking may return closer to unity. For this reason, many people who are born blind or deaf or with other congenital conditions, for example, have higher utility values for their health state than people with the same level of impairment who have acquired the sensory loss or disability (Heydebrand et al, 2005).

Halo effects: Conversely, when people receive an intervention that improves their health state or offers hope of relief, the immediate effect may be a sharp rise in their utility valuation. This seems particularly the case for pain relief, after cancer surgeries or following self efficacy or behaviour modification programs, for example (Lorig et al, 2005). However, in time, the higher utility values may not be sustained.

Confounding factors: It may be difficult for people to separate out the impacts of different comorbid conditions on their overall utility, to separate out the impacts of other significant life events (that may have occurred recently or in the distant past) and to separate the effects of concurrent interventions.

Effect size problems: It may be difficult for people to measure very small changes in health states or changes that occur very gradually over long periods of time. Symptom reduction may be measured rather than the elimination of the problem, per se (Osborne et al, 2006).

Health profiles: People may value states differently according to where on a timeline or life cycle that they occur.

Heterogeneity between respondents: People of different ages, gender, ethnicity, socioeconomic status or outlook on life may rank the utility of the same clinical health states very differently. They may have different needs that are not well reflected in 'average' measures and may be at very different states of psycho-social readiness for interventions. Some depressed respondents, for example, may rank their QoL as less than zero, which presents difficulties in a policy-making setting.

Disability Adjusted Life Years (DALYS)

The World Health Organization (WHO), the World Bank and Harvard University developed a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990, projected to 2020 (Murray and Lopez, 1996), known as the burden of disease and injury approach. Methods and data sources are detailed further in Murray et al (2001).

Like QALYs, the approach is non-financial, where pain, suffering and premature mortality are measured according to a scale of 'disability weights' which, conversely to a QALY, range from 0 representing a year of perfect health and 1 representing death. The DALY approach has been adopted and applied in Australia by the AIHW with a separate comprehensive application in Victoria. Mathers et al (1999) from the AIHW estimate the burden of disease and injury in 1996 and Begg et al

(2007) have recently updated these estimates, including separate identification of premature mortality (Years of Life Lost due to Premature Mortality or YLL) and morbidity (Years of Healthy Life Lost due to Disability or YLD) components.

> A DALY consists of two components: premature mortality (Years of Life Lost - YLL) and morbidity (Years of Life Lost due to Disability - YLD), which is based on the disability weight of a condition.
>
> DALYs = YLLs + YLDs

In any year, the disability weight of a disease (for example, 0.18 for a broken wrist) reflects a relative health state. In this example, 0.18 would represent losing 18% of a year of healthy life because of the inflicted injury, if this level of disability were sustained over a full year.

The determination of disability weights in the DALY approach is based on the views of international experts using extensive referencing and consultation processes. The approach has been successful in avoiding the subjectivity of individual valuation inherent in the QALY approach and avoids the problem of utility values worse than death. It has been criticised by some, however, as being paternalistic, 'lumpy' (values are discrete whereas severity of health states may be a continuous scale), as lacking comprehensiveness (some conditions are not included) and as failing to account for individual differences (although this latter aspect is seen by others as a strength of the approach).

That said, the DALY approach has its critics. Drummond (2005) criticises the consultation process in Geneva in 1995 as not being extensive enough, and not adequately passing on the time trade off or standard gamble methods. He also criticises the limited inputs to DALY weights and age weighting (although both these problems have been overcome in Australia, the latter by dropping the age weighting). Others, such as the National Institute of Clinical Excellence (NICE) in the UK, prefer to return to SF-36 and EQ-5D values[6], and indeed these are necessary to calculate the values of the diseases missing from the original WHO report. Access Economics understands that the burden of disease and injury methodology may be revisited by the WHO with a view to update.

In Australia the AIHW has adopted particular disability weights in its burden of disease analysis, based on those adopted globally by the WHO. These weights are presented in Appendix B and are suggested by Access Economics for use in Australia when valuing different health states, for consistency and as the best currently available. These weights also have the major virtue of being transparent. In the absence of such weights, policy makers and workers in the field may fall back on other methods,

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6 SF-36 is a short form survey of QoL comprising 36 questions http://www.sf-36.org/tools/SF36.shtml, while EQ-5D stands for the 'European quality of life – 5 dimensions' measure http://www.euroqol.org/

including a role for arbitrary judgements. That is, judgements will always be made about the value of different health states. It is best practice that those judgements be explicit, rather than implicit and unexamined.

It should be noted, however, that for some health states, particular weights are not available and, in these cases, decision makers may need to refer to the published literature on QALYs for those health states, with triangulation and reality testing in relation to comparator conditions from the AIHW list of disability weights.

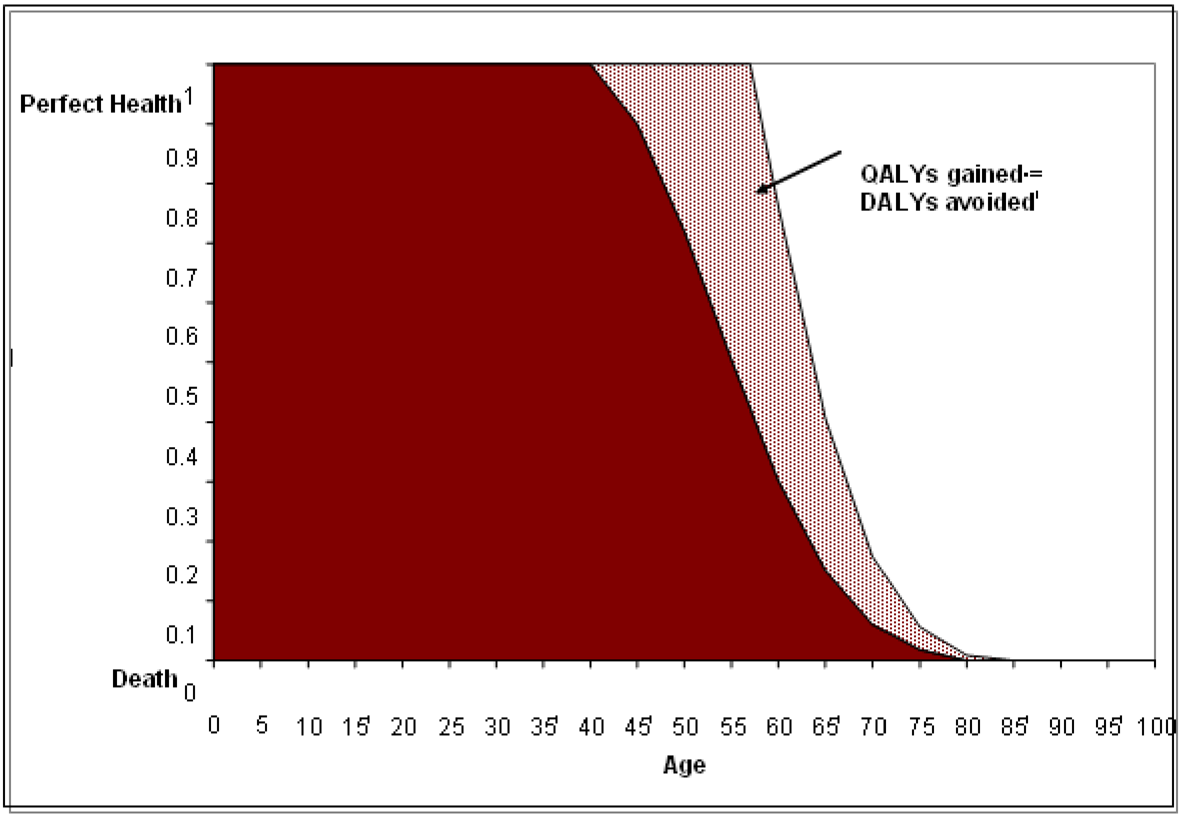
A final point to note is that years of life lost (YLL) is calculated relative to life expectancy based on the benchmark of the highest reported national life expectancy in the world (Japanese women). To calculate YLL a life table is constructed.

A useful software tool for use in calculating burden of disease (eg, calculating prevalence when incidence, remission and mortality are known) is DISMOD-II, which can be downloaded from http://www.who.int/healthinfo/boddismod/en/index.html

A graphical representation of a hypothetical intervention that increases longevity and QoL is depicted in Figure 2—1. In this example, a person has close to perfect health to age 40 years and then loses QoL due to one or more health conditions[7] until expected death at 80 years (the x-intercept of the curve). The hypothetical intervention increases the person's life expectancy to age 85 years by delaying onset of morbidity to age 60 years and reducing its impacts thereafter at each year of age. The heavy shading represents QALYs prior to the intervention while the lighter shading represents QALYs after the intervention.

7 Occupational exposures and hazards accounted for some 2% of the total burden of disease and injury in Australia in 2003 (Begg et al, 2007).

Figure 2—1 Effect of a hypothetical intervention on QALYS and DALYS: Example



Strengths And Criticisms Of QALY and DALY Metrics

The attempt to place value or to rank different health states has been strongly criticised in some quarters due to the uncertainty and variability surrounding the rankings and their implications in terms of potential rationing of health services (some groups may receive services while others are excluded). Others (eg, some disability groups) criticise the implicit principle that the quality of some lives is less than the quality of other lives, and dislike the terminology 'burden of disease', holding the view that neither the people nor the health states represent a 'burden' to society (preferring 'wellbeing' terminology). While weighting disability states does bias against lifesaving interventions for disabled persons, it also biases towards QoL-improving interventions as there is more gain to be had. For people with chronic diseases, this is considered likely to be a positive trade-off.

Another criticism is that the metrics may fail to adequately account for the *proportion* of remaining lifespan. For example, some argue that a 20% reduction in lifespan would have the same value if one had five remaining years of life or 50 remaining years of life, while others claim that the only aspect of value is the dead-alive state, so any years remaining have the same value. Note that this policy would bias interventions against young people.

Advantages of the QALY and DALY metrics are that they are able to facilitate comparability between individuals with different conditions and across nations (including nations with different national incomes). However, some nations have subsequently adopted variations in weighting systems for DALYs that limit this comparability. For example, in some countries DALYs are age-weighted although, in Australia, DALYs are considered equal for people of all ages.

The main problem with the DALY/QALY approach is that it is not financial and is thus not directly comparable with most other cost measures. Health and wellbeing is currently not included in gross domestic product (GDP), yet it may have been one of the greatest sources of growth in living standards in the past century (Murphy and Topel, 2005), with the economic value from reduced mortality estimated by Yale University at around 40% of consumption (Nordhaus, 1999:15). The potential scale of the value of this 'intangible' has thus resulted in an attempt to develop appropriate economic frameworks to estimate the value of life and accord a 'shadow price' to a unit of healthy life (ie, VSL or VSLY). These frameworks are based on traditional neoclassical assumptions, which are examined in the next sections.

Applicability of Walrasian Assumptions

Leon Walras (1834-1910) made the first attempt in neoclassical economics to model a set of prices for a whole economy at which all markets would clear, providing general equilibrium. Every general equilibrium position is Pareto efficient (ie, no one can be made better off without making someone else worse off), but a number of assumptions must hold – consumer preferences must be locally non-satiated (ie, there is always a preferable level of consumption close to any given level of consumption); consumers must be rational; markets must be complete; there must be no externalities and information about all prices (both now and in the future) must be perfect.

Moreover, since every efficient allocation of resources can be supported by some set of prices, all that is required to reach a *particular* outcome is a redistribution of initial endowments, after which the market can be left alone to do its work and there will be no trade off between efficiency and equity. However, the conditions for this to occur require that consumers' preferences are convex (ie, they reflect diminishing marginal utility).

Under these assumptions, rational individuals and firms acting in free, well informed competitive markets will generally maximise social welfare.

Prices in markets will adjust in response to individuals and firms exercising choice.

> Individuals will seek to maximise their welfare (utility), taking into account their own wants and needs (preferences), their budget constraint and the prices they face. Conceptually they may also take into account the utility they derive from changes in others' utility (eg, altruism).

> Firms choose what, how and where to produce with the aim of maximising profits. Competition will drive firms to meet evolving consumer preferences at least cost, using increasingly efficient techniques.

While in many cases a free, well informed, competitive market will achieve welfare-maximising outcomes, often there exists market failure due to the breakdown of one or all of these assumptions. The following sections address why this may occur in the 'market' for life.

Rationality

People do not always appear to behave rationally, even in making decisions that affect the length and quality of their life (as well as more minor decisions). Particular cases in point include people with a mental illness, people who are addicted to abusive substances (including illicit drugs, alcohol and tobacco), children, and the frail aged, particularly people with dementia.

> Some 25.7% of Australians (4 million adults in 2005) have a mental illness (Access Economics, 2007 based on ABS, 1997 and interim health and demographic data). Anxiety disorders (11.9% of Australians), substance abuse (8.7%; principally alcohol abuse, 6.5%) and depression (6.2% prevalence), are the most common mental illnesses in Australia. In 2003, mental illnesses accounted for over 13% of the burden of disease (Begg et al, 2007), not accounting for downstream effects such as suicide and self-harm, which are higher for people with a mental illness. There is uncertainty in relation to whether such actions could be considered fully rational.

> In addition, around 3.2 million Australians in 2005 (21.3% of Australians aged 18 years and over) smoked tobacco daily (ABS, 2006). Since 38.3% of all adult smokers have a mental illness (Access Economics, 2007), around 2.0 million Australians are estimated to smoke who do not have a mental illness. There is debate in relation to the degree of rationality involved in harmful addictive behaviours.

> In addition to the adults, there are an estimated 4.8 million Australian children (aged under 18 years) and some 200,000 Australians with dementia.

From these data, a case might be made that around half the Australian population may not meet the rationality criterion. While some (including eminent) economists might argue that these agents are all behaving rationally as utility maximisers at some level (eg, Becker and Murphy, 1988; Cawley, 1999), the literature generally reflects concerns that addictive behaviours, particularly among people with severe mental illness, bring into serious question the applicability of traditional neoclassical microeconomic assumptions and hence frameworks of utility maximisation. Caplan (2006) states that:

'Even confirmed economic imperialists typically acknowledge that economic theory does not apply to the seriously mentally ill.'

Friedman (1962) argues this is because children and the mentally ill do not have stable, well-ordered preferences so rational behaviour and full information breaks down. In Australia in relation to tobacco smoking, Professors David Collins (Dept of Economics, Macquarie University) and Helen Lapsley (School of Medicine, University of Queensland) have written on the costs of smoking in Australia for various government agencies, including the cost of tobacco as a real cost to society (Collins and Lapsley, 2005). They argue that if all drug abuse ceased to exist, the consequent reduction in consumption would release resources which could be used for other consumption or investment uses, with 'abusive' defined as a substance that a) has an overall negative attributable fraction in burden of disease analysis, and b) is addictive. In contrast to the 'rational addiction' literature, they thus conclude that smoking is a 'bad' and its consumption is not easily explicable in rational neoclassical terms (see also Section 2.2.3).

Information

People also do not always have access to perfect information, but must navigate complex systems in order to derive current information eg, in relation to risk of injury, compensation payments or specialist clinical data relevant to their health outcomes. In the health sector, consumers generally do not have the necessary expertise to make decisions by themselves that would optimise their own best interests – they need to rely on the advice of their doctors and pharmacists (information asymmetries).

Accessing perfect information regarding future health outcomes is even more unlikely. Collins and Lapsley (2005) note that neoclassical theory demands a situation of full knowledge of the future consequences of a behaviour at the time at which an action was undertaken, and that a high proportion of tobacco and other addictions are acquired in early or mid teens when the presence of full information (as well as rationality) is questionable.[8] The growing prevalence of childhood obesity is a particular

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[8] They also argue that, with addictive products such as tobacco, the objective of consumption is often to avoid highly unpleasant effects of withdrawal – rather than to gain any positive benefits. Since the withdrawal effects result from previous consumption of the addictive drug, avoidance of such effects cannot be viewed as a 'benefit' of consumption

concern of policy makers in part because it is a predictor of obesity and associated worse health outcomes in later life (cardiovascular disease, diabetes, cancers and osteoarthritis), that children are unlikely to fully take into account in their diet and exercise consumption 'choices' today (Ebbeling et al,2002).

In addition, it can be very difficult to accurately assess the impacts of very small changes in risks, either currently or in the future. For example, rational consumers may make decisions to go parachuting or bungee jumping, despite increased risk to life, because their perception of the risk may be smaller than it actually is. This is also complicated by the fact that healthy life is a joint product in the consumption and production of all other goods and services.

Externalities

An externality is a cost or benefit resulting from an economic transaction that falls on third parties in society ie, agents not directly involved in the transaction. Externalities can be positive, when an external benefit is generated, or negative, when an external cost is imposed upon others. Externalities often occur in relation to the use of a public good. For example, air is a public good and production that causes air pollution may impose costs on others, including potentially worse health outcomes.

Because the participants who are party to the transaction do not bear all the costs or reap all the gains, in a competitive market too much or too little of the good or service may be produced and consumed from the point of view of social welfare optimisation. If third parties benefit substantially, such as in areas of education or safety, then the good will be underprovided and/or under-consumed; if costs to 'the public' exceed costs to the individual, then the good will be over-provided. For example, returning to the example of smoking, the costs are not borne fully by the smoker but have detrimental impacts on others, including passive smokers and particularly children who are adversely impacted by greater risk of low birth weight, Sudden Infant Death Syndrome, asthma and other health conditions. In addition, taxpayers pay for health system expenditures and other costs associated with smoking.

In health and safety there are numerous external benefits and costs for the rest of society.

> **External benefits**: For example, if a person chooses to vaccinate against an infectious disease, they also decrease the risk of transmitting the disease to non-vaccinated members of society. Thus they do not capture the full benefit of their actions, while the third parties can 'free ride' on external benefits that they have not paid for.

- **External costs**: People who experience a workplace incident or who have poor health are more likely to require care (sometimes provided for 'free' by friends or family carers), to have higher government service use (more hospital and GP visits[9], more likelihood of receiving the Disability Support Pension or other welfare transfers) and to have lower productivity (thus lower taxation revenue). Thus they do not capture the full cost of their actions and this presents another moral hazard dilemma. Examples of potentially fatal externalities include drink driving victims or bystanders in occupational accidents.

In the transport sector, positive externalities of transport networks may include the ability to provide emergency services, increases in land value and agglomeration benefits. Negative externalities are wide-ranging and may include local air pollution, noise pollution, light pollution, safety hazards, community severance and congestion. The contribution of transport systems to potentially hazardous climate change is a significant negative externality which is difficult (but not impossible) to evaluate quantitatively.

A key externality of improving an individual's poor health state, or improving their safety in relation to the risk of adverse health states, is the social utility derived from improving equity. Some arguments justifying the pursuit of a minimum level of health and safety in the population include (Marmor and Boyum, 1999, reflective also perhaps of Amartya Sen's work):

- healthy life is the most basic and fundamental of all human needs;
- health is central to the ability of individuals to pursue their life as they would choose ie, healthy life is an input into all other consumption and production;
- market based rewards are justifiable only if people are healthy enough to participate in the economy;
- the initial endowment of health is a requirement for equity in opportunity, so differences in income should be based on effort rather than 'bad luck' in health;
- the health and safety of children is of particular importance due to long term impacts; and
- health and safety are needed to exercise political freedom.

Figure 2—2 illustrates positive externalities in the market for healthy life or, in practice, for interventions that generate healthy life. The private demand curve D for these interventions is lower than the social demand curve D' due to the presence of these externalities (lack of information

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[9]Around 70% of health expenditures are financed by Federal and State Governments, with very low marginal (out of pocket) costs to health service consumers.

and rationality that cause consumers to under-consume, social utility from improving health equity), crossing the supply curve S at point B (the social equilibrium) rather than A (the private market equilibrium). If governments provide a subsidy to consumers of P'-P per unit of the intervention, then the amount of health interventions consumed (and hence healthy life gained) will increase from H to H'.

Figure 2—2 Positive externalities in the market for healthy life

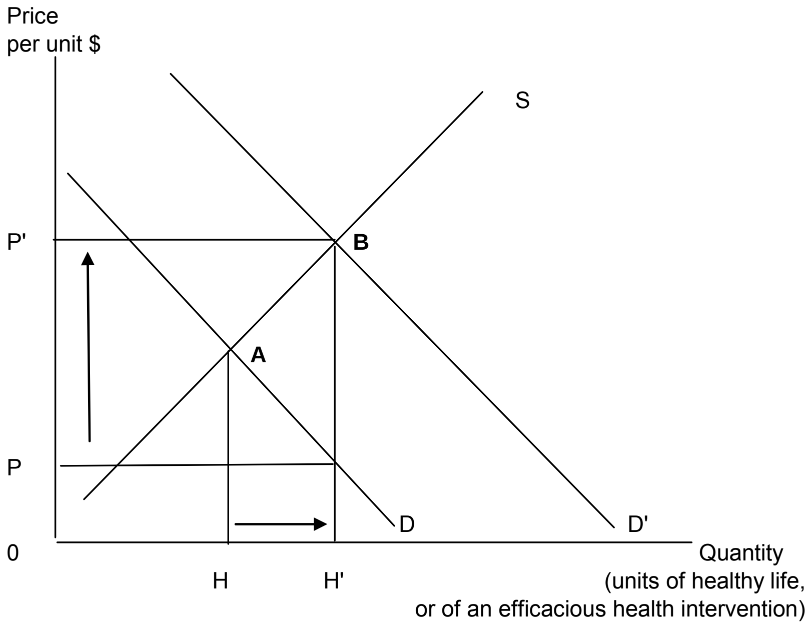
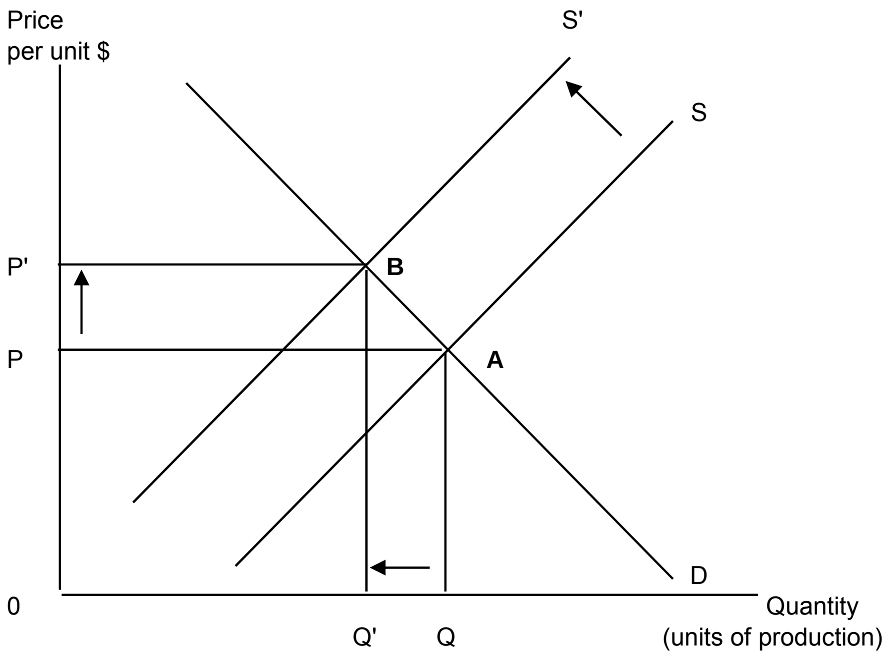


Figure 2—3 illustrates the converse case where negative externalities (risks to healthy life) are not taken into consideration by producers. In these cases, governments may regulate a particular level of safety to be achieved, which will increase costs to producers by P'-P (per unit of production), causing a shift upward in the supply curve from S to S' and a contraction of production from Q to Q'.

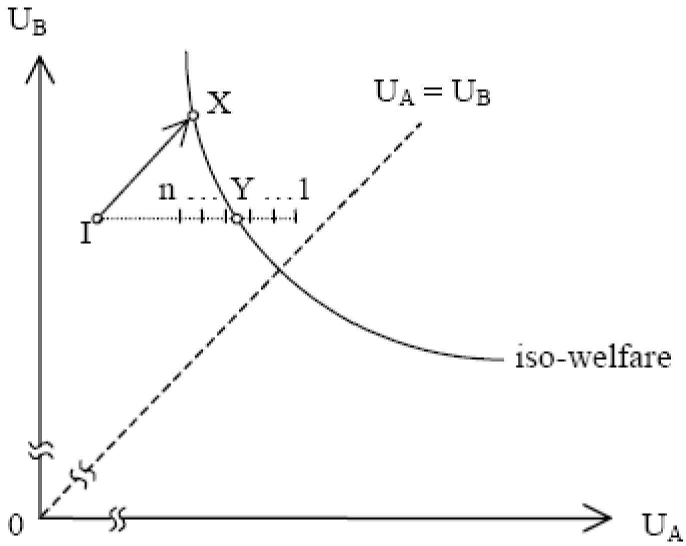
Figure 2—3 Negative externalities (risks to healthy life) in product markets



In health in civil societies (including Australia), delivering equitable health outcomes to different population groups is considered a social objective – as, for example, reflected in the principle of universal entitlement embedded in Medicare and the PBS and the priority given to safety regulation – such that people in different regions, with different socioeconomic status, of different ethnicities or gender, and with different health conditions have equal access to services that enable equitable health outcomes in terms of mortality and morbidity. In particular, societies believe that budget constraints should not unduly limit access to a minimum level of health.

The way this type of social welfare optimisation framework works in choosing between different interventions is represented in Figure 2—4, which depicts an iso-welfare curve where society is indifferent between trading off the utility of $U_{A,}$ the health of the less advantaged group and $U_{B,}$ the health of the more advantaged group. Suppose I is the initial point before an intervention, X is the outcome offered by Intervention 1, and the horizontal broken line is the set of options (1 to n) offered by Intervention 2 (say, in relation to indigenous health). Then Y is the point at which society is indifferent between the two interventions. The framework is also useful in explaining altruism, by changing the shape of the iso-welfare function.

Figure 2—4 Comparing interventions using a welfare economics framework



While externalities exist, Governments can intervene in health and safety markets to increase the likelihood that scarce resources are efficiently allocated (and thus maximise society's welfare, including health and safety equity) through taxation or subsidisation, regulation, and the provision or funding of products or services.

Market Tradeability

A final fundamental assumption is the operation of free and competitive markets in which goods and services can be traded. There are a number of reasons why this assumption may not hold in the 'market' for life.

> **Biological and physiological constraints**: In many cases it is not possible for people to reallocate units of healthy life among each other. While markets in organs exist (although these are not generally condoned), in most cases it is difficult for one person to transfer units of healthy life to another person.

> **Technological constraints**: It is also currently technologically impossible to indefinitely prolong healthy life for any individual. For a majority of lost DALYs, there is no ability to change the outcome for the individual.

> **Budget constraints**: As noted in the previous section, budget constraints may limit socially optimal allocations of resources to purchase healthy life years for the most disadvantaged, if these externalities are not addressed through government interventions.

Other Matters: The Labour-Leisure Choice

There are other matters that are not well explained by economic theory. The shadow price for a 'resource' (healthy life) that is jointly consumed in all other consumption is difficult to estimate from a Lagrangian function. There is also the issue of whether utility is derived solely from consumption of goods and services and the extent to which utility involves various non-consumption benefits (eg, positive relationships with others). A final matter is the way that the same activity might be valued in different contexts – eg, tasks like cooking or driving can be counted as paid work and included in GDP, domestic chores or leisure activities, and economic frameworks do not cope well with this variability.

There is one other area of economic theory that needs to be mentioned in a little more detail in this context, which relates to the theory of the allocation of time. Becker (1965:299) foreshadowed that:

> *Economic development has led to a large secular decline in the work week, so that whatever may have been true of the past, today it is below fifty hours in most countries, less than a third of the total time available. Consequently, the allocation and efficiency of non-working time may now be more important to economic welfare than that of working time; yet the attention paid by economists to the latter dwarfs any paid to the former. Fortunately, there is a movement underway to redress the balance.'*

Becker applied consumer theory to the labour-leisure choice where leisure is considered one good and labour the other (in a two-good world). A consumer has a finite and scarce amount of time (known as the time endowment or T) and must make a choice between labour (L), which earns income for consumption and leisure (l), which does not.

ie, $l + L = T$ and $l + (T-l) = T$

If the individual consumes what they earn then their consumption (C) is:

$C = w*(T-l)$ where w is their wage rate.

Consumer theory can then be applied (substitution and income effects) to investigate the impacts of policies such as welfare benefits and labour taxation.

The labour-leisure choice is deemed to occur 'in any period'. In reality, people tend to make these choices over a lifetime. Most people in western economies spend little time during childhood in the workforce and plan for increased leisure in retirement as well. The labour-leisure choice is thus a lifetime allocation decision, rather than one based on a particular year. This has implications how the lifetime value of production should be ascribed by age. For example, if the value of life at each year of age mapped income or even consumption, it might be lumpy, with a peak in the prime working years. Due to the intertemporal nature of the labour-leisure choice, utility from each year of life may be much more of a constant.

Chapter 3: Measurement Approaches

Until recently many economists and policy makers argued that it was not possible to place a value on human life. Irving Fisher observed in 1909 that 'it is impossible in any true sense to measure human life in dollars and cents' (Motha, 1990). Broome (1978) argued that if death is immediate and no bequests are permitted, the dollar value of life is infinite, since money is of no use to a dead person, and CBAs involving deaths are thus inappropriate.

Despite the difficulties of measuring the value of life, most economists and public policy makers recognise that, given the scarcity of resources for public projects and the consequent need for efficient allocation, if such valuations are not made explicitly then they will be made implicitly through decisions about which projects proceed and the funding accorded to competing projects. Any allocative decision that affects individual risk levels implicitly places a priority or a value on life and a major purpose of CBAs, and of this review, it to assist in making these values more explicit.

The Value of A 'Statistical' Life

'The valuation of life is generally an emotive issue fraught with philosophical and conceptual problems. Consequently, it is an issue riddled with controversy and debate. It is also associated with seeming irrationalities. For example, society will usually go to great lengths to save identified lives such as sailors stranded in mid-ocean or a child in need of expensive surgery. However, when the lives to be saved are anonymous, as for example in the case of funding research into cures for disease that would save lives in the future, public response may not be quite as generous. This apparent irrationality may be due to the greater sense of responsibility and claims of conscience associate with identified lives as opposed to anonymous lives.' Motha (1990:1).

The concept of a 'statistical' life has evolved in order to distinguish the value of the life of an anonymous or unknown individual from the life of a known or particular person. The distinction, however, implicitly makes value judgements: that the utility value of healthy life to the person whose life it is, or to those known to that person, is not relevant and that the anonymous valuation is the correct perspective from which to make an assessment. Corollaries, also arguable, are that anonymous valuation will be considerably less than that of the individual and those known to him/her and that policy decisions based on such valuations can be removed from their downstream impacts on specific lives. While these aspects will be discussed in subsequent sections, the terminology 'statistical' is retained in this report.

Traditional Productivity Approaches

The lost productivity method to estimating VSL and VSLY is based on the expected earnings of the individual, and is based on neoclassical economic theory. Wages and other marginal costs are assumed to equal the value of the marginal revenue generated by an additional worker under conditions of full employment (Berger et al, 2001). Lost product is thus the value of the wages (measured as average earnings) plus other inputs to production (capital, plant and equipment, land, enterprise etc) multiplied by the number of workdays missed. For reduced productivity while working, a percentage of this calculation is generally used.

Human Capital and Frictional Approaches

Nevertheless productivity approaches have been used in the absence of other methods to impute a value for lost life essentially as the market value of lost earnings.

> The human capital approach estimates the net present value (NPV) of the future stream of lost earnings as a result of a reduced health state.

$$NPV = \Sigma Y_i/(1+r)^{\wedge}{}_i \text{ where } i=0,1,2....n \text{ where}$$

Y_i = income in year i, n = years of remaining life and r = discount rate.[10]

> The frictional approach is used in situations of high unemployment[11] or in short term situations to estimate only the production lost (or additional costs incurred) between when a person stops working and when they return to work, are replaced by another worker or, alternatively, for the time period required to restore production to its pre-incident state (Koopmanschap et al, 1995; Brady et al, 1997).

[10] Some calculations truncate the income stream at average retirement age, while more sophisticated calculations estimate the probability of employment each year and multiply that by the expected income stream in employment in each year.

[11] In this situation society may not suffer as large a loss, as the previously unemployed worker who generated no income now generates an income, while the injured worker no longer generates an income.

> The human capital approach is an accounting approach that uses the discounted present value of a worker's future earnings as a proxy for the cost of premature death, injury or illness. It characterises people as a labour source and input to the production process and implies the value to society of preventing an incident is the saving in potential output or productivity capacity (BTE, 2000:19-20).

The frictional approach is not generally applicable in Australia in cases of severe injury or disease that result in death, exiting the workforce or reduction in hours worked over the long term. This is because, in an economy operating at near full employment, there is not an unemployed labour pool from which to draw idle resources. Rather, markets and wages must adjust slightly and, overall, there is a reduction in productive capacity as a result of the reduced availability of the labour input. The human capital method is the appropriate method to use in such cases, and also reflects the investment in trained labour.

The human capital method generally has been preferred to the frictional approach in western countries in relation to OHS interventions designed to prevent serious injuries and disease (eg, Leigh et al, 2000 in the US; NOHSC, 2004 in Australia). The reason for choosing the human capital method tends to be a general recognition that after the initial disruption until production is restored to former levels (most relevant for minor injuries), there is essentially the loss of the labour resource (when there is permanent disability or fatality) over the longer term, which reduces the capacity of the economy to produce at any given level of unemployment. An implicit assumption is that the change is of insufficient size to affect the overall clearing of the labour market. For large shocks, the validity of this assumption needs to be reconsidered.

The human capital approach is useful to estimate productivity losses, as they are of interest to policy makers, but form only a component of the VSLY. The human capital valuation could be considered to be an absolute lower bound on the VSLY.

The lost productivity approach is the simplest methodology to use, but may suffer from several serious drawbacks as a measure of VSL and VSLY (O'Brien and Gafni 1996:289; Berger et al, 2001).

- It violates basic economic fundamentals regarding individual sovereignty, measuring not how much the individual values healthy time, but rather what others value as their healthy time.
- The approach assumes that there are no imperfections in the labour market such as discrimination, free movement of labour, and so on.
- Unpaid work, such as household production and caring for others, are largely ignored.

- The choice of wage rate can be an issue – most studies use an all-industry average wage rate, whereas some use a minimum wage or industry-specific rate.[12]
- The choice of time period can also be an issue, with some studies using a fixed period, and other using a variable period (such as life expectancy).
- It does not capture the value of all the other reasons for living other than to work (consumption, other sources of utility from leisure) – ie, the quality of healthy life aspects.
- It raises equity issues regarding the VSLY of the disabled, aged, children and others not in the paid workforce.

'Mark-Ups' for Leisure and Other Variations

In attempting to take account of the value of unpaid work and leisure, a hybrid approach has been adopted in some cases where the value of lost leisure time (or time spent in unpaid work) is estimated as some proportion of the value of earnings. Common proportions are 30% or 40% (eg, Hogan, 2003).

Other early approaches to valuing life are listed below (Motha, 1990).

- The discounted consumption approach measures the total gain (in terms of value of consumption) that an individual receives for remaining alive.
- The implicit value approach involves determining the value from past investments by public policy makers that have reduced mortality rates.
- The insurance value approach uses the insurance premium paid and probability of death to calculate the VSL.
- The court award approach uses the value awarded by courts to the next of kin as compensation for the death of an individual, payable by the one held responsible for the death.

In the Australian transport sector, a hybrid approach has been adopted. Austroads (2007, 2006) values cost per crash (2005 prices) by severity ranging (by jurisdiction) from $1.93- $2.07 million for non-urban fatalities and $1.65-$1.82 million for urban fatalities. Serious injuries range from $453,600-$530,800 (non-urban) and $416,000-$441,600 (urban). Minor injuries range from $18,600-$20,100 (non-urban) and $18,000-$$19,600 (urban). Austroads recommends use of per casualty level data to develop crash costs for specific situations (eg, for people seriously injured in a fatal crash in an outer metro area in Victoria).

[12] This has been a particular issue in compensation payments to people who are higher than average income earners (Pope, 2006).

These costs are based on Austroads (2003) – which in turn is based on earlier reports including BTE (2000) and Bureau of Transport and Communications Economics (1996) – and includes labour lost 'in the workplace' and lost 'in the household' and the value of the 'QoL'. Household labour is valued at 83% of the workplace labour for all crashes, while the 'QoL' is valued at 92% and 209% of the workplace labour respectively for fatal and serious injury crashes. Costs other than these three are workplace disruption, criminal prosecutions, correctional services, ambulance, hospital inpatient and other medical costs, long term care costs, funeral and coroner costs, vehicle costs (mainly repairs), insurance claims (potentially double-counting the vehicle repair and ambulance costs) and general costs (such as travel delays, insurance administration and police/fire attendance). These other costs represented 11% of total costs for fatal accidents, 76% for serious accidents and 83%

for other accidents. Essentially the hybrid approach to costing developed in 1996 has been serially updated based on CPI and allowing for compositional effects (eg, changes in the severity patterns of incidents).

Willingness to Pay Approaches

An alternative approach to valuing human life is the willingness to pay (WTP) approach, which originated in the 1960s (eg, Schelling, 1968). Since this time, the economic literature has focused on people's WTP (or willingness to accept) changes in actual or risked tradeoffs between healthy life and money.

> The willingness to pay approach estimates the value of life in terms of the amounts that individuals are prepared to pay to reduce risks to their lives. It uses stated or revealed preferences to ascertain the value people place on reducing risk to life and reflects the value of intangible elements such as QoL, health and leisure. While it overcomes the theoretical difficulties of the human capital approach, it involves more empirical difficulties in measurement (BTE, 2000:20-21).

