Report Cover Page

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Measuring the cost of human morbidity and mortality from zoonotic diseases
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Summary
This report assesses tools for measuring the costs of human morbidity and mortality, with a focus on their utility for biosecurity risk assessment. The approaches described include case-based approaches, disability adjusted life years (DALYs), quality adjusted life years (QALYs), cost of illness studies (COI), willingness to pay (WTP), and integrated quantitative/semi-quantitative approaches. The report finds that DALYs are most useful as measures of population health burden of disease and QALYs as measures of the effectiveness of interventions. DALYs should be used for making comparisons between and among zoonotic and non-zoonotic diseases. Conversion of measures to dollars could be useful whenever budgetary decisions are determined by monetary costs and when such inputs are required for cost–benefit analyses. If a wider set of consequences is considered, the review recommends cost of illness (COI) studies. The report suggests that a bottom–up approach is more suitable for measuring monetary burden of illness due to zoonotic diseases. The willingness-to-pay (WTP) approach may be warranted if 'intangible' costs are important. Structured decision methods provide a means for partitioning the scientific assessment of the total cost or burden of disease, from the social choices that emerge in setting priorities.

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Measuring the cost of human morbidity and mortality from zoonotic diseases

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Contents

EXECUTIVE SUMMARY

This report assesses tools for measuring the monetary and non-monetary costs of human morbidity and mortality, with a focus on their utility for biosecurity risk assessment. The approaches described include case-based approaches, disability adjusted life years (DALYs), quality adjusted life years (QALYs), cost of illness studies (COI), willingness to pay (WTP), and integrated quantitative/semi-quantitative approaches.

These approaches vary in their output and resource demands. The best approach depends on the purpose for which the cost data are to be used. DALYs are the most common measures of population health burden of disease, and QALYs as measures of the effectiveness of interventions, however both can and have been used for each purpose. In Australia, burden of disease data are available for a number of non-zoonotic diseases (AIHW, 2007). Although DALYs and QALYs are widely used in the health sector, policy-makers in other sectors need to be guided on the strengths and weaknesses of these measures.

Conversion of health-adjusted quality of life year measures to dollars could be useful whenever budgetary decisions are determined by monetary costs and when such inputs are required for cost–benefit analyses (e.g. in non-health sectors). If this approach is to be used, the process for translating the DALY/QALY to dollar costs needs to be transparent. Some approaches are outlined in this report.

In some instances, it may be important to account for a wider set of consequences than the impact on premature death and years with disability/quality of life at the population level, including the use of health services and associated costs, and loss of productivity. These are typically valued in cost of illness (COI) studies. Costs can be measured by using actual expenditure data on illnesses that have occurred previously, or modelled using forecast levels or scenarios of illness (Verikios et al., 2010).

COI studies involve either top–down or bottom–up approaches. This report strongly suggests that a bottom–up approach is more suitable for measuring monetary burden of illness due to zoonotic diseases. On a practical level, top–down costings are often undertaken as data are often more readily available and less costly to collect. However, given the potentially significant investments in disease management associated with zoonotic diseases, the investment in data is likely to be justified in terms of the accuracy of cost estimates.

The willingness-to-pay (WTP) approach is an alternative to COI that measures what individuals would be willing to pay to improve health or reduce the risk of illness. It provides a way of estimating a value, in dollar terms, of a reduction in risk of illness and its associated morbidity and mortality consequences. The

latter is often referred to as the Value of a Statistical Life. Techniques for estimating WTP can be resource-intensive, but can be derived from existing (previously published) estimates. Unfortunately, they are not available for all health states and are unlikely to be available for new and emerging zoonotic diseases.

The WTP approach overcomes a disadvantage of COI approaches in that it allows the 'intangible' costs, that are otherwise not valued, to be translated into a monetary form and included in the overall cost estimation, although they are not valued explicitly. COI studies can be combined with WTP approaches. This report highlights the potential for omissions and double-counting and the need to make explicit the costs that are included and excluded when using multiple methods for costing the consequences of zoonotic diseases. This report also outlines techniques for building equity weights into QALYs and DALYs.