'The economic question being dealt with here is not about how much an individual would be willing to pay to avoid his or her certain death or how much compensation that individual would require to accept that death. In this respect, the term 'value of life' is an unfortunate phrase that does not reflect the true nature of the question at hand. Most people would be willing to pay their total wealth to avoid certain death; and there is probably no finite sum of money that could compensate an individual for the sure loss of life. Rather, the economic question is about how much the individual would be willing to pay to achieve a small reduction in the probability of death during a given period or how much compensation that individual would require to accept a small increase in that probability.' Freeman (1993)

To illustrate how the VSL is estimated, suppose that an individual is willing to pay (accept) $20 for a reduction (increase) of risk of death of 1 in 100,000. Thus the VSL is 20*100,000 = $2 million. Alternatively if an individual is willing to pay $0.25 for a reduction in the risk of 1 in 100,000 of paraplegia for 1 year with a disease weighting of 0.5, then the VSLY is $50,000. To extrapolate this to the VSL then the simplest approach is:

$$VSL = VSLY * E$$

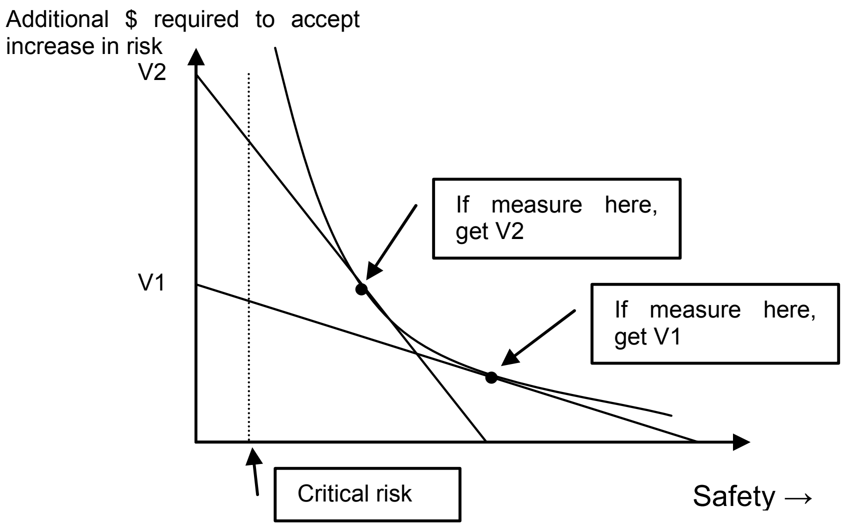
where E is the individual's life expectancy or, taking into account time preferences:

$$VSL = \Sigma VSLYi/(1+r)^{\wedge}{}_{i} \text{ where } i=0,1,2....n \text{ where}$$

$VSLY_i$ = VSLY in year i, n = years of remaining life and r = discount rate.

This approach assumes that the VSLY does not change with the base level of risk, however. Broome (1978) argued that at some level of critical risk individuals are not willing to trade off any more health and the VSLY approaches infinity, and thus the value of at which you measure risk influences the final estimated VSL (Figure 3—1).

Figure 3—1 VSL estimate dependent on base level of risk (Broome theory)



This concept helps explain why people tend to value specific lives under threat (eg, Beaconsfield miners) as more valuable than anonymous lives, in contrast to most WTP source studies, which are based on purchasing a minor reduction in the risk of death rather than buying out the risk of certain death. We now turn to these different empirical valuation methods. In general, there are two main methods for empirically measuring VSL:

- stated preference valuation methods; and
- revealed preference valuation methods.

Stated Preference Valuation Methods

Stated preference approaches attempt to elicit VSL or VSLY through hypothetical or referenced evaluation. They can be used to estimate the benefits of policies that place people beyond the range of their choice making experience (eg, changes in job risk not experienced, new life saving drugs, OHS interventions). They avoid issues such as the ability to pay and provide greater control over scenarios (disease, potential treatments, risk faced, and so on), information and externalities. For example, the individual being asked about preferences may be asked to 'exclude the impact on future earnings'. They circumvent the absence of markets for healthy life by presenting consumers with hypothetical markets in which they have the opportunity to pay for the outcome in question. The hypothetical market may be modelled after either a private goods market or a political market. However, because reality checks may be difficult and decision-makers in some studies may have unlimited budgets, there can be questions regarding the validity of the values selected (more so than the ranking). That said, better-designed studies use referencing and can hence pivot attribute levels to trade around real world levels experienced, a way of making estimates more realistic.

The terminology varies in relation to stated preference approaches. 'Stated choice' models tend to refer to more recent and sophisticated stated preference models used widely in transport safety, while 'contingent valuation' (CV) has more of an association with older, American and possibly more controversial stated preference models used in environmental valuations, where CV remains the most widely used method for estimating non-use values[13]. The CV method involves directly asking people, in a survey, how much they would be willing to pay or accept for specific outcomes eg, the amount of compensate on they would be willing to accept to give up a wetland (or a year of healthy life). It is called 'contingent' valuation because people are asked to state their WTP contingent on a specific hypothetical scenario. In this sense there seems little difference in the terms CV and stated preference. In both cases the defining characteristic is that they do *not* infer values from

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[13] Because CV is used to value non-market purchases that may not involve direct participation, these values are sometimes referred to as 'passive use' values. In the environmental applications, they include everything from the basic life support functions associated with ecosystem health or biodiversity, to the enjoyment of a scenic vista or a wilderness experience, to appreciating the option to fish or bird watch in the future, or the right to bequest those options to your grandchildren. It also includes the value people place on simply knowing that giant pandas or whales exist.

actual real world decisions, as the revealed preference methods do (see Section 3.3.2).

> Another difference is between the *choice* and the *valuation*. The main differences are in the design of the question(s), and the data analysis. The statistical analysis for stated choice is often more complicated than that for stated valuation, requiring the use of discrete choice analysis methods to infer WTP from the tradeoffs made by respondents. Rizzi and Ortuzar (2006) state that:

'CV usually implies a trade-off between probabilities of risk and money in a context not completely specified… The context in which we set up the choice situations here [in their study] is well defined, easily understood by most people, and real market restrictions are introduced to prevent respondents producing unlikely responses. This has the effect of tempering responses, and precluding people to produce 'outliers'. De Blaeij et al (2002) reported a similar finding.'

Stated preference surveys were first applied in the 1960s when surveys were used to estimate the value that hunters and tourists placed on a particular wilderness area. The survey results were compared to an estimation of value based on travel costs and good correlation was found. In the 1980s the CV method rose to prominence in the US when CV surveys were used for quantitative valuations in relation to the Exxon Valdez oil spill in Prince William Sound. The technique has also been used in Australia to value areas of the Kakadu National Park (Carson et al, 1994).

The fact that stated preference models are based on what people say they would do, as opposed to what they are observed to do, is the source of their greatest strengths and its greatest weaknesses. The conceptual, empirical, and practical problems associated with developing dollar estimates of economic value on the basis of how people respond to hypothetical questions about hypothetical market situations (with hypothetical budgets) are debated constantly in the economics literature. Although researchers are attempting to address these problems, many economists, jurists, policy-makers, psychologists and sociologists, for many different reasons, do not believe the dollar estimates that result from stated preference models are valid and will not accept their results. Caution is suggested in relation to spending money on stated preference studies and about using their results.

There are essentially three stated preference approaches that may be used to estimate the VSL or the VSLY.

> **Ex-post**: if you were experiencing condition x, how much would you be willing to pay for obtaining the benefits from intervention z?

> **Ex-ante**: if the chance of experiencing condition x were y%, how much would you be willing to pay for obtaining intervention z?

> **Ex-ante (insurance based)**: what would you be willing to pay for an insurance against incurring costs for intervention z in case of condition

x? (This method is claimed to be most reflective of real world situations.)

In general, due to the presence of risk aversion, a larger WTP will result from an ex-post approach compared to ex-ante, and a larger WTP will result from an ex-ante approach (not insurance based) compared to an ex-ante approach (that is insurance based).

Both the nature of the intervention and of the alternative influence the results. If the intervention is life-saving, then risk aversion is taken into account; if it is life-extending, then the length of time left is taken into account, compared to if the intervention only improves QoL but not longevity. If the individual is comparing the intervention to no intervention, then Broome's argument may come into play (see previous section) and the value of large changes in risk can be accounted for. If the intervention is one that the person does *not* prefer to no treatment, some approaches might force the individual to place a positive (or zero) WTP value on the treatment (when in fact it would be negative), which would bias the results upwards (Donaldson et al, 2006).

Surveys are commonly used in the stated preference approach. The survey method of eliciting values also impacts on the estimated VSLY (O'Brien and Gafni, 1996).

- **Open-ended scale**: how much would you be willing to pay? This can be cognitively difficult, as most people are not used to specifying their 'price', rather than shopping around or bargaining.
- **Closed-ended scale**: also known as a discrete choice approach, where respondents are simultaneously shown two or more different alternatives and their characteristics, and asked to identify the most preferred alternative in the choice.

Take-it-or-leave-it/dichotomous choice: respondents are asked whether they are willing to pay a certain amount (random price given) for a particular described benefit. Often the results are in the high WTP range because there is no income constraint.

Bidding games: respondents are provided with changing proposed amounts until they are indifferent between choosing the intervention or not. The result often depends on the range provided, methodology used (bottom-up, top-down or ping-pong) and the starting point. Standard gambles, time tradeoffs and other techniques listed in Section 2.1.2 are also used.

Paired rating: respondents are asked to compare two alternate situations and are asked to rate them in terms of strength of preference. For instance, people might be asked to compare two OHS programs and their outcomes, and state which is preferred, and whether it is strongly, moderately, or slightly preferred to the other program.

Contingent ranking surveys ask individuals to compare and rank alternate program outcomes with various characteristics, including costs. For instance, people might be asked to compare and rank, in order of preference, several mutually exclusive programs under consideration, each of which has different outcomes and costs.

Mathers et al (1999:10) summarise the four main methods as per the box.

Rating Scales – a chart displays two health states with the most preferred rated at 100 and the least preferred rated at 0. Individuals must indicate on the chart where other health states would fall.

Standard Gamble – Individuals must consider two alternatives. In the first, their health state is certain. In the other, there are two possible health states, one better than the certain state (ie, ideal health) and one worse (ie, death). The probability that the best state occurs is varied until the subject is indifferent to their health state being certain. This probability, or point of indifference, is the 'utility' of the health state under consideration.

Time trade-off – Individuals are asked to choose between a longer life, or a shorter life but in good health. The length of the shorter life is varied until the individual is indifferent between the two.

Person trade-off – An individual must choose between a lesser health benefit for a larger number of people, or a larger health benefit for a smaller number of people. For example, saving a larger number of lives but having less than ideal health, and saving a smaller number of lives but with ideal health.

Framing effects, the level of ignorance (realism versus full information), and the presence of a strategic incentive to truthfully reveal their WTP also impact on the stated preference measure of VSL and VSLY. Some example survey questions for a private good and a public policy are presented below, adapted from Johannesson et al (1996).

Private good: 'In the US, about 1 in 5,000 people die annually in traffic. A possible measure to reduce the traffic risk is to equip cars with safety equipment, such as airbags. Imagine a new type of safety equipment. If this equipment is installed in your car, the risk of dying in a traffic accident will be cut in half for you and everyone else travelling in the car. This safety equipment must be tested and serviced each year to make sure that it is working correctly. Would you choose to install this safety equipment in your car if it will cost you $A per year?' [YES or NO]

Public policy: 'In the US, about 1 in 5,000 people die annually in traffic. The number of deaths can be reduced if we devote more resources to preventing traffic accidents. We can, for example, straighten out turns, build safer crossings, and increase the supervision of traffic. Imagine a program that cuts in half the risk of you and everyone else dying in a traffic accident. Are you willing to pay $A per year more in taxes on your car for this program?' [YES or NO]

With both questions, A might take on values of $30, $150, $300, $750, $1500, or $3000 for each survey respondent. The VSL would be calculated as equal to the average WTP divided by the reduced risk of death (δR). The reduced risk of death is equal to the number of lives saved divided by the affected population. If the average WTP = $500 and δR = .0001 (1 in 10,000), then VSL = 500/.0001 = $5 million.

Although stated preference models have the potential to generate highly stratified results based on age, gender, SES, time, location, type and situation/setting of the trade-off, and any other granularity desired, the major limitations are:

> it is not clear that the variation in responses reflects actual/real variation since answers are not validated;

  -this is an important consideration, particularly if such variation is then used to determine different access for different groups to life-enhancing interventions;

> variability does not just reflect strata but varies depending on how a question is framed and the survey approach adopted, and is highly sensitive to what people believe they are being asked to value, as well as the context that is described in the survey;

> in many studies, people are making decisions about the value of others' 'statistical' lives rather than their own, which (like the human capital approach) violates individual sovereignty and may result in inaccurate accounting for the value of certain lives.

In relation to the latter point, for example, the people asked in the survey to value the life of a child would not include that child's future children, so there is likely to be a bias towards the age-group surveyed (and away from younger or older people). This also becomes relevant in explaining the 'n'-curve observed in some studies using this approach (Section 4.3.2).

In addition, the application of a stated preference approach is generally a complicated, lengthy, and expensive process. In order to collect useful data and provide meaningful results, the survey must be properly designed, pre-tested, and implemented. Survey questions must focus on specific outcomes and contexts that are clearly defined and understood by respondents. Section 4.3.4 provides an example of good stated choice experimental design provided by ITLS. Carson (2000), as well as summarising the major issues and positions taken in the technical debate over the use of stated preference (CV) approaches, presents key design and implementation issues involved in undertaking a survey and the reader is provided with a set of factors to examine in assessing the quality of a CV study. Some criteria for good stated preference survey design are provided in the following box.

Tips for stated preference survey design to value life[14]

Before designing the survey, learn as much as possible about how people think about the health outcome. Consider people's familiarity with the outcome, as well as the importance of such factors as quality, quantity, accessibility, the availability of substitutes, and the reversibility of the change.

Choose the survey sample based on the appropriate population.

The choice scenario must provide an accurate and clear description of the change in health status associated with the event, program, investment, or policy choice (intervention) under consideration. If possible, convey this information using photographs, videos, or other multi-media techniques, as well as written and verbal descriptions.

Unlike ordinary survey questions, which sometimes ask respondents whether they are willing to pay x dollars to improve 'air quality,' the nature of the changes to be valued must be specified in detail. It is also important to make sure that respondents do not inadvertently assume that other non-health improvements are included. For example, if people are asked to value only reductions in air pollution as it affects their health, it would be important to make sure that they do not include their value for the environmental benefits in their stated WTP amount.

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[14] Adapted from

http://www.ecosystemvalutation.org/contingent_choice.htm

Discrete choice format is generally accepted as preferable to open-ended format.

The survey must specify the mechanism by which the WTP payment will be made, for example through increased taxes. The respondent must believe that if the money was paid, whoever was collecting it could effect the specified change.

Respondents should be given budget constraints.

Specify whether comparable services are available from other sources, when the intervention is going to be provided, and whether the losses or gains are permanent or temporary (and if so for how long).

Respondents should understand the frequency of payments required, for example monthly or annually, and whether or not the payments will be required over a long period of time in order to maintain the change. They should also understand who would have access to the intervention and who else will pay for it, if it is provided.

In the case of collectively held goods, respondents should understand that they are currently paying for a given level of supply. The scenario should clearly indicate whether the levels being valued are improvements over the status quo, or potential declines in the absence of sufficient payments.

If the household is the unit of analysis, the reference income should be the household's, rather than the respondent's, income.

Thoroughly pre-test the valuation questionnaire for potential biases. Pre-testing includes testing different ways of asking the same question, testing whether the question is sensitive to changes in the description of the outcome being valued, and conducting post-survey interviews to determine whether respondents are stating their values as expected.

Include validation questions in the survey, to verify comprehension and acceptance of the scenario, and to elicit socioeconomic and attitudinal characteristics of respondents, in order to better interpret variation in responses across respondents.

The in-person interview is the most expensive survey administration format, but is generally considered to be better than telephone interviews or mail surveys, especially if visual materials are to be presented.

Interview a large, clearly defined, representative sample of the affected population.

Achieve a high response rate and a mix of respondents that represents the population.

Whatever survey instruments and survey designs are used, and whatever response rate is achieved, make sure that survey results are analysed and interpreted by professionals before making any claims about the resulting dollar values.

This presentation of stated preference approaches is lengthy, more so than for the revealed preference section following. The balance in the report derives from the balance in the literature. A summary is provided below.

Summary – advantages of stated preference approaches

- They are very flexible and can be used to estimate the economic value of virtually anything. However, they are best able to estimate values for goods and services that are easily identified and understood by users and that are consumed in discrete units (unlike healthy life), and only if there is no observable behaviour available to deduce values through other means.
- CV is the most widely accepted method for estimating total economic value, including all types of non-use, or 'passive use,' values. CV can estimate use values, as well as existence values, option values and bequest values.
- Though stated preference models require competent survey analysts to achieve defensible estimates, the results tend not to be too difficult to analyse and describe. Dollar values can be presented in terms of a mean or median value per capita or per household, or as an aggregate value for the affected population.
- Stated preference models have been widely used, and a great deal of research is being conducted to improve methods, make results more valid and reliable, and better understand strengths and limitations. Internal validity can often now be checked (ie, whether the data are consistent with theory such as positive income elasticities), and sometimes also externally validated if there is a real world situation which is similar enough to use as a benchmark.
- Some people prefer the stated preference approach due to the weaknesses of the revealed preference approach – self-selection, information and market imperfections, base level of risk and budget constraints.

Summary – issues and limitations of stated preference approaches

- Although stated preference methods have been widely used for the past three decades, there is considerable controversy over whether they accurately measure people's WTP.

- People have practice making choices with market goods, so their purchasing decisions in markets are likely to reflect their true WTP. Surveys assume that people understand the outcome in question and will reveal their preferences in the contingent market just as they would in a real market. However, most people are unfamiliar with placing dollar values on health outcomes and may not have an adequate basis for stating their true value, particularly in the absence of specific context (Sunstein, 2000).
- The expressed answers to a WTP question in a stated preference format may be biased because the respondent is actually answering a different question from the one the surveyor had intended. Rather than expressing value for the good, the respondent might actually be expressing their feelings about the scenario or the valuation exercise itself. For example, respondents may express a positive WTP because they feel good about the act of giving for a social good eg, to save someone's life (referred to as the 'warm glow' effect); they may state a positive WTP in order to signal that they place importance on improved health outcomes in general (Subramanian and Cropper, 2000).
- Respondents may give different WTP amounts, depending on the specific payment vehicle chosen. For example, some payment vehicles, such as taxes, may lead to protest responses from people who do not want increased taxes. Others, such as a contribution or donation, may lead people to answer in terms of how much they think their 'fair share' contribution is, rather than expressing their actual value for the good.
- Some researchers argue that there is a fundamental difference in the way that people make hypothetical decisions relative to the way they make actual decisions. For example, respondents may fail to take questions seriously because they will not actually be required to pay the stated amount. Responses may be unrealistically high if respondents believe they will not have to pay for the good or service and that their answer may influence the resulting supply of the good. Conversely, responses may be unrealistically low if respondents believe they will have to pay.
- The payment question can either be phrased as the conventional 'What are you willing to pay (WTP) to receive this outcome?', or in the less usual form, 'What are you willing to accept (WTA) in compensation for giving up this health state?' In theory, the results should be very close. However, when the two formats have been compared, it has been consistently found that people treat gains and losses asymmetrically and require a substantially larger increase in wealth to compensate for a loss than the amount they would be willing to pay for an equivalent gain (Guria et al, 2005). The higher valuation in willingness to accept approaches has been explained as a cognitive problem; WTA gives individuals the perception of a property right over the decision of getting in a risky situation (Marquez, 2006). Critics have claimed that this result invalidates the stated preference

approach, showing responses to be expressions of what individuals would like to have happen rather than true valuations.

> If people are first asked for their WTP for one part of an outcome (eg, averting an accident where they damage a single leg bone) and then asked to value a more serious outcome (eg, the whole leg), or vice versa, the amounts stated may be similar. This is referred to as the 'embedding effect.'

> In some cases, people's expressed WTP for something has been found to depend on where it is placed on a list of things being valued. This is referred to as the 'ordering problem.'

> Many early studies attempted to prompt respondents by suggesting a starting bid and then increasing or decreasing this bid based upon whether the respondent agreed or refused to pay such a sum. However, it has been shown that the choice of the starting bid affects respondents' final WTP response.

> Strategic bias arises when the respondent provides a biased answer in order to influence a particular outcome. If a decision to deliver an OHS intervention such as regular ergonomic checks, for example, depends on whether or not the survey produces a sufficiently large value for the benefits of the checks, the respondents who are prone to back pain may be tempted to provide a higher value than their true valuation.

> Information bias may arise whenever respondents are forced to value attributes with which they have little or no experience. In such cases, the amount and type of information presented to respondents may affect their answers. In addition, people tend to think that a certain risky event is more likely to occur or has greater impact than other events if they have a memory of its occurrence, so people tend to overestimate WTP for highly publicised events and under-estimate less publicised events. Sunstein (2005) argue that fear and other irrational motivators can have major impacts on stated preference findings.

> Non-response bias is a concern when sampling respondents, since individuals who do not respond are likely to have, on average, different values from individuals who do respond.

> Estimates of the value of life using stated preference are difficult to validate externally.

> When conducted to the exacting standards required, stated preference methods can be very expensive and time-consuming, because of the extensive pre-testing and survey work.

> Many people, including jurists, policy-makers, economists, and others, do not believe the results of stated preference approaches.

Revealed Preference Valuation Methods

In the revealed preference approach (also known as the 'hedonic pricing' or 'hedonic wage' approach), real world empirical studies are used to seek information about people's behaviour when actually faced with trade-offs. These studies are limited in that only those trade-offs experienced by people can be used to infer the VSL.

A major advantage is that the approach is self-validated, since the prices derived are from actual purchases, risk-taking behaviours or other exchanges, which commonly include:

- compensating wage differentials;
- product market studies eg, cost of airbags actually purchased or fire safety devices (such as smoke alarms) installed;
- housing decisions eg, the discount in rent demanded to live near chemical factories (Hatfield et al, 2002);
- compensation through the civil court system, less preferable because decisions are often based on financial impacts and may be blurred by the existence of punitive damages; and
- public sector decisions, also less preferable because of the *circularity problem* ie, was the original societal decision maker correct in the first place?

Compensating wage differentials, the most common type of study (Marquez, 2006), use information on people's job choices to estimate WTP for job risk changes. The WTP for a risk change is equal to the wage differential generated from labour markets. Suppose that there is a 5 in 10,000 chance of a job fatality (this is a high job risk, higher than for the mining industry). If there are 10,000 workers, there will be 5 random deaths, but we can reduce the job risk and the number of deaths by 20% (from 5 to 4 in 10,000), at a cost. If the individual is willing to accept a wage $0.25 lower per hour for the lower job risk (but no less), then the annual value of the risk change is $0.25*2000 = $500 (assuming 2,000 hours worked per year). With 10,000 workers, VSL = $500*10,000=$5,000,000.

The advantage of labour market studies is the availability of data and different levels of risks which allow researchers to conduct multivariate econometric studies and successfully control for a variety of potentially confounding factors (Fried, 1969) using the function:

$$Y = \alpha + \beta\text{Risk} + \lambda\text{Education} + \theta\text{Gender} + \ldots + \varepsilon$$

Where Y is the income, Risk is the number of fatalities (or injuries) over the number of cases and Education, Gender and so on are other variables that affect and control the estimation of the coefficients. The identification of the β coefficient then defines the VSL as the social mean marginal rate of substitution of own wealth for safety (Dranove, 2003).

Limitations of the revealed preference approach are:

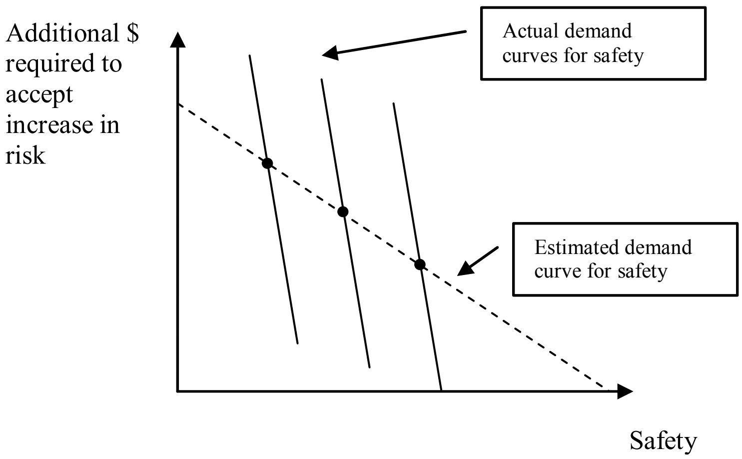
> potential imperfections or extraneous influences in labour (or product) markets such as imperfect information, and income/wealth or power asymmetries that can may difficulty in correctly perceiving the risk or in negotiating an acceptable change in wage (price);

> variability with the base level of risk (Broome theory, as previously discussed);

> blurring the health benefits with the non-health benefits such as compensation for a poorer work environment or the process of care;

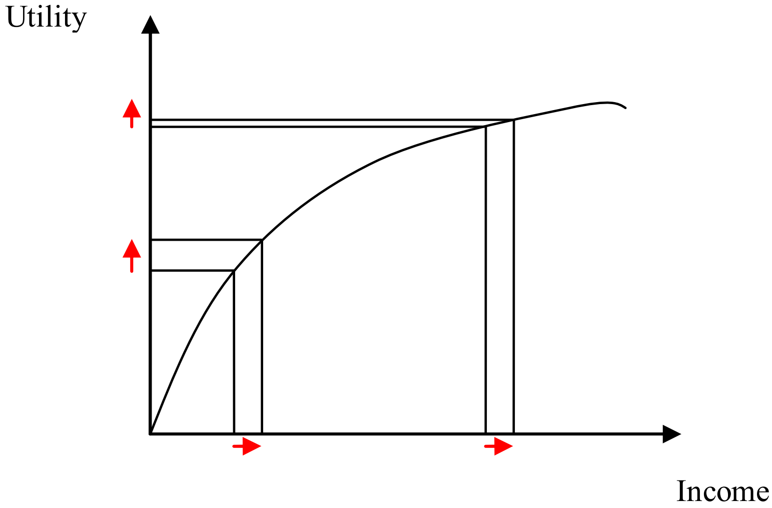
> selection bias, where individuals may self-select into particular jobs depending on other non-observable characteristics that econometric analysis cannot control for, such as the level of risk aversion – consequently econometric analysis may actually be formulating a demand curve for risk based on a series of points on different demand curves (known as the *identification problem* – see Figure 3—2), which would result in an underestimation of the WTP for a decrease in risk (and thus an underestimation of the VSLY). It may be possible to investigate the level of self-selection by asking pre-questions about risk-aversion, although this is still experimental.

Figure 3—2 The identification problem in revealed preference studies



For revealed preference studies, individuals take into account their ability to pay or their marginal utility of income (as income rises, the value an individual places on an additional dollar falls– see Figure 3—3). Consequently an individual with a lower level of income may be more willing to accept an increase in risk to health compared to an individual with a higher level of income. Empirical studies show that the SES of the population surveyed impacts strongly on estimates of the VSL.

Figure 3—3 The marginal utility of income effect



The Office of Best Practice Regulation (2007:124-6) appears to prefer revealed preference to stated preference methods.

'As a rule, estimates of individuals' valuations of goods and services from observing their behaviour in markets tend to be more credible than those from survey questionnaires. Observing purchasing decisions directly reveals preferences, whereas surveys elicit statements about preferences. Survey respondents may have little incentive to take the question seriously, invest in obtaining the information necessary to answer it accurately, or be truthful. They bear little cost for inaccurate or ill-considered answers and may have an incentive to exaggerate.'

Converting VSL to VSLY: Discount Rates

In both stated and revealed preference estimates the most common output is VSL rather than VSLY (see the private good/public policy example and the wage-risk example in the previous sections), since in most cases the risk of death is the outcome of interest. Hence most studies require conversion of the VSL to a VSLY. Some source studies, in particular those focused on different health states (morbidity) rather than mortality, need to convert the VSLY to VSL, as in the preambular introduction to Section 3.3. That section presented the formula for the conversion as:

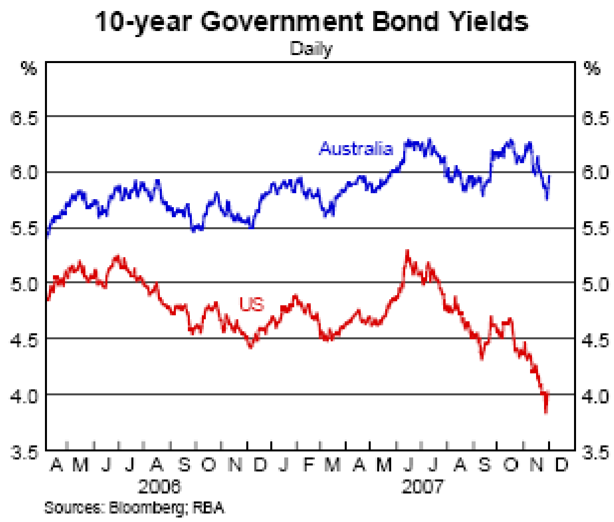
$$VSL = \Sigma VSLYi/(1+r)^{\wedge}{}_i \text{ where } i=0,1,2....n$$ where

$VSLY_i$ = VSLY in year i, n = years of remaining life and r = discount rate.

Clearly there is a need to know n (the years of remaining life), to determine an appropriate value for r (the discount rate), and to know any variation in VSLY by age or be prepared to use an average (the latter approach is suggested in Section 5.1.3). The years of remaining life at any given age should be based on average life expectancy tables.

Choosing an appropriate discount rate is a subject of some debate, as it varies depending on what type of future income or cost stream is being considered. The discount rate for VSL/VSLY conversions needs to appropriately take into account risks, inflation, positive time preference and expected productivity gains.

> Risk and positive time preference: The absolute minimum option that one can adopt in discounting future expected healthy life streams is to set future values on the basis of a risk free assessment about the future ie, assume the future flows are similar to the certain flows attaching to a long-term Government bond. From recent history the long term nominal bond rate has averaged 5.8% per annum (see the following chart). If there were no positive time preference, people would be indifferent between having something now or a long way off in the future, so this applies to all flows of goods and services.



- Nonetheless some studies do include a risk premium, although in many cases the reasons are unclear. Austroads (2007) uses a discount rate of 7% in their calculations of costs per crash and per injury (ie, a risk premium of some 1.2%), but the stream is not a stream of healthy life calculated from WTP studies – rather it is a combination of cost components many of which do entail risk (see Section 3.3.2).

> Inflation: The Reserve Bank has a clear mandate to pursue a monetary policy that delivers 2% to 3% inflation over the course of the economic cycle. This is a realistic longer run goal and an inflation rate in this range (2.8%) is used in arriving at the discount rate for healthy life below. It is important to allow for inflation in order to derive a real rather than nominal rate.

In discounting healthy life, an appropriate real discount rate for Australia is suggested as 5.8 – 2.8 = 3%.

The estimate was triangulated with other discount rates from the literature. By far the most common rate used to discount healthy life in the literature reviewed is 3% – both in Australia (eg, Mathers et al, 1999; Begg et al, 2007, both AIHW) and overseas (eg, perhaps the most eminent being Nordhaus, 2002 (Yale); Murphy and Topel, 2005 (University of Chicago); Cutler and Richardson, 1998 (Harvard); World Health Organization, 2002; Aldy and Viscusi, 2006).

Returning to Australia, Abelson et al (2006) provides the following explanation for adopting a 3% discount rate in looking at the cost of foodborne illness in Australia, as it was 'considered to best reflect the individuals' time preference rates [which…] are generally lower than the opportunity cost of capital due to the tax wedge (see Chapter 7, Abelson 2003a).'

DOTARS commented in the consultation process that: 'BTRE has argued strongly against including a risk premium in the discount rate for evaluation of public sector projects, see Reports 100 and 110 on our website[15]. While you are right to dismiss including a risk premium, even if risk were not taken account of in the source study for the VSL, the risk premium approach would only be correct under very restrictive assumptions that are most unlikely to hold in practice.'

Adding a risk premium to the discount rate to adjust for risk in cost–benefit analyses (CBAs) of public sector projects can distort project rankings. It alters costs and benefits according to a particular pattern over time, which will be correct only under assumptions that would rarely hold in practice. (BTRE, 2005:v)

General Critique and Overview of WTP Methods

WTP methods are increasingly preferred to measure VSL and VSLY. Even organisations that have not yet moved to adopt these valuations (eg, DOTARS in the consultation process) acknowledge that WTP approaches are superior to productivity approaches due to their ability to assign value to time spent outside the workplace and hence reflect a more appropriate value of healthy life. Australian Transport Council (2006) notes that, in the transport sector: 'The current Australian approach can be described as a human capital approach with an element of WTP grafted on… By way of comparison, WTP values used in European countries range from $1.8 million to $4.2 million (1998 Australian dollar equivalents)… If Australia switched to the WTP approach, higher unit

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[15] BTRE (1999) and BTRE (2005).

crash costs would alter the pattern of infrastructure expenditure to give higher priority to safety.'

Within the various WTP approaches, there is a paradox. In making revealed preference choices regarding the valuation of life, people are fundamentally constrained by budgets. To relieve the budget constraint using stated preference approaches may result in unrealistic choices. In both cases the true VSLY might be somewhat elusive.

Revealed preference methods are generally preferred due to concerns about the accuracy and consistency of stated preference approaches and the conceptual superiority of data based on actual, real world, binding market transactions. While revealed preference data may also be subject to measurement error, the stated preference survey operator has a high burden of proof to satisfy before the results can be seen as meaningful.

If people are unable to reveal their WTP for particular options through their purchases or by their behaviour, the only option for estimating WTP may be by asking them questions. Well designed stated preference models may be the only option available if, for some reason, a particular valuation is desired in relation to a specific intervention. For example, it may be desired to stratify toll road charges by the time of day (and week/month) travelled and in different road conditions (eg, rain/shine), in order to maximise the extraction of consumer surplus from toll road users.

However, while stated preference models provide the opportunity to collect such specific (and stratified) information for particular types of variables (eg, travel time), their value is less clear in relation to the broader purpose of valuing life if, at the end of the day, there would be limited stratification of the intervention, as is mostly the case in publicly provided or financed interventions, due to equity or other policy objectives.

A mixture of revealed preference and stated choice modelling (the latter pivoted from revealed preference) may be the best way to proceed (Rose et al, in press 2008).

Assuming individuals are rational and fully informed, WTP valuations may differ depending on the base level of risk, the remaining time of healthy life remaining, and the health profile experienced. These *a priori* postulates are tested in the next chapter.

> If an individual is risk averse, then the less health or safety that he/she possesses the less willing he/she is to risk some loss in health or safety for a monetary pay off. This is particularly so in health and safety as many risks are irreversible and not continuous.

> The less time an individual has (eg, the older the individual) then the less willing the individual is to risk some loss in health for a monetary pay off. Again, this is particularly so if the time risked includes special life-moments such as Christmas or a grandchild's birthday.

> The WTP may be dependent on the previous health profile and the health to be experienced in the future. For example, if an individual will experience a lower level of health in the future, they may value perfect health now more than another individual who will experience perfect health now and in the foreseeable future.

Interventions that deliver health and safety benefits also result in additional impacts not captured by QALYs or resource usage, but do result in increased welfare. For example, location of care close to friends and family and the process of care may improve the individual's sense of respect and privacy, or reassurance from obtaining additional information about their prognosis. The WTP may not capture this additional benefit, although this should be taken into account in evaluation analysis.

There is difference of opinion regarding how well people can internalise tiny risks, although Rizzi and Ortuzar (2006) found that 'people can internalise risk, expressed as fatal crashes, in a consistent way from an economic point of view.'

Finally there remains controversy regarding whose preferences should be included. Principles of consumer sovereignty would suggest that the best valuation is provided by the individual affected, although there is also a case for including family and friends as well other members of society who may place social welfare value on a stranger's wellbeing (Donaldson et al, 2006).

Despite these theoretical and methodological issues there are numerous practical advantages in using WTP compared to other measures of health benefit. First, it enables a global view of the impact of health programs: it captures not only the health benefit per se, but can also capture the future health care costs avoided and increased productivity due to better health. It can also capture the value of health programs beyond the direct health outputs, and the WTP for externalities. Finally it fits into the framework of cost-benefit analysis used by many Government departments in the evaluation of their programs (transport etc), and thus facilitates decisions regarding the allocation of resources across a broad range of Government programs.

Chapter 4: VSL and VSLY Estimates from the Literature

This chapter provides the findings from the literature review of VSL and VSLY estimates produced by 244 studies (17 Australian and 227 international studies) between 1973 and June 2007. Estimates are split by sector and country, as significant differences exist. The chapter also analyses VSLY estimates, although only 19 studies (nine Australian and ten international studies) have been found that discuss such estimates. The studies are categorised as stated preference, revealed preference, mixed and other/unknown (which include studies where the VSL/VSLY used is based on other literature, is unknown, or is based on implicit valuation eg, from the evaluation of a funded program).

The study findings are first simply presented by sector and country, also making observations about the type of study and its age. However, in calculating an appropriate value for Australian use in public sector cost benefit analysis and decision making, the poorer quality studies are excluded and a meta-analysis is performed using MIX software of the high quality studies (ie, more recent studies that have either a midpoint and standard deviation or other minimum-maximum range). A summary of the results from all VSL and VSLY studies can be found in Appendix A.

Findings from the Literature

An important consideration in using international literature was consideration of the conversion rates from different currencies and periods to 2006 Australian dollars. In each case purchasing power parities were used for the relevant years based on published tables from the OECD[16]. Australian estimates were inflated based on consumer price inflation. Only studies since the 1970s and from economies with similar GDP per capita were included in the analysis in order to minimise any potential impact from income effects. The economies included North American and European countries, Japan, South Korea, Taiwan and Hong Kong.

Translating results from other countries, even if similar in income, to 2007 Australian dollars in this manner may not be valid if there are different approaches to study methods or to intrinsic valuations due to cultural or ethnic factors. For example, Rizzi and Ortuzar (2006) offer both reasons as explanations of why their Chilean VSL values differ from figures obtained in developed countries – namely lower risk consciousness and risk aversion of drivers in Chile, together with 'the use

[16] While some of the studies were from before 1988 these had been converted in the meta-analyses into years from 1988 onwards. Hence, only data from 1998 were required (see Appendix A).

of stated valuation as well as stated choice in developed country valuations', highlighting the 'importance of conducting local studies rather than transferring imported values.'