Decision-making can never be entirely quantitative, 'scientific' or value-free because the tradeoffs between incommensurate values are essentially social decisions. Structured decision analysis provides a means for partitioning the scientific assessment of the total cost or burden of disease, from the social choices that emerge in setting priorities. Priorities may be determined by the impact of an illness on society in comparison to other illnesses — measured in DALYs/QALYs, COI studies, WTP, or by multi-criteria analysis that identifies a preferred scenario (e.g. combining incidence, severity, DALYs, COI, public concern). Potential cost savings for particular interventions may be included through the use of cost-effectiveness, cost–benefit, or cost–utility analysis.

More detailed recommendations for costing the morbidity and mortality impact of zoonotic diseases are provided at the end of this report (Section 6). In summary, it is recommended that:

1. Burden of disease should be considered as one of a number of measures of the consequence of illness, when using cost data (both monetary and non-monetary) to inform the magnitude of an issue when priority-setting.

2. Strategies should be developed to inform policy-makers in non-health sectors about the properties and value of DALYs and QALYs as measures of the consequence of illness and of policy effectiveness, respectively.

3. Health-adjusted quality of life measures should be converted to dollar figures whenever decisions are determined by monetary costs and when such inputs are required for cost–benefit analyses.

4. Costs due to use of health services and loss in productivity should be included in any consequence assessment of zoonotic diseases.

5. A multi-criteria approach should be considered in the assessment of zoonotic diseases when decisions are affected by other, non-human health, consequences.

6. Double-counting should be avoided by making explicit what costs are included and excluded when using integrated or multi-criteria approaches to consequence assessment.

7. A bottom–up approach should be the preferred option in any COI study designed to estimate the monetary burden of illness due to zoonotic diseases.

8. Modelling should be considered to forecast potential consequences of zoonotic diseases introduced through imports of animals and animal products, or in instances where consequence data in Australia are not readily available.

9. If the expected costs of a zoonotic threat exceed values that are considered to be 'major', it is recommended that DAFF partner with DoHA/FSANZ or other appropriate organisations, facilitated through a memorandum of understanding (Beale Review Recommendation 41) or other appropriate policy vehicles, to undertake a full economic analysis of the costs related to the associated illness. When rapid decision making is necessary local and international data or agreed upon estimates (e.g. government prescribed VSL) should be used when they are available to estimate costs. When local and international data are not available, experts should be used to estimate the magnitude of the consequences of a zoonotic threat. Analysts should use structured elicitation methods to elicit estimates and uncertainties, and should document their approaches.

10. Decision-makers should consider the likely impact of policy options through the use of model-based scenarios that estimate the outcomes of alternatives.

11. Either DALYs saved or QALYs gained should be used as one of a number of measures of policy effectiveness — see also Recommendation 10.

12. Equity should be considered in the estimate of consequence of illness.

1. BACKGROUND

This report aims to assess tools for measuring the monetary and non-monetary cost of human morbidity and mortality. Such tools may be used in consequence assessment of zoonotic diseases as part of Biosecurity Australia's import risk analysis (IRA) process, and in other areas of the Department's interests where human health consequences are assessed and evaluated. A method for estimating or modelling the cost to human morbidity and mortality of such things as zoonotic diseases associated with agricultural or food imports will inform priority-setting decisions concerning regulatory interventions that may include pre-border and border quarantine, post-border surveillance and monitoring, and emergency responses. These tools are especially important as international trade is burgeoning in terms of its magnitude and diversity (Hulme, 2009), and because decision makers need to estimate the marginal and cumulative risk of zoonotic diseases from additional trade (Pavlin et al., 2009), where these risks are a function of the source area, volume and kind of imports (Costello et al., 2007).

This report was commissioned in response to the 'Beale Review' *One Biosecurity: a working partnership* (Beale, 2008), and the preliminary Australian Government response to this review. The three recommendations from the Beale Review relevant to import risk analysis and human health are:

Recommendation 37c

> The Biosecurity Commission should consult with relevant Australian Government agencies, including the departments having responsibility for agriculture, health, environment and foreign affairs and trade, with the states and territories and with other appropriate stakeholders relevant to import access proposals;

Recommendations 41

> A memorandum of understanding should be developed between the National Biosecurity Commission and the Department of Health and Ageing to cover human health aspects of Biosecurity Import Risk Analyses; and

Recommendation 42

> The National Biosecurity Commission should have the professional capacity to assess risks to the environment and human health in a Biosecurity Import Risk Analysis to the same quality as agricultural assessments.

Recommendation 42 is most pertinent. This work is also consistent with calls for international actions to strengthen international and national capacity for surveillance, prevention, control and eradication of zoonotic diseases. Meslin (2008) urged countries to conduct an assessment of the possible negative impact on public health of national programs/policies that might promote the import of zoonotic diseases (e.g. change in farming practices) and to identify public health costs (among other costs), to 'demonstrate the benefits of surveillance and control of zoonotic disease' (Meslin, 2008).

The terms of reference for this review were to provide a comprehensive and up-to-date literature review of methods for measuring the 'value of a human life' (or 'price of a human life'), including economic and other approaches to measuring the cost of human morbidity and human mortality. According to the terms of reference, the review should:

- include a critical review of methods used in Australia and overseas, particularly in the United States and the European Union;
- note in particular any methods that have been or are being used by state (or provincial etc.) or national government agencies or governments;
- note in particular any legislative requirements of any state (or provincial etc.) or national government agencies or governments that specify any methods for measuring the cost of human morbidity and human mortality; and
- provide a detailed and robust justification for a recommended method or methods for use in consequence assessment of zoonotic diseases considered in Biosecurity Australia's import risk analyses.

This report begins with a review of governmental processes and legislation in relation to consequence analysis within a biosecurity risk analysis framework. It follows with an exploration of methods for measuring the monetary and non-monetary cost of human morbidity and mortality and the 'value of a human life' in Australia and overseas, noting in particular those methods that have been used or are being used by government agencies. The report then follows with a discussion of the overall characteristics of each and what needs to be considered when choosing an approach to measuring the monetary and non-monetary cost of human morbidity and mortality for use in consequence assessment of zoonotic infections in Biosecurity Australia's biosecurity risk analysis.

2. SCOPE OF THE REPORT

The different approaches to costing human morbidity and mortality (monetary and non-monetary) that are explored in this report encompass the human health consequences and costs of personal and societal burden of morbidity and mortality. This review will not, however, evaluate aspects of social perceptions or political sensitivities concerning these human health issues.

One of the key assumptions of this report is that probability of exposure and the kind and magnitude of consequences are separate components of expected loss and should be considered separately. This report focuses on the latter — and how consequences can be costed in monetary and non-monetary terms. The methods explored in this paper are relevant to both forecasted and existing hazards as described more fully below.

2.1 FORECASTING POTENTIAL OR ESTIMATING EXISTING IMPACTS OF ZOONOTIC DISEASES

The monetary and non-monetary costs and consequences of potential zoonotic hazards to which a community is not yet exposed (e.g. bovine spongiform encephalopathy, BSE) can be forecast using risk modelling techniques that use exposure and impact data from previously 'exposed' countries. Costs and consequences of hazards that already exist in a community (e.g. foodborne diseases) can be estimated directly, by retrospective analysis of the impact of illness associated with that hazard, or by prospective analysis for exposures with unknown future sequelae, incubation periods (e.g. BSE) (Brown et al., 2001)[1] or illnesses that have chronic or long-term consequences and need for medical care.

Forecasting the potential impact of zoonotic diseases on health and estimating the monetary and non-monetary morbidity and mortality related costs associated with that impact requires a number of steps. It first requires estimating the number of people who could be exposed to a particular zoonotic disease under different conditions or entry pathways, and, amongst those, the proportion of those exposed who are likely to feel the direct impact of disease – that is, become ill.