It is relevant to some degree that Australians are culturally and ethnically diverse. It is also possible to stratify studies by broad methodological group, so the conversion was not considered inappropriate in this case and differences between countries were thus deemed in general to potentially reflect actual differences in preferences and potentially in VSL/VSLY.

Health And Safety Sectors

While the health sector is an obvious choice for the measurement of the value of a statistical life, only twelve studies (two Australian and ten international studies) produced VSL estimates from the health sector. Most studies (97 studies, including four Australian and 93 international studies) focused on occupational safety when producing VSL estimates. This is usually done by measuring the wage premium people require in order to accept an increased risk in occupational safety.

As can be seen in Figure 4—1 and Figure 4—2, estimates for occupational safety vary significantly by country and are highest for the UK and Japan, but lowest for Taiwan, Korea and Hong Kong. The Australian estimate for VSL in occupational safety is very close to the international average, while the estimate for VSL in health is lower than the international average, which is strongly caveated due to the fact that only two findings were included and both were based on implicit measurement (see next section).

Figure 4—1 Range of VSL estimates (means) by study and country – health and occupational safety, 2006 A$million

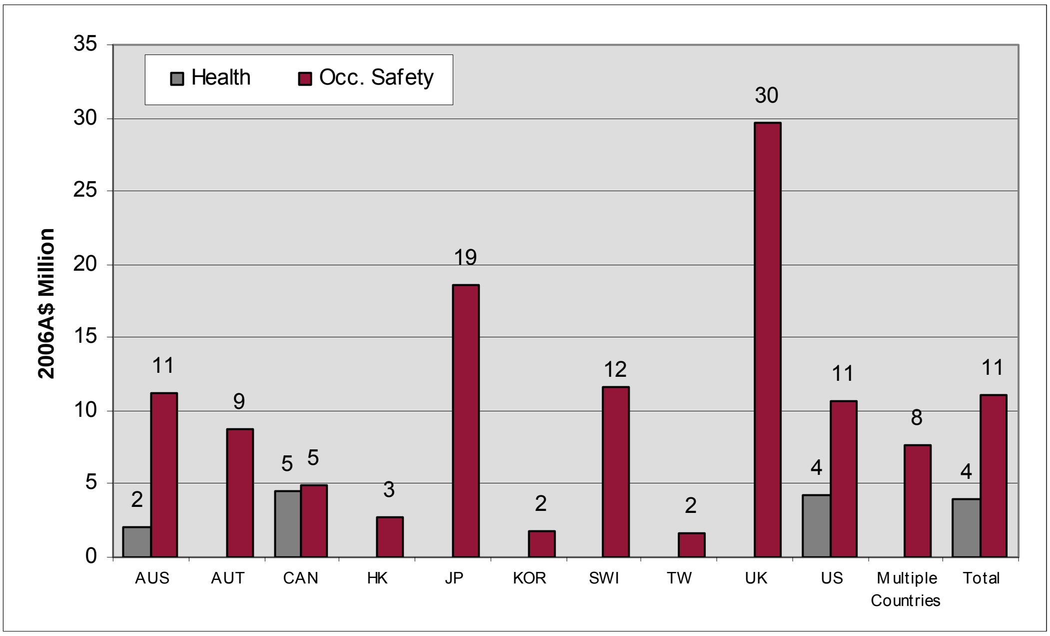
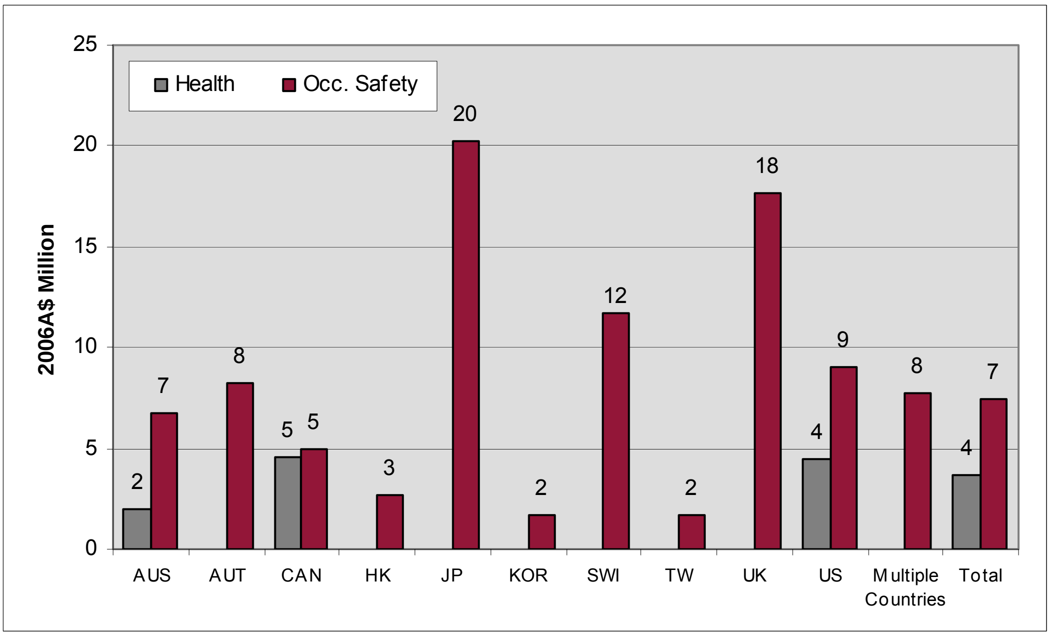


Figure 4—2 Range of VSL estimates (medians) by study and country – health and occupational safety, 2006 A$million



Health

The value of a human life that is applied in the health sector is relatively low. In 12 studies from Australia, Canada and the US, it ranged from A$0.2 to A$9.0 million and had a mean of A$4.0 million and a median of A$3.7 million.

Australian VSL estimates

In Australia, VSL estimates in the health sector were based on Abelson et al (2006), which in turn were based on values from the year 2003 of $1 million and $2.5 million (2003 dollars). The $1 million figure (and $60,000 for VSLY) is based on DoHA (2003), which notes it 'represents a conservative valuation of the estimated willingness to pay values for human life that are used most often in similar studies.' (DoHA, 2003:11-12). The $2.5 million estimate is based on Abelson (2003b). The mean (and median) in 2006 prices is A$2.02 million (Table 4—1). Abelson et al (2006:3-4) summarises:

'When the data are not age-specific, the study adopts a value of life lost of $2.5 million. This figure is based on Abelson (2003b), which provides a comprehensive survey of methods and results for valuing life. Traditionally Australian authorities put a value on life of about $1.0 million (for example e NSW Roads and Traffic Authority 2004). This figure is based on a human capital valuation in that it represents the present value of future earnings foregone.

'However, as shown in Abelson (2003b), this approach is not consistent with economic valuation (willingness-to-pay or WTP) principles. The value of something, including life and health, is what individuals are willing to pay for it. In the case of life, the value of a life is derived from what individuals are willing to pay to reduce the risk of death. If people are willing to pay $2,000 on average to reduce the risk of death by 1 in 1,000, the value of one life is $2.0 million (that is, $2,000 x 1,000). **Drawing on WTP studies, most estimates of WTP values for life fall in the range of $2.5 million to $7.0 million.** [emphasis added]

'When there are data on deaths by age group, we estimate the present annual value of the number of years lost. To do this, we need estimates of the value of life over a year, the number of years lost and a discount rate. To obtain an annual value of life, we convert the life value of $2.5 million to an annual figure. Assuming that 40 years of life are foregone and that an individual's real rate of time discount is 3%, a capital value of $2.5 million equates to the $108,000 per annum used in this report.[17] The average numbers of years lost for each type of foodborne illness is estimated using life tables.'

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[17] $2.5 million = $108,000/1.03 + $108,000/(1.03)^2 + ...$108,000/(1.03)^{40}

Table 4—1 VSL estimates for health, Australian studies, 2006 A$million

Study	Year	Study Type	Min VSL	Max VSL	Point VSL	Std. Dev.
Abelson et al	2006	Other	---	---	1.15	---
Abelson et al	2006	Other	---	---	2.88	---

Other signifies implicit, based on other literature or unknown source.

International VSL estimates

International (ie, US and Canadian) VSL estimates were based on a mix of stated and revealed preference methods (ie, higher quality data than Australia), averaging A$4.3 million but with substantial variation, between A$0.2 million and A$9.0 million (Table 4—2). The median was A$4.4 million. There was not much difference between US and Canadian studies, which had a median of A$4.4 million and A$4.5 million respectively. Post-1990 studies had a higher median VSL (A$4.7 million) than studies before 1990 (A$2.0 million).

Table 4—2 VSL estimates for health, international studies, 2006 A$million

Study	Year	Country	Study Type	Min VSL	Max VSL	Mean VSL	Median VSL	Std. Dev.
All international studies	1973-2000	US/Canada	Mixed	0.20	9.00	4.32	4.43	---
US studies	1973-2000	US	Mixed	0.20	8.69	4.27	4.43	---
Canadian studies	2000	Canada	Mixed	2.69	9.00	4.52	4.52	---
Post-1990 studies	1973-1989	US/Canada	Mixed	2.69	9.00	5.00	4.74	---
Pre-1990 studies	1990-2000	US/Canada	Mixed	0.20	6.01	2.73	1.99	---

Mixed signifies a combination of stated and revealed preference methods

VSLY estimates

The only VSLY estimate for the health sector was based on an Australian study for DoHA and had a value of A$108,000 in 2003 dollars (see citation above) which equates to A$124,378 in 2006 dollars, although Abelson et al (2006) conservatively did not inflate the 2003 estimate to 2006 dollars. In line with the practice for other studies adopted in this report, we have converted to 2006 dollars (Table 4—3).

Table 4—3 VSLY estimates for health, 2006 A$

Study	Year	Country	Study Type	Min VSLY	Max VSLY	Point VSLY	Std. Dev.
Abelson et al	2006	Australia	Other	---	---	124,378	---

Occupational Safety

Occupational safety and wage risk was the area that was analysed the most in the literature. In 97 international studies, VSL estimates ranged from A$0.3 million to A$117.0 million with a mean of A$11.1 million – the highest average VSL in the different sectors analysed – and a median of A$7.4 million.

Australian VSL estimates

In Australia, there was significant variation in the four VSL estimates for OHS, ranging from A$2.9 million to A$28.4 million with a mean of A$11.2 million and a median of A$6.8 million (Table 4—4). However, excluding Miller et al's study, which had an outlier VSL of A$28.4 million, the mean VSL for the three remaining Australian studies was A$5.5 million, which is lower than the mean VSL from the 97 international studies. The median was A$6.6 million.

Table 4—4 VSL estimates for occupational safety, Australian studies, 2006 A$million

Study	Year	Study Type	Min VSL	Max VSL	Point VSL	Std. Dev.
Kniesner & Leeth	1991	Revealed	---	---	6.90	2.77
Miller et al	1997	Other	---	---	28.40	2.16
NOHSC	2004	Other	---	---	2.87	---
Viscusi	2005	Revealed	---	---	6.63	---

International VSL estimates

VSL estimates for occupational safety from the 97 international studies had a mean ofA$11.1 million and a median of A$7.6 million (Table 4—5). The 54 US studies produced a mean VSL of A$10.7 million which was slightly lower than other studies (A$11.6 million), although the US median was higher (A$9.0 million, compared with A$6.4 million in other studies). Post-1990 studies produced a higher mean and median VSL (A$12.1 million and A$7.9 million) than pre-1990 studies (A$9.4 million and A$6.9 million).

Table 4—5 VSL estimates for occupational safety, international studies, 2006 A$million

Study	Year	Country	Study Type	Min VSL	Max VSL	Mean VSL	Median VSL	Std. Dev.
All international studies	1974-2007	Multiple	Mixed	0.32	117.04	11.08	7.59	---
US studies	1974-2006	US	Mixed	0.47	32.89	10.69	9.02	---
Other studies (excl. US)	1982-2007	Multiple	Mixed	0.32	117.04	11.61	6.38	---
Post-1990 studies	1974-1989	Multiple	Mixed	0.32	117.04	12.06	7.94	---
Pre-1990 studies	1990-2007	Multiple	Mixed	0.47	25.93	9.44	6.90	---

VSLY estimates

Six studies (one Australian, one UK and four US studies) discussed VSLY estimates for occupational safety. Estimates varied between A$93,187 and A$3.57 million per life year and had a mean VSLY of A$996,027 and a median of A$810,254 (Table 4—6). The Australian NOHSC policy study was based on what was assessed to be at the conservative end of the spectrum of WTP VSLY estimates, and the UK study was based primarily on compensation payments (ie, not WTP). While the 1990 Moore and Viscusi estimates are listed as 'Other', they are likely to be based on revealed preference, given the authors' other work.

Table 4—6 VSLY estimates for occupational safety, 2006 A$

Study	Year	Country	Study Type	Min VSLY	Max VSLY	Point VSLY	Std. Dev.
NOHSC	2004	Australia	Other	---	---	119,589	---
Davies & Teasdale	1995/6	UK	Other	---	---	93,187	---
Moore & Viscusi	1990	US	Other	---	---	1,167,207	---
Moore & Viscusi	1990	US	Other	---	---	1,500,470	---
Moore & Viscusi	1988	US	Revealed	424,870	481,730	453,300	---
Moore & Viscusi	1989	US	Revealed	1,713,694	3,571,118	2,642,406	---

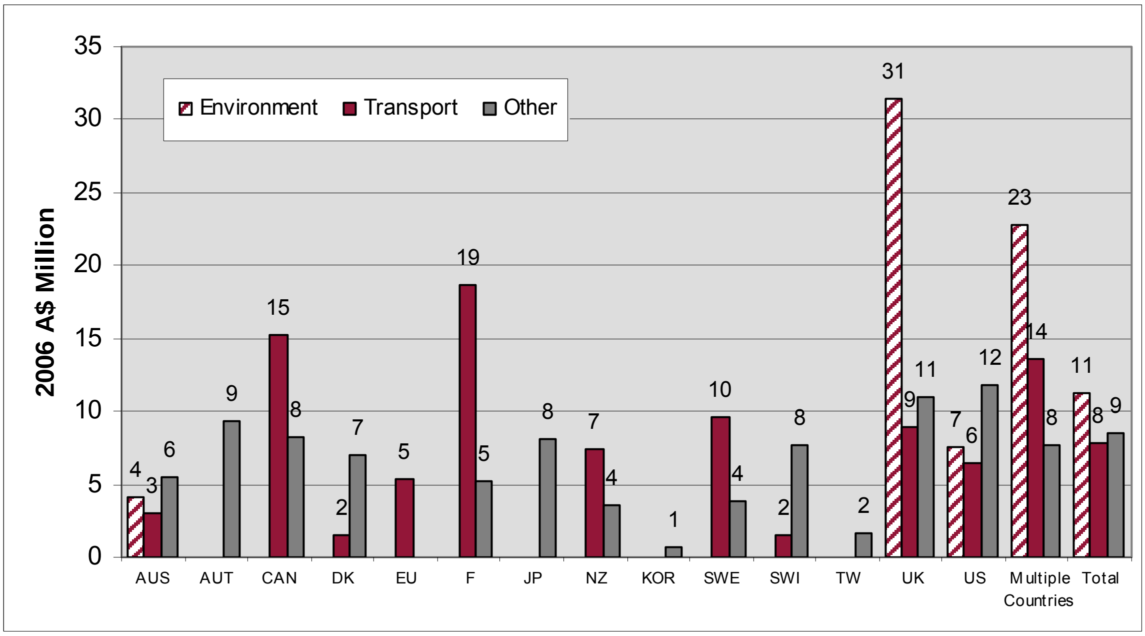
Other Sectors

Other sectors that use evaluation measures to evaluate programs and determine funding priorities include transport safety, environmental hazard control, crime prevention, fire safety and others.

VSL in transport safety was discussed in 69 studies (four Australian and 65 international studies), while a further 21 studies (two Australian and 19 international studies) discussed VSL in environmental hazard control. The remaining 49 studies (five Australian and 44 international studies) are based on VSL estimates in other specified or unspecified sectors.

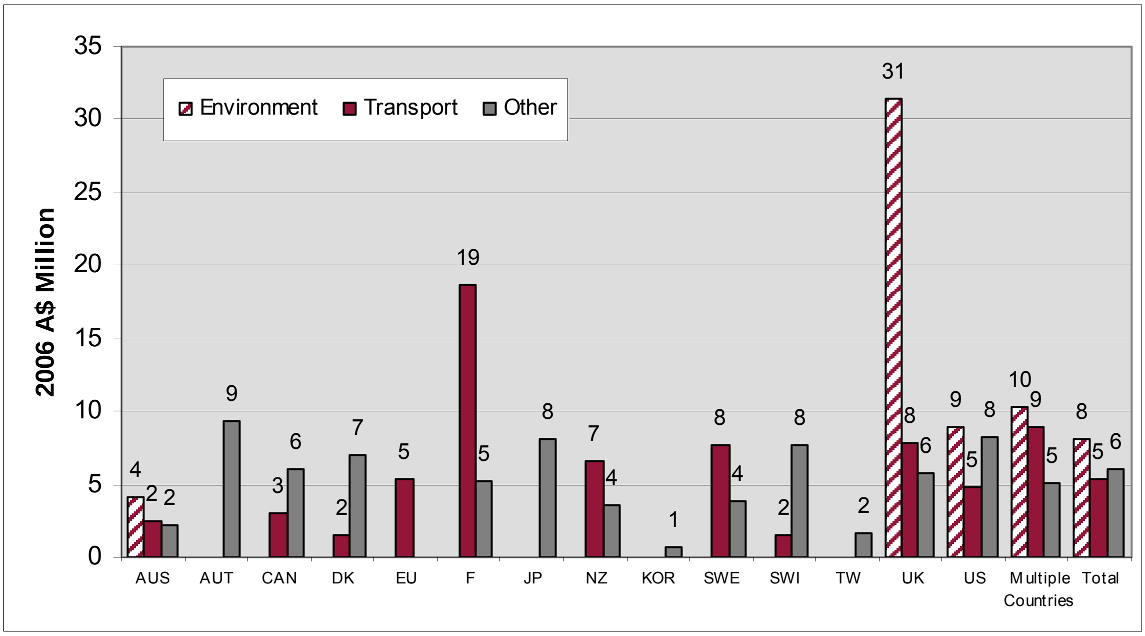
As was the case with VSL estimates in health and occupational safety, VSL estimates in environmental protection, transportation and other sectors also vary by country. Again, UK estimates in environment and other sectors are much higher than those of other countries, while UK VSL estimates in transport safety are close to the average. France and Canada are the two countries with the highest VSL estimates when it comes to transport safety. Australia has lower than average VSL estimates in environment protection, transport safety and other sectors (Figure 4—3 and Figure 4—4).

Figure 4—3 Range of VSL estimates (means) by study and country – other sectors, 2006 A$million



Note: 'Other' includes Consumption, Crime, Fire Safety and Mixed Studies

Figure 4—4 Range of VSL estimates (medians) by study and country – other sectors, 2006 A$million



Note: 'Other' includes Consumption, Crime, Fire Safety and Mixed Studies

Transport

Transportation imposes negative externalities on society (such as fatal and non-fatal accidents and air pollution) and governments often place a value on these externalities when evaluating programs to alleviate the impacts. While road improvements are often aimed at reducing fatalities, not all road engineering treatments are aimed only at increasing road safety. Many have reduced travel times as the primary objective.

Values for international VSL estimates in transport ranged from A$0.2 million to A$50.8 million with a mean of A$7.9 million and a median of A$5.4 million.

Australian VSL estimates

VSL estimates in the four Australian transport studies included were lower than VSL estimates in international transport safety. In 2006 dollars, they ranged from A$1.3 million to A$5.4 million and had a mean of A$3.0 million and a median of A$2.5 million (Table 4—7). The CASA estimate was provided by CASA based on current practice; the hybrid approach of the Australian Transport Council and BTE studies is discussed in Section 3.5; while the Black Spot Program estimate is implicit, based on evaluation of the program. Note that studies using 'other' valuation are excluded from the meta-analysis due to lower quality and to avoid the potential problem of determining future policy from past policy rather than from empirical evidence.

Table 4—7 VSL estimates for transport safety, Australian studies, 2006 A$million

Study	Year	Study Type	Min VSL	Max VSL	Point VSL	Std. Dev.
CASA	2006	Other	---	---	3.00	---
Australian Transport Council	2000	Other	---	---	1.99	---
BTE	2000	Other	1.29	1.80	1.55	---
BTE - Black Spot Program	2001	Other	---	---	5.41	---

International VSL estimates

VSL estimates from the 65 international studies varied between A$0.2 million and A$50.8 million and had a mean of A$8.2 million and a median of A$5.4 million (Table 4—8). With A$6.4 million and $4.7 million, the 27 US studies had slightly lower mean and median VSL estimates than the other international studies (A$9.5 million and $7.0 million respectively).

Table 4—8: VSL estimates for transport safety, international studies, 2006 A$million

Study	Year	Country	Study Type	Min VSL	Max VSL	Mean VSL	Median VSL	Std. Dev.
All international studies	1973-2007	Multiple	Mixed	0.24	50.83	8.19	5.41	---
US studies	1973-2006	US	Mixed	0.24	50.83	6.39	4.74	---
Other studies (excl. US)	1974-2007	Multiple	Mixed	0.24	50.83	9.47	6.95	---
Post-1990 studies	1990-2007	Multiple	Mixed	0.24	50.83	8.34	3.23	---
Pre-1990 studies	1973-1989	Multiple	Mixed	0.24	34.02	6.48	5.41	---

VSLY estimates

VSLY in transport safety was analysed in four studies, with a median of $123,755. The two Australian ones were A$87,611 and A$131,993 and had a mean and a median of A$109,802 (neither are WTP studies), while the international studies varied between A$84,450 and A$884,487 with a mean and median of A$442,747, with the revealed preference study markedly higher (Table 4—9).

Table 4—9 VSLY estimates for transport safety, 2006 A$

Study	Year	Country	Study Type	Min VSLY	Max VSLY	Point VSLY	Std. Dev.
CASA	2006	Australia	Other	---	---	131,993	---
BTE	2000	Australia	Other	74,727	100,495	87,611	---
Donaldson	2006	UK	Other	84,450	146,582	115,516	---
Dreyfus & Viscusi	1995	US	Revealed	655,468	884,487	769,978	---

Environmental Protection

Several government departments, such as the environmental protection agencies (EPAs), use a wide range of values in estimating the health benefit of reducing emissions and other environmental toxins in other industries.

VSL estimates from the 21 studies (including two Australian and 19 international studies) ranged from A$0.1 million to A$132.9 million and had a mean of A$11.2 million and a median of A$8.1 million. However, the extreme values were mainly due to a single study by Kochi et al (2006). Excluding this study, VSL estimates were a narrower, but still broad, range from A$0.9 million to A$31.4 million, with a mean of A$8.5 million and a median of A$7.8 million.

Australian VSL estimates

VSL estimates used for environmental protection in Australia tended to be lower than their international counterparts, ranging from A$0.9 million to A$7.2 million with a mean and median VSL of A$4.2 million (Table 4—10).

Table 4—10 VSL Estimates for environmental protection, Australian Studies, 2006 A$million

Study	Year	Study Type	Min VSL	Max VSL	Mean VSL	Std. Dev.
Bryant et al.	1992	Other	0.86	1.43	1.15	---
RCG/Hagler Bailey	1994	Other	---	---	7.21	---

International VSL estimates

VSL estimates from the 19 international studies ranged from A$0.1 million to A$132.9 million and had a mean of A$12.0 million and a median of A$9.8 million. Most studies using VSL for environmental protection are US-based – only Kochi et al (2006) looks at the UK and Japan (as well as the US). US studies ranged from A$0.9 million to A$13.6 million with a mean of A$7.5 million and a median of A$8.9 million. US EPA valuations of a statistical life ranged from A$2.7 million to A$10.3 million, although the majority of EPA values were above A$8 million, which explains the mean of A$8.5 million and higher median – A$9.9 million (Table 4—11).

Table 4—11 VSL estimates for environmental protection, international studies, 2006 A$million

Study	Year	Country	Study Type	Min VSL	Max VSL	Mean VSL	Median VSL	Std. Dev.
All international studies	1981-2006	Multiple	Mixed	0.14	132.85	11.96	9.79	---
All international studies (excl. Kochi et al. 2006)	1981-2006	Multiple	Mixed	0.85	31.44	8.93	8.92	---
US studies	1981-2006	US	Mixed	0.85	13.61	7.48	8.92	---
Other studies (excl. US)	2006	Multiple	Mixed	0.14	132.85	24.49	13.08	---
Post-1990 studies	1990-2006	Multiple	Mixed	0.14	132.85	14.31	9.95	---
Pre-1990 studies	1981-1989	US	Mixed	0.85	7.58	3.14	2.06	---
EPA studies	1985-1999	US	Revealed	2.69	10.26	8.53	9.87	---

VSLY estimates

Four studies looked at the VSLY in the context of environmental protection, with a median of A$155,327. While the only international study produced a VSLY as high as A$242,994 for the US, the three Australian studies averaged A$172,838, varying between A$32,609 and A$418,244 (Table 4—12). However, the Bryant et al (1992) study was a human capital ‘hybrid’ (like the BTE approach) and the NHMRC study (type unknown) is, given the period, also unlikely to be a WTP study.

Table 4—12 VSLY estimates for environmental protection, 2006 A$

Study	Year	Country	Study Type	Min VSLY	Max VSLY	Mean VSLY	Std. Dev.
Bryant et al.	1992	Australia	Other	24,638	40,580	32,609	---
NHMRC	1993	Australia	Other	---	---	67,660	---
RCG/Hagler Baily	1994	Australia	Other	---	---	418,244	---
Ackerman & Heinzerling	2004	US	Other	---	---	242,994	---

Others

VSL estimates are also derived from other areas including consumer choice, crime and fire safety. Estimates that are based on mixed study areas – particularly those from meta-analyses – are also included in this section. Again there is substantial variation between the VSL estimates from 44 studies analysed, from A$0.7 million to A$84.7 million with a mean of A$8.5 million and a median of A$6.0 million.

Australian VSL Estimates

Australian VSL estimates in other sectors vary between A$1.5 million and A$17.7 million and had a mean of A$5.5 million and a median of A$2.2 million (Table 4—13). None were classified as revealed or stated preference approaches.

Table 4—13 VSL estimates in other sectors, Australian studies, 2006 A$million

Study	Year	Study Type	Min VSL	Max VSL	Mean VSL	Std. Dev.
Bellavance et al.	2007	Other	---	---	17.65	15.20
Law Reform Commission of Victoria	1990	Other	---	---	1.50	---
Mayhew	2003	Other	---	---	2.18	---
Mayhew	2003	Other	---	---	1.74	---
Miller	2000	Other	3.66	5.41	4.67	---

International VSL estimates

As in most of the previous sections, international VSL estimates tended to be higher than their Australian counterparts, ranging from A$0.7 million to A$84.7 million with an average of A$8.9 million and a median of A$6.5 million (Table 4—14).

Table 4—14 VSL estimates in other sectors, international studies, 2006 A$million

Study	Year	Country	Study Type	Min VSL	Max VSL	Mean VSL	Median VSL	Std. Dev.
All international studies	1973-2007	Multiple	Mixed	0.66	84.70	8.90	6.50	---
US studies	1977-2007	US	Mixed	1.02	42.27	11.77	8.26	---
Other studies (excl. US)	1973-2007	Multiple	Mixed	0.66	84.70	7.35	5.40	---
Post-1990 studies	1973-1989	Multiple	Mixed	1.02	42.27	8.03	6.20	---
Pre-1990 studies	1990-2007	Multiple	Mixed	0.66	84.70	10.50	5.36	---

VSLY estimate

Three studies looked at VSLY estimates in other sectors with values for a life year ranging from a very low A$10,089 to A$107,924 and a mean of A$66,355 and a median of A$65,674 (Table 4—15). None were classified as revealed or stated preference approaches.

Table 4—15 VSLY estimates in other sectors, 2006 A$

Study	Year	Country	Study Type	Min VSLY	Max VSLY	Mean VSLY	Std. Dev.
Law Reform Commission of Victoria	1990	Australia	Other	---	---	65,674	---
Mason et al.	2003	UK	Other	53,878	94,892	74,385	---
Baker et al.	2003	Multiple	Other	10,089	107,924	59,007	---

Summary Of Simple Analysis

Based on 244 studies analysed, the mean VSL estimate was A$9.4 million and the median was A$6.6 million. However, the 17 Australian estimates included had a lower mean (A$5.7 million) and median (A$2.9 million), reflecting the large number of implicit valuations in the Australian group (there were only two estimates based on revealed preference and none based on stated preference in Australia) and the small sample size. In contrast, the remaining 227 international studies had a mean of A$9.6 million and a median of A$6.7 million (Table 4—16, Figure 4—5 and Figure 4—6).

VSL estimates varied significantly by study area: a statistical life had a mean value of A$11.1 million and a median of A$7.4 million when it came to occupational safety, but only A$4.0 million and $3.7 million for health.

Although the VSL has been analysed in many different studies, analyses focusing on the VSLY are much rarer. Only 19 studies were found where the VSLY was explicitly reported in the study – this is due in part to the fact that many studies have been framed in terms of preventing fatalities so only the VSL is reported (and rarely the mean age of the source group from which to derive a VSLY). Those had a mean VSLY estimate of A$433,437 (Table 4—16) and a median of A$119,589, which was strongly influenced by the nine Australian estimates of which many were based on implicit valuation (around one third of the 19 studies included were Australian implicit valuation estimates). The Australian mean VSLY was only A$124,095 (median A$87,611). The ten international studies produced a much higher average VSLY (mean of A$711,845 and median of A$348,147) due to the different (higher quality) methods.

Table 4—16 Summary of VSL and VSLY estimates

		Health	Occ. Safety	Transport	Environment	Others	Total
VSL, 2006A$m	*Mean*	**4.0**	**11.1**	**7.9**	**11.2**	**8.5**	**9.4**
	Median	**3.7**	**7.4**	**5.4**	**8.1**	**6.0**	**6.6**
	Range	0.2-9.0	0.3-117.0	0.2-50.8	0.1-132.9	0.7-84.7	0.1-117.0
Australian VSL, 2006A$m*	*Mean*	**2.0**	**11.2**	**3.0**	**4.2**	**5.5**	**5.7**
	Median	**2.0**	**6.8**	**2.5**	**4.2**	**2.2**	**2.9**
	Range	1.2-2.9	2.9-28.4	1.3-5.4	0.9-7.2	1.5-17.7	0.9-28.4
International VSL, 2006A$m	*Mean*	**4.3**	**11.1**	**8.2**	**12.0**	**8.9**	**9.6**
	Median	**4.4**	**7.6**	**5.4**	**9.8**	**6.5**	**6.7**
	Range	0.2-9.0	0.3-117.0	0.2-50.8	0.1-132.9	0.7-84.7	0.1-132.9
VSLY, 2006A$	*Mean*	**124,378**	**996,027**	**276,275**	**190,377**	**66,355**	**433,437**
	Median	**124,378**	**810,254**	**123,755**	**155,327**	**65,674**	**119,589**
	Range	124,378	93,187-3,571,118	74,727-884,487	24,638-418,244	59,007-74,385	24,638-3,571,118

* Australian estimates are influenced by a large proportion (over half) of implicit valuation (policy-based) studies.

Figure 4—5 Summary of VSL estimates (means) by sector and Australia/international, 2006 A$million

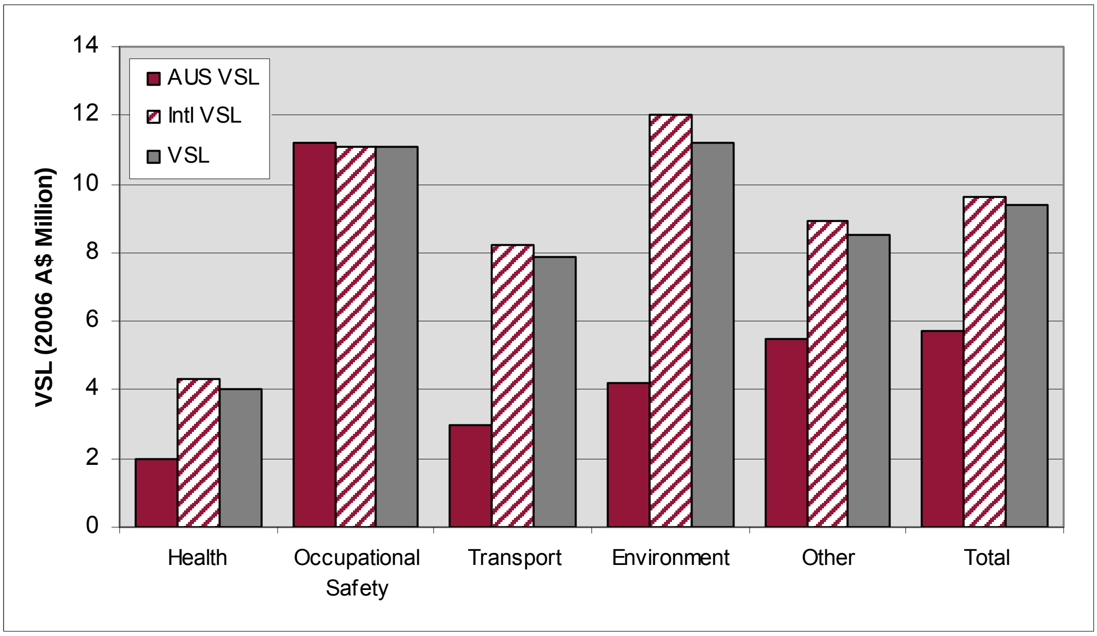
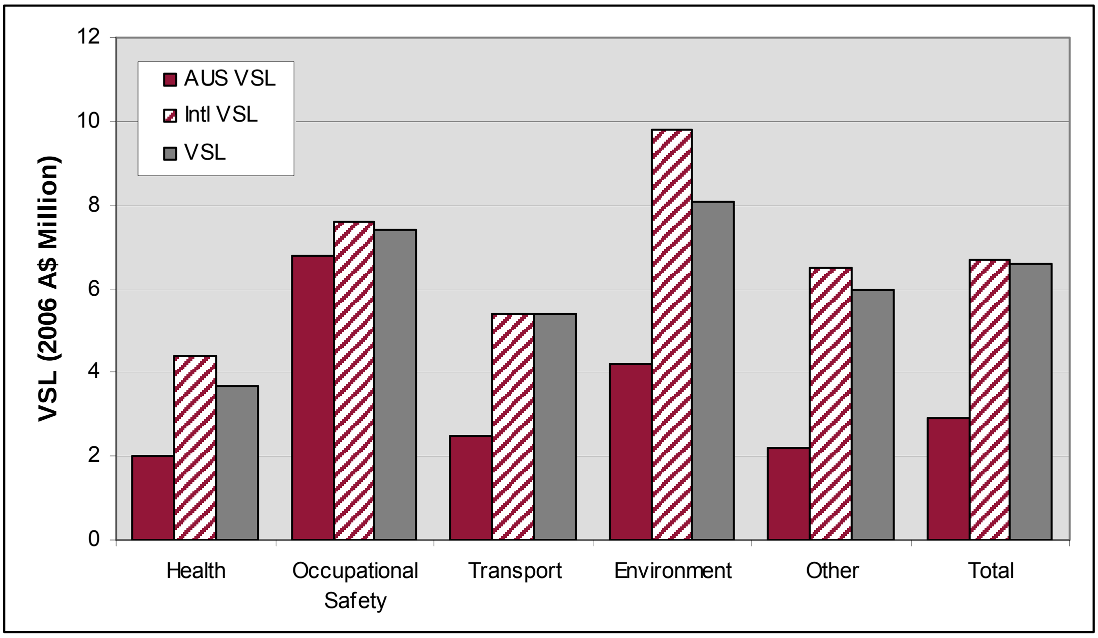
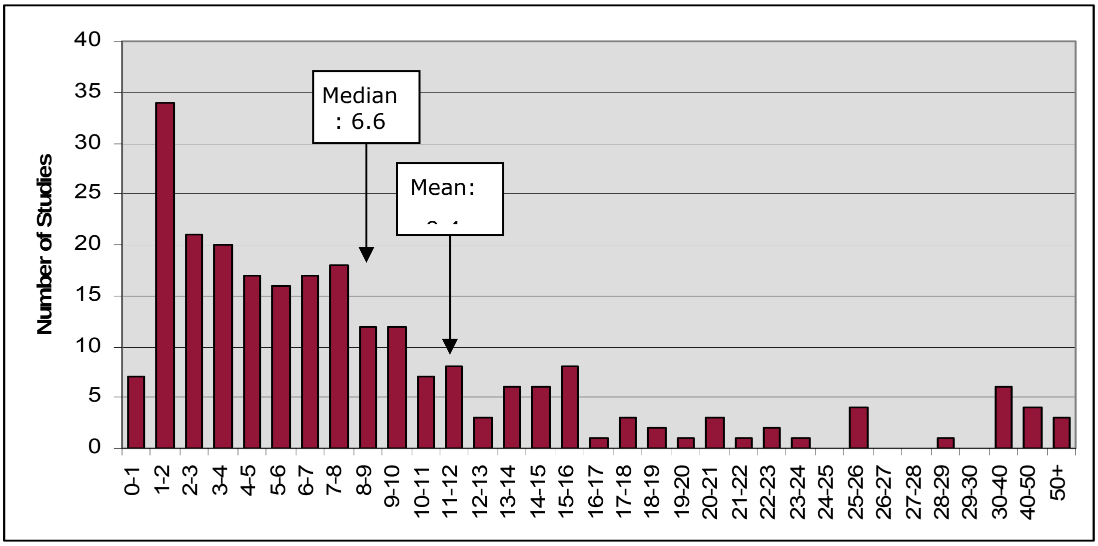


Figure 4—6 Summary of VSL estimates (medians) by sector and Australia/international, 2006 A$million



Although the mean VSL was estimated to be around A$9.4 million, almost two-thirds of VSL estimates are below A$9 million, while nearly half of them are below A$6 million (the median was A$6.6 million). Only 5% of studies had a VSL of A$30 million or higher (Figure 4—7 below). Note that, in the figure, the horizontal axis switches from a 'single million' scale up to A$30 million to three broader groups thereafter to condense the long right tail.