In contrast, estimating the morbidity and mortality related impact and costs associated with zoonotic diseases that are already active in the community requires information on (or an estimation of) the number of people who have become ill from the disease. Most impact and cost of illness studies explore hazards that are actively present within the community (e.g. foodborne disease).

[1] Variant Creutzfeldt–Jakob disease (vCJD) is transmitted by ingestion of contaminated meat products from beef infected with BSE. vCJD can have an incubation period of decades (Brown et al. 2001).

It is outside the scope of this report to explore methods for estimating the potential level of exposure of a zoonotic agent. The scope of this report also excludes the need to estimate, of those potentially exposed, who is likely to fall ill. It is assumed that a risk assessment will estimate the actual or potential number of cases of illness resulting from a population's exposure to a zoonotic agent before estimating the costs and consequences of that exposure.

This report explores the methods used to estimate the impact and cost of illness associated with a particular individual and, if the costs are to be presented at the population level, aggregated based on the pre-determined estimate of the total numbers of cases of disease. The approaches explored in this report are relevant to both forecast and retrospectively estimated cases of illness.

3. THE BIOSECURITY CONTEXT

3.1 IMPORT RISK ANALYSIS

Countries that are signatories to the World Organisation for Animal Health (OIE) are required to follow IRA processes set down by the OIE Terrestrial Animal Health Code (OIE, 2011a). The IRA processes set down by the OIE (2011a) are framed against four key stages and general principles that include hazard identification, risk assessment, risk management and risk communication:

- Hazard identification involves identifying the source of a risk and the potential adverse effects of exposure to the imported animal/animal meats/non-animal foods. Hazards that exist in the exporting country but not the country considering import are of particular importance.

- Risk assessment is described to be 'the evaluation of the likelihood and the biological and economic consequences of entry, establishment and spread of a hazard within the territory of an importing country.' (OIE, 2011b). According to the OIE Terrestrial Animal Health Code (OIE 2011a) the process of risk assessment consists of four interrelated steps:

  – *Release assessment* is the description of 'the biological pathway(s) necessary for an importation activity to 'release' (that is, introduce) pathogenic agents into a particular environment, and estimating the [likelihood] of that complete process occurring' (OIE 2011a, p. 3).

  – *Exposure assessment* is the description of 'the biological pathway(s) necessary for exposure of animals and humans in the importing country to the hazards…and estimating the [likelihood] of the exposure (s) occurring (OIE, 2011a, p. 3).

- *Consequence assessment* is the identification of potential biological, environmental and economic consequences. Direct consequences (e.g. public health consequences, animal infection and disease, production losses and facility closure) need to be considered, while indirect consequences (e.g. surveillance and control costs, compensation costs, potential trade losses, adverse consumer reaction) are also important (OIE 2011a).

- *Risk estimation* is the integration of all results derived 'from the release assessment, exposure assessment, and consequence assessment to produce overall measures of risks associated with the hazards identified at the outset' (OIE 2011a, p. 4).

- Risk management is the 'process of deciding upon and implementing measures to achieve the [member country's] appropriate level of protection, whilst at the same time ensuring that negative effects on trade are minimised' (OIE 2011a, p. 5).

- Risk communication is 'the process by which information and opinions regarding hazards and risks are gathered from potentially affected and interested parties during a risk analysis, and by which the results of the risk assessment and proposed risk management measures are communicated to the decision makers and interested parties in the importing and exporting countries' (OIE 2011a, p. 5).

This report is primarily concerned with providing tools to serve the objectives of consequence assessment within the risk assessment phase of an IRA. In particular, this report is concerned with exploring those tools used to cost the monetary and non-monetary consequences to human health of import of animal species and products.

3.2 CURRENT APPROACHES TO ASSESSING HUMAN HEALTH CONSEQUENCES

Burgeoning trade strains border inspection facilities in all jurisdictions. Several countries have adopted inspection approaches that aim to reduce 'risks of violation' (e.g. Robinson et al., 2011) and protect public health by reducing illness and human health risk.