Figure 4—7 Histogram of all VSL estimates



Compared to estimates from other countries, and reflecting the large number of implicit valuation estimates, Australia's mean VSL from the studies was in the lower third of the range – only greater than the average for Denmark, Hong Kong, South Korea and Taiwan. Countries such as the UK and Japan had average VSL estimates that were three times as high as that for Australia (Figure 4—8). In the UK, for example, 13 studies (50%) were revealed preference, seven were stated preference and only six were 'other'. Table 4—17 shows the ranges of VSL estimates by country and study area.

Figure 4—8 VSL estimates by country (2006 A$million)

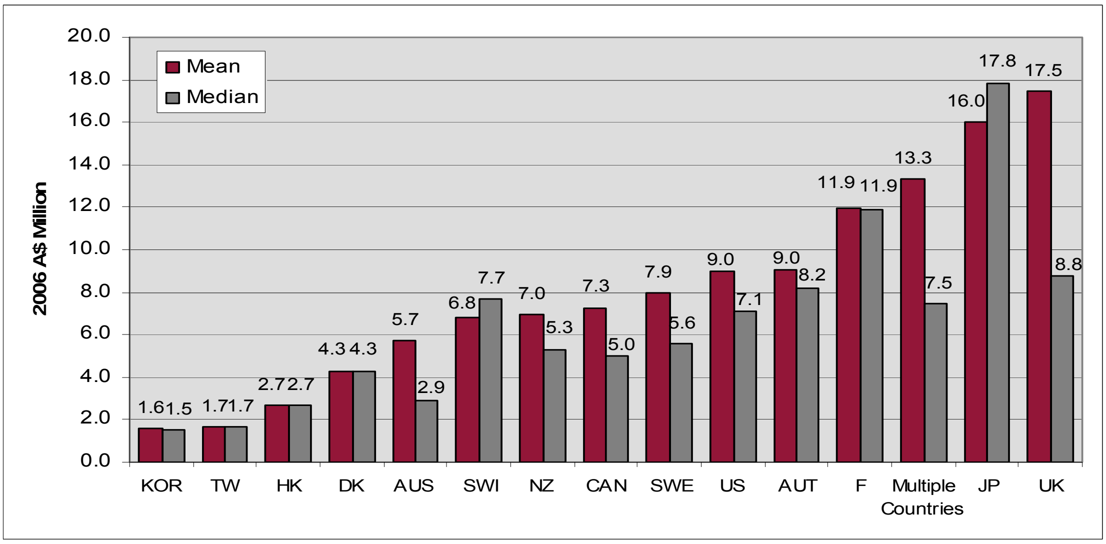
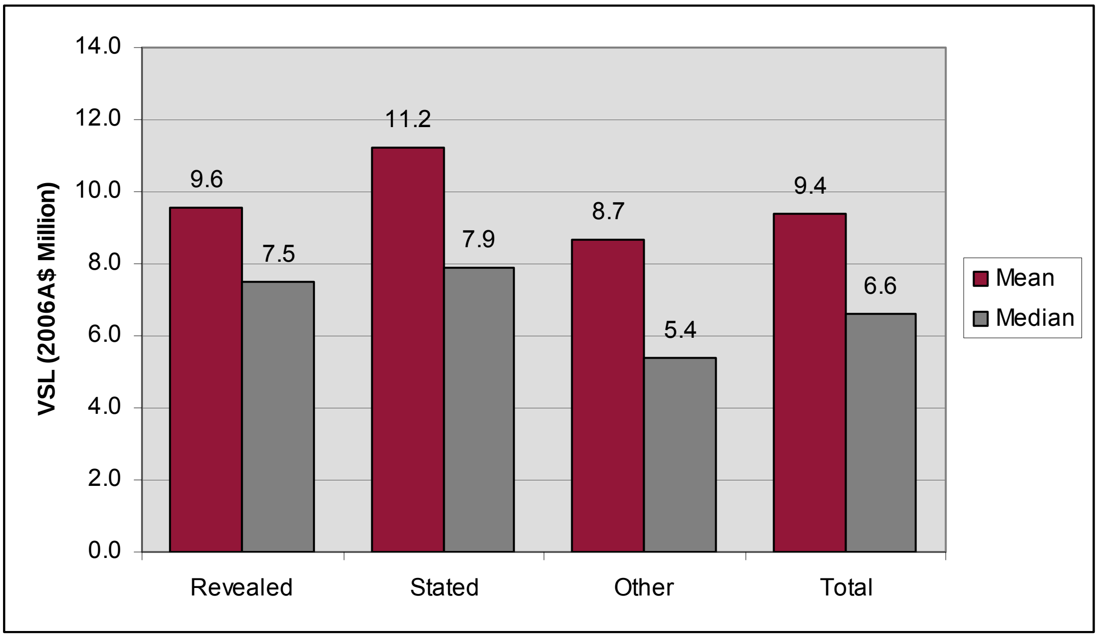


Table 4—17 Ranges of VSL estimates by country, 2006 A$million

	No. of studies	Health	Occ. Safety	Transport	Environ-ment	Other	Total	Mean	Median
Australia	17	1.2-2.9	2.9-28.4	1.3-5.4	0.9-7.2	1.5-17.7	**0.9-28.4**	**5.7**	**2.9**
Austria	5	---	2.6-13.2	---	---	5.4-13.2	**2.6-13.2**	**9.0**	**8.2**
Canada	17	2.7-9.0	0.8-7.8	0.7-41.1	---	3.7-14.5	**0.7-41.1**	**7.3**	**5.0**
Denmark	2	---	---	1.3-1.9	---	6.6-8.7	**1.3-8.7**	**4.3**	**4.3**
Europe	1	---	---	5.4	---	---	**5.4**	**5.4**	**5.4**
France	2	---	---	1.5-35.8	---	5.1-7.3	**1.5-35.8**	**11.9**	**11.9**
Hong Kong	1	---	2.7	---	---	---	**2.7**	**2.7**	**2.7**
Japan	4	---	15.3-20.2	---	---	8.2-12.2	**8.2-20.2**	**16.0**	**17.8**
New Zealand	10	---	---	1.1-21.4	---	2.8-4.2	**1.1-21.4**	**7.0**	**5.3**
South Korea	6	---	1.3-2.5	---	---	0.7-1.3	**0.7-2.5**	**1.6**	**1.5**
Sweden	7	---	---	2.1-44.1	---	2.1-6.8	**2.1-44.1**	**7.9**	**5.6**
Switzerland	5	---	10.0-13.6	1.4-1.7	---	7.3-12.9	**1.4-13.6**	**6.8**	**7.7**
Taiwan	7	---	0.3-2.9	---	---	1.4-1.9	**0.3-2.9**	**1.7**	**1.7**
UK	26	---	2.1-117.0	1.0-34.0	31.4	1.4-41.3	**1.0-117.0**	**17.5**	**8.8**
US	117	0.2-8.7	0.5-32.9	0.2-50.8	1.1-13.6	1.0-42.3	**0.2-50.8**	**9.0**	**7.1**
Multiple	17	---	0.5-30.0	0.2-50.8	0.1-132.9	0.7-84.7	**0.2-132.9**	**13.3**	**7.5**
All	**244**	**0.2-9.0**	**0.3-117.0**	**0.2-50.8**	**0.1-132.9**	**0.7-84.7**	**0.1-132.9**	**9.4**	**6.6**
Mean	**---**	**4.0**	**11.1**	**7.9**	**11.2**	**8.5**	**9.4**	**---**	**---**
Median	**---**	**3.7**	**7.4**	**5.4**	**8.1**	**6.0**	**6.6**	**---**	**---**

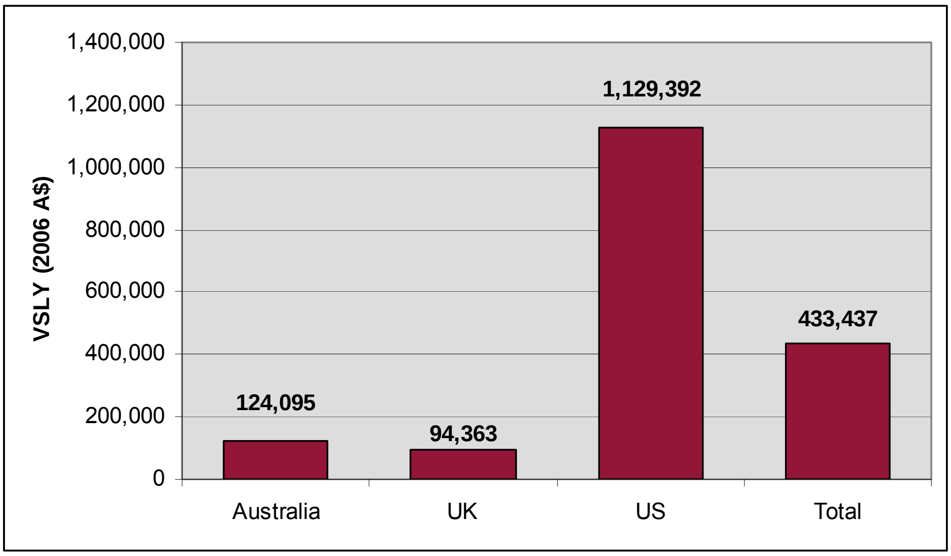
Comparing different methodologies, studies based on the revealed preference approach produced slightly lower VSL estimates (mean of A$9.6 million, median of A$7.5 million) compared to studies based on the stated preference approach (mean of A$11.2 million, median of A$7.9 million) (Figure 4—9). However, many of the studies could not be classified and fell into the 'Other' category, of which more were lower (implicit) value studies (mean of $8.7 million, median of $5.4 million).

Figure 4—9 VSL estimates by study type (2006 A$million)



As was the case with VSL estimates, VSLY estimates from the 19 studies that reported these varied significantly by country. While Australian studies produced an average VSLY of A$0.12 million, US studies estimated it to be an average of A$1.1 million. The international average was A$0.43 (Figure 4—10). In this case the variation can quite clearly be accorded to the nature of the studies included. In the case of Australia and the UK, all 12 studies are 'other' in type and all the Australian ones are policy-based estimates. In contrast, of the US studies, at least half and it appears five of the six are revealed preference studies.

Figure 4—10 VSLY estimates by country (2006 A$)



Meta-Analysis of Selected Studies

In order to get a better idea of the appropriate VSL estimate, a meta-analysis was conducted using MIX (Meta-Analysis with Interactive Explanations) 1.61 software, since it is an easy-touse package validated by Bax et al (2006). [18]

Meta-analysis is a statistical technique that enables the calculation of a best estimate of a parameter from multiple studies. Either fixed effect or random effect models can be used. In this case a random effect model was used as this is appropriate when there is not one 'true' effect (the singular parameter in the fixed effect model) but rather there is certain (random/stochastic) distribution of effects that have produced the empirical values of the studies. This means that the expected variability among these empirical values is based on more than just sampling error (the latter is the case in fixed effect models). This extra variability is often described as 'variability due to an unexplained variable' and makes the interpretability of the resulting statistic no longer similar to the initially defined outcome parameter. Random effects models produce wider confidence intervals that are probably more realistic, particularly when measuring VSL from studies where age is likely to be the underlying 'unexplained variable'

In a meta-analysis the empirical values of each study are weighted according to their informativeness of the produced data. The variance of the empirical values is used as an inversely related measure of informativeness (ie, the larger the variance, the smaller the informativeness). Inverse variance plus τ is the only random effects weighting method in the MIX program and was developed by DerSimonian and Laird. The weighting statistic is produced by adding 'τ' as an estimate of the variance of the parameter distribution (in the random effects approach the parameter of interest is assumed to have a normal distribution with variance τ). The τ is 0 when the heterogeneity statistic Q is smaller than it degrees of freedom, in which case the fixed effect inverse variance approach produces the same results as the random effects approach.

The meta-analysis consisted of including or excluding studies on the basis of quality and comparability criteria, pooling the results from included studies and then reporting on the findings. The inclusion/exclusion criteria were as follows:

1 Recency: only studies from 1980 onwards were included. The reason for this criterion was that uncertainty regarding the conversion to current US dollars and potential income effects is likely to be larger with the oldest studies. Thus 18 studies before 1980 were excluded.

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[18] How to use MIX software to conduct meta-analysis is discussed on http://www.mix-for-meta-analysis.info/.

2 Reported range or standard deviation: it was considered desirable to include studies that reported a range or point estimate with a standard deviation, in particular given the software used to conduct the meta-analysis, rather than just a point estimate alone, since a point estimate alone tends to impart a false sense of precision into the random effects model used[19] and may also be indicative of poorer quality studies. Indeed, application of this criterion eliminated many of the implicit valuation studies (which also helps to remove the circularity effect of future policy being based on speculative past policy, again enhancing the quality of the estimate). Thus 111 studies that just reported a point estimate were excluded.

3 Outliers: a few studies that report exceptionally high or low estimates, or exceptionally high standard deviation, were also considered to be of dubious quality. The specific studies excluded are summarised below, with rationale for their exclusion.

- Bellavance et al (2007) reported four sub-studies where the standard deviation was over 70% of the point estimate in the US, over 80% in Australia and the UK and over 100% in Canada.
- Kochi et al (2006) reported six sub-studies where the standard deviation averaged over 60% and the estimates were considerably higher than other comparable studies (see Section 4.1.2.2, for example).
- There were three inexplicably high studies relative to their comparable groups – Arabsheibani and Marin (2000) and Sandy et al (2001) in the UK; and a 1999 EPA study in the US. The latter two also had high standard errors.
- There were three unusually low studies relative to their comparable groups – Knieser and Leeth (1991) in the US; Bryant et al (1992) in Australia; and Miller (2000) in South Korea.

Thus in total 16 outlier studies were excluded.

Note that a sub-study of a different population, in a different country or of a different type (and thus generating a different estimate) is the unit of observation, although naturally some may be written up in the same publication.

The remaining 99 of the original 244 studies were considered suitable to pool in the meta-analysis and these studies are highlighted in bold in the table at Appendix A. Those studies had a mean of A$9.4 million and a median of A$7.1 million, hence VSL estimates are similar to the overall sample. In the meta-analysis, the VSL was estimated to be A$6.0 million with a 95% lower confidence limit of A$5.4 million and a 95% upper confidence limit of A$6.7 million (see results in the following box).

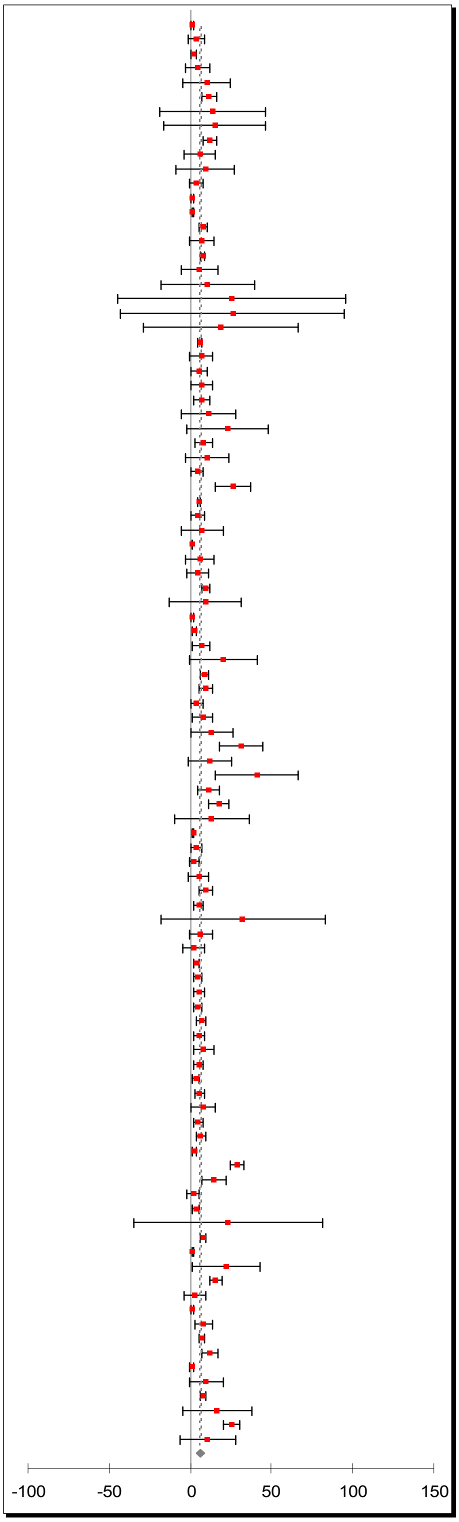
[19] Recall that the reciprocal or inverse variance is used to weight the data.

META-ANALYSIS

General	
Number of studies	99
Number of participants	Not available
MD (IV+t) - Random effects model	
Meta-analysis outcome	6.036
95% CI lower limit	5.3614
95% CI upper limit	6.7105
z	17.5378
p-value (two-tailed)	< 0.0001
Heterogeneity	
t^2	5.5388

Figure 4—11 presents the forest plot that charts the empirical values (red dots) on the x-axis together with the confidence intervals of the 99 studies analysed, thus showing the relative differences between the results of the studies included in the meta-analysis. The size of the dots varies with the relative size of the weights of the studies in the analysis, but since the weights range from 0.01% to 2.13% for each of the studies, the dots appear to be of same size. Weights were automatically generated by the meta-analysis software as 'Inverse Variance + t' using random effects estimation. The bottom grey diamond refers to the pooled value.

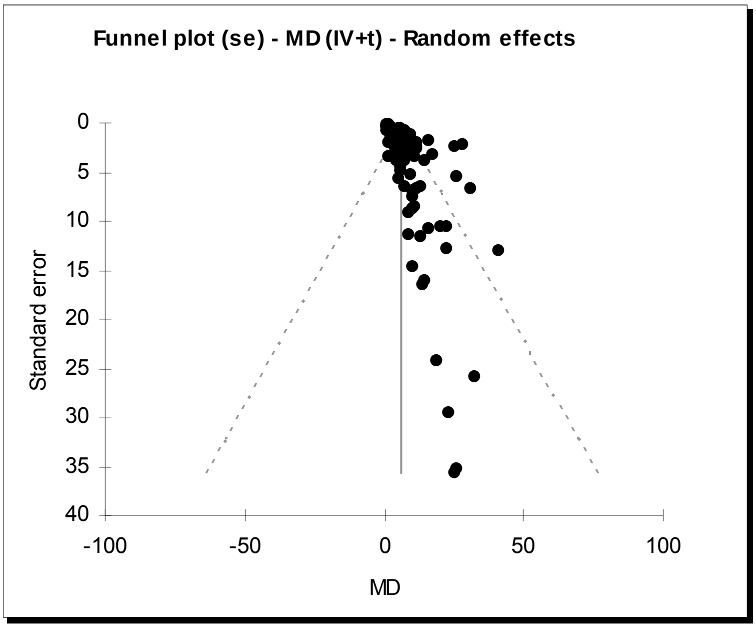
Figure 4 – 11 Standard Forest Plot, Random Effects



The underlying methodology is crucial to the VSL estimate and – as it has been pointed out in previous studies (see, for instance, Ashenfelter and Greenstone, 2004) – omitted variables and publication bias may distort results. These are explored below, and found not to be a problem in this analysis.

Testing for publication bias: One way of assessing the presence of publication bias is to examine a funnel plot (Figure 4—12). Funnel plots display the studies included in the meta analysis in a plot of effect size against sample size. As smaller studies have more chance of variability than larger studies, the expected picture is one of a symmetrical inverted funnel. As VSL values are not negative, studies are clustered on the positive side. In this case, estimates with lower VSL values appear to have lower standard errors and the plot indicates an absence of publication bias.

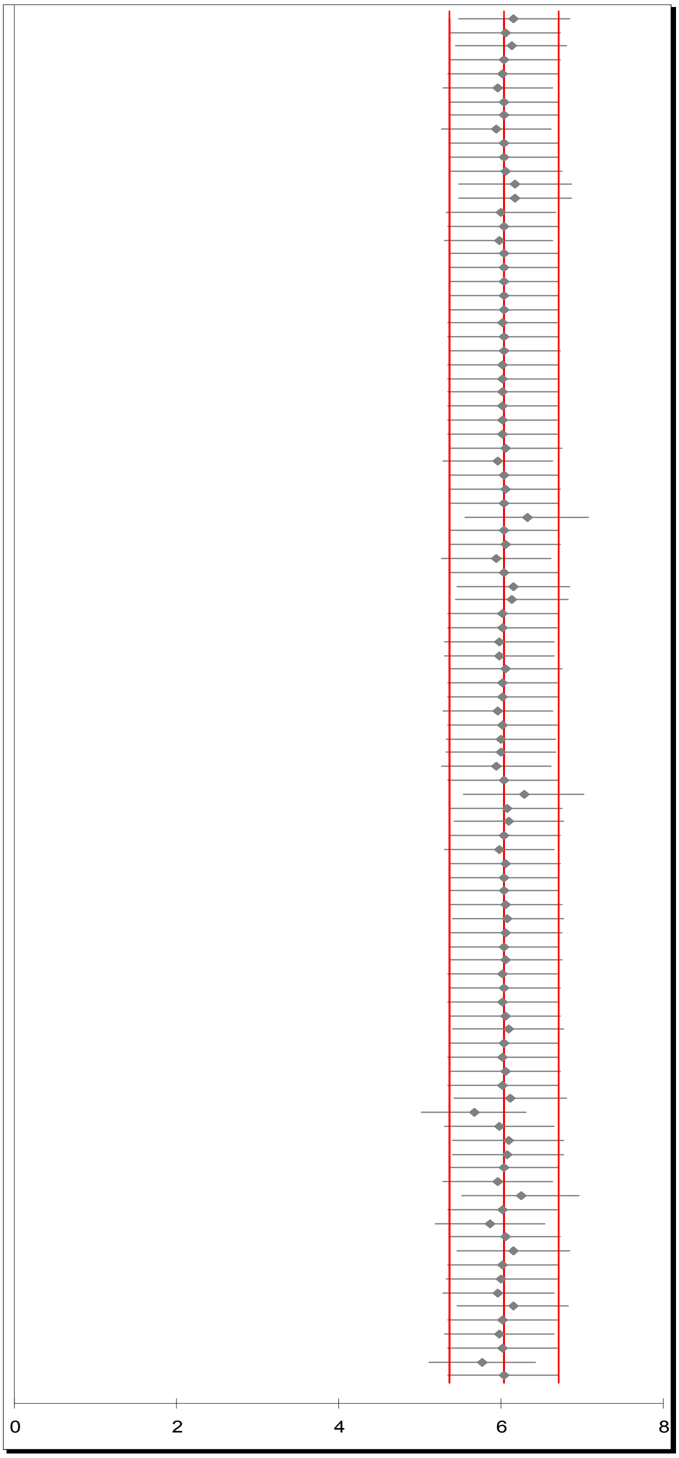
Figure 4—12 Funnel plot



Testing for exclusion sensitivity: Figure 4—13 is an exclusion sensitivity plot that shows the estimated VSL is not sensitive to the exclusion of single studies. In this case, there are no obvious outliers and excluding single studies does not affect the overall result significantly (ie, the value after exclusion remains within the confidence intervals of A$5.4 million and A$6.7 million). Excluding the most extreme studies leads to the following results: Hansen and Scuffham (1995) increases the VSL to A$6.3 million (with a minimum of A$5.6 million and a maximum of A$7.1 million), while excluding Miller et al (1997) reduces the VSL to

A$5.7 million (with a minimum of A$5.0 million and a maximum of A$6.3 million).

Figure 4—13 Exclusion Sensitivity Plot



To summarise, the mean from the meta-analysis of quality studies was $6.0 million with a range from the exclusion sensitivity plot of $5.0 million to $7.1 million. This provides a robust and replicable method for estimating an appropriate average VSL range for Australia and similar countries.

However, because of the greater variability shown across all the source studies, particularly across sectors, the suggested range is based on the 'raw' study median values, which ranged from $3.7 million in the health sector to $8.1 million in the environment sector.

Discussion and Conclusions

A feature of the 'raw' VSL estimates presented above was the variation that reflects the fact that the people who were undertaking the studies were of different ages. A 65 year old worker could be expected to report a VSL around half that of a 15 year old worker, for example, in a wage-risk study. Unfortunately in most studies the average age of the subjects of the study was not able to be determined (noting that the random effects meta-analysis was able to account for age and other variation). There were only a relatively small number of VSLY studies located and only three of these were known to be revealed preference studies (preferred). The differences in VSL and VSLY estimates that we could analyse from the literature reflected country and year of study (income and birth-year cohort effects) and methodology (sector, broad type of study). Variations that we were unable to analyse, but which may have contributed to the variation, include factors such as detailed methodology (eg, WTP compared to willingness to accept), the probability of death or harm (ie, risk) and how accurately people perceive it, private compared to public safety (relevant for transport safety) and the purpose of study (scholarly vs policy).

De Blaeij et al (2003), for instance, found in their meta-analysis of 30 international studies evidence that policy studies produced lower VSL estimates than scholarly studies, that studies based on stated preference methodology produced higher VSL estimates than studies based on revealed preference methodology (as we found, although the differencewas not great) and that, in the case of transport safety, private safety measures produced a higher VSL estimate than public safety measures (because of the free-rider problem inherent in relation to public goods). Aldy and Viscusi (2006) further argue that the VSL is not only determined by age, but also by birth-year cohort effects and the life-cycle consumption pattern.

Different Methodological Approaches, Similar Answers?

A common question is, if stated and revealed preference methods yield similar findings, does this validate the robustness of the estimates? Interestingly the stated and revealed preference estimates in the studies included in this literature review were found to be very similar; however, this appears in our view to be coincidental, although the hypothesis could be tested econometrically. Although regression analysis was beyond the scope of this study, it may be useful if the key control variable (mean age at the time of the study) were able to be identified from the studies (noting this may not be possible) given further investigation. There were no stated preference studies underlying the 19 VSLY estimates to compare with the revealed preference estimates although again, further research may uncover a greater number of VSLY estimates in the future, including stated preference estimates, from which econometric analysis would be recommended.

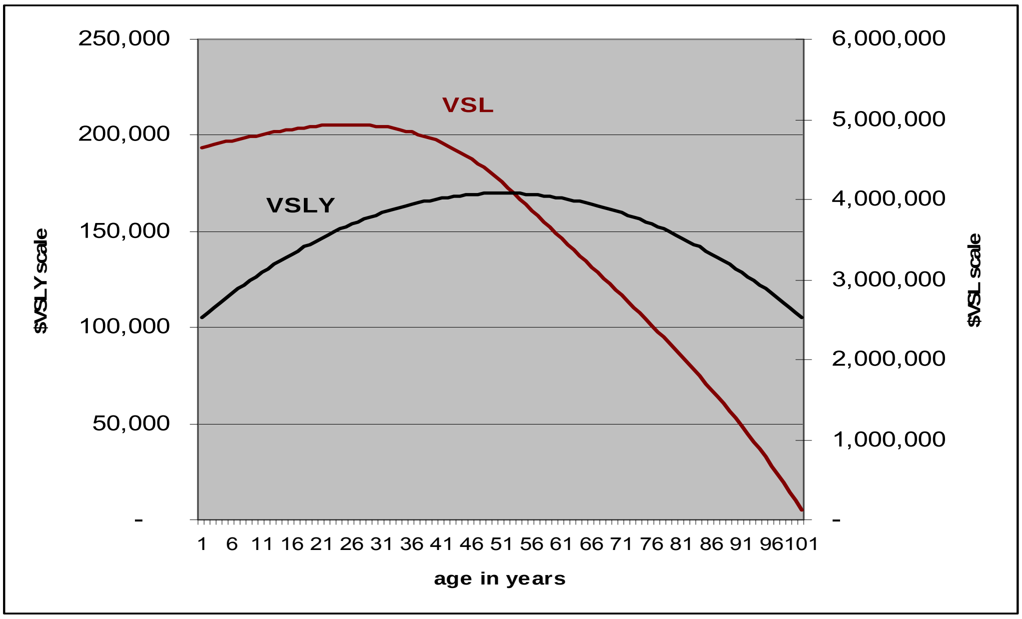
The problem is one of multi-dimensional heterogeneity that single dimensional comparisons or single equation models do not handle well. Shogren and Stamland (2006) addressed this using a general method of moments approach that uses functional relationships between underlying parameters and observed data, to estimate a person's WTP for mortality risk reduction. This approach yielded consistent estimates and performed well even when combining data from different sources that was sampled at different low frequencies.

A similar research approach extended to morbidity as well as mortality is suggested for consideration in Australia over the longer term – namely, an extended search for parameters within existing studies in order to econometrically estimate functional parameters, and the estimation across sectors of WTP using revealed and carefully formulated stated choice studies, to provide further information on VSLY.

Age-Gender Patterns

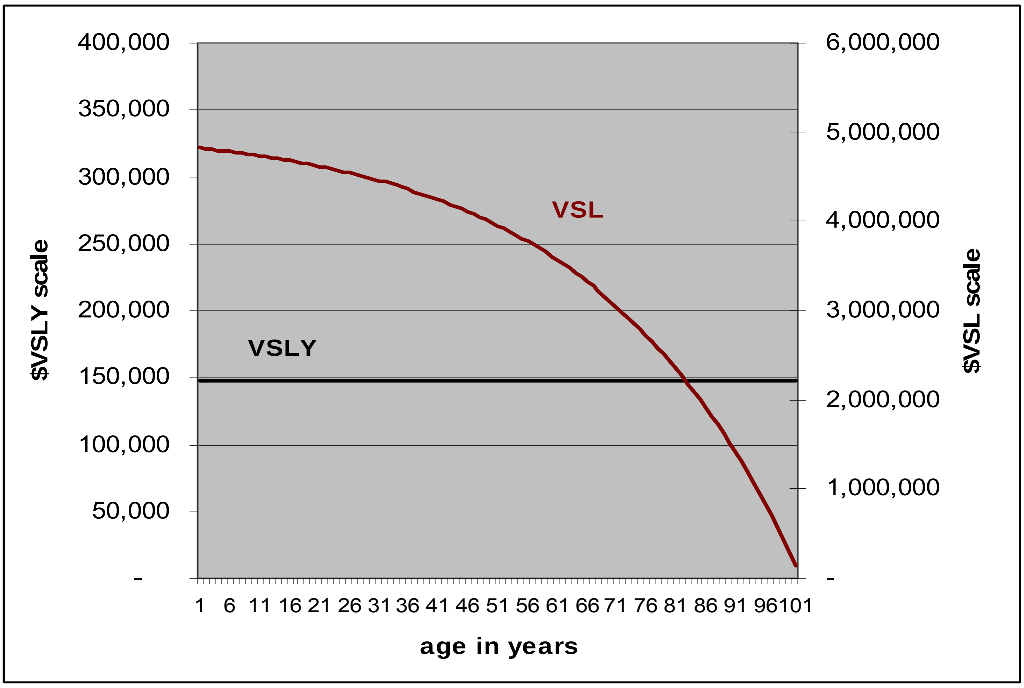
Aldy and Smyth (2006) claim that VSL and hence VSLY estimates vary by age (following an inverted-U shape over the life cycle), as per Figure 4—14. Other studies have not reported an n-curve in the VSLY (nor hence in the VSL) but, instead, a downward-sloping VSL and flat VSLY (Figure 4—15).

Figure 4—14 The N curve (inverted U curve)



Note: Hypothetical scales.

Figure 4—15 'Flat' VSLY and downward-sloping VSL



Note: Hypothetical scales.

The n-curve was modelled by Mason et al (2005) taking into account factors other than future life expectancy (such as a basic value of living), and thus continues to place a significant value on an individual who only has a few days of life left to live. Suppose Mi is the ith individual's marginal rate of substitution of wealth for risk of death, Ei is the ith individual's life expectancy, and u is the error rate.

$$M_i = \alpha + \beta * E_i$$

The M_i-versus-age has been found to be an inverted U-shape, peaking in middle age. To estimate α (the basic value of living), the value of M of an 80 year old individual (with assumed zero expected life expectancy) was used. Then β (the VSLY) can be estimated by taking the difference between M_i of a 40 year old and the 80 year old, taking into account expected life expectancy. The final model provided a distribution of the VSL depending on the remaining life expectancy. More complex functional forms can also be used where α may depend upon the age of the individual, and the relationship to life expectancy is not linear.

Bruce and Halvorsen (2006) provide a useful summary of the state of play as follows:

'Attempts to empirically determine the relationship, if any, between VSL and age have been inconclusive. In a stated preference study cited by the EPA as supporting lower VSLs for the elderly, Jones-Lee et al (1985) obtained evidence that VSL was positively related to age and negatively related to age-squared, but the results were not consistently significant statistically. Also using the stated preference approach, Johannesson, Johansson and Löfgren (1997) obtained an inverted-U relationship and estimated that the VSL at age 60 is about four-fifths that of age 40 and the VSL at age 70 is about two-thirds that of age 40.

'While most stated preference studies have investigated individuals' valuations of risks to themselves, Cropper et al (1994) investigated the general public's preferences for saving persons of different ages. They asked respondents to choose between two programs, one of which would save 200 younger persons (either 20 or 40 years old) and a given number (ranging from 100 to 6,000) of 60- year olds. Their results indicate an inverted-U relationship, with the most preferred age to save lives being 28. The median number of 60-year-olds who are equivalent to one younger person is approximately seven, with the results largely unaffected by whether the younger age was specified to be 20 or 40. The responses were also not found to be significantly affected by the age of the respondents.

'Revealed preference studies have also found some evidence of an inverted-U shape for the VSL. Viscusi and Aldy (2006) note that of eight studies of labor markets that included an age-mortality risk interaction, five obtained statistically significant evidence of a U-shaped relationship. However, the results are often improbable, implying negative VSLs beginning at relatively low ages. Using age group specific mortality risk data, Viscusi and Aldy (2006) obtain more plausible results. They estimate that the VSL is highest for the 35-44 age group and that the VSLs for the 45-54 and 55-62 age groups are three-fifths and two-fifths,respectively, of the VSL for the 35-44 age group.'

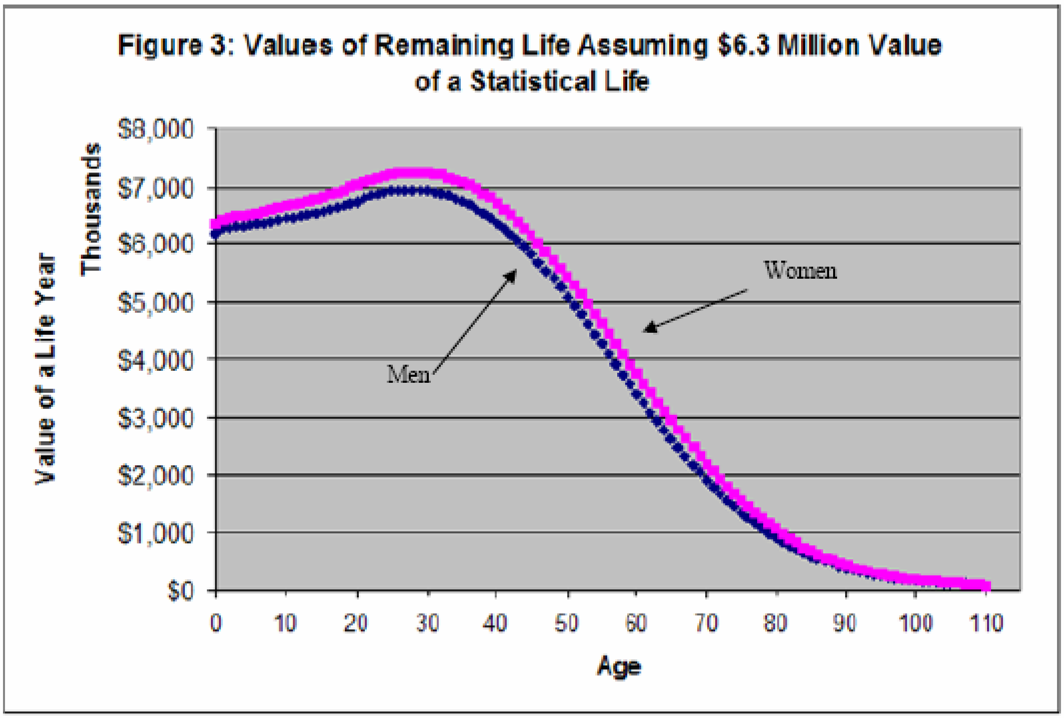
Those who have not found the curve have suggested that it may be due to sample bias (eg, the inclusion of people under analysis who might are in the middle age group and hence value their own lives more than others – see Section 3.3.1) or due to a greater breakdown of the Walrasian framework (in particular information and rationality) for the very young and very old, or both.

An important issue is that the magnitude of age differences, where the n-curve has been found, has not been that substantial, so it may be a second order issue. Murphy and Topel (2005) mathematically derive the function of the VSL curve showing the predominantly downward slope of the curve (Figure 4—16). The VSL curve for females is slightly higher than for males at all ages due to higher life expectancy for women.

The Murphy and Topel model is elegant in its mathematical formulation – so elegant that it is tempting just to plonk in an agreed VSL (with high and low sensitivities) and adopt it lock, stock and barrel. Indeed, after providing the rationale for the VSL that they adopt, the authors advocate this (Murphy and Topel, 2005:20).

'According to Viscusi's (1993) survey, this literature yields a 'reasonable range' of values for $V_{\lambda}(a)$ of US$4 million to US$9 million per statistical life, expressed in current (2004) dollars, while Viscusi and Aldy (2003) provide a tighter range for US data at US$5.5 to US$7.5 million. Government agencies and panels regularly update these estimates to account for economic growth, new methods, and evidence; for example since 1999 the Environmental Protection Agency used a value of US$6.3 million per statistical life in its cost benefit analyses (Dockins et al, 2004). These estimates are typically founded on regression analyses of risk income tradeoffs for working-age individuals, so for the calculations that follow we will assume that the survivorship-weighted average value of a statistical life for individuals between the ages of 25 and 55 is US$6.3 million. Readers who prefer a different value may adjust things accordingly, as most of our later estimates are scalable.'

Figure 4—16 Murphy and Topel relationship between VSL and age



Notes: See equation (14). Estimates are based on *v(t)* from Figure 2a, assuming an average value of a statistical life of $6.3 million between ages 25 and 55. Valuations of a life year are assumed identical for men and women.

However, the only point of contention might be that the lifecycle calibration of utility (v(t)) is determined wholly by income and consumption patterns. Despite the sophistication of the modelling, and while utility that is not income or consumption is valued (since the hedonic WTP is used for the VSL), the pattern of such utility is not captured in the shape or, more specifically, is presumed to follow the same patterns as income and consumption. The value to children of playing, or to the elderly of chatting with friends, is missed.

Socioeconomic Status And Ethnicity

Safety is a normal good, meaning that those with higher income have a higher WTP (or less of a budget constraint), resulting in higher VSL. The sensitivity of VSL to income has been shown in at least three individual studies (Viscusi and Evans, 1990; Persson et al, 1995; Jones-Lee et al, 1987) and in a meta-analysis conducted by Miller (2000). This also explains why VSLY estimates in developing countries are so much lower than those in developed countries.

Society's willingness to pay is linked to people's ability to pay. As noted earlier, poorer people have a different risk-cost trade-off than the more affluent; this is a reflection of their actual preferences. Viscusi and Aldy

(2003) found that a 10% increase in one's income will raise the VSL by 5% to 6% (using hedonic wage methods) and others have also quantified the extent of the elasticity – Aldy and Smyth (2006) show variation in VSLY by income and assets.

This has many implications. In the private sector, it enables producers to target life-saving or life-enhancing innovations to higher income individuals – there is a strong correlation between low SES and poorer health outcomes across almost all therapeutic areas. Indeed, after age, SES is the prime single determinant of health status in Australia (noting that two way correlation may also be evident). In the public sector, does it then follow that the VSLY used in policies and regulations that reduce risks to higher income individuals should be higher than the VSLY for regulations that reduce risk for lower income people? This counters the equity externalities (recall Section 2.2.3) identified as the reason for the public intervention in the first place – discussed further in the discussion of policy implications in Section 5.1.3.

Because income elasticity has been found to be positive, the US EPA has adjusted current VSL estimates for anticipated income growth over time (ie, increasing VSL over time to account for rising real income). However the EPA did not support adjustments to the base VSL for other factors that may differ between study and policy cases, and that may affect VSL, including cross-sectional income.

The opening discussion in Section 4.1 noted that VSL/VSLY valuations may be different across different individuals, regions and countries because attitudes of people to risk are different in terms of risk aversion and in terms of cultural preferences for risks (Pearce, 1998; Rizzi and Ortuzar, 2006). Aldy and Smyth (2006) also observe that VSLY estimates vary by race and gender, but note that the main driver of this is SES – the differences in labour market compensation underlying the wage differential in the WTP calculations. Attitudes to risk aversion and cultural preferences for risk largely reflect the human capital investment process that, like education, is intricately linked in the income growth path.

Moreover, like SES, this has different implications in the private and public contexts. For example, there have been questions surrounding the level of informed consent operating when pharmaceutical companies target people in very poor countries to participate in early phase human trials. However, this is a rational strategy given the ethnicity/SES-risk tradeoff relationship (albeit the ethics may well be monitored). Conclusions regarding the public policy implications are also drawn in Section 5.1.3.

Health Status, Risk Preferences AND Other Stratification

Murphy and Topel (2005) argue that WTP for changes in survival do not depend on the level of health, which is consistent with the Environmental Protection Agency's Science Advisory Board (2000):

'There are no published studies that show that persons with physical limitations or chronic illnesses are willing to pay less to increase their longevity than persons without those limitations. People with physical limitations appear to adjust to their conditions, and their willingness to pay to reduce fatal risks is therefore not affected.'

However, they also note that this does *not* mean that health has no value, so the DALY/QALY approach to measuring benefit for different states or aversion of negative ones is not invalidated (Sections 2.1.2 and 2.1.3).

Another question is how to treat differences in individual or situational risk preferences. Sunstein (2000) finds that people are willing to pay a VSLY premium (which we interpret to reflect social utility) to:

- avoid deaths that involve a high degree of pain and suffering;
- protect children;
- avert catastrophes;
- protect against dangers when the costs of risk avoidance are high;
- protect vulnerable or traditionally disadvantaged groups against certain risks.

Certainly there is a wealth of evidence that has and can be collected in this regard, but it is used more in the private sector than in public policy evaluations. Moreover, the importance of the experimental design of the stated preference studies that underlie such evidence cannot be overemphasised. As noted in Section 3.3.1, the shortfalls in experimental design of stated preference studies have substantially limited the quality and believability of findings in the past.

However, over time and with the maturation of experimental design theory, researchers use increasingly more 'complex' choice settings to study choice behaviour (Hensher, 2006a).The generation of stated choice experiments has evolved to become an increasingly significant but complex component of stated choice studies, and construction of stated choice designs has very much become the domain of the specialist. ITLS has developed such expertise. Rose and Bliemer (2002) note that analysts are now able to determine when particular attribute level values should be shown to respondents in the choice survey and to specify and account for large numbers of attributes simultaneously. The attribute level values in the screenshot (Figure 4—17) relate to attribute levels of a design associated with each of the alternatives, which may differ for each individual as well as over each choice situation, generating potentially infinite numbers of attribute parameters. The assignment of these values can then occur in a systematic (ie, non-random) manner through application of experimental design theory. Steps in designed stated choice experiments are illustrated in Figure 4—18 and described in detail in Rose and Bleimer (2002). These include defining the amount of information as the number of attributes associated with each choice set, investigating how this information is processed as complexity is varied, and the development of ordered heterogeneous logit models (Hensher, 2006a). Using this approach (Hensher, 2006a) found that individuals adopt a range of 'coping' strategies consistent with how they process information in real markets, so aligning 'choice complexity' with the amount of information to process is potentially misleading – it is *relevancy* that matters.

Figure 4—17 An example of a labelled stated choice situation

North-West Sydney Transport

Practice Game

		Light Rail connecting to Existing Rail Line	New Heavy Rail	Bus	Existing M2 Busway	Existing Train line	Car
Main Mode of Transport	Fare (one-way) / running cost (for car)	$ 7.50	$ 4.50	$ 6.00	$ 5.50	$ 7.50	$ 5.60
	Toll cost (one-way)	N/A	N/A	N/A	N/A	N/A	$ 2.20
	Parking cost (one day)	N/A	N/A	N/A	N/A	N/A	$ 8.00
	In-vehicle travel time	124 mins	113 mins	105 mins	45 mins	45 mins	90 mins
	Service frequency (per hour)	10	3	3	6	3	N/A
	Time spent transferring at a rail station	4 mins	6 mins	N/A	N/A	N/A	N/A
Getting to Main Mode	Walk time OR	4 mins	3 mins	15 mins	60 mins	15 mins	N/A
	Car time OR	1 mins	1 mins	4 mins	13 mins	5 mins	N/A
	Bus time	2 mins	2 mins	N/A	15 mins	8 mins	N/A
	Bus fare	$ 2.00	$ 2.00	N/A	$ 2.25	$ 3.10	N/A
	Time Getting from Main Mode to Destination	15 mins	8 mins	15 mins	30 mins	8 mins	5 mins
Thinking about each transport mode separately, assuming you had taken that mode for the journey described, how would you get to each mode?		Walk / Drive / Catch a bus	Walk / Drive / Catch a bus	Walk / Drive	Walk / Drive / Catch a bus	Walk / Drive / Catch a bus	
Which main mode would you choose?		Light Rail	New Heavy Rail	Bus	Existing Busway	Existing Train	Car

Back   Next

Source: Rose and Bliemer (2002:2).

Figure 4—18 Steps in designing a stated choice situation

Model → **Experimental design** → **Questionnaire**

Model:

$$V_1 = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$
$$V_2 = \beta_1 x_3 + \beta_3 x_4$$

Experimental design:

	x_1	x_2	x_3	x_4
1.	-1	-1	-1	-1
2.	-1	-1	-1	1
3.	-1	1	1	-1
4.	-1	1	1	1
5.	1	-1	1	-1
6.	1	-1	1	1
7.	1	1	-1	-1
8.	1	1	-1	1

Questionnaire:

Which mode would you choose in the following situations?

1.	*Car*	*Train*
Travel time:	10 min.	10 min.
Cost/fare:	$1	$1
Your choice:	☐	☐

2.	*Car*	*Train*
Travel time:	10 min.	10 min.
Cost/fare:	$1	$1.50
Your choice:	☐	☐

3.	*Car*	*Train*
Travel time:	10 min.	15 min.
Cost/fare:	$1.50	$1
Your choice:	☐	☐

…
…

Source: Rose and Bliemer (2002:3).

The use of well-designed stated preference models is important in building an information base to solve a particular problem. It can also be used to stratify the VSLY in accord with any dimension desired. However, the implications of basing policy on any particular dimension, such as age or SES, are complex (Section 5.1.3). Moreover Hensher (2006b) found that although, when each design dimension was assessed without controlling for the other dimensions there was evidence to support differences in aggregate mean WTP attributable to certain dimensions, but when aggregated mean estimates were conditioned on *all* design dimensions, there were no systematic differences due to specific design dimensions.

'Net' Values and Other Adjustments

A final consideration before drawing conclusions regarding the range and sensitivity of estimates from our literature review and the available theory and evidence, is a technical question in relation to whether and how the VSLY should be adjusted for:

- any benefits (and costs) to third parties from their life; and
- any other costs or benefits to the individual calculated in that process, to avoid double counting.

In relation to the first question, Goulder (2006) notes that the calculation of benefits from avoided premature mortality should include both the WTP of individuals likely to benefit directly but also the WTP of third parties who have empathy for or are affected in other ways by the directly affected individuals. For example, the elderly receive significant taxpayer funded pensions and health care benefits so in deciding to purchase a year of extra healthy life, there is also an implicit assumption to fund such expenditures.

To address this depends on which method has been used in the calculation of the VSLY;

1 a stated preference method using others' views; or

2 a stated or revealed preference method using the individual's own utility.

The first is essentially measuring social utility. With the assumption of perfect information, these factors are already taken into account in the WTP valuation. As such, there is no need to 'net out' any transfers.

The second method reflects the individual's utility and may include only some (presumably limited) third-party effects, such as the preferences of close family members and general social conscience, reflected in the WTP measure. Essentially, though the WTP reflects the individual's valuation, again with an assumption of perfect information regarding current and future costs and benefits. It may be important to take other third party impacts into account in the analysis, so that cost and benefits can be calculated by bearer and the distributional impacts analysed. For the individual, it thus becomes important to net out the costs that would theoretically at least, have already been taken into account in their WTP valuation.

These costs typically include:

> health expenditures that they themselves would bear;
> productivity impacts and out-of-pocket expenses; and
> welfare or other transfer payments received.

Murphy and Topel (2005) include a netting process to deduct the rising costs of medical care from technological progress over time, concluding that some 36% of the gains in healthy life over 1970-2000 were purchased through health expenditures and should be netted out of the calculation of the total gains in healthy life over the period. This is similar in concept to what Access Economics undertakes when we calculate the 'net' estimate of healthy life. All the costs paid for by the individual are subtracted from the 'gross' value of healthy life to estimate the net value of healthy life gained. It is a simple accounting process as illustrated in Table 4—18.

Table 4—18 Worked example of netting out costs borne by the individual

	Individuals $m
Gross cost of lost wellbeing	**500**
Minus production losses net of tax	50
Minus health costs borne out-of-pocket	10
Minus transfers	20
Minus other costs borne out-of-pocket	10
Net cost of lost wellbeing	**410**

The netting out process is undertaken at the end of the analysis when the distribution of all costs and benefits is known. This is partly due to practical considerations but also avoids the problem of netting out productivity costs and other costs that have strong age associations. The reasons for avoiding the age allocation are that (a) it is usually not required and (b) the netting out process can occasionally lead to anomalous results. An example of this is briefly presented below.

An anomaly occurs when the price of an intervention increases, and the individual pays for a large proportion of it, the net value of the burden of disease falls. Although of course the price increase of the therapy is still counted in total costs, the distributional effect is a little counter-intuitive. Clearly this is a product of the assumption of perfect information of current and future prices and the averaging process for the VSLY. Our conclusion is that anomalies like this one rarely have impacts on overall CEA results and need to be lived with.

Chapter 5: The Role of VSLY in Decision Making

Core Issues

Large Estimates and Budget Constraints

The estimates from the literature for VSL and VSLY in the previous two chapters are high in the sense that it is unlikely that the lives of all Australians could be purchased for the prices calculated from the literature in any given period, due to budget constraints. It is important to understand the reasons for this.

First, the estimates are calculated based on changes at the margin. Some studies relate to people making decisions involving only small incremental changes in health or risk, but many are based on the risk or actual aversion of death. However, in this case 'at the margin' really refers to the fact that not all of the adverse events contemplated in the literature are likely (on the basis of actuarial probabilities) to occur simultaneously and it is not currently technologically or biologically feasible to purchase vast quantities of years of healthy life all in one go from postulated interventions. While life expectancy is increasing at around three weeks per annum, and while investments in healthy life are occurring across a number of fronts, we are constrained in our ability to gain large quantities of extra healthy life. Cancer and cardiovascular disease account for some 37% of Australia's burden of disease (Begg etal, 2007) and, although mortality rates from both conditions have been declining for decades, we are technologically constrained in our ability to accelerate reduction in incidence or mortality from these conditions. While investment in health research is being prioritised (with more than doubling of real expenditures through NHMRC in recent years), research itself has limited capacity to resolve these immediate constraints.

Hence the price expressed in the VSLY reflects what individuals and society on average will currently pay for any life-enhancing opportunities currently available, acknowledging the reality that we cannot yet purchase extra units of life in a planned way at a going, average market rate. If it were ever the case that we could trade life in this way, some might expect the VSLY to fall to something in line with GDP per capita minus a subsistence level of consumption (since without such consumption the person would be dead anyway). However, in such a situation GDP per capita itself might change fundamentally as people altered their labour-leisure choice patterns and other decisions in order to overcome income constraints to getting more healthy life into their basket of consumption. We might expect fundamental changes in the socially optimal general equilibrium set of prices. On the other hand, healthy life would still be inextricably linked to both income and consumption.[20]

There are two important points in relation to the budget constraint.

> While some individuals might trade all they own for another year of their own healthy life, their budget constraint may still underestimate the utility value of healthy life to that individual – and current economic frameworks (not to mention imperfect capital markets) do not deal well with goods of such an order of magnitude of individual utility, particularly when healthy life is required in order to consume all other goods and services and to produce income.

1. What would happen if a terrorist group (or aliens) threatened to bombard the country with nuclear warheads that would eliminate all Australian life, in exchange for a monetary sum? Without exploring possible counterterrorism strategies (ie, assuming the threat was real, imminent and the terrorist could not be identified or located), what sum would we be willing to pay to avert this threat, and would it be in the order of, say, $4 million (VSL)*20 million people ie, $80 trillion? While we might be WTP $80 trillion, we could not actually make the payment given that our annual GDP is around $900 billion and our national net worth is around $5 trillion (not counting the value of natural endowments). Now suppose we could scrounge grants of some $45 trillion from international allies, and the terrorist agreed that with an upfront payment of $50 billion, they would not set loose the warheads if we paid them the real value of the $80 trillion, and we had until 2027 to do this. This would mean changing national labour leisure choices to increase GDP to around $2bn pa in real terms, at a 3.3% discount rate (since immigration and emigration are impossible in the hypothetical scenario) and changing our environmental preferences potentially also to exploit a greater proportion of our natural heritage. We would have to live largely in subsistence living conditions for the period, except for assets not convertible to cash. Would we make this choice, or decide to bring on the nukes?

2. Conversely suppose an Australian researcher invented a process that slowed oxidation processes such that life expectancy increased to 200 years, with associated prolongation of middle but not old age? At what price would we purchase the technology? And would we make the same sorts of reallocation choices, mortgaging the now higher productive capacity elements of our now longer lives into partial slavery effectively, to make the purchase?

> However, in a policy-making context (and also in a private purchasing context) we are in fact buying marginal units of life in the current constrained way, so the VSLY from the literature (the average of

[20] It might be interesting in this context to consider some hypothetical situations

similar incremental decisions[21]) is the appropriate VSLY to apply in decision-making. In a sense it is still currently irrelevant whether life is or is not more valuable than all other goods and services combined (as counted in GDP). However, this aspect (the government budget constraint) does come into play when considering interventions delivered to large numbers of Australians from taxation financed expenditures (see Section 5.3).

For public policy making purposes though, it is also important to address two other major issues:

1. the potential difference between individual valuations of life and government decisions to intervene (essentially to trade health between individuals by deciding which programs to fund or which regulations to enact); and

2. the stratification of VSLY by various criteria.

Whose Value?

A clear message from the analysis was that there is a difference between the social utility derived from governments intervening to protect human life and individuals' valuation of it at the margin.

In the case of revealed preference studies, it could fairly safely be assumed that the estimates reflect individuals' choices regarding their own lives (although this would be an approximation as they might, for example, take into account the perceived impacts on others eg, bystanders, loved ones). In the stated preference studies, the estimates reflect a combination of individuals' and others' choice (people in surveys may be asked questions about choices regarding their own life or about the lives of others). The lack of major differences between the findings of the stated preference and revealed preference models did not distinguish between these effects, and it would be interesting to test this econometrically, controlling for a number of confounding factors (eg, age, gender, SES, sector/intervention, fatality/disability, other relevant factors), to see if there is a significant difference. We would see this further research as valuable, potentially also to shed light on democratic views in relation to the extent of intervention in different situations. [22]

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[21] This is relevant as it means it is not necessary to apply the 'rule of half' that might apply in relation to other decisions where consumer surplus is involved (eg, BTE, 1999).

[22] It was not possible in the time available for this analysis to itemise the studies reviewed by whether the individual themselves or someone else was making the life-risk tradeoff. To do this would require the acquisition and audit of all the source studies in various meta-analyses, for example and, even so, may not enable the determination of the precise framing of questions asked in each study.

The distinction is important because the implication for policy-makers is that, on average across all interventions and sectors, government should intervene to the social VSLY only, after which point individuals (who could afford to) could 'top up' their spending to the intervention point. Recall the 'subsidy' amount P'-P from Figure 2—2 and the regulation impacts in Figure 2—3. However, a concern with this is that the only potential method of obtaining data of this nature would be from stated preference approaches, which are less well accepted than revealed preference studies. Only very high calibre stated preference studies should be included, if this approach were to be adopted, with the proviso that coverage were still deep enough to increase certainty in the estimates. This becomes relevant in the consideration of public financing thresholds in Section 5.4.

Stratification of the VSLY

The richness of stated preference models permit, if desired, the stratification of the VSLY by an almost infinite range of possible criteria. Even some revealed preference studies show variation of VSLY by key characteristics.

In some situations, governments are unable to distinguish whose lives will be saved or enhanced through interventions – for example, in spending on national defence. In other cases, interventions might be targeted at population groups that exhibit particular characteristics, with the most common stratifications of interest being by age, gender, SES, sector, regionality and jurisdiction (eg, speed limitations in school zones, obstetric services in regional Australia, interventions for the frail aged, OHS regulations in the mining sector).

A key question is whether, when a particular groups of people can be identified, different VSLYs should be used, reflecting the most reliable stratification possible from the data. There are different views on this issue. For example, in an unpublished paper Kenkel (2001) concludes: 'When different agencies reduce similar health risks for similar populations, they should use consistent estimates of the VSL; but each agency should use VSL estimates that are specific to the health risk and population affected by its regulations. This presents a challenge for both the research community that generates VSL estimates and the policymaking community that uses them.'

There are a number of important arguments why such stratification may not be desirable, even if it were possible (ie, if robust data were available).

1 Stratification would need to rely primarily on stated preference approaches with its associated limitations, uncertainty and lack of general acceptance of these studies currently. Designing new studies for each intervention may impose large costs and time delays on implementing

any intervention, which may not be desirable for life saving interventions where timing as well as budget can be very important.[23]

2 Normative principles of social justice would be brought into question. These are embedded in many sectors of Australian society, most notably in the health and aged care sector where principles of universal entitlement and equal access to services are espoused. To deny certain groups treatment received by others may be particularly counterintuitive in relation to SES, since higher SES people would be more likely to qualify for treatment based on their higher VSLY, yet the health equity externality and *raison d'etre* for public financing is premised on providing access to lower SES groups. Most groups can be stratified by SES, which would result in higher VSLY for air travellers compared to rail or road travellers (since people who fly are generally of higher SES), lower VSLY for women (who have lower lifetime earnings relative to men) and lower VSLY for particular ethnic groups (eg, indigenous Australians), regional Australians, and jurisdictions with lower Gross State Product per capita. Within OHS, on this basis different standards might be applicable to professionals rather than to manufacturing sector workers. The implications of such stratification would be challenging, although such measures have been suggested overseas (eg, waste dumping in Africa where measured VSLY is relatively low).

3 The 'slippery slope'. It might nonetheless be tempting to stratify the VSLY based on particular criteria. For example, a lower VSLY may be preferred in the road transport sector for historical and stakeholder reasons, and perhaps due to the view that the VSLY is indeed lower in this setting or that the social preference for intervening is lower (we were unable to find evidence for either view in this analysis). Another example might be where a health intervention is targeted at a large group of older people, and a lower VSLY is desired to be used for budget restraint reasons (and perhaps due to the view that the VSLY is lower for older people, which is not supported by strong evidence overall in the literature). We would suggest that if a different VSLY is desired in different sectors (or other different groups), that sensitivity analysis is also always presented using the benchmark VSLY (see Sections 5.4 and 5.6), which would assist policy makers in relation to comparability across sectors, interventions and target groups.

In summary, in public decision making processes there seems to be a strong case for moving to a benchmark average VSLY to be used in evaluation analysis, at least as one scenario presented to decision makers.

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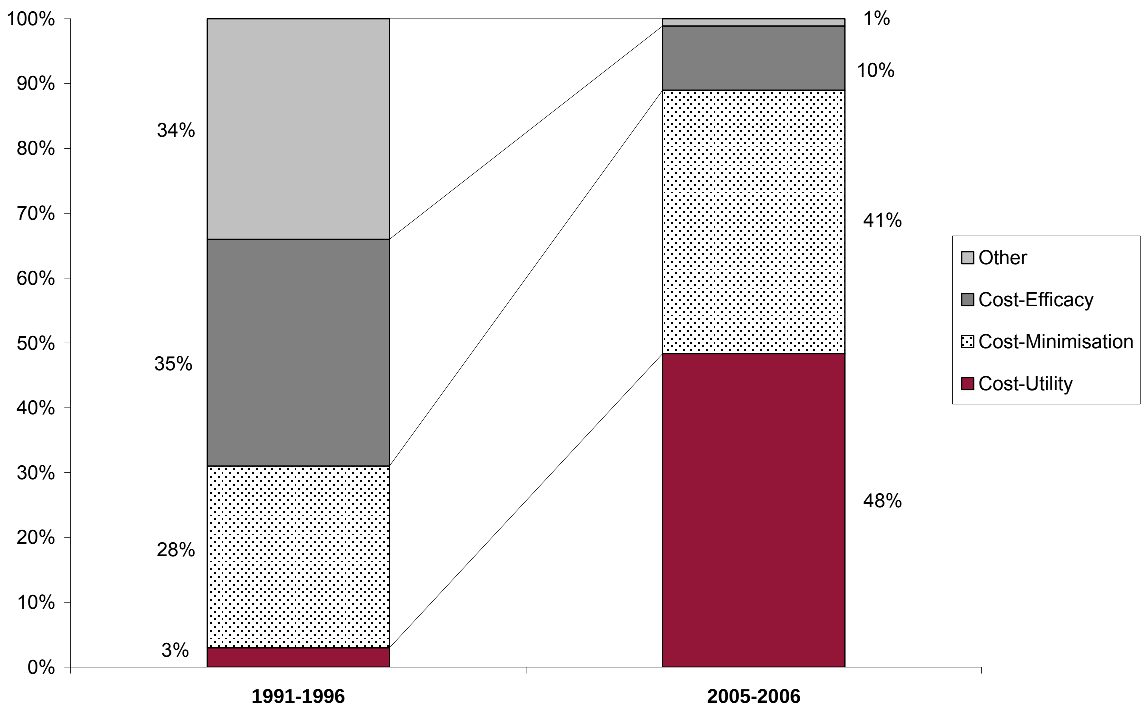
[23] That said, Claxton (1999) also notes that while delays may cause health losses, making mistakes from using the wrong VSLY can also cause health losses by funding the wrong programs or enacting poor regulations (which are hard to undo). So there may also be benefits from delaying until better data on social preferences are obtained.

Efficiency Evaluation in Policy Making

Cost effectiveness analysis measures the efficiency of an intervention in relation to its desired outcome.

Cost benefit analysis (CBA) and cost utility analysis (CUA) are the most common evaluation tools in policy analysis where health and safety are involved. Cost efficacy and cost minimisation analysis (CMA) are mostly used in relation to funding pharmaceutical interventions, where the proposed drug is demonstrated to be no worse therapeutically than other drugs, at the same or a lower price (ie, fewer dollars per patient spent maintaining a specified level of blood pressure control). Figure 5—1 shows different methods of economic evaluation of medicines by PBAC.

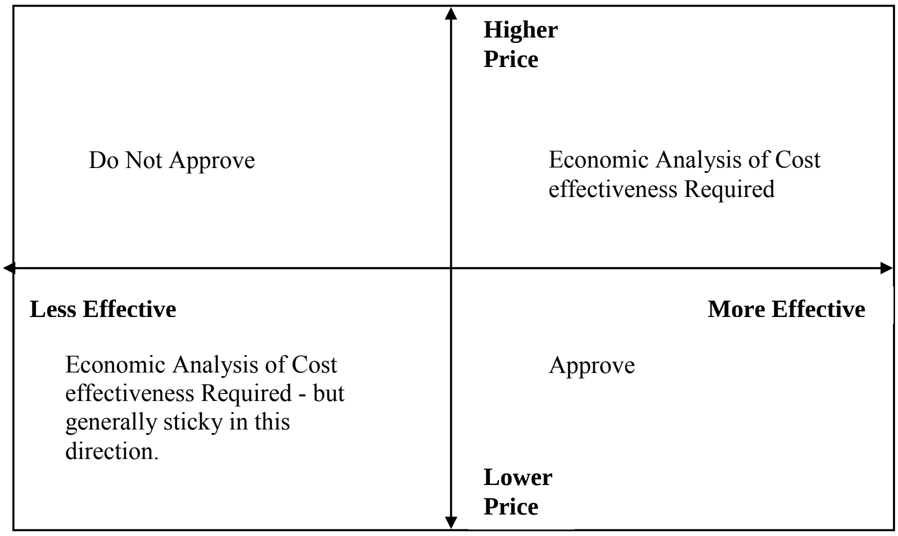
Figure 5—1 Increased use of CMA and CUA in PBAC submissions over time



Sources: George et al (1999) and PBS Public Summary Documents (July 2005 to March 2006).

The decision box (Figure 5—2) is typical in the pharmaceutical sector, where the comparator drug is highly relevant to the financing decision. If the drug has a lower price and is at least as effective, it is approved (CMA); if higher and less effective, it is not approved; and in any other case, other analysis is required (usually CUA)

Figure 5—2 Public financing decision box



Cost efficacy analysis is declining in use in PBAC, and also in other parts of the health sector and, anecdotally at least, in other sectors. The major tool used by the Office of the ASCC and OBPR is CBA, which is rarely used in the health sector since either the health benefits of the treatment are ignored (which is often the significant outcome of the treatment) or it requires explicitly placing a value on each QALY, which may be more controversial than simply reporting the $/QALY.

CBA has long been the tool used most commonly in justifying public policy 'if it produced social gains in excess of social losses so that it was possible for winners from the policy to compensate losers' (Persky, 2001).

One solution to this problem is to include the VSLY conversion in the CBA, but also to report the cost per QALY (ie, to report both CUA and CBA). This is easy to do, since essentially the same cost and benefit components are calculated in each approach. The only difference is that the VSLY is required for the CBA.

The CBA would include all the costs and benefits in dollar terms. It is considered desirable to report the CUA as well since the VSLY component is different from the other components in that it:

> is frequently very large;

> is different in nature (less tangible, healthy life is not included in GDP);

> its valuation is consequently less certain; and

> sensitivity analysis with high and low VSLY estimates may change the outcomes of the CBA.

These differences might be masked in a CBA but are considered relevant in public policy decision making processes, hence the suggestion that CUA ratios are also reported.

The $/QALY ratio should include the net dollar costs from the CBA (ie, excluding the net dollar value of the QALYs) in the numerator, and the QALYs in the denominator. If the numerator is negative (ie, there are net dollar benefits without valuing QALYs) and the denominator is positive, the intervention is described in CUA as *cost saving* rather than *cost effective.* This distinction in terminology might also be useful in the case of other interventions where the primary purpose of the intervention may be another outcome and the improvement in healthy life is secondary.

Technological innovation continues to enhance the scope to delay death and improve the QoL of Australians. However, the technology generally comes at a higher cost and governments are thus faced with the problem of funding these escalating costs, particularly in the health and aged care sector, either through:

> increasing funding through taxes or decreasing expenditure on other programs; or

> quantitative rationing of who receives interventions (usually through waiting lists); or

> making price-based choices regarding the level of care governments are willing to provide.

Other Public Financing Considerations

In the market for health and safety, many governments attempt to collect the best available information and (from a society's perspective) either reimburse or otherwise publicly finance certain interventions on the basis of decisions about externalities relating to that intervention (Arrow et al, 1996). Formal CEA or CBA is sometimes (but not always) used in this decision making process. This section addresses other public financing considerations, using the pharmaceutical sector as a brief case study.

> Total budgetary (opportunity) cost – if financing an intervention consumes a large proportion of the available budget, then other interventions cannot be financed or additional revenue must be raised, which may not be politically popular. Fully financing interventions that target large numbers of people and/or have a high cost per person would violate the goal of equal access for other people in need of other interventions (eg, people with different health conditions) and may also bring into question the 'incremental' nature of the VSLY price (see Section 5.1.1).

  - The budget cost is generally the major limiting consideration in publicly financed interventions.

> Health equity – in order to ensure that small sections of the population do not bear an inordinate proportion of the stock of poor health (again for equity reasons), governments may be more inclined to fund interventions that are the only intervention available to a

particular sub-group (eg, 'orphan drugs', unsniffable fuel subsidies) or conditions that are acute and life threatening (the 'rule of rescue').

> Socioeconomic equity – in order to ensure everyone has access to essential interventions and to slow the slide into poverty due to sickness, governments may be more inclined to reimburse particular interventions if the market price would be high relative to income and/or wealth, possibly pushing the person below the poverty line.

> Whether considered a lifestyle drug – governments may be less inclined to reimburse treatment that is considered non-essential or the prevalence/severity of the condition can be (perhaps better) reduced through changes in lifestyle, such as diet, exercise or avoidance of an addictive substance (eg, tobacco).

> Whether the condition is chronic or acute – as years of life saved is much easier to measure than changes in QoL, severe acute conditions may be more likely to be reimbursed compare to chronic conditions.

> The degree of innovation – governments may be more inclined to reimburse highly innovative interventions in order to promote further R&D into treatments.

> Availability and effectiveness of alternative therapies – governments may consider interventions providing only marginal improvements in cost effectiveness to be 'nonessential', especially in economies where choice is relatively less valued. Because each person is different, there may be diversification value in having alternative intervention alternatives.

Evidence of the balancing of these various priorities in practice can be illustrated by analysing data from the pharmaceutical sector. The relationship between incremental cost effectiveness ratio (ICER) thresholds and the probability of recommendation for PBS listing in Australia was investigated by Access Economics using multiple regression analysis, using data from PBS Summary documents for the period July 2005 to March 2006 for 72 drugs (excluding minor submissions) including type of submission, type of analysis, budgetary impact, number of people treated and the ICER, if applicable. While 54% of the submissions resulted in a positive recommendation, submissions that were for an extension in the use of the drug (such as a new indication or extension to a greater population) were more likely to be successful than a new submission or a re-submission of a drug that was previously rejected. Submissions that provided a cost minimisation analysis were more likely to receive a positive recommendation than a cost utility or cost efficacy analysis. Over the period, 33 submissions were based on a cost utility analysis (equally distributed across new, extensions and re-submissions), of which 33% were accepted.

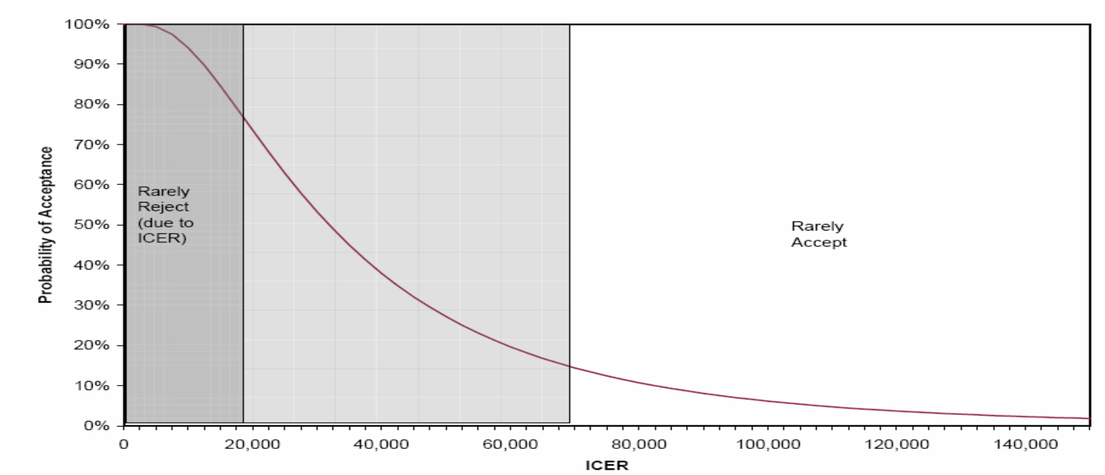
Using a pooled probit model of the natural log of the midpoint of the ICER, the initial analysis found that a higher ICER had a statistically significant negative impact on the likelihood of receiving a positive recommendation (-1.35, $X_2>0.0166$). When a variable representing the budgetary impact was introduced, the results for that variable were not significant, but this was likely to be due to sample size limitations, large bandwidths of budget impacts, and because part of the budgetary effect would be captured by the higher ICER. As more data become publicly available, a more detailed analysis will become possible.

The relationship is illustrated in Table 5—1 and Figure 5—3. A negative non-linear relationship is evident between the ICER and the probability of reimbursement in Australia rather than a consistent 'threshold' for decision making purposes, reflecting the other policy considerations taken into account. The analysis suggests that a drug with an ICER of A$32,000/QALY has a 50% chance of being accepted, which falls to 12% for an ICER of A$75,000/QALY and 6% for an ICER of A$100,000/QALY.

Table 5—1 Likelihood of PBAC acceptance for listing, econometric results

Dependent Variable: Method:	Accept Probit		
Variable	**Coefficient**	**Standard Error**	**Pr > Chi Sq**
Constant	13.9970	5.9995	0.0196
Log(ICER)	-1.3497	0.5632	0.0166
Log-likelihood	-16.77901		
Number of observations	33		

Figure 5—3 Likelihood of PBAC acceptance for listing, Australia



Source: Based on data from PBS Public Summary documents (July 2005 to March 2006).

In Australia, although guidelines are provided, the weighting given to other policy considerations is not explicitly provided. However, this process has recently become a great deal more transparent – the advice is as follows. [24]

'In making decisions as to whether to recommend that a proposed drug be listed on the PBS, PBAC considers many factors. Each of these factors might have a separate influence on the decision to list the proposed drug on the PBS and, depending on the circumstances of each consideration, might influence PBAC in favour of, or against, a recommendation to list. More than one factor might be relevant to each consideration.

'Tables A1.1 and A1.2 in Appendix 1 list relevant factors, which are divided into two groups: quantitative and qualitative. The qualitative factors (Table A1.2) include some of the underlying assumptions implicit in such concepts as quality adjusted life-years and discounting. To enable consistency across submissions regarding these factors, a particular position has been adopted (which is specified in these guidelines in the sections indicated by the cross-references in the tables). However, in certain circumstances, it might be reasonable to argue that a different position should be considered.

'Individual factors are not weighted equally by PBAC in its decision-making process, and different factors might be more or less important in different situations. In other words, the importance of any particular factor cannot be quantified. The descriptions provided in Appendix 1 represent PBAC's understanding at the present time. PBAC continues to reflect on its processes and to further develop its understanding of these matters.'

Thresholds and Benchmarks

Given the interplay of different considerations in public policy making processes and most notably the government budget constraint in the case of healthy life, are benchmarks or threshold financing levels appropriate as guidelines to industry and in decision-making processes? This may relieve some of the externalities and underlying reasons for government intervention while also enabling a balance of priorities. Recalling the decision box in Figure 5—2, if CUA is used, there remains the need to define criteria in quadrants I and III (top right and bottom left) to determine which interventions will be financed. If an intervention option is not dominant (higher benefit, lower costs) or dominated (lower

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[24] Pharmaceutical Benefits Advisory Committee (2002) Guidelines for the Pharmaceutical Industry, Commonwealth Department of Health and Aged Care, Australia and http://www.aodgp.gov.au/internet/wcms/publishing.nsf/Content/pbacguidelines-index~pbacguidelinespart1~ pbacguidelines-part1+4 More detail can be found in Appendix 1 of http://www.aodgp.gov.au/internet/wcms/publishing.nsf/content/pbacguidelines-index~pbacguidelines-appendixes

benefit, higher costs), then comparison of the ICER to the threshold is required. This decision is made in one of two main ways:

- a league table of ICERs is drawn up until the available budget is entirely utilised; or
- a benchmark is developed against which the intervention is compared and financed in whole or in part, in conjunction with other public policy criteria.