The Canadian Food Inspection Agency (CFIA), which is responsible for managing Canadian human health risks associated with trade, determines the risks associated with imports by making assessments of the import controls, surveillance procedures, and control measures of exporting countries; the documentation of shipments to verify certification provisions and regulations are met, and statistically-

based product sampling and analysis to confirm that residues do not exceed Canadian standards (Canadian Food Inspection Agency, 2000). This is followed by a hazard identification of species or animal products, which involves identifying all the diseases that are potentially associated with the species/commodity. The Terrestrial Animal Health Division (TAHD) of the CFIA uses this information to allow or prohibit the importation of animals and animal-sourced products (Canadian Food Inspection Agency, nd).

Under Australian administrative arrangements, Biosecurity Australia provides advice to the Director of Animal and Plant Quarantine in relation to the life or health of animals and plants, while risks to human health are the responsibility of the Australian Government Department of Health and Ageing (DoHA). Risks to human health associated with the consumption of imported chicken meat or chicken meat products are assessed by Food Standards Australia New Zealand (FSANZ) (Biosecurity Australia, 2008). The approach to risk analysis for food-related health risk used by FSANZ is based on the general framework endorsed by Codex. In addition, FSANZ monitors food safety incidents worldwide and provides advice to the Australian Quarantine Inspection Service (AQIS) on monitoring and testing imported food. Food entering Australia is subject to the *Imported Food Control Act 1992*, which provides for the inspection and control of imported food using a risk-based border inspection program, the AQIS Imported Food Inspection Scheme (IFIS). FSANZ advises AQIS on the risk categorisation of foods for inspection under the IFIS (Australian Quarantine Inspection Service, nd).

IRAs are conducted by Biosecurity Australia and are undertaken where there is no quarantine policy or where a significant change in existing quarantine policy is being considered. For example, an IRA would be conducted for new commodities that have not previously been imported into Australia and commodities that are already imported but the import request is from a different country/area with a significantly different pest and disease status. The process followed in conducting an IRA is outlined in the IRA Handbook 2011 (Australian Government Department of Agriculture Fisheries and Forestry, 2011). In these IRAs, outcomes for risk estimation are set out (in semi-quantitative form) in a matrix (see Table 1, from the DAFF generic IRA for pig meat) that is used to combine likelihood of entry, exposure, establishment and spread with consequences of entry, exposure, establishment and spread (Australian Government Department of Agriculture Fisheries and Forestry, 2004).

Consequences are scored in one of six categories scaled from negligible to extreme, depending on the severity of the impact (ranging from ‘unlikely to be discernible’ to ‘highly significant’) and its extent, ranging from local to national. Impacts are assessed separately for each of six criteria. The approach considers direct effects of the disease agent on the life and health of animals and on the environment, and

indirect consequences such as eradication costs, effects on domestic and international trade, impacts on the environment and on communities. The overall seriousness of the impacts is assessed from the maximum consequence rating in any of the six criteria (e.g., Biosecurity Australia 2008). The impacts on human health, including the economic consequences of human morbidity/mortality, are not currently included in this consequence assessment process.

Table 1. Risk estimation matrix

Likelihood of entry, exposure, establishment and spread	*Negligible impact*	*Very low*	*Low*	*Moderate*	*High*	*Extreme impact*
High likelihood	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible likelihood	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

Consequences of entry, exposure, establishment and spread

Source: DAFF Generic IRA for Pig Meat Final IRA Report (Australian Government Department of Agriculture Fisheries and Forestry, 2004)

The US Department of Agriculture's Food Safety and Inspection Service (FSIS) is 'responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labelled and packaged'(USDA, nd-a). IRAs are conducted by the Animal and Plant Health Inspection Service (APHIS). Although public health consequences are not assessed by APHIS' regulatory authority (USDA, 2000), IRAs occasionally address human health issues (e.g. USDA, 2005). However, US IRAs treat consequences as additive, irrespective of their nature or source and typically they are described qualitatively, without application of any explicit economic or human health metrics (USDA, 2007).