It should be noted that while the league table approach has intuitive appeal from a fiscal restraint perspective, it is generally much harder to withdraw an approved intervention than to introduce a new one (regardless of how much more cost effective it may be).

Marquez (2006) recommends establishing and adjusting 'floors and limits' to regulation expenditure through statutory measures such as minimum and maximum values for life saved, adjusting these for qualitative factors, and resisting the urge to 'respond to social fear' achieved not through 'regulating or over regulating but through education and reassurance'.

For regulatory purposes, the goal of the calculations is to estimate how much societies value the government's efforts to reduce risks to their healthy life. For example, Scandinavian countries and other social democracies may have higher ICER thresholds for refusing intervention than in Australia or other liberal democracies, to align with preferences for political systems that place greater emphasis on social justice achieved through higher taxation. More empirical research in this area may be of value.

The fundamental issue here is that the VSLY from the literature is not equal to the public financing threshold per se and is not an argument for the government to pay for its purchase up to $VSLY/QALY. The extent that the government should pay depends upon a different set of arguments in relation to the extent of externalities (of which a major one is the social equity objective in relation to healthy life) or the public good nature (eg, roads) that constrain private purchasing decisions.

For example, band-aids may be very cost effective, even cost-saving, but this is not a reason for government to fund them. In this example, the cost of bandaids to the individual is small and the budget impact and clinical impacts of failure to provide the intervention are judged not to warrant public sector intervention on health equity grounds. The decision to intervene is made on a different basis from cost effectiveness alone, and may be better assessed from social choice models designed to establish the thresholds for particular groups of interventions (call them 'portfolios' and, indeed, they may well align with government departments or groups of departments) than from the incremental VSLY.

If an externality exists that warrants public sector intervention, theoretically the threshold used to determine funding for new interventions should be the shadow price of the budget constraint within that portfolio: the opportunity cost of the marginal intervention displaced. Ideally this would equate across all portfolios, if budgets were set optimally through the political process. However, in the real world portfolio budgets may not be set optimally, so the threshold would be based on the ICER of the marginal program displaced by the new program, calculated by the relevant government department in order to allocate resources efficiently (Claxton et al, 2007). Differing budget constraints across government budgets may thus mean that different thresholds might emerge in different portfolios.

Claxton's conclusion may indeed already be evident in the sectoral interventions publicly financed historically in Australia and around the world (Section 4.1). Conceptually, in sectors where there are frequent and substantial potential interventions, the budget constraint may loom larger (eg, health and aged care). Interventions in transport and other sectors such as fire or crime represent mid-range levels of risk to mid-sized populations (hence providing a case for a mid-range threshold level for financing, while interventions that reduce very small risks or are targeted at smaller populations may require warrant higher thresholds (eg, in environmental regulations or occupational safety). In each case, the reason for the departure from an average threshold will need to be carefully and explicitly communicated to stakeholders.

In practice, the ICER threshold or threshold range is then the one used in cost effectiveness analysis. Call this λ_i where λ depicts a threshold used in a public financing decisions and I reflects the portfolio (the sector or group of interventions within the sector sharing similar externalities that warrant that threshold). Consequently the decision rule is to approve the intervention is:

$$\Delta C / \Delta Q < \lambda_i$$

Where ΔC is the change in costs of the intervention and ΔQ is the change in the QALYs gained. This equation can be rearranged to:

$$\lambda i * \Delta Q\$ - \Delta C > 0$$

where $\Delta Q\$ = \Delta Q * VSLY$.

This is equivalent to the cost benefit approach using the threshold (Claxton 1999).

We suggest that such thresholds are developed across portfolios concerned with implementing lifesaving measures, using cost effectiveness thresholds to evaluate programs and determine funding priorities. Naturally, policy makers are still able to take factors other than the social utility into account in their decisions, should they choose.

COAG (2004:38-39) does not comment on the appropriate valuation of life and, while noting the range in one study, does not make mention that

VSL may vary depending on age or the method of valuation, which may be important factors in explaining such differences.

'The main disadvantage of cost benefit analysis is that difficulties can arise in evaluating costs and benefits for which there are no market prices. The application of cost-benefit analysis to regulations intended to reduce risk inevitably requires that a value be placed on human life. While this has been done in some of the literature, there is a wide variety of approaches used to arrive at this value as well as a wide range of values. For example, in the United States, one study of various measures showed a variation from $0.1 m per life saved to $125 m per life saved. In a climate of limited resources, it is probably not difficult to decide which of these two measures it would be preferable to introduce. Such attempts have often been viewed as controversial. In contrast, cost-effectiveness analysis avoids explicitly valuing human life and instead focuses on the costs of a specified output such as that of saving a life (or reducing injury at a specified level).'

However, Access Economics suggest that both metrics (net benefit and ICER) are presented in prospective and retrospective evaluation findings.

Indexation Over Time

Since the VSLY is expressed in dollar terms, it should be indexed over time by an appropriate inflator. In this case CPI is used as it is consistent with the deflator in the discount rate discussion (Section 3.4). ABS (2004) in its *Measures of Australia's Progress* that a good headline indicator should:

- be relevant to the particular dimension of progress;
- where possible, focus on outcomes for the dimension of progress (rather than on say, the inputs or processes used to produce outcomes);
- show a 'good' direction of movement (signalling progress) and 'bad' direction (signalling regress) - at least when the indicator is considered alone, with all other dimensions of progress kept equal;
- be supported by timely data of good quality;
- be available as a time series;
- be sensitive to changes in the underlying phenomena captured by the dimension of progress;
- be summary in nature;
- preferably be capable of disaggregating by, say, geography or population group; and
- be intelligible and easily interpreted by the general reader.

That said, Claxton (2006) argues that it is not true that a *budget threshold* (λi in the previous section) should be indexed, since government budgets do not necessarily increase with CPI over time or maintain their relativities to GDP. Moreover, the marginal program displaced may be more effective due to technology improvements, in which case the threshold may actually decrease over time.

Best Practice Principles and Next Steps

Drawing together the evidence from previous sections, this section summarises some principles to bear in mind in undertaking evaluation analyses and suggestions for some next steps, in particular in relation to develop pubic financing criteria. In designing analyses for public decision making purposes regarding regulation and financing interventions to enhance safety and wellbeing in Australia going forward, the following principles are suggested.

1 Be aware that any attempt to value life in dollar terms is limited by the unique nature of healthy life and that neoclassical assumptions of perfect information and rationality may not apply. It is the extent of these market failures and externalities that is the *raison d'etre* for the government intervention, rather than the value of human life per se.

2 Measuring changes in risks to life provides a value for *safety* while valuing the utility of different health states provides estimates of *wellbeing*. Estimate safety/wellbeing in QALYs or DALYs, preferably with separate estimates of life years saved (LYS) and morbidity avoided as per Begg et al (2007).

3 For health states other than mortality, use disability weights from DALY tables (Appendix B) to allocate utility associated with various health states. If a disability weight is required that is not available in the table, use the most robust utility value available from the literature (or expert opinion in the worst case) and triangulate it against similar health states that have weights in the table; conduct sensitivity analysis around the disability weight. (Use the metric '$/QALY' rather than '$/DALY averted' for simplicity of terminology.)

4 Calculate all of the costs and benefits associated with the intervention by who bears them – individuals (if families are included use the term 'households'), Federal and State governments, employers, and other relevant entities in society. The net costs to the individual must be netted out of from the gross value of wellbeing.

5 A variety of techniques may be used to evaluate the efficiency of an intervention, including:

> - cost benefit analysis (CBA), which measures the net present value (NPV) of dollar costs compared to the net present value of dollars saved;

> - cost efficacy analysis, which measures the net costs (excluding the dollar value of QALYs) per LYS (or another outcome measure); and

> - cost utility analysis (CUA), which measures the net costs (excluding the dollar value of QALYs) per QALY gained. If the net cost is negative (ie, if there is a net benefit excluding the dollar value of QALYs), the intervention's CUA could be described as cost saving rather than cost effective.

6 Because the dollar value for the VSLY estimate is likely to be large and associated with a higher level of uncertainty than most financial estimates, it is suggested that:

> - sensitivity analysis accompanies the estimates, for example using high and low levels of a VSLY; and

> - cost utility analysis (CUA), and potentially also $/LYS, is used alongside cost benefit analysis (CBA) in public decision making so that the dollar value of the QALY benefit is transparently reported.

7 Avoid productivity or hybrid approaches to value safety/wellbeing, although the productivity impacts may still need to be calculated as part of the analysis.

> In general, if the goal is to measure individual utility, and revealed preference data are available, they should be used, reflecting consumer sovereignty.

> If no revealed preference data are available, or if the goal is to measure social or private utility in specific situations, stated preference approaches may be more appropriate.

8 A suggested ballpark average VSL is $6.0 million in 2006 Australian dollars with sensitivity analysis suggested at $3.7 million and $8.1 million.

> This equates to an average VSLY of $252,014 ($155,409 to $340,219), using a discount rate of 3% over an estimated 40 years remaining life expectancy.

9 The empirical evidence appears inadequate currently to robustly stratify the average VSLY on the basis of age.

10 The externalities that provide the *raison d'etre* for government interventions are based largely on social utility from enhancing socioeconomic equity and health equity, so it would seem self-defeating to stratify VSLY on the basis of income, wealth, ethnicity, or other criteria that correlate strongly with SES, in public policy making.

11 Naturally policy makers are still able to take factors other than the social utility into account in their decisions. An important consideration is the budget constraint, which may vary across different portfolios of interventions given different types of externalities in different sectors (eg, some sectors may have more 'public good' characteristics than others) and given imperfect historical budget allocation mechanisms. Thus the value of the marginal intervention displaced may not equate across portfolios.

12 While the VSLY should be used in public decision making, as needed, to apply to individual's own valuation of healthy life, social valuations for public financing decisions should be based on thresholds reflecting the extent of externalities, potential compensation of any losers and budget constraints.

13 The decision rule to approve an intervention should be (CUA):

$$\Delta C / \Delta Q < \lambda i$$

where ΔC is the change in costs of the intervention, ΔQ is the change in the QALYs and λi is the ICER threshold for portfolio $_i$. Rearranging, the CBA decision rule is:

$$\lambda i * \Delta Q\$ - \Delta C > 0$$

where $\Delta Q\$ = \Delta Q * VSLY$.

14 It will therefore be important to determine financing thresholds in different sectors/portfolios. Further carefully designed research may be desirable to this end, using specialists capable in experimental design theory and practice.

> _ Portfolio thresholds should also be surrounded with sensitivity analysis based on high and low bounds, as with VSLY.

15 Since the VSLY and portfolio thresholds are expressed in dollar terms, they should be indexed over time to inflation (CPI is suggested here), reviewing λ_i/VSLY over time for each portfolio to reflect potential changes in technology and preferences.

Table 5—2 Average VSLY under different longevity and discount rate assumptions (2006A$)

Life expectancy at average VSL	43 years		40 years	
Discount rate	**3%**	**3.30%**	**3%***	**3.30%**
Base case ($6.0m)	242,902	254,739	**252,014**	263,612
Low case ($3.7m)	149,789	157,089	**155,409**	162,561
High case ($8.1m)	327,917	343,897	**340,219**	355,876

* Suggested.

Appendix A – Studies In The Literature Analysis

Range of Statistical Life Values by Study and Country – Health and Occupational Safety (2006 A$Million)

Study Year[25] Study Area Study Type Min VSL Max VSL VSL Std. Dev.

Australia

Abelson et al 2003 Health Other 1.15 ---

Abelson et al 2003 Health Other 2.88 ---

Australian

Transport Council

2000 Transport Other 1.99 ---

Bellavance et al. 2007 Other Other 17.65 15.20

Bryant et al. 1992 Environment Other 0.86 1.43

BTE 2000 Transport Other 1.29 1.80

BTE - Black Spot

Program

2001 Transport Other 5.41 ---

CASA 2006 Transport Other 3.00 ---

Kniesner & Leeth 1991 Occ. Safety Revealed 6.90 2.77

Law Reform

Commission of

Victoria

1990 Other Other 1.50 ---

Mayhew 2003 Other Other 2.18 ---

Mayhew 2003 Other Other 1.74 ---

Miller 2000 Other Other 3.66 5.41 4.67

Miller et al. 1997 Occ. Safety Other 28.40 2.16

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[25] Conversion is based on the year of the study where possible and otherwise the year of publication.

NOHSC 2004 Occ. Safety Other 2.87 ---

RCG/Hagler Bailey 1994 Environment Other 5.38 9.04 7.21 ---

Viscusi 2005 Occ. Safety Revealed 6.63 ---

Austria

Bellavance et al. 2007 Other Other 13.20 ---

Maier et al. 1989 Occ. Safety Stated 2.64 7.30

Miller 2000 Other Other 5.41 7.85 5.58 ---

Viscusi 2005 Occ. Safety Revealed 6.16 10.27

Weiss et al. 1986 Occ. Safety Revealed 13.22 ---

Canada

Alberini et al. 2002 Occ. Safety Other 0.76 1.39

Alberini et al. 2002 Occ. Safety Other 1.96 5.54

Belhadji 1994 Transport Stated 1.57 ---

Bellavance et al. 2007 Other Other 14.47 16.41

Cousineau et al. 1991 Occ. Safety Revealed 7.59 0.73

Dionne & Lanoie 2002 Other Mixed 6.00 ---

Hara Associates 2000 Health Other 2.69 9.00

Krupnick et al. 2000 Health Stated 3.20 ---

Lanoie et al. 1995 Transport Stated 41.09 13.00

Martinello &

Meng 1992 Occ. Safety Revealed 4.97 1.50

Meng 1989 Occ. Safety Revealed 6.38 3.69

Meng & Smith 1990 Occ. Safety Revealed 1.92 3.56

Meng & Smith 1999 Occ. Safety Other 3.72 0.96

Miller 2000 Other Other 3.66 5.41 4.43 ---

Transport

Canada 1996 Transport Other 0.68 5.46

Viscusi 2005 Occ. Safety Revealed 6.16 7.42

Vodden et al. 1994 Occ. Safety Revealed 7.83 ---

Denmark

Kidholm 1995 Transport Stated 1.27 1.88

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Miller 2000 Other Other 6.63 8.72 6.96 ---

Europe

Eurocontrol 2007 Transport Other 5.40 ---

France

Desaigues &

Rabl

1995 Transport Stated 1.50 35.83

Miller 2000 Other Other 5.06 7.32 5.21 ---

Hong Kong

Siebert & Wei 1998 Occ. Safety Other 2.69 ---

Japan

Bellavance et al. 2007 Occ. Safety Other 20.24 ---

Kniesner & Leeth 1991 Occ. Safety Revealed 20.24 10.59

Miller 2000 Other Other 7.67 12.21 8.16 ---

Viscusi 2005 Occ. Safety Revealed 15.32 ---

New Zealand

Guria et al. 1999 Transport Stated 4.00 ---

Hansen &

Scuffham

1995 Transport CPLS 1.08 1.23

Leung & Guria 2006 Transport Stated 4.99 21.37

Leung & Guria 2006 Transport Stated 6.16 14.05

Leung & Guria 2006 Transport Stated 6.16 21.37

Leung & Guria 2006 Transport Stated 7.08 18.00

Leung & Guria 2006 Transport Stated 4.99 8.25

Miller 2000 Other Other 2.79 4.19 3.52 ---

Miller & Guria 1991 Transport Stated 1.87 2.99

Miller & Guria 1991 Transport Revealed 2.43 ---

South Korea

Bellavance et al. 2007 Occ. Safety Other 2.45 ---

Kim 1985 Occ. Safety Other 1.66 ---

Kim & Fishback 1993 Occ. Safety Other 1.26 ---

Kim & Fishback 1999 Occ. Safety Revealed 2.45 0.51

Miller 2000 Other Other 0.70 1.40 0.66 ---

Viscusi 2005 Occ. Safety Revealed 1.26 ---

Sweden

Johannesson et

al.

1996 Transport Stated 8.90 10.72

Miller 2000 Other Other 4.88 6.80 5.63 ---

Persson 1989 Transport Other 3.33 ---

Persson &

Cedervall

1991 Transport Stated 2.08 44.06

Persson et al. 1995 Transport Stated 7.24 8.26

Persson et al. 2001 Transport Stated 3.92 ---

Soderquist 1994 Other Stated 2.11 ---

Switzerland

Baranzini &

Ferro Luzzi

2001 Occ. Safety Other 9.95 13.27

Miller 2000 Other Other 7.32 12.91 7.73 ---

Schwab Christe 1995 Transport Stated 1.54 ---

Schwab Christe

& Soguel

1995 Transport Stated 1.39 1.67

Viscusi 2005 Occ. Safety Revealed 9.95 13.58

Taiwan

Bellavance et al. 2007 Other Other 1.89 ---

Hsueh & Wang 1987 Occ. Safety Other 2.88 ---

Liu & Hammitt 1999 Occ. Safety Other 1.11 ---

Liu & Smith 1996 Occ. Safety Other 1.67 ---

Liu et al. 1997 Occ. Safety Other 1.89 0.17

Miller 2000 Other Other 1.40 1.92 1.43 ---

Viscusi 2005 Occ. Safety Revealed 0.32 1.42

United Kingdom

Arabsheibani &

Marin

2000 Occ. Safety Revealed 45.58 9.76

Beattie et al. 1998 Transport Stated 2.28 25.79

Bellavance et al. 2007 Other Other 41.31 33.17

Carlin & Sandy 1991 Transport Revealed 1.31 ---

Carthy et al. 1999 Transport Stated 6.84 8.91

Davies & Teasdale 1995/6 Occ. Safety Other 2.12 ---

Donaldson 2006 Transport Other 2.93 ---

Elliott & Sandy 1996 Occ. Safety Revealed 84.70 ---

Folsom & Leigh 1984 Occ. Safety Revealed 15.90 ---

Folsom & Leigh 1984 Occ. Safety Revealed 17.68 ---

Ghosh et al. 1975 Transport Revealed 2.87 ---

Jones-Lee 1992 Other Stated 6.61 ---

Jones-Lee 1976 Transport Revealed 7.72 ---

Jones-Lee 1976 Transport Stated 34.02 ---

Jones-Lee et al. 1983 Transport Stated 1.01 17.23

Jones-Lee et al. 1985 Transport Stated 8.55 ---

Kochi et al. 2006 Environment Revealed 31.44 6.82

Maclean 1979 Other Stated 8.95 ---

Marin &

Psacharopailos

1982 Occ. Safety Revealed 9.55 2.11

Melinek 1974 Transport Revealed 1.33 ---

Melinek et al. 1973 Other Revealed 1.43 ---

Miller 2000 Other Other 3.66 5.58 4.80 ---

Sandy et al. 2001 Occ. Safety Other 9.00 117.04

Siebert & Wei 1994 Occ. Safety Revealed 22.40 10.66

UK Department of

the Environment,

Transport and

Regions

1988 Other Other 2.74 ---

Viscusi 2005 Occ. Safety Revealed 6.63 ---

United States

Ackerman &

Heinzerling

2004 Environment Other 5.53 ---

Acton 1973 Health Stated 0.20 ---

Alberini et al. 2002 Occ. Safety Other 1.05 2.30

Alberini et al. 2002 Occ. Safety Other 1.66 7.22

Aldy & Viscusi 2003 Occ. Safety Revealed 4.99 ---

Aldy & Viscusi 2003 Occ. Safety Revealed 14.26 ---

Aldy & Viscusi 2003 Occ. Safety Revealed 15.56 ---

Aldy & Viscusi 2003 Occ. Safety Revealed 12.59 ---

Aldy & Viscusi 2006 Occ. Safety Revealed 4.99 15.56

Aldy & Viscusi 2006 Occ. Safety Revealed 5.95 ---

Aldy & Viscusi 2006 Occ. Safety Revealed 7.42

Aldy & Viscusi 2006 Occ. Safety Revealed 9.81

Aldy & Viscusi 2006 Occ. Safety Revealed 8.12

Aldy & Viscusi 2006 Occ. Safety Revealed 2.42

Arnould & Nichols 1983 Occ. Safety Other 2.13 ---

Atkinson &

Halvorson

1990 Transport Revealed 7.71 ---

Baker 1973 Transport CPLS 1.40 21.03

Baker 1973 Transport Revealed 11.29 ---

Bellavance et al. 2007 Other Other 10.76 7.85

Berger & Gabriel 1991 Occ. Safety Other 12.03 2.11

Blomquist 1979 Transport Revealed 2.56 ---

Blomquist &

Miller

1992 Transport Revealed 2.45 9.49

Blomquist et al. 1996 Transport Other 2.69 15.64

Brown 1980 Occ. Safety Other 3.86 2.22

Butler 1983 Occ. Safety Other 2.05 ---

Caltrans 2006 Transport Other 4.32 ---

Chestnut et al. 1999 Environment Other 7.05

Cohen 1980 Transport CPLS 0.65 ---

Corso et al. 2000 Transport Stated 3.97 9.42

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CPSC 1995 Other Revealed 8.84 ---

CPSC 2000 Other Revealed 7.90 ---

Dardis 1980 Other Revealed 1.22 ---

Dickens 1984 Occ. Safety Other 5.53 6.48

Dillingham 1979 Occ. Safety Other 3.25 ---

Dillingham 1985 Occ. Safety Revealed 6.62 3.67

Dillingham &

Smith

1984 Occ. Safety Other 5.20 2.47

Dillingham et al. 1984 Occ. Safety Other 4.72 9.50

Dillingham et al. 1990 Occ. Safety Other 5.41 8.84

Dorman &

Hagstrom

1998 Occ. Safety Other 13.74 32.06

Dorsey 1983 Other Other 15.16 ---

Dorsey & Walzer 1983 Occ. Safety Other 18.59 ---

Dreyfus & Viscusi 1995 Transport Revealed 6.89 ---

EPA 1985 Environment Revealed 2.69 ---

EPA 1988 Environment Revealed 7.58 ---

EPA 1996 Environment Revealed 9.95 ---

EPA 1997 Environment Revealed 9.95 ---

EPA 1998 Environment Other 9.79 ---

EPA 1999 Environment Revealed 9.95 ---

EPA 1999 Environment Revealed 6.16 9.95

EPA 1999 Environment Other 10.26 6.84

FAA 1985 Transport Revealed 1.58 ---

FAA 1988 Transport Revealed 2.37 ---

FAA 1990 Transport Revealed 3.16 ---

FAA 1996 Transport Revealed 4.74 ---

FAA 1998 Transport Other 4.74 ---

FDA 1996 Health Revealed 4.74 ---

FDA 1996 Health Revealed 8.69 ---

FNS (USDA) 1994 Health Revealed 2.69 5.53

Frankel 1979 Other Stated 42.27 ---

FSIS (USDA) 1996 Health Revealed 3.00 ---

Garbacz 1989 Other Revealed 5.36 ---

Garbacz 1991 Other Revealed 7.45 ---

Garen 1988 Occ. Safety Revealed 25.93 5.59

Gayer et al. 2000 Health Other 5.05 5.84

Gerking et al. 1988 Occ. Safety Stated 6.90 ---

Gilbert & Smith 1984 Occ. Safety Other 1.42 ---

Hakes & Viscusi 2005 Transport Other 2.71 11.98

Herzog &

Schottleman

1987 Occ. Safety Revealed 20.89 ---

Ippolito & Ippolito 1984 Health Revealed 1.99 ---

Jenkins et al. 2001 Transport Other 2.21 6.79

Jenkins et al. 2001 Transport Other 2.21 4.58

Jenkins et al. 2001 Transport Other 1.90 4.42

Jenkins et al. 2001 Transport Other 3.32 6.79

Jondrow et al. 1983 Transport Revealed 3.23 ---

Kniesner & Leeth 1991 Occ. Safety Revealed 0.73 0.49

Kniesner & Viscusi 2005 Occ. Safety Revealed 8.05 ---

Kniesner et al. 2005 Occ. Safety Revealed 7.68 9.71

Kniesner et al. 2006 Occ. Safety Other 7.97 10.87

Kochi et al. 2006 Environment Revealed 11.82 6.82

Landefeld 1979 Health Other 6.01 ---

Leigh 1987 Occ. Safety Revealed 21.12 ---

Leigh 1991 Occ. Safety Other 11.29 3.44

Leigh 1995 Occ. Safety Other 17.55 3.29

Lott & Manning 2000 Occ. Safety Other 2.37 4.74

Low &

McPheters

1983 Occ. Safety Other 2.20 1.59

Ludwig & Cook 2001 Other Stated 8.44 ---

McDaniels 1992 Transport Stated 14.14 50.83

Miller 2000 Other Other 5.76 7.85 6.40 ---

Moore & Viscusi 1988 Occ. Safety Revealed 14.47 3.78

Moore & Viscusi 1988 Occ. Safety Revealed 14.82 ---

Moore & Viscusi 1989 Occ. Safety Revealed 15.84 ---

Moore & Viscusi 1990 Occ. Safety Other 32.89 ---

Moore & Viscusi 1990 Occ. Safety Other 32.85 ---

Moore & Viscusi 1990 Occ. Safety Other 32.85 ---

Morrall 1986 Transport CPLS 0.24 3.17

Mulligan 1977 Other Stated 1.02 ---

Needleman 1980 Occ. Safety Other 0.47 ---

Olson 1981 Occ. Safety Other 19.54 ---

Portney 1981 Environment Revealed 0.85 ---

Smith 1974 Occ. Safety Other 14.58 6.08

Smith 1976 Occ. Safety Other 9.34 ---

Smith 1983 Occ. Safety Revealed 1.42 ---

Smith et al. 1984 Occ. Safety Other 14.49 17.07

Thaler & Rosen 1975 Occ. Safety Other 1.54 0.94

US Department of

Transportation

2006 Transport Other 4.34 ---

Violette &

Chestnut

1983 Environment Other 1.14 1.71

Viscusi 1992 Environment Other 6.13 13.61

Viscusi 1980 Other Other 8.69 24.01

Viscusi 2003 Other Other 25.49 2.40

Viscusi 2004 Other Other 8.07 0.95

Viscusi 1978 Occ. Safety Other 3.86 2.22

Viscusi 1981 Occ. Safety Other 13.20 ---

Viscusi 2005 Occ. Safety Revealed 11.06 ---

Viscusi & Aldy 2003 Occ. Safety Mixed 1.11 32.85 10.58 8.84

Viscusi et al. 1989 Transport Other 5.43 ---

Viscusi et al. 1991 Transport Stated 15.48 ---

Winston &

Mannering

1984 Transport Revealed 3.23 ---

Multiple Countries

Bellavance et al. 2007 Other Other 0.73 84.70 15.04 16.08

De Blaeij et al. 2003 Transport Mixed 0.24 50.83

De Blaeij et al. 2003 Transport Revealed 1.33 9.49

De Blaeij et al. 2003 Transport Stated 1.01 50.83

De Blaeij et al. 2003 Transport CPLS 0.24 21.03

Dionne & Lanoie 2002 Other Mixed 10.62 ---

Dionne & Lanoie 2002 Transport Mixed 7.25 ---

Dionne & Lanoie 2002 Transport Mixed 6.64 ---

Dionne &

Michaud

2002 Occ. Safety Other 0.47 30.04 11.08 8.56

Gegax et al. 1991 Occ. Safety Revealed 4.32 2.18

Kochi et al. 2006 Environment Mixed 0.14 132.85

Kochi et al. 2006 Environment Mixed 0.97 19.34 7.51 3.34

Kochi et al. 2006 Environment Revealed 13.08 6.54

Kochi et al. 2006 Environment Stated 3.90 1.81

Leeth & Ruser 2003 Other Other 4.30 ---

Miller 1990 Other Other 5.02 1.48

Mrozek & Taylor 2002 Other Other 3.3 ---

Note: ‘Other’ in column 3 (study area) includes Consumption, Crime, Fire Safety and Mixed Studies.

‘Other’ in column 4 (study type) signifies implicit valuation, based on other studies or unknown.

CPLS = cost per life saved

Bolded studies were included in the meta-analysis after applying the exclusion criteria.

VSLY ESTIMATES BY COUNTRY (2006A$)

Study Year Study Area Study Type Min VSLY Max VSLY VSLY Std. Dev.

Australia

Abelson et al 2003 Health Other 69,099

Abelson et al 2003 Health Other 124,378

Bryant et al. 1992 Environme

nt

Other 24,638 40,580

BTE 2000 Transport Other 74,727 100,495

CASA 2006 Transport Other 131,993

Law Reform

Commission of

Victoria

1990 Crime Other 65,674

NHMRC 1993 Environment Other 67,660

NOHSC 2004 Occ. Safety Other 119,589

RCG/Hagler Baily 1994 Environment Other 418,244

United Kingdom

Davies & Teasdale 1995/6 Occ. Safety Other 93,187

Donaldson 2006 Transport Other 84,450 146,582

Mason et al. 2003 Multiple Other 53,878 94,892

United States

Ackerman &

Heinzerling

2004 Environment Other 242,994

Dreyfus &

Viscusi

1995 Transport Revealed 655,468 884,487

Moore & Viscusi 1990 Occ. Safety Other 1,167,207

Moore & Viscusi 1990 Occ. Safety Other 1,500,470

Moore & Viscusi 1988 Occ. Safety Revealed 424,870 481,730

Moore & Viscusi 1989 Occ. Safety Revealed 1,713,694 3,571,118

Multiple Countries

Baker et al. 2003 Various Other 10,089 107,924

PARAMETERS USED IN CONVERSION RATES, BY YEAR

AUS AUT CAN DK F JP KOR NZ SWE SWI UK US AUS CPI

1987 1.25 0.96 1.24 8.91 1.02 198.99 470.79 1.42 7.87 2.00 0.54 1.00 **83.4**

1988 1.32 0.94 1.25 8.95 1.01 193.86 489.80 1.51 8.09 1.99 0.55 1.00 **89.4**

1989 1.37 0.93 1.26 9.05 1.01 191.09 498.96 1.53 8.42 1.98 0.57 1.00 **96.2**

1990 1.38 0.93 1.25 8.97 0.99 188.40 530.91 1.52 8.82 1.99 0.59 1.00 **103.2**

1991 1.37 0.93 1.25 8.90 0.98 187.38 567.69 1.48 9.28 2.03 0.61 1.00 **106.5**

1992 1.35 0.94 1.23 8.85 0.98 186.15 597.20 1.47 9.16 2.03 0.62 1.00 **107.6**

1993 1.34 0.95 1.22 8.70 0.97 182.93 620.86 1.47 9.23 2.03 0.62 1.00 **109.5**

1994 1.33 0.95 1.21 8.66 0.97 179.32 655.67 1.46 9.28 2.02 0.62 1.00 **111.6**

1995 1.32 0.95 1.21 8.59 0.96 174.85 690.04 1.46 9.42 2.00 0.62 1.00 **116.8**

1996 1.32 0.94 1.21 8.55 0.95 170.45 711.81 1.47 9.31 2.01 0.63 1.00 **119.8**

1997 1.32 0.94 1.21 8.56 0.93 168.52 732.44 1.45 9.37 1.93 0.62 1.00 **120.1**

1998 1.31 0.94 1.19 8.52 0.93 166.58 766.56 1.45 9.46 1.90 0.63 1.00 **121.1**

1999 1.30 0.93 1.19 8.41 0.93 162.04 754.89 1.43 9.34 1.93 0.64 1.00 **122.9**

2000 1.31 0.91 1.23 8.41 0.92 154.93 753.19 1.45 9.19 1.90 0.63 1.00 **128.4**

2001 1.33 0.92 1.22 8.33 0.90 149.42 761.49 1.47 9.32 1.89 0.62 1.00 **134.0**

2002 1.34 0.91 1.23 8.43 0.90 143.67 778.77 1.47 9.36 1.80 0.61 1.00 **138.1**

2003 1.35 0.88 1.24 8.47 0.93 138.47 783.30 1.46 9.25 1.76 0.62 1.00 **141.9**

2004 1.36 0.87 1.25 8.40 0.92 133.10 782.19 1.47 9.18 1.73 0.62 1.00 **145.2**

2005 1.38 0.87 1.25 8.40 0.90 127.52 755.82 1.46 9.21 1.70 0.62 1.00 **149.1**

2006 1.39 0.86 1.23 8.37 0.89 124.50 744.47 1.47 9.17 1.68 0.62 1.00 **154.4**

Source: OECD for purchasing power parity, Australian Bureau for Statistics for CPI.

Appendix B – Disability Weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
Communicable diseases, maternal and neonatal conditions		
A. Infectious & parasitic diseases		
1. Tuberculosis		
Pulmonary tuberculosis	0.295	GBD weight
Extra-pulmonary tuberculosis	0.300	GBD weight
2. Sexually transmitted diseases (non HIV/AIDS)		
a. Syphilis		
Primary syphilis	0.148	GBD weight
Secondary syphilis	0.048	GBD weight
Tertiary syphilis (cardiovascular)	0.196	GBD weight
Tertiary syphilis (gummas)	0.102	GBD weight
Tertiary syphilis (neurologic)	0.283	GBD weight
Syphilis (congenital)	0.315	GBD weight
b. Chlamydia		
Conjunctivitis	0.180	GBD weight
Urethritis	0.067	GBD weight
Cervicitis	0.049	GBD weight
Pelvic inflammatory disease	0.420	GBD weight
Ectopic pregnancy	0.549	GBD weight
Chronic pelvic pain	0.122	GBD weight
Infertility	0.180	GBD weight
Tubo-ovarian abscess	0.549	GBD weight
c. Gonorrhoea		
Urethritis	0.067	GBD weight
Cervicitis	0.049	GBD weight
Pelvic inflammatory disease	0.420	GBD weight
Ectopic pregnancy	0.549	GBD weight
Chronic pelvic pain	0.122	GBD weight
Infertility	0.180	GBD weight
Tubo-ovarian abscess	0.549	GBD weight
d. Other sexually transmitted disease		
Pelvic inflammatory disease	0.420	GBD weight
Ectopic pregnancy	0.549	GBD weight
Chronic pelvic pain	0.122	GBD weight
Infertility	0.180	GBD weight
Tubo-ovarian abscess	0.549	GBD weight
3. HIV/AIDS		
Diagnosed asymptomatic HIV	0.200	Dutch weight
Symptomatic HIV	0.310	Dutch weight
AIDS	0.560	Dutch weight
AIDS-terminal phase	0.950	Dutch weight
4. Diarrhoeal diseases and gastroenteritis		
Uncomplicated episode	0.093	GBD age-specific weights. Average shown here
Complicated episode	0.420	Dutch weight for complicated episode (50%) plus GBD weight for uncomplicated episode (50%)
5. Childhood immunisable diseases		
a. Diphtheria		
Cases	0.230	GBD Weight
Neurological complications	0.078	GBD Weight
Myocarditis	0.323	GBD Weight
b. Whooping cough		
Pertussis episode	0.178	GBD Weight
Mental retardation (treated)	0.420	GBD Weight (0.394 0-4years, 0.420 5-14 years)
Mental retardation (untreated)	0.483	GBD Weight (0.394 0-4years, 0.420 5-14 years)
c. Tetanus		
Cases	.0612	GBD Weight
d. Poliomyelitis		
Poliomyelitis	0.369	GBD Weight
e. Measles		
Episodes	0.152	GBD Weight
Measles encephalitis	0.338	GBD Weight for neurological sequelae of encephalitis
Sub-acute sclerosing panencephalitis	0.930	Dutch weight for end-stage disease

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
f. Rubella		
Episodes	0.152	GBD weight for measles episode
Congenital cataract	0.430	Dutch weight for severe vision loss
Congenital heart disease	0.350	Dutch weight for heart failure
Congenital deafness	0.230	Dutch weight
g. Haemophilus influenza type b (Hib)		
Epiglottitis	0.152	GBD weight for haemophilus influenza episode
Meningitis	0430	Average of weights for meningitis manifestations
Septicemia	0.350	GBD weight
Pneumonia	0.230	Estimated using EQ5D + regression model
6. Meningitis		
Acute episode	0.913	Estimated using EQ-5D + regression model
After effects up to 6 months	0.226	Estimated using EQ-5D + regression model
VP shunt	0.170	Dutch weight for motor deficit
Hearing loss	0.234	Average of Dutch weights for mild, moderate and severe loss
Seizure disorder	0.110	Dutch weight
Less severe development problems	0.100	Average of Dutch weights for developmental problems
Mental retardation	0.250	Dutch weight
Motor deficit + mental retardation	0.760	Dutch weight
Less severe developmental problems	0.100	Based on Dutch weights for developmental problems
Scarring/deformity	0.133	Based on GBD amputation weights
7. Septicaemia		
Cases	0.613	GBD age-specific weights (average shown here)
8. Arbovirus infection (incl. Ross River fever)		
a. Ross River virus infection		
Acute phase	0.258	Dutch weight for moderate rheumatoid arthritis
Chronic phase	0.140	Dutch weight for mild rheumatoid arthritis
b. Barmah Forest virus		
Acute phase	0.258	Dutch weight for moderate rheumatoid arthritis
Chronic phase	0.140	Dutch weight for mild rheumatoid arthritis
c. Other arbovirus infection		
Australian encephalitis	0.613	GBD weight for Japanese encephalitis
Japanese encephalitis	0.613	GBD weight
Kunjun	0.613	GBD weight for Japanese encephalitis
Cognitive impairment	0.451	GBD weight
Neurological sequelae	0.334	GBD weight
d. Dengue fever		
Dengue haemorrhagic fever	0.172	GBD age-specific weights (average shown here)
9. Hepatitis		
a. Hepatitis A		
Uncomplicated episode	0.093	GBD age-specific weights (average shown here)
Complicated episode	0.420	Dutch weight for complicated episode (50%) plus GBD weight for uncomplicated episode (50%)
Prolonged or relapsing episode	0.140	Dutch weight for mild depression
b. Hepatitis B		
Cases	0.000	Asymptomatic cases only
Acute symptomatic episode	0.210	Dutch weight
Chronic symptomatic episode	0.360	Dutch weight
Compensated liver cirrhosis	0.310	Dutch weight
Decompensated liver cirrhosis	0.840	Dutch weight
Hepato-cellular cancer	-	See sequelae and weights for F5, Liver cancer
c. Hepatitis C		
Cases	0.000	Asymptomatic cases only
Acute symptomatic episode	0.210	Dutch weight for Hepatitis B
Chronic symptomatic episode	0.360	Dutch weight for Hepatitis B
Compensated liver cirrhosis	0.310	Dutch weight
Decompensated liver cirrhosis	0.840	Dutch weight
Hepato-cellular cancer	-	See sequelae and weights for F5, Liver cancer
10. Malaria		
Episodes	0.175	GBD age-specific weights (average shown here)
Neurological sequelae (treated)	0.436	GBD weight for 0-4 years
Anaemia	0.012	GBD age-specific weights (average shown here)

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
11. Trachoma		
Moderate vision loss	0.170	Dutch weight
Severe vision loss	0.430	Dutch weight
B. Acute respiratory infections		
1. Lower respiratory tract infections		
Influenza episode	0.047	Estimated using EQ-5D + regression model
Acute bronchitis episode	0.132	Estimated using EQ-5D + regression model
Pneumonia episode	0.373	Estimated using EQ-5D + regression model
2. Upper respiratory tract infections		
Acute nasopharyngitis	0.014	Estimated using EQ-5D + regression model
Acute sinusitis	0.061	Estimated using EQ-5D + regression model
Pharyngitis/tonsillitis	0.061	Estimated using EQ-5D + regression model
3. Otitis media		
Acute episodes	0.090	Dutch weight for 1 day severe pain plus 4 days moderate pain
Chronic Otitis media	0.110	Dutch weight for early acquired mild to moderate hearing loss
Deafness	0.233	Dutch weight for early acquired sever hearing loss
C. Maternal conditions		
1. Maternal haemorrhage		
Cases	0.011	GBD weight for moderate anaemia
Severe anaemia	0.093	GBD weight
2. Maternal septis		
Episodes	0.000	GBD weight
Infertility	0.180	GBD weight
3. Hypertension in pregnancy		
Episodes	0.117	Estimated using EQ-5D + regression model
Neurological sequelae	0.399	GBD weight
4. Obstructed labour		
Episodes	0.349	Estimated using EQ-5D + regression model
5. Abortion		
Episodes spontaneous abortion	0.000	GBD weight
Episodes induced abortion	0.000	GBD weight
Infertility	0.180	GBD weight
D. Neonatal causes		
1. Birth trauma & asphyxia		
Deafness	0.230	Dutch weight
Seizure	0.110	Dutch weight
Cerebral palsy without intellectual disability	0.170	Dutch weight
Mild intellectual disability	0.290	Dutch weight
Moderate intellectual disability	0.430	Dutch weight
Severe intellectual disability	0.820	Dutch weight
Profound intellectual disability	0.760	Dutch weight
2. Low birth weight		
Mild permanent disability	0.110	Dutch weight for mild to moderate early acquired hearing loss
Severe hearing loss	0.370	Dutch weight
Vision loss	0.170	Dutch weight for moderate vision loss
Epilepsy	0.110	Dutch weight
Cerebral palsy without intellectual disability	0.170	Dutch weight
Mild intellectual disability	0.290	Dutch weight
Moderate intellectual disability	0.430	Dutch weight
Severe intellectual disability	0.820	Dutch weight
Profound intellectual disability	0.760	Dutch weight
3. Neonatal infections		
Acute neonatal episode	0.894	Dutch weight for acute meningitis episode
Deafness	0.370	Dutch weight
Motor deficit	0.170	Dutch weight
Mild intellectual disability	0.290	Dutch weight
Moderate intellectual disability	0.430	Dutch weight
Severe intellectual disability	0.820	Dutch weight
Profound intellectual disability	0.760	Dutch weight

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
4. Other neonatal causes		
Mild intellectual disability	0.290	Dutch weight
Moderate intellectual disability	0.430	Dutch weight
Severe intellectual disability	0.820	Dutch weight
Profound intellectual disability	0.760	Dutch weight
Cerebral palsy without intellectual disability	0.170	Dutch weight for motor deficit
E. Nutritional deficiencies		
1. Protein-energy malnutrition		
Stunting	0.002	GBD weight
Wasting	0.053	GBD weight
Development disability	0.024	GBD weight
2. Iron-deficiency anaemia		
Non-anaemic iron deficiency	0.005	Estimated using EQ-5D + regression model
Mild anaemia	0.005	GBD weight
Moderate anaemia	0.011	GBD weight
Severe anaemia	0.090	GBD weight
Very severe anaemia	0.250	GBD weight
Cognitive impairment	0.024	GBD weight
3. Other nutritional deficiencies		
Iodine deficiency goiter	0.026	GBD weight for Grade 2 Goitre
F. Malignant neoplasms		
1. Mouth and oropharynx cancers		
Diagnosis and primary therapy	0.560	Dutch weight for oesophageal cancer
State after intentionally curative primary therapy	0.370	Dutch weight for oesophageal cancer
In remission	0.370	Dutch weight for oesophageal cancer
Disseminated cancer	0.900	Dutch weight for oesophageal cancer
Terminal stage	0.930	Dutch weight for oesophageal cancer
2. Oesophagus cancer		
Diagnosis and primary therapy	0.560	Dutch weight
State and intentionally curative primary therapy	0.370	Dutch weight
Irradically removed or disseminated carcinoma	0.900	Dutch weight
Preterminal and terminal stages	0.930	Dutch weight for end-stage disease
3. Stomach cancer		
Diagnosis and primary therapy	0.530	Dutch weight
State after intentionally curative therapy	0.380	Dutch weight
Irradically removed or disseminated carcinoma	0.730	Dutch weight
Preterminal and terminal stages	0.930	Dutch weight for end-stage disease
4. Colorectal cancer		
Diagnosis and primary therapy	0.430	Dutch weight
State after intentionally curative primary therapy	0.200	Dutch weight
In remission	0.430	Dutch weight
Irradically removed or disseminated carcinoma	0.830	Dutch weight
Terminal stage	0.930	Dutch weight for end-stage disease
5. Liver cancer		
Diagnosis and initial treatment	0.430	Dutch weight for colorectal cancer
State after intionally curative primary therapy	0.200	Dutch weight for colorectal cancer
Clinically disease free	0.200	Dutch weight for colorectal cancer
Irradically removed/disseminated/preterminal	0.830	Dutch weight for colorectal cancer
Terminal phase	0.930	Dutch weight for end-stage disease
6. Gall bladder cancer		
Diagnosis and initial treatment	0.430	Dutch weight for colorectal cancer
State after intionally curative primary therapy	0.200	Dutch weight for colorectal cancer
Clinically disease free	0.200	Dutch weight for colorectal cancer
Irradically removed/disseminated/preterminal	0.830	Dutch weight for colorectal cancer
Terminal phase	0.930	Dutch weight for end-stage disease
7. Pancreas cancer		
Diagnosis and initial treatment	0.430	Dutch weight for colorectal cancer
State after intionally curative primary therapy	0.200	Dutch weight for colorectal cancer
Disseminated	0.830	Dutch weight for colorectal cancer
Terminal phase	0.930	Dutch weight for colorectal cancer

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
8. Lung cancer		
Diagnosis and primary therapy of operable non small cell cancer	0.440	Dutch weight
Disease free after primary therapy for non small cell cancer	0.470	Dutch weight
Diagnosis and primary therapy for non operable non small cell cancer	0.760	Dutch weight
Disseminated non small cancer	0.910	Dutch weight
8. Lung cancer cont		
Terminal stage non small cell cancer	0.930	Dutch weight for end-stage disease
Diagnosis and chemotherapy small cell cancer	0.680	Dutch weight
Diagnosis free after primary therapy for small cell cancer	0.470	Dutch weight
Small cell cancer in remission	0.540	Dutch weight
Relapse/terminal stage small cell cancer	0.930	Dutch weight for end-stage disease
9. Bone and connective tissue cancers		
Diagnosis and primary therapy	0.350	Provisional weight based on Dutch weight
State after intentionally curative primary therapy	0.300	Provisional weight based on Dutch weight
In remission	0.300	Provisional weight based on Dutch weight
Disseminated carcinoma	0.750	Provisional weight based on Dutch weight
Terminal stage	0.930	Dutch weight for end-stage disease
10. Melanoma		
Primary treatment, no evidence dissemination	0.190	Dutch weight
No evidence of dissemination after initial treatment	0.190	Dutch weight
Primary treatment, lymph node but no distant dissemination	0.430	Dutch weight
In remission	0.190	Dutch weight
Disseminated melanoma	0.810	Dutch weight
Terminal phase	0.930	Dutch weight for end-stage disease
11. Non-melanoma skin cancer		
Basal cell carcinoma	0.050	Dutch weight
Squamous cell carcinoma undisseminated	0.070	Dutch weight
Squamous cell carcinoma disseminated	0.400	Dutch weight
Squamous cell carcinoma-local recurrence	0.500	Dutch weight
Terminal phase	0.930	Dutch weight
12. Breast cancer		
Diagnostic, primary therapy, non-invasive tumor <2 cm	0.260	Dutch weight
Diagnostic, primary therapy, tumor 2-5 cm or lymph node dissemination	0.690	Dutch weight
Diagnostic, primary therapy, tumor >5 CM	0.810	Dutch weight
Disease free after initial treatment	0.260	Dutch weight
In remission	0.260	Dutch weight
Disseminated cancer	0.790	Dutch weight
Terminal phase	0.930	Dutch weight
13. Cervix cancer		
Diagnosis and primary therapy	0.430	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.200	Provisional weight based on Dutch weights
In remission	0.200	Provisional weight based on Dutch weights
Disseminated carcinoma	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
14. Uterus cancer		
Diagnosis and primary therapy	0.430	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.200	Provisional weight based on Dutch weights
In remission	0.200	Provisional weight based on Dutch weights
Disseminated carcinoma	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
15. Ovary cancer		
Diagnosis and primary therapy	0.430	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.200	Provisional weight based on Dutch weights
In remission	0.200	Provisional weight based on Dutch weights
Disseminated carcinoma	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
16. Prostate cancer		
Diagnostic, primary therapy, localized cancer	0.270	Dutch weight
Follow-up without active therapy (watchful waiting)	0.270	Dutch weight
In remission	0.200	Dutch weight
Clinically disease-free after primary therapy	0.180	Dutch weight
Hormone refractory cancer	0.640	Dutch weight
Terminal stage	0.930	Dutch weight for end-stage disease
17. Testicular cancer		
Diagnosis and primary therapy	0.270	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.180	Provisional weight based on Dutch weights
In remission	0.180	Provisional weight based on Dutch weights
Disseminated carcinoma	0.640	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
18. Bladder cancer		
Diagnosis and primary therapy	0.270	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.180	Provisional weight based on Dutch weights
In remission	0.180	Provisional weight based on Dutch weights
Disseminated carcinoma	0.640	Provisional weight based on Dutch weights
Terminal stage		Dutch weight for end-stage disease
19. Kidney cancer		
Diagnosis and primary therapy	0.270	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.180	Provisional weight based on Dutch weights
In remission	0.180	Provisional weight based on Dutch weights
Disseminated carcinoma	0.640	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
20. Brain cancer		
Diagnosis and primary therapy	0.680	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.180	Provisional weight based on Dutch weights
Disseminated carcinoma	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
21. Thyroid cancer		
Diagnosis and primary therapy	0.270	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.180	Provisional weight based on Dutch weights
In remission	0.180	Provisional weight based on Dutch weights
Disseminated carcinoma	0.640	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
22a. Non-Hodgkin's lymphoma		
Low grade, dissemination stage I and II	0.190	Dutch weight
Low grade, dissemination stage III and IV	0.610	Dutch weight
Intermediate/high grade, dissemination stage I	0.550	Dutch weight
Intermediate/high grade, dissemination stage II, III or IV	0.750	Dutch weight
Temporary remission after treatment	0.190	Dutch weight
Preterminal phase	0.750	Dutch weight
Terminal phase	0.930	Dutch weight for end-stage disease
Complete remission	0.190	Dutch weight
22b. Hodgkin's lymphoma		
Low grade, dissemination stage I and II	0.190	Dutch weight
Low grade, dissemination stage III and IV	0.610	Dutch weight
Intermediate/high grade, dissemination stage I	0.550	Dutch weight
Intermediate/high grade, dissemination stage II, III or IV	0.750	Dutch weight
Temporary remission after treatment	0.190	Dutch weight
Preterminal phase	0.750	Dutch weight
Terminal phase	0.930	Dutch weight for end-stage disease
Complete remission	0.190	Dutch weight
23. Multiple myeloma		
Diagnosis and primary therapy	0.190	Provisional weight based on Dutch weights
State after intentionally curative primary therapy	0.190	Provisional weight based on Dutch weights
In remission	0.190	Provisional weight based on Dutch weights
Disseminated carcinoma	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
24a. Acute myeloid leukemia		
Diagnosis and primary therapy	0.550	Provisional weight based on Dutch weights
Stage after intentionally curative primary therapy	0.190	Provisional weight based on Dutch weights
Preterminal stage	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
24b. Chronic myeloid leukemia		
Diagnosis and primary therapy	0.550	Provisional weight based on Dutch weights
Stage after intentionally curative primary therapy	0.190	Provisional weight based on Dutch weights
In remission	0.190	Provisional weight based on Dutch weights
Preterminal stage	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
24c. Acute lymphoid leukemia		
Diagnosis and primary therapy	0.550	Provisional weight based on Dutch weights
Stage after intentionally curative primary therapy	0.190	Provisional weight based on Dutch weights
In remission	0.190	Provisional weight based on Dutch weights
Preterminal stage	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
24d. Chronic lymphoid leukemia		
Diagnosis and primary therapy	0.550	Provisional weight based on Dutch weights
Stage after intentionally curative primary therapy	0.190	Provisional weight based on Dutch weights
In remission	0.190	Provisional weight based on Dutch weights
Preterminal stage	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
G. Other neoplasms		
1. Uterine myomas		
Symptomatic cases	0.066	Estimated using EQ-5D + regression model
Hysterectomy or myomectomy	0.349	Estimated using EQ-5D + regression model
Reproductive disability	0.180	GBD weight for infertility
2. Benign brain tumour		
Diagnosis and primary therapy	0.680	Provisional weight based on Dutch weights
State after intentionally curative primary	0.180	Provisional weight based on Dutch weights
Preterminal stage	0.750	Provisional weight based on Dutch weights
Terminal stage	0.930	Dutch weight for end-stage disease
H. Diabetes mellitus		
1. Type 1 diabetes		
Cases	0.070	Dutch weight
Retinopathy-moderate vision loss	0.170	Dutch weight
Retinopathy-sever vision loss	0.430	Dutch weight
Cataract-mild vision loss	0.020	Dutch weight
Cataract-moderate vision loss	0.170	Dutch weight
Cataract-severe vision loss	0.430	Dutch weight
Glaucoma-mild vision loss	0.020	Dutch weight
Glaucoma-moderate vision loss	0.170	Dutch weight
Glaucoma-sever vision loss	0.430	Dutch weight
Neuropathy	0.190	Dutch weight
Nephropathy	0.290	Dutch weight
Diabetic foot	0.220	GBD weight
Amputation-toe	0.064	GBD weight
Amputation-foot or leg	0.300	GBD weight
2. Type 2 diabetes		
Cases	0.070	Dutch weight
Retinopathy-moderate vision loss	0.170	Dutch weight
Retinopathy-sever vision loss	0.430	Dutch weight
Cataract-mild vision loss	0.020	Dutch weight
Cataract-moderate vision loss	0.170	Dutch weight
Cataract-severe vision loss	0.430	Dutch weight
Glaucoma-mild vision loss	0.020	Dutch weight
Glaucoma-moderate vision loss	0.170	Dutch weight
Glaucoma-sever vision loss	0.430	Dutch weight
Neuropathy	0.190	Dutch weight
Nephropathy	0.290	Dutch weight
Diabetic foot	0.220	GBD weight
Amputation-toe	0.064	GBD weight
Amputation-foot or leg	0.300	GBD weight

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
I. Endocrine and metabolic disorders		
1. Non-deficiency anaemia		
a. Thalassaemia		
Very severe anaemia	0.250	GBD weight
b. Other non-deficiency anaemia		
Genetically inherited anaemia	0.090	GBD weight
Severe anaemia	0.090	GBD weight
Very sever anaemia	0.250	GBD weight
2. Cystic fibroses		
Cases	0.530	Dutch weight for sever COPD
3. Hemophilia		
Sever cases	0.270	Weight based on QALY measurements
Moderate cases	0.050	Weight based on QALY measurements
J. Mental disorders		
1. Substance use disorders		
a. Alcohol dependence and harmful use		
Harmful use	0.110	Dutch weight for drinking problem
Moderate dependence	0.330	Average of Dutch weights for problem drinking and manifest alcoholism
Manifest alcoholism	0.550	Dutch weight
b. Heroin or polydrug dependence and harmful use		
Cases	0.270	Locally derived weight, slightly higher that GBD weight 0.252
c. Benzodiazepine dependence and harmful use		
Cases	0.184	Extrapolation by Australian mental health experts
d. Cannabis dependence and harmful use		
Cases	0.113	Extrapolation by Australian mental health experts
e. Other drug dependence and harmful use		
Stimulant dependence and harmful use	0.110	Dutch weight for problem drinking
Other drug dependence	0.113	Dutch weight for cannabis dependence
Analgesic nephropathy	0.290	Dutch weight for diabetic nephropathy
2. Schizophrenia		
Cases	0.434	Composite GBD weight-psychosis (30%), treated schizophrenia
3. Affective disorders		
a. Major depression		
Dysthymia cases	0.140	Dutch weight for mild depression
Major depressive episode-mild	0.140	Dutch weight
Major depressive episode-moderate	0.350	Dutch weight
Major depressive episode-severe	0.760	Dutch weight
b. Bipolar affective disorder		
Cases	0.176	Composite Dutch weight-mild depression (50%) non episodes, 25% moderate depression, 25% local extrapolated weight for episodic manic phase
4. Anxiety disorders		
a. Panic depression		
Mild to moderate panic disorder	0.160	Dutch weight
Severe panic disorder	0.690	Dutch weight
b. Agrophobia		
Mild to moderate agrophobia	0.110	Dutch weight
Sever agrophobia	0.550	Dutch weight
c. Social phobia		
Mild to moderate social phobia	0.170	Dutch weight
Severe social phobia	0.590	Dutch weight
d. Generalized anxiety disorder (GAD)		
Mild to moderate GAD	0.170	Dutch weight
Severe GAD	0.600	Dutch weight
e. Obsessive compulsive disorder (OCD)		
Mild to moderate OCD	0.170	Dutch weight
Severe OCD	0.600	Dutch weight
f. Post traumatic stress disorder (PTSD)		
Mild to moderate PTSD	0.130	Dutch weight
Severe PTSD	0.510	Dutch weight

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
g. Separation anxiety disorder		
Mild to moderate separation anxiety disorder	0.110	Dutch weight for mild to moderate agrophobia
Sever separation anxiety disorder	0.550	Dutch weight for severe agrophobia
5. Borderline personality disorder		
Symptomatic cases	0.540	Extrapolation by Australian mental health experts
6. Eating disorders		
a. Anorexia nervosa		
Cases	0.280	Dutch weight
b. Bulimia nervosa		
Cases	0.280	Dutch weight
7. Childhood conditions		
a. Attention-deficit hyperactivity disorder		
Mild	0.020	Dutch weight
Moderate to severe	0.150	Dutch weight
b. Autism and Asperger's syndrome		
Autism cases	0.550	Dutch weight
Asperger's syndrome cases	0.250	Average of Dutch weights for moderate/severs ADHD and for autism
8. Mental retardation (no defined aetiology)		
Mild intellectual disability	0.290	Dutch weight
Moderate intellectual disability	0.430	Dutch weight
Severe intellectual disability	0.820	Dutch weight
Profound intellectual disability	0.760	Dutch weight
K. Nervous system and sense organ disorder		
1. Dementia		
Mild	0.270	Dutch weight
Moderate	0.630	Dutch weight
Severe	0.940	Dutch weight
2. Epilepsy		
Epilepsy	0.110	Dutch weight
3. Parkinson's disease		
Initial stage	0.480	Dutch weight
Intermediate stage	0.790	Dutch weight
End-stage	0.920	Dutch weight
4. Multiple sclerosis		
Relapsing-remitting phase	0.330	Dutch weight
Progressive phase	0.670	Dutch weight
Progressive from onset	0.670	Dutch weight
5. Motor neuron disease		
Cases	0.670	Dutch weight for progressive phase of multiple sclerosis
6. Huntington's chorea		
Initial stage	0.480	Dutch weight for initial stage of Parkinson's disease
Intermediate stage	0.790	Dutch weight for intermediate stage Parkinson's disease
End-stage	0.920	Dutch weight for end-stage Parkinson's disease
7. Muscular dystrophy		
Initial stage	0.480	Dutch weight for initial stage Parkinson's disease
Paraplegia	0.570	Dutch weight
Quadriplegia	0.840	Dutch weight
8. Sense organ disorders		
a. Glaucoma		
Cases	0.000	GBD and Dutch weights
Mild vision loss	0.020	Dutch weight
Moderate vision loss	0.170	Dutch weight
Severe vision loss	0.430	Dutch weight
b. Cataracts		
Cases	0.000	GBD and Dutch weights
Mild vision loss	0.020	Dutch weight
Moderate vision loss	0.170	Dutch weight
Severe vision loss	0.430	Dutch weight

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
c. Age-related vision loss		
Mild vision loss	0.020	Dutch weight
Moderate vision loss	0.170	Dutch weight
Severe vision loss	0.430	Dutch weight
d. Adult-onset hearing loss		
Mild hearing loss (25-34 dBTL)	0.020	One half Dutch weight for mild hearing loss
Mild hearing loss (35-44 dBTL)	0.040	Dutch weight
Moderate hearing loss	0.120	Dutch weight
Severe hearing loss	0.370	Dutch weight
L. Cardiovascular disease		
1. Rheumatic heart disease		
Rheumatic fever	0.047	Regression weight for influenza
Rheumatic heart disease		
- Untreated	0.323	GBD weight
- Treated	0.171	GBD weight
2. Ischaemic heart disease		
Angina pectoris	0.178	Dutch weight
Acute myocardial infarction	0.395	GBD (treated) age-specific weights (average shown here)
Heart failure	0.353	Dutch weight
3. Stroke		
First-ever stroke with full recovery	0.000	
Mild permanent impairments	0.360	Dutch weight
Moderate permanent impairments	0.630	Dutch weight
Severe permanent impairments	0.920	Dutch weight
4. Inflammatory heart disease		
Cardiomyopathy cases	0.353	Dutch weight for heart failure
Endocarditis cases	0.353	Dutch weight for heart failure
Myocarditis cases	0.353	Dutch weight for heart failure
Pericarditis cases	0.353	Dutch weight for heart failure
5. Hypertensive heart disease		
Cases	0.352	Based on Dutch weight for heart failure
6. Non-rheumatic valvular disease		
Cases	0.060	Dutch weight for mild heart failure
7. Aortic aneurysm		
Cases	0.430	Dutch weight for early colorectal cancer
8. Peripheral arterial disease		
Cases	0.248	Estimated using EQ-5D + regression model
Amputation	0.209	GBD weight
M. Chronic respiratory disease		
1. Chronic obstructive pulmonary disease		
Mild to moderate COPD	0.170	Dutch weight
Severe COPD	0.530	Dutch weight
2. Asthma		
Mild Asthma	0.030	Dutch weight
Severe asthma	0.230	Estimated using EQ-5D + regression model and Australian data on severity distribution of disability
3. Other chronic respiratory disease	0.164	Provisional weight – average weight for COPD
N. Disease of the digestive system		
1. Peptic ulcer disease	0.066	Dutch weight
2. Cirrhosis of the liver	0.339	GBD weight
3. Appendicitis	0.463	GBD weight
4. Intestinal obstruction		
Cases	0.463	Dutch weight for appendicitis
Stoma closed	0.211	Estimated using EQ-5D + regression model
Stoma continuing	0.211	Estimated using EQ-5D + regression model
5. Diverticulitis		
Cases	0.400	Dutch weight for inflammatory bowel disease – active exacerbation
Stoma closed	0.211	Estimated using EQ-5D+ regression model
Stoma continuing	0.211	Estimated using EQ-5D + regression model
6. Gall bladder and bile duct disease		
Cases	0.349	Estimated using EQ-5D + regression model

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
7. Pancreatitis		
Cases	0.349	Estimated using EQ-5D + regression model
8. Inflammatory bowel disease		
Crohn's disease	0.224	Dutch weight
Ulcerative colitis	0.224	Dutch weight
Stoma closed	0.211	Estimated using EQ-5D + regression model
Stoma continuing	0.211	Estimated using EQ-5D + regression model
9. Vascular insufficiency of intestine		
Cases	0.400	Dutch weight for inflammatory bowel disease – active exacerbation
Stoma closed	0.211	Estimated using EQ-5D + regression model
Stoma continuing	0.211	Estimated using EQ-5D + regression model
o. Genitourinary disease		
1. Nephritis and nephrosis		
End-stage renal failure with dialysis	0.290	Dutch weight for diabetic nephropathy
End-stage renal failure with transplant	0.290	Dutch weight for diabetic nephropathy
Transplant patient	0.110	GBD weight for treated renal failure, Dutch weight for uncertain prognosis
Untreated end-stage renal failure	0.104	GBD weight
2. Benign prostatic hypertrophy		
Symptomatic case	0.038	GBD weight
Prostatectomy	0.349	Estimated using EQ-5D + regression model
Urethral stricture	0.151	GBD weight
Impotence	0.195	GBD weight
Severe urinary incontinence	0.157	Estimated using EQ-5D + regression model
3. Urinary incontinence		
Occasional urine leakage	0.000	No weight for occasional urine leakage
Moderate incontinence	0.025	GBD weight for stress incontinence (0.33 for 60+)
Severe incontinence	0.157	Estimated using EQ-5D + regression model
4. Other genitourinary disease		
Menstrual disorders	0.033	Estimated using EQ-5D + regression model
Hysterectomy	0.349	Estimated using EQ-5D + regression model
Reproductive disability following hysterectomy		
- for menorrhagia	0.180	Estimated using EQ-5D + regression model
- for genital prolapse	0.180	Estimated using EQ-5D + regression model
- for endometriosis	0.180	Estimated using EQ-5D + regression model
Other short-term reproductive disability	0.180	GBD weight
Other long-term reproductive disability	0.180	GBD weight
P. Skin diseases		
1. Eczema	0.056	Estimated using EQ-5D + regression model
2. Other skin diseases	0.056	Estimated using EQ-5D + regression model
Q. Musculoskeletal diseases		
1. Rheumatoid arthritis		
Mild	0.210	Dutch weight
Moderate	0.370	Dutch weight
Severe	0.940	Dutch weight
2. Osteoarthritis		
Grade 2 (radiological) hip or knee (asympt.)	0.010	Dutch weight
Grade 2 symptomatic	0.140	Dutch weight
Grade 3-4 (radiological) hip or knee (asympt.)	0.140	Dutch weight
Grade 3-4 symptomatic	0.420	Dutch weight
3. Chronic back pain		
Episodes	0.060	Dutch weight
4. Slipped disc		
Episodes	0.060	Dutch weight for back problems
Excision or destruction of disc	0.060	Dutch weight for back problems
Chronic pain	0.125	Estimated using EQ-5D + regression model
5. Occupational overuse syndrome		
Mild handicap or disability	0.056	Estimated using EQ-5D + regression model
Moderate handicap	0.293	Estimated using EQ-5D + regression model
Severe or profound handicap	0.516	Estimated using EQ-5D + regression model
6. Osteoporosis		
Diagnosed cases	0.009	Estimated using EQ-5D regression model

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
7. Other musculoskeletal disorders		
Recent non-chronic episodes	0.060	Dutch weight for low back pain
Chronic conditions	0.060	Dutch weight for low back pain
R. Congenital anomalies		
1. Anencephaly		
Liveborn cases	1.000	
2. Spina bifida		
Low-level spina bifida aperta	0.160	Dutch weight
Medium-level spina bifida aperta	0.500	Dutch weight
High-level spina bifida aperta	0.680	Dutch weight
3. Congenital heart disease		
Surgically treated congenital atrial or ventricular septal defect	0.030	Dutch weight
Child/adolescent in permanent stage after surgical treatment for Fallot's tetralogy or transposition of great arteries	0.200	Dutch weight
Young adult in permanent stage after surgical treatment for Fallot's tetralogy or transposition of great arteries	0.110	Dutch weight
Child/adolescent in permanent stage after surgical treatment for pulmonary stenosis	0.020	Dutch weight
Young adult in permanent stage after surgical treatment for pulmonary stenosis	0.160	Dutch weight
Complex not curatively operable congenital heart disease	0.720	Dutch weight
4. Cleft lip and/or palate		
Cleft palate – untreated	0.231	GBD weight
Cleft palate – treated	0.015	GBD weight
Cleft lip – untreated	0.098	GBD weight
Cleft lip – treated		GBD weight
5.Digestive system malformations		
a. Anorectal atresia		
Cases	0.850	GBD weight for anorectal atresia
Longterm disability	0.037	GBD weight for symptomatic urethritis
b. Oesophageal atresia		
Cases	0.850	GBD weight for anorectal atresia
Longterm disability	0.037	GBD weight for symptomatic urethritis
c. Other digestive system malformations		
Small intestine atresia	0.850	GBD weight for digestive system atresias
Other	0.850	GBD weight for digestive system atresias
6. Urogenital tract malformations		
a. Renal agenesis		
Bilateral renal agenesis or dysgenesis	0.850	GBD weight for renal agenesis
Unilateral renal agenesis or dysgenesis	0.037	GBD weight for symptomatic urethritis
End-stage renal failure	0.294	Dutch weight
b. Other Urogenital tract malformations		
Hypospadias	0.000	Assumed negligible ongoing disability
Cystic kidney disease	0.037	GBD weight for acute urethritis
Obstructive defects of renal pelvis and ureter	0.037	GBD weight for renal diseases
Other urinary tract malformations	0.290	Dutch weight for renal failure
7. Abdominal wall defect		
Cases	0.850	GBD weight for abdominal wall defect
Long-term disability	0.200	Dutch weight for permanent stage treated CVD malformations
8. Down syndrome		
Child aged 0-9 with other malformations	0.690	Dutch weight
Child aged 0-9 without other malformations	0.510	Dutch weight
Person aged 10-39 years	0.350	Dutch weight
Adult 40 years of age and over	0.650	Dutch weight
9. Other chromosomal conditions		
Mild intellectual disability	0.290	Dutch weight
Moderate intellectual disability	0.430	Dutch weight
Severe intellectual disability	0.820	Dutch weight
Profound intellectual disability	0.760	Dutch weight

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
S. Oral health		
1. Dental caries		
Episode resulting in filling	0.005	Dutch weight
Episode resulting in tooth loss	0.014	Estimated using EQ-5D + regression model
2. Periodontal disease		
Gingivitis	0.000	Dutch weight
Pockets 6mm or more deep	0.001	Dutch weight
3. Edentulism		
Cases	0.004	Estimated using EQ-5D + regression model
T. Ill – defined conditions		
1. Sudden infant death syndrome	0.000	
2. Chronic fatigue syndrome		
Mild handicap	0.137	Estimated using EQ-5D + regression model
Moderate handicap	0.449	Estimated using EQ-5D + regression model
Severe or profound handicap	0.760	Estimated using EQ-5D + regression model
U. Injuries – type of injury sequelae		
1. Fractures		
Skull – short term	0.431	GBD weight
Skull – long term	0.350	GBD weights (0.404 for ages 65+)
Face bones	0.223	GBD weight
Vertebral column	0.266	GBD weight
Rib or sternum	0.199	GBD weight
Pelvis	0.247	GBD weight
Clavicle, scapula or humerus	0.153	GBD weight
Radius or ulna	0.180	GBD weight
Hand bones	0.100	GBD weight
Femur-short term	0.372	GBD weight
Femur-long term	0.272	GBD weight
Patella, tibia or fibula	0.271	GBD weight
Ankle	0.196	GBD weight
Foot bones	0.077	GBD weight
2. Injured spinal cord	0.725	GBD weight
3. Dislocations		
Shoulder, elbow or hip	0.074	GBD weight
Other dislocation	0.074	GBD weight
4. Sprains		
5. Intracranial injuries		
Short-term	0.359	GBD weight
Long-term	0.350	GBD weight
6. Internal injuries	0.208	GBD weight
7. Open wound	0.108	GBD weight
8. Injury to eyes		
Short-term	0.108	GBD weight for open wound
Long-term	0.298	GBD weight (0.301 for ages 0-14)
9. Amputations		
Thumb	0.165	GBD weight
Finger	0.102	GBD weight
Arm	0.257	GBD weight
Toe	0.102	GBD weight
Foot	0.300	GBD weight
Leg	0.300	GBD weight
10. Crushing	0.218	GBD weight
11. Burns		
Less than 20% short-term	0.158	GBD weight
Less than 20% long-term	0.001	GBD weight
20 to 60% short-term	0.441	GBD weight
20 to 60% long-term	0.255	GBD weight
Greater than 60% short-term	0.441	GBD weight
Greater than 60% long-term	0.255	GBD weight
12. Injured nerves		
Short-term	0.064	GBD weight
Long-term	0.064	GBD weight
13. Poisoning	0.608	GBD weight (0.611 for ages 0-14)

ANNEX TABLE B: Disease categories and disability weights

Disease category, subcategory, or sequelae	Disability Weight	Comments
V. Unintentional injuries		
1. Road traffic accidents	0.149	Average weight across all injury sequelae
2. Other transport accidents	0.142	Average weight across all injury sequelae
3. Poisoning	0.593	Average weight across all injury sequelae
4. Falls	0.141	Average weight across all injury sequelae
5. Fires/burns/scalds	0.172	Average weight across all injury sequelae
6. Drowning	0.211	Average weight across all injury sequelae
7. Sports injuries	0.118	Average weight across all injury sequelae
8. Natural and environmental factors	0.158	Average weight across all injury sequelae
9. Machinery accidents	0.112	Average weight across all injury sequelae
10 Suffocation and foreign bodies	0.162	Average weight across all injury sequelae
11. Adverse effects of medical treatments	0.433	Average weight across all injury sequelae
a. Surgical and medical misadventure	0.380	Average weight across all injury sequelae
b. Adverse effects of drugs in therapeutic use	0.453	Average weight across all injury sequelae
12. Other unintentional injuries	0.112	Average weight across all injury sequelae
a. Cutting and piercing accidents	0.157	Average weight across all injury sequelae
b. Striking and crushing accidents	0.157	Average weight across all injury sequelae
c. Other unintentional injuries	0.111	Average weight across all injury sequelae
W. Intentional injuries		
1. Suicide and self-inflicted injuries	0.447	Average weight across all injury sequelae
2. Homicide and violence	0.166	Average weight across all injury sequelae
3. Legal intervention and war	0.120	Average weight across all injury sequelae

Source: Mathers et al (1999)

Appendix C – Example of a RIS Cost Benefit

Analysis

A Regulatory Impact Statement (RIS) in occupational health and safety (OHS) regulation typically requires cost benefit analysis (CBA) that, in turn, can require the estimation of the benefits of occupational incidents averted and the consequent saving of human life and wellbeing. Valuing the prevention of fatalities and disability can be complex and Access Economics has thus provided this guide as an appendix to the main report, to assist the Office of the ASCC in preparing CBAs for RIS purposes. This accords with OBPR (2007:68):

'The Government requires that RISs include a comprehensive assessment of the expected impact (costs and benefits) of each feasible option. The objective should be to choose the most appropriate option for resolving the identified problem and to provide readily accessible evidence to support this decision.'

In turn, this aligns with COAG (2004:2) that Regulatory Impact Assessments should 'identify the need for regulation and quantify the potential benefits and costs of regulation.' OBPR (2007:69-87) summarise the key issues to be addressed in the RIS (noting that consultation with affected parties is a requirement of the process) as follows:

> Who is affected by the problem and who is likely to be affected by proposed solutions? Identify and categorise the expected economic, social and environmental impacts of the proposed options as likely costs and benefits.

> Assess the costs and benefits that will be experienced by different stakeholder groups, including small business, and by the community as a whole.

> Quantify these impacts where significant. Quantify the compliance costs on business. Examine the effect of each option on individuals, and on the cumulative burden on business.

> Summarise outcomes for each option examined. Identify the data sources and assumptions used in making these assessments, and any gaps in data.

This guide sets out a practical approach to undertaking CBA in the context of RIS consideration, using a worked example. The detailed approach to each RIS will naturally vary. That said, the following broad process is typical in CBA analysis and accords well with the OBPR dotpoints above and with the nine CBA steps in OBPR (2007:116-123).[26] The appendix is structured to reflect this process.

1 Identify options, costs and benefits conceptually expected to be associated with each option and the timeframes over which these are likely to occur.

2 Establish methodological processes to quantify the costs and benefits.

3 Estimate the costs and benefits using modelling techniques.

4 Report the findings and perform sensitivity testing.

Step 1: Identify Options, Costs, Benefits and Timeframes

In the RIS context, CBA is undertaken in relation to a number of potential policy options, with:

1 the first option typically retention of the status quo;

2 other option(s) typically some proposed change(s) to a standard or regulation; and

3 the final option typically involves a non-regulatory, self-regulatory or co-regulatory approach.

In this guide, a deliberately generalised example is used along these lines as follows, for a proposed regulation in the mining industry that provides additional protections to prevent falls. The scenario and data in the CBA guide are all hypothetical.

> Option 1 – Retention of current diverse arrangements between different jurisdictions.

> Option 2 – Develop a national regulation that brings consistency to jurisdictional practices and is expected *a priori* to increase safety overall.

> Option 3 – Encourage industry to self-regulate towards general safety objectives.