A useful resource for economic information in relation to food, farming, natural resources and rural development is the Economic Research Service (ERS) within the US Department of Agriculture (USDA).

The ERS conducts a research program to inform public and private decision-making on economic and policy issues involving food, farming, natural resources, and rural development (USDA Economic Research Service, nd). The ERS has developed a Foodborne Illness Cost Calculator. This calculator estimates the costs of illness (COI) and premature death for a number of endemic foodborne illnesses (e.g. *Campylobacter*-induced gastroenteritis). Although not directly related to imported zoonotic diseases, these COI findings have been used in regulatory cost-benefit and impact analyses. This approach is described later in this report.

There are relatively few published reports of the findings of consequence assessments from IRAs of particular commodities outside Australia and New Zealand (Burgman et al., 2010). This is surprising in the light of the OIE framework on Import Risk Analyses (OIE, 2010) and the development of risk-based import inspection and microbiological testing programs in a number of countries. There is a larger amount of work on some diseases (e.g. BSE, avian influenza; see for example Walhstrom et al., 2002, Tesfa et al., 2004, Sugiura, 2004) with potential consequences that are at present of unknown magnitude.

Where IRAs have been published (mainly in Australia), consequence has been assessed either semi-quantitatively (see Table 1) with human health being considered as one part of total consequence among a number of other factors (e.g. animal health, the environment) or considered outside the IRA assessments. In contrast, there are a number of academic peer-reviewed studies and technical reports concerning the costs associated with human health consequences of foodborne and zoonotic diseases. These studies and technical reports highlight the numerous approaches to measuring the monetary and non-monetary costs associated with morbidity and mortality. These approaches are described in Section 4.

4. MEASURING COSTS ASSOCIATED WITH MORBIDITY AND MORTALITY

4.1 COSTING CONSEQUENCES

Academic peer-reviewed studies and technical reports on the cost of foodborne and zoonotic diseases highlight two phases in the conduct of these studies. The earlier phase is defined largely by scientific elicitation studies. These studies involve expert stakeholders and scientists, using semi-quantitative approaches with risk rating forms or algorithms to determine the level of risk. For many of these studies, risk was not restricted to the burden or cost of human disease but incorporated other societal risks (e.g. public support or perception of dangers for a particular import decision). Such studies have been conducted in Australia (Ross and Sumner, 2002) and Germany (Krause and Working Group on Prioritization at the Robert Koch Institute, 2008).

Hensen et al. (2007) in Canada provide the best rationale in support of this approach. The authors' *Multi-Factorial Risk Prioritization Framework* considers four factors — public health, consumer risk perceptions and acceptance, market-level impacts, and social sensitivity (Hensen et al., 2007). The framework is based on the systematic organisation and analysis of data on these multiple factors in which decision makers place explicit values on different criteria to develop risk priorities.

The later phase is defined more by quantitative approaches to estimating the burden of foodborne and zoonotic disease, alongside the financial costs of foodborne and zoonotic disease. The National Institute for Public Health and Environment (RIVN) in the Netherlands and the Emerging Pathogens Institute of the University of Florida have been influential. Batz and Morris and other authors from the Food Safety Research Consortium (of which the Emerging Pathogens Institute is a part) have developed the Foodborne Illness Risk Ranking Model (FIRRM) (Batz et al., 2007), which has influenced US Government priorities on foodborne illness risks. FIRRM is a decision tool used to examine the public health burden of foodborne illnesses due to microbiological hazards from specific food. Users can rank pathogen–food combinations by different measures of annual disease burden, including estimated cases, hospitalisations, and deaths, as well as by estimated cost of illness and loss in QALYs.