The CBA then compares:

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[26] OBPR (2007:127) also notes that, in the case of costs and benefits that are difficult to measure, such as health and safety: ‘When policy officers do not have the resources or expertise to conduct an original study, they may want to ‘plug in’ values from previous studies. Frequently used plug-ins include the value of a statistical life or life year, value of travel time savings, the cost of noise pollution and the cost of air pollution.’ This report is designed to assist the Office of the ASCC both with the CBA process and with appropriate, best available ‘plug-ins’ for VSLY.

- Option 2 relative to Option 1; and
- Option 3 relative to Option 1.

In this guide only Option 2 relative to Option 1 is considered, as Option 3 relative to Option 1 can be evaluated in a similar manner.

The main evaluation criterion is incremental net benefit, measured in terms of the net present value (NPV) of benefits minus the NPV of costs over a particular time horizon. This can also be presented easily as the benefit: cost ratio – ie, the NPV of benefits divided by the NPV of costs.

In line with the body of the report, it is also suggested that the incremental cost effectiveness ratio (ICER) is reported too, due to the uncertainty surrounding the Value of a Statistical Life Year (VSLY). The ICER metric should be presented as net financial benefits per Disability Adjusted Life Year (DALY) averted (ie, $/DALY). Net financial benefits exclude the dollar value of DALY savings and hence avoid the need to agree on an appropriate VSLY.

Identify Conceptual Costs and Benefits

Typically there are costs and benefits associated with any regulatory change. These can be considered *a priori* and tabulated so that the relationships are clear, together with sources for how they can be estimated. A suggested framework for the worked example is provided in the table below. In the example, the costs and benefits are incurred by workers, firms and governments. In the real world, other stakeholder groups such as consumers and interest groups may also naturally experience costs or benefits that should be considered in the CBA as well, but for simplicity are not included in this example.

CBA FRAMEWORK FOR AN EXAMPLE RIS CBA

Cost/Benefit category	Source of data/ method
Option 2 relative to Option 1	
Costs (1) = 1.1 + 1.2 + 1.3	
1.1 Compliance costs for firms changing to new arrangements	Survey
1.2 Additional costs for workers	Survey
1.3 Additional costs for governments	Direct consultation process
Benefits (2) = 2.1 + 2.2	
2.1 Benefits of consistent regulation	Survey
2.2 Incidents averted due to OHS compliance *multiplied* by average cost per incident averted (including direct and indirect costs*) *equals* Value of incidents averted (financial, QALYs, total), shared between worker, firm, government/society	NDS for trends in incidents; literature analysis for the impact of the change; NOHSC (2004) and this report for wellbeing
Net social benefits: NPV of (2)-(1)	
Benefit:Cost Ratio and $/QALY	

Note: NOHSC= National Occupational Health and Safety Commission. * As per NOHSC (2004), cost components included are: production disturbance costs; human capital costs; medical and rehabilitation costs; administrative costs (including legal investigation and travel costs); other costs (caring for disabled workers, aids and home modifications); suffering costs (measured in QALYs, with the option of converting to a dollar indicative value, using the VSLY).

Timeframes

The most common timeframes for CBAs are around ten years, as this typically allows times for benefits to flow through and for the effect of any lumpy up-front costs to be absorbed. It is also important to select a base year, which is usually the year that the regulation is likely to take effect. In this guide example, it is assumed that the regulation will take affect on 1 July 2008 so the base year is financial year 2008-09 (reported as 2008 for brevity in the tables and other financial years are similarly reported by opening year ie, the periods can be interpreted as 'financial year starting 1 July of'). The period for the CBA is 2008-2017.

Step 2: Establish a Methodology for Quantifying Costs and Benefits

To accurately measure economic costs and benefits, it is frequently necessary to ascertain the views of stakeholders and to search the literature and data sources to ascertain likely impacts and appropriate valuation methodologies used in other similar studies, if these exist.

Consultation processes and literature and data search protocols should naturally be clearly described and referenced in the CBA.

Consultation Processes

Consultation processes are often necessary to validate that all appropriate costs and benefits have been included in the CBA and to quantify the extent of impacts. Consultation processes may include workshops, telephone or face-to-face interviews, surveys, focus groups and/or comments processes on draft documents.

In the example in this guide, in the mapping of costs and benefits in Step 1, it was thought appropriate to determine the potential compliance costs of firms and workers (Cost Items 1.1 and 1.2) and the benefits of consistent regulation (Benefit Item 2.1) using a purpose designed survey of firms. It is advantageous to collect data as far as possible stratified by type of cost/benefit, year it is likely to be incurred and who experiences it (the firm, the employee, the government, or others). Sometimes there is a desire to stratify the impacts by other factors, such as whether the firm is small, medium sized or large, or by the age/gender or industry of the employee, for example.

For a survey it is necessary to:

- decide on the form of the survey eg, paper-based, electronic – emailed or web-based, or computer assisted telephone interview (CATI);
- decide who will field the survey;
- decide an appropriate sample size given likely response rates;
- carefully design the survey questions;
- identify the target respondents and the pilot sample;
- pilot the survey and modify questions in light of pilot responses;
- field the final survey; and
- analyse the results to acquire the desired parameters.

For Cost Item 1.3 (the costs to government of changing to the new regulation) in the example, are collected by direct telephone conversation discussions with contacts in each jurisdiction that currently does not have the regulation – identifying the additional costs that these jurisdictions would face, by type of cost and when it is likely to be incurred.

Literature And Data Searches

Literature review and data searches are commonly used to establish the parameters of change. These are crucial to the analysis and typically drive the findings.

Common sources of information are the National Data Set for Compensation-based Statistics (NDS), data from Australian Bureau of Statistics (ABS) surveys and publications (eg, *Work Related Injuries*, the *Labour Force Survey*, demographic data and employment data by industry).

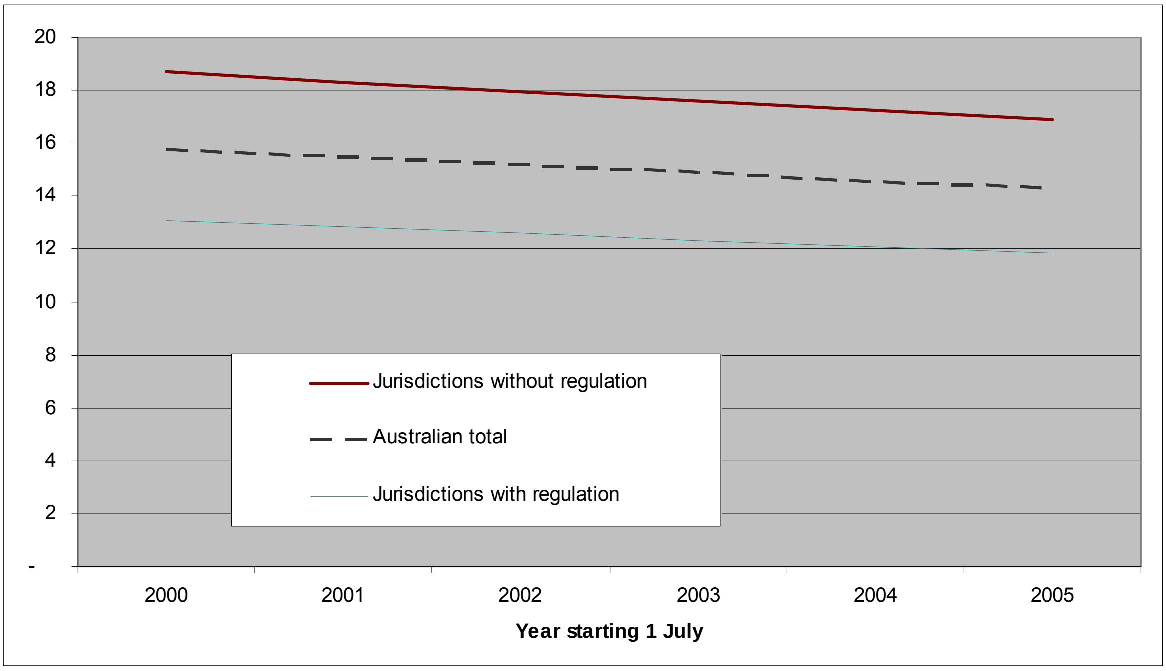
In the example in this guide, the reduction in incidents needs to be calculated for Benefit Item 2.2. In this case, suppose a literature search is used, assisted by the DEEWR library, to identify the effect of a particular regulatory change on incidents based on overseas experience with an almost identical regulatory intervention and with mining working conditions in that country similar to those in Australia. Published peer-reviewed journal articles are identified by the DEEWR library that show a range of different estimated findings from various samples of mines resulting from the proposed change in storage arrangements.

MIX meta-analysis is used to determine the overall impact on incidents and it is found that over all the samples there is a 30% (95% CI: 25%-35%) reduction in falls incidents per 1,000 workers over the year following the introduction of the regulation, compared to before the regulation, after controlling for other factors. After this one-off fall in rates, the literature also suggests there is no further change to trends in rates.

The severity pattern of the reduction in incidents, however, was found to be slightly more concentrated on fatalities (2% of incidents resulted in fatalities), due to the nature of the proposed regulation. If this were not the case, the default position would be that neither fatalities nor less severe incidents are over-represented in the reductions ie, they should follow the severity pattern of incidents before the regulatory change and, if no data are available, the default parameter from NOHSC (2004) across all incidents (injury and disease, compensated and uncompensated) is 1.5%.

The next step is to analyse NDS data in relation to the trends in falls incidents per 1,000 workers in Australia in the mining industry. These show a downward trend over five years of 2% per annum as illustrated in the figure below. Moreover, from the data by jurisdiction, a significant difference in the level of incidents per 1,000 workers is found between the jurisdictions that already have the proposed regulation (introduced before 2000) and those that do not, with the former some 29.9% lower than the latter (see table over page).

Falls incidents in mining, jurisdictions with and without regulation and Australian total, 2000-2005 (per 1,000 workers)



As such, the literature and cross-sectional data corroborate each other to imply that a parameter of a one-off decrease of 29.9% is appropriate to model as the impact effect for the jurisdictions currently without the regulation, to bring them to the rates of the other jurisdictions from the year the regulation is introduced and thereafter. Note that in a CBA it is unusual to have two sources of parameters estimates – from the international literature and from cross-sectional data – that corroborate each other so well. In most cases, there is only one source available, or the estimates do not corroborate each other well and a best estimate needs to be made.

Falls incidents in mining, jurisdictions with and without regulation and Australian total, 2000-2005 (per 1,000 workers)

Year starting 1 July	Jurisdictions with regulation	Jurisdictions without regulation	Australian total
2000	13.10	18.70	15.80
2001	12.84	18.33	15.48
2002	12.58	17.96	15.17
2003	12.33	17.60	14.87
2004	12.08	17.25	14.57
2005	11.84	16.90	14.28

Source: Hypothetical NDS data

While analysing the data on falls incidents in mining, it is usually important to identify the component of total falls historically that result in fatalities. In this case, however, the proportion of fatalities in reduced incidents will be modelled as 2% in line with the literature findings. If this proportion were not available, it is possible to use the average from NOHSC (2004) across all incidents of 1.5% (as mentioned above).

NDS data are also useful to estimate the unit cost of a compensation claim, which is another important input for estimating Benefit Item 2.2.

Suppose the Office of the ASCC has data for mean and median costs for mining industry claims, with the latest available data being for (the year starting 1 July) 2005, which generally include all severity categories except the cost of injuries of less than one week (since these are rarely compensated so data are usually too sparse to confidently report). However, the mean cost data are less reliable in the most recent years, because the largest cost claims can take the longest to settle. As such only mean cost data from 2000 to 2003 are used. Median costs are affected in a similar way, but tend to be affected to a lesser extent. As such, median costs are a better indication of trends, while mean costs are a better indication of levels. Both data series show nominal increases in costs of 6% on average per annum for the years available, so this nominal increase in cost per claim is projected over the whole period. Real costs are also calculated (in 2008 dollars) with an imputed inflation rate of 3% per annum, based on (hypothetical) wage inflation rates in the mining sector from ABS data since a large component of these costs are productivity losses.

Falls incidents in mining, financial costs per claim, Nominal and real, Australia, 2000-2005

Year starting 1 July	Nominal		Real (2008 dollars)	
	Mean	Median	Mean	Median
2000	**22,250**	**16,000**	27,995	20,131

2001	**23,585**	**16,960**	28,835	20,735
2002	**25,000**	**17,978**	29,700	21,357
2003	**26,500**	**19,056**	30,591	21,998
2004	28,090	**20,200**	31,509	22,658
2005	29,776	**21,412**	32,454	23,338

Source: Hypothetical NDS data in bold; other data derived and projected.

Note: NDS data on compensated costs is updated annually for five years and should be revisited for currency.

It is unusual for mean and median costs to rise at the same rate as portrayed in this example. If they differ, the median rate should be used as it is more reliable, but the mean cost for 2000 should be used to benchmark against average costs for all Category 2-5 compensated incidents in all industries. The latter is estimated as $21,080 (also from NDS data), so falls in mining are slightly more costly than the mean of all incidents by a factor of 1.056. If costs had been found to be less than the overall mean, this factor would be less than unity.

The NOHSC (2004) Report

The cost of occupational injury and disease, estimated by Access Economics in 2004 for NOHSC for the base year 2000-01, is useful in the calculation of the average benefit of the incidents averted (Benefit Item 2.2), while noting it might soon be appropriate to revisit this estimate and undertake a costing of OHS incidents for a later year.

The report obtained an estimate of (financial) costs of $33.2 billion (5.0% of then GDP), plus an estimate of the cost of pain and early death of some $57 billion. The study utilised an incidence approach to cost measurement, which is appropriate for CBAs in RIS work, and distinguished:

> compensated from uncompensated cases;

> injury from disease;

> (five) different severity categories those being:

_ Category 1 – off work for less than one week;

_ Category 2 – off work for more than one week, full return to work;

_ Category 3 – off work for more than one week, partial return to work;

_ Category 4 – do not return to work (permanently disabled);

_ Category 5 – fatality;

> types of costs by six conceptual cost groups; and

> who bears the cost (employer, worker or society).

The report also developed a more structured categorisation of costs that distinguished real economic costs from financial transfers. This avoided previous double-counting and misallocation, for example of including welfare payments and taxation losses as part of total real costs, when they are in fact transfers from society to the worker.

The study identified six conceptual cost groups, consistent with the thrust of the literature, where each group can be viewed as contributing a total net cost to Australia. Within each group there may be flows between the 'burden-bearers' – employers, workers and society.

The conceptual groups are outlined below, with costs in 2000-01 dollars.

> Production disturbance costs ($1.4 billion) comprise the value of production lost between the incident and when a worker either returns to work or is (fully or partially) replaced, as well as the staff turnover costs – the latter treated as a cost 'brought forward'. The employer bears a significant proportion of the PDC burden ($600 million) through overtime premium payments, sick leave and employer excess payments.

> Human capital costs ($25.7 billion) are the most important single item, reflecting the lost productive capacity of the worker over the longer term – until retirement age. Some $11.7 billion of this cost is borne by workers through lower incomes, while $14 billion is borne by society through welfare payments ($4.8 billion), taxation losses ($4.3 billion) and compensation payments (around $4.8 billion).

> Medical costs ($2.0 billion), including rehabilitation costs of $1 billion, cover the health and 'return to work' expenses of the worker. These may be understated since it is unclear the extent to which the compensation data is capturing unbilled transactions such as treatment at public hospitals, as well as private health insurance claims or other gaps.

> Administration costs ($1.4 billion in total) include legal costs ($454m), the cost of investigating claims and administration of the compensation system ($524m), travel costs for workers ($419m) and the cost of bringing forward funerals ($8m).

> Transfer costs ($1.5 billion in total) are the deadweight loss (DWL) of administering the welfare system ($257m) and the efficiency losses associated with the need to fund additional welfare payments and replace lost income tax ($1.1 billion) following occupational incidents.

> Other costs result from changes to the scope of the estimates.

> These include the real costs of carers ($895m) and of aids and modifications ($281m) that can be required by Category 4 workers who develop disabilities as a result of occupational incidents.

> Damage to property was considered conceptually different and excluded from the costs of occupational incidents that result in injury or illness to humans. Loss of goodwill consequent on injury or disease

was also excluded since it was considered neither substantial nor readily measured.

> An important suggestion was to include an estimate of the cost of suffering and early death, utilising willingness to pay methodology and the concept of the value of a statistical life (VSL). This produced results in line with those from a major study in the US, in that this cost item is substantially higher than all the other cost items put together, ranging from $57 billion to as much as $126 billion.

Since the underlying concepts and their measurement are somewhat controversial, it was suggested that this cost item be separately reported.

> The report identified the number of incidents by injury, disease, compensated and uncompensated cases, and by severity of the incident. Overall there were just under 350,000 occupational incidents estimated in 2000-01, around 3.8% of the workforce.

Employers bore an estimated $1 billion (3%) of the total costs. Workers bore around $13.7 billion (41%) and society – through the compensation system and government sector – bore $18.5 billion (56%). However, it is important to note that employers also pay the workers' compensation premiums from which society meets in part its lion's share. Were an 'ex ante' measurement approach adopted rather than an 'ex-post' one, the community share would be lower (around 35%) and the employer share would be higher (around 24%), since over $7 billion extra would be borne by the employers. It was also noted that employers, in turn, may pass on the higher premiums in higher prices, or may use them to negotiate lower overall wage and salary payments. Thus in general equilibrium the compensation costs are spread across the economy.

A final point to note is that the cost per incident (benefit per incident averted) is not likely to vary much by the size of the firm or by jurisdiction, since the main elements are healthy life, human capital, production and medical costs, which would be dependent much more on the nature and severity of the incident rather than on the size of the firm or the jurisdiction in which the incident occurred. The implicit assumption is thus that while incident rates might vary in respect of these two factors, the average cost per incident would remain broadly constant.

The average cost per incident from NOHSC (2004) is presented in the next table.

Average financial cost per incident, 2000-01

Severity category	Average cost per incident
1 Full return to work, absence < 1 week	$1,481
2 Full return to work, absence > 1 week	$11,803
3 Partial return to work	$188,847
4 Permanent disability, no return to work	$859,035
5 Fatality	$674,108
Average cost, all categories	**$94,865**

Source: NOHSC (2004).

The average financial cost per incident of $94,865 was found to be substantially higher than the average compensated cost per claim for Category 2-5 compensated incidents only, which was estimated as $21,080 in 2000-01 in the previous section, by a factor of 4.50.

Step 3: Estimate Costs and Benefits

The third step is to estimate the costs and benefits from the parameters identified in the literature and data search.

Compliance Costs for Firms and Workers

In a CBA, different types of costs would each be separately identified – eg, additional expenditure on falls protection equipment, productivity losses due to changed work practices, and so on. However, since the total is all that is necessary as an input to the CBA, for simplicity for this worked example, this is the only aspect reported in the table below, with the data directly from the survey highlighted in bold.

Cost of changing to the new regulation borne by firms and workers, jurisdictions without regulation, 2008 and future years (2008 dollars)

	Year starting 1 July 2008	Future years
Firm costs, $ per firm	**120,000**	**30,000**
Average workers per firm	**150**	**150**
Costs for firms, $ per	800	200

worker		
Costs for workers, $ per worker	**200**	**100**
Workers (number)*	10,000	10,000
Total costs, firms ($)	8,000,000	2,000,000
Total costs, workers ($)	2,000,000	1,000,000
Total costs, firms & workers ($ pa)	10,000,000	3,000,000

Source: Bolded items – hypothetical specialised mining industry survey data; * ABS data.

- In this case there are no costs of changing for the jurisdictions that already have the regulation, so the Australian totals are simply the total of the jurisdictions without regulation (10,000 workers in all). Firms and workers were asked to report their costs in estimated 2008 dollars.
- In the survey, firms could only report their firm-wide costs ($120,000 per firm, on average in 2008 and $30,000 per annum thereafter) and number of workers (150 per firm on average, with no change expected), so an average cost per worker is derived ($800 per annum in 2008 and $200 per annum thereafter).
- In the survey of workers, workers estimated the costs they would bear personally as $200 in 2008 and $100 per annum thereafter.
- The number of workers in the industry would be derived from ABS data (projected – in this case with flat projected growth) and the total costs thus calculated.

> The cost of the proposed regulatory change to firms is thus estimated as $8 million in 2008 and $2 million per annum thereafter, in 2008 dollars.
>
> The cost of the proposed regulatory change to workers is thus estimated as $2 million in 2008 and $1 million per annum thereafter, in 2008 dollars.

Additional Costs for Governments

In our hypothetical example, talking to each of the relevant policy implementation areas of jurisdictions that did not have the proposed regulation, enabled estimates of costs for each of the jurisdictions of changing to the new regulation that would be borne by State/Territory Governments. Once again, in the CBA such costs would be specifically identified eg, public sector staff costs, costs of education and awareness raising materials (information dissemination), enforcement, and so on. However, since the total for each is all that is necessary for the CBA, for simplicity this is the only aspect reported in the table below.

Cost of changing to the new regulation borne by state/territory governments, jurisdictions without regulation, 2008 and future years (2008 dollars)

	Year starting 1 July 2008	Future years
Jurisdiction 1	1,000,000	500,000
Jurisdiction 2	2,000,000	1,000,000
Jurisdiction 3	3,000,000	1,500,000
Jurisdiction 4	4,000,000	2,000,000
Total costs, governments ($ pa)	**10,000,000**	**5,000,000**

Source: Hypothetical consultation processes.

The cost of the proposed regulatory change to government is thus estimated as $10 million in 2008 and $5 million per annum thereafter, in 2008 dollars.

Benefits of Greater Consistency

In the survey of firms, only small benefits of greater consistency were estimated to be derived, as presented, on average in the following table. (The benefit from consistency would vary depending on the extent that firms operated across jurisdictions and their size.)

Benefits of greater consistency from changing to the new regulation for firms, all jurisdictions, 2008 and future years (2008 dollars)

	Year starting 1 July 2008	Future years
Firm benefits, $ per firm	**7,500**	**1,500**
Average workers per firm	**150**	**150**
Benefits for firms, $ per worker	50	10
Workers (number)*	20,000	20,000
Total benefits, firms ($)	1,000,000	200,000

Source: Bolded items – hypothetical specialised mining industry survey data; * Hypothetical ABS data.

The benefit of the proposed regulatory change to firms due to greater consistency is estimated as $1 million in 2008 and $0.2 million per annum thereafter, in 2008 dollars.

Benefits of Reduced Incidents

The calculation of the benefits of reduced incidents is the most complex part of the analysis. A key assumption in the analysis is that the difference in incident rates between jurisdictions with legislation and those without legislation is attributable to the lack of legislation, and evidence supporting this assumption should be provided in the CBA. Then the reduction in incidents per annum is derived, as explained in the next section.

Number of incidents

The reduction in the number of incidents is derived from the parameters and data from the literature and data section above. The number of workers is found to be equally divided between the jurisdictions currently with the regulation and those without, according to (hypothetical) ABS data, with flat growth in both sets of jurisdictions projected over the CBA time horizon. The 2% per annum decline in mining falls incidents is assumed to continue in the absence of the regulatory change, but in the case of Option 2, the incident rate for the jurisdictions without the regulation decreases by 29.4% to the incident rate of the jurisdictions with the regulation, from 2008 onwards.

Falls in mining, incidents, 2008-2017, Option 1 and Option 2

Year starting 1 July	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Workers										
Jurisdictions with regulation	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Jurisdictions without regulation	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Total workers	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Incident rate										
Jurisdictions with regulation	11.14	10.92	10.70	10.49	10.28	10.07	9.87	9.68	9.48	9.29
Jurisdictions without regulation	15.91	15.59	15.28	14.97	14.67	14.38	14.09	13.81	13.54	13.26
Incidents										
Jurisdictions with regulation	111.4	109.2	107.0	104.9	102.8	100.7	98.7	96.8	94.8	92.9
Jurisdictions without regulation, Option 1	159.1	155.9	152.8	149.7	146.7	143.8	140.9	138.1	135.4	132.6
Jurisdictions without regulation, Option 2	111.4	109.2	107.0	104.9	102.8	100.7	98.7	96.8	94.8	92.9
Total incidents, Option 1	**270.5**	**265.1**	**259.8**	**254.6**	**249.5**	**244.5**	**239.7**	**234.9**	**230.2**	**225.6**
Total incidents, Option 2	**222.9**	**218.4**	**214.1**	**209.8**	**205.6**	**201.5**	**197.5**	**193.5**	**189.6**	**185.8**
Difference	**47.6**	**46.7**	**45.8**	**44.8**	**43.9**	**43.1**	**42.2**	**41.4**	**40.5**	**39.7**

The number of incidents estimated to be averted due to the proposed regulatory change gradually declines over the period from 47.6 incidents averted in 2008 to 39.7 incidents averted in 2017 for Option 2 compared to Option

The gradual decline reflects the gradual tapering of the percentage decline in incidents overall as rates gradually approach zero (due to other factors).

Financial cost per incident

Factoring up costs by 4.50 (to allow for costs that are not compensated), the average cost per fall in mining is calculated in real terms as shown in the next table.

Mean cost per fall in mining (2008 dollars)

Year starting 1 July	Mean cost per incident
2000	125,984
2001	129,763
2002	133,656
2003	137,666
2004	141,796
2005	146,050
2006	150,431
2007	154,944
2008	159,592
2009	164,380
2010	169,312
2011	174,391
2012	179,623
2013	185,011
2014	190,562
2015	196,279
2016	202,167
2017	208,232

These real costs can then be applied to the difference in incidents between Option 1 and Option 2, in order to estimate the total financial benefits of falls averted.

Falls averted in mining, financial benefits, 2008-2017, Option 2 (2008 dollars)

Year starting 1 July	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Difference	47.6	46.7	45.8	44.8	43.9	43.1	42.2	41.4	40.5	39.7
Average real cost ($2008) per fall	159,592	164,380	169,312	174,391	179,623	185,011	190,562	196,279	202,167	208,232
Financial benefit (falls averted), $m	**7.60**	**7.67**	**7.75**	**7.82**	**7.89**	**7.97**	**8.04**	**8.12**	**8.19**	**8.27**

The real financial benefits of potential mining falls averted due to the proposed regulation are estimated as $7.60 million in 2008, rising to $8.27 million in 2017, for Option 2 compared to Option 1.

Burden of Disease

The financial benefits of falls averted are, however, not the only benefits. There is also the value of the 'burden of disease' that is averted – both the premature mortality component and the disability component.

Burden of disease is measured in disability adjusted life years (DALYs) and is comprised of two components – the premature mortality component measured in Years of Life Lost due to premature death (YLL) and the disability component measured in Years of healthy life Lost due to Disability (YLD).

Estimating the value of the burden of disease is a two-step process:

1 estimating the number of DALYs averted; and

2 ascribing a value to these DALYs, both in gross and net terms.

To estimate the number of DALYs, it is necessary to employ the split between fatal and nonfatal incidents averted from the literature and data section above, which was found to be 2% for fatalities.

Thus in 2008, for example, of the 47.6 incidents estimated to be averted due to the proposed regulation, 0.95 of these are fatalities and 46.69 are estimated to be non-fatal.

YLL is then calculated by multiplying 0.95 by the estimated and discounted number of years of life remaining based on average life expectancy. This requires data on the age-gender distribution of the deaths due to falls in mining, which may be able to be derived from NDS data. However, the usual case is that the age-gender distribution of deaths is not available. In this case, an estimate of 23.81 years is used, which is an estimate of the average life years remaining across all incidents, discounted at 3% per annum. The selection of this discount rate is explained in Section 3.4, and 23.81 is the ratio of the suggested (base case) VSL to VSLY[27], for consistency with the other calculations in the CBA.

> Thus, in 2008 the YLL averted due to the proposed regulatory change is estimated as 22.7 DALYs, falling to 18.9 DALYs by 2017.

YLD is calculated by multiplying the non-fatal falls averted by an appropriate disability weight, as outlined in the Appendix B tables (based on weights used by the AIHW in turn derived from the global burden of disease disability weights). For falls, this weight is 0.141. As with YLL, it is also necessary to estimate the period over which this weight applies ie,

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[27] VSL(Y): Value of a statistical life (year) estimates – see Chapter 4 and Section 5.6 (especially Table 5—2).

the period of the disability, which could be derived from NDS data if the age-gender distribution and the severity distribution are known. However, also as with YLL, this is usually not the case, so an estimate is used based on the average distribution of non-fatal incidents by severity from NOHSC (2004).

> Category 1 incidents comprise over half with an imputed duration of half a working week (2.5 days).

> Category 2 incidents comprise 33.9% with an imputed average duration of six months.

> Category 3 and 4 incidents together comprise the remaining 14.7% of non-fatal incidents and are permanent, so the disability weight applies to remaining life expectancy, estimated (see above) as 23.81 years on average. For Category 3, if the worker has a period off work and then only ever returns part-time, it implies that the injury has an effect that has will last the rest of his or her life ie, the same duration of impact on average as for the workers who never return (Category 4).

Average duration of OHS incidents

	All OHS incidents (2000-01)	% non-fatal	Average duration (years)
Less than five days	177,098	51.4%	0.01
Temporary full return	116,620	33.9%	0.50
Temporary partial return	23,213	6.7%	23.81
Permanent non-fatal	27,355	7.9%	23.81
Total non-fatal	344,286	100%	3.67

Source: Based on NOHSC (2004). Note: Totals may not sum exactly due to rounding.

The weighted average duration of a non-fatal OHS incident is thus estimated as 3.67 years and, for 2008, YLD = 3.67 * 0.141 * 46.69 = 24.16 DALYs.

Thus, in 2008 the YLD averted due to the proposed regulatory change is estimated as 24.2 DALYs, falling to 20.1 DALYs by 2017.

Total DALYs averted are then calculated as YLL + YLD for each year and multiplied by the VSLY of $266,843 for 2008 in 2008 dollars. This 2008 VSLY is the 2006 VSLY estimated in the main body of the report of $252,014 multiplied by two years of inflation (2.9% in each year, from the Access Economics Macroeconomic model) to calculate the 'gross' value of the DALYs averted – 46.8 DALYs in 2008 ($11.8 million) falling to 39.1 DALYs by 2017 ($9.9 million).

However, it is necessary to bear in mind that the wage-risk studies underlying the calculation of the VSL take into account all known personal impacts – suffering and premature death, lost wages/income, out-of-pocket personal health costs and so on – so the estimate of the value of DALYs should be treated as a 'gross' figure. However, costs specific to the falls that are unlikely to have entered into the thinking of people in the source wage/risk studies should *not* be netted out (eg, publicly financed health spending, care provided voluntarily).

The netting out process utilises the parameter from NOHSC (2004) that the average individual's share of the financial costs of OHS incidents is 41%. Thus:

Net DALYs = Gross DALYs minus 41% * Financial benefits from incidents averted

In this case, net DALYs in 2008 equal 11.8 – 41% * 7.6 = $8.7 million.

Thus, in 2008 the net value of the DALYs averted due to the proposed regulatory change is estimated as $8.7 million, falling to $6.5 million by 2017.

Falls in mining, burden of disease averted and its value, 2008-2017, Option 1 and Option 2

Year starting 1 July	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fatalities averted (2%)	0.95	0.93	0.92	0.90	0.88	0.86	0.84	0.83	0.81	0.79
Non-fatal falls averted	46.69	45.76	44.84	43.94	43.07	42.20	41.36	40.53	39.72	38.93
YLL	21.43	21.00	20.58	20.17	19.76	19.37	18.98	18.60	18.23	17.86
YLD	22.88	22.42	21.97	21.53	21.10	20.68	20.27	19.86	19.47	19.08
DALYs	44.31	43.42	42.55	41.70	40.87	40.05	39.25	38.46	37.69	36.94
Gross value of DALYs averted ($m)	11.82	11.59	11.35	11.13	10.90	10.69	10.47	10.26	10.06	9.86
Net value of DALYs averted ($m)	8.71	8.44	8.18	7.92	7.67	7.42	7.18	6.93	6.70	6.47

Step 4: Report Findings and Sensitivity Analysis

The final part of the CBA is to compare the NPV of the costs and benefits, to report the findings in the 'base case' with potential sensitivity analysis surrounding key parameters.

Cost Benefit and Cost Effectiveness Analysis

For the year starting 1 July 2008, costs of the proposed new regulation (Option 2 compared to Option 1) are estimated as $20 million – of which $8 million were borne by firms, $2 million by workers and $10 million by governments. Financial benefits are estimated as $8.6 million, of which $1 million are the benefits to firms of greater consistency and the remainder are the financial benefits of mining falls averted. So there is a net financial cost of $11.4 million in 2008. However, this is reversed in later years, although the NPV over the whole period still shows a net financial cost of $10.2 million in 2008 dollars, using a discount rate for these real streams of 3% per annum.

> The NPV of the DALYs averted, however, more than offsets the net financial costs, so the total net benefit over the forecast horizon is

estimated as $57 million, although noting there is still a total net cost in 2008 of $2.7 million.

> The benefit-cost ratio over the period in NPV terms is 0.88 for the financial streams and 1.69 for the total streams, including the value of the DALYs averted.

> The ICER overall is $28,475/DALY averted, being $257,230/DALY in the first year but cost saving thereafter.

It can also be informative to summarise who bears the net costs and benefits.

> Workers are the clear beneficiaries with $18.7 million the NPV of net financial benefits and $85.7 million the NPV of total benefits (workers gain the whole value of the net DALYs, as well as 41% of the financial benefits from incidents averted).

> Firms gain only 3% of the financial benefits from incidents averted and Governments 56% (NOHSC, 2004), and firms are worst off, losing $18.9 million in NPV terms in 2008 dollars.

Cost benefit and cost effectiveness summary, 2008-2017

Year starting 1 July	2008	2009	2010	2011	2012	2013	2014	
Costs								
1.1	8.00	2.00	2.00	2.00	2.00	2.00	2.00	
1.2	2.00	1.00	1.00	1.00	1.00	1.00	1.00	
1.3	10.00	5.00	5.00	5.00	5.00	5.00	5.00	
Total costs	**20.00**	**8.00**	**8.00**	**8.00**	**8.00**	**8.00**	**8.00**	
Benefits								
2.1	1.00	0.20	0.20	0.20	0.20	0.20	0.20	
Financial component of 2.2	7.60	7.67	7.75	7.82	7.89	7.97	8.04	
Total financial benefits	**8.60**	**7.87**	**7.95**	**8.02**	**8.09**	**8.17**	**8.24**	
DALYs averted	44.31	43.42	42.55	41.70	40.87	40.05	39.25	
$ DALYs	8.71	8.44	8.18	7.92	7.67	7.42	7.18	
Total benefits (inc DALYs)	**17.31**	**16.31**	**16.13**	**15.94**	**15.76**	**15.59**	**15.42**	
Net benefits (financial), $m	- 11.40	- 0.13	- 0.05	0.02	0.09	0.17	0.24	
Net benefits (total), $m	- 2.69	8.31	8.13	7.94	7.76	7.59	7.42	
Benefit:cost ratio (financial)	0.43	0.98	0.99	1.00	1.01	1.02	1.03	
Benefit:cost ratio (total)	0.87	2.04	2.02	1.99	1.97	1.95	1.93	
net fin. costs/DALY averted	257,230	2,881	1,245	cost saving	cost saving	cost saving	cost saving	cos

Summary of financial benefits and net benefits by bearer, 2008-2017

Year starting 1 July	2008	2009	2010	2011	2012	2013	2014	
Financial benefits by bearer								
Firms	1.23	0.43	0.43	0.43	0.44	0.44	0.44	
Workers	3.12	3.15	3.18	3.21	3.24	3.27	3.30	
Government	4.26	4.30	4.34	4.38	4.42	4.46	4.50	
Net financial benefits by bearer								
Firms	- 6.77	- 1.57	- 1.57	- 1.57	- 1.56	- 1.56	- 1.56	-
Workers	1.12	2.15	2.18	2.21	2.24	2.27	2.30	
Government	- 5.74	- 0.70	- 0.66	- 0.62	- 0.58	- 0.54	- 0.50	-
Net total benefits by bearer								
Firms	- 6.77	- 1.57	- 1.57	- 1.57	- 1.56	- 1.56	- 1.56	-
Workers	9.82	10.59	10.35	10.13	9.90	9.69	9.47	
Government	- 5.74	- 0.70	- 0.66	- 0.62	- 0.58	- 0.54	- 0.50	-

Sensitivity Analysis

This report suggests use of a VSLY in 2006 dollars of $252,014 in CBAs, with sensitivity analysis conducted at $155,409 and $340,219. Inflating to 2008 dollars for this Appendix example means a base case of $266,843 with sensitivity analysis at $164,553 and $360,238. Other parameters that would be likely candidates for sensitivity analysis might be:

> 29.9% reduction compared to a higher or lower rate;
> average costs for firms ($800/worker in 2008 and $200/worker thereafter)
> average costs for workers ($200/worker in 2008 and $100/worker thereafter)
> costs for governments ($10 million in 2008 and $5 million thereafter)
> benefits for firms ($1 million in 2008 and $0.2 million thereafter)
> 3% increase in real costs per compensated case;
> the factors for total cost per incident of 4.5 and 1.056;
> 2% fatalities and 23.81 estimated life years remaining for fatalities; and
> disability weight of 0.141 and 3.67 years average duration.

Approaches to sensitivity analysis can include modelling high and/or low scenarios, or performing more complex distributional modelling (eg, @RISK) if warranted – perhaps if the outcome is very marginal between Options.

In this case a high-low sensitivity analysis on the VSLY is presented as an example, which simply involves substituting the parameters above in the modelling, as well as the associated values for the VSL.

> Naturally the net financial benefits do not change, nor the financial benefit-cost ratio or ICER.
> The total benefits range between $20 million and $90 million and the benefit-cost ratio is thus estimated to lie between 1.24 and 2.09.

Base case, high and low scenario of VSL and VSLY

	Base	High	Low
VSL	6,000,000	8,100,000	3,700,000
VSLY	266,843	360,238	164,553
Net financial benefits	- 10.19	- 10.19	- 10.19
Net total benefits	56.77	90.19	20.17
Financial benefit-cost	0.88	0.88	0.88
Total benefit-cost	1.69	2.10	1.25
$/DALY averted	28,475	28,475	28,475

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