Another important development in the US, as previously noted, is the USDA's Economic Research Service (ERS), which has developed a Foodborne Illness Cost Calculator (USDA, nd-b). This calculator estimates the costs of illness and premature death for a number of foodborne illnesses. Other important research includes (Abelson et al., 2006) who made a detailed estimate of costs of foodborne disease in Australia (Abelson et al., 2006) and New Zealand (Applied Economics, 2010a). Cressey and Lake (2007) also undertook a detailed estimate of costs of foodborne disease in New Zealand (Cressey and Lake, 2007) and developed a priority-setting process for foodborne illnesses (Cressey and Lake, 2008). The work of these various groups will be drawn upon extensively in defining best practice in measuring and costing (in monetary and non-monetary terms) the human consequences of imported foodborne and zoonotic diseases, presented in the following sections of this report.

Health Impact Assessment (HIA) studies have some similarities with the Import Risk Assessment processes (enHealth Council, 2001, WA Department of Health, 2007). Both involve the estimation of the likely effects of planned environmental decisions (e.g. new infrastructure or new government or commercial activities that alter the human environment so as to produce possible effects on human health). They include as processes risk assessment, risk management and risk communication. However it is not useful to closely follow HIA processes in the conduct of IRAs. HIAs address a much more diverse range of potential environmental threats to human health and typically have not focused on overall

parameters that summarise disease burden or costs.

4.2 METHODS FOR COSTING CONSEQUENCES TO HEALTH

The approaches to measuring the monetary and non-monetary costs of human illness include:

- Case-based approaches (with unity weighting and special reference to vulnerable groups);
- Disability adjusted life years (DALYs)/Quality adjusted life years (QALYs);
- Cost of Illness (COI);
- Willingness to Pay (WTP); and
- Semi-quantitative approaches.

An estimation of the monetary/non-monetary burdens and cost of illness can include one or more of these approaches and may be presented at the individual level or multiplied by the total number of cases to give an estimate of the costs and consequences at the population level. Each of these methods for measuring the costs of human illness is described in this section.

4.2.1 Cases of Disease

In some cases, individuals experience an illness in more or less the same way. However, it is more likely that different individuals experience different levels of impact of a disease. The costs and consequences can be estimated for these different individuals and multiplied by the total number of cases experiencing these different levels of severity or sequelae.

The number of cases of illness can be measured as incidence or prevalence. The incidence of a disease is the number of new cases for a given population over a particular period (e.g. 12 months). The prevalence of a disease is the total number of cases per population at a particular time or period. The longer the duration of an illness, (e.g. chronic arthritis) the greater will be the difference between incidence and prevalence of that disease. In addition, a disease with a large incidence may have low prevalence if cases are rapidly fatal (Rothman, 1986).

Different population groups are likely to feel the impact of zoonotic diseases more than others. For example, effects are often more severe among young children, the elderly and people who are immune-compromised. The more severe an illness the greater the impact on the individual in terms of intensity and duration of pain, loss of function, life years lost, loss of income and the types and duration of medical care. If costs and consequences associated with different sequelae of an illness are not ‘accurately estimated’, then the overall population level costs could be overestimated or underestimated, depending

on the analyst's assumptions about severity. For instance, if it is assumed incorrectly that all people who acquire an illness suffer serious complications then the impact of that illness will be overestimated.

It is worth noting that a lack of consequence data does not preclude estimation of impact as models can be constructed with regard to costs and effects of different outcome scenarios. For example, researchers at Monash University (Verikios et al., 2010) simulated the effects of two influenza A H1N1 pandemics; the relatively mild 2009 outbreak and also a more severe episode. The scenarios were based on the susceptible–exposed–infected–removed model of infectious disease transmission. The model also incorporated the presence of 'unobserved (mild and non-presenting)' cases and a degree of pre-existing immunity (Verikios et al., 2010).

A useful approach to mapping different levels of severity, sequelae and consequent pathways of care has been used by Kemmeren and colleagues in their estimation of the burden and costs of selected foodborne pathogens in Denmark (Kemmeren et al., 2006) and Batz and colleagues in their estimation of the burden and costs of foodborne and zoonotic diseases (Batz et al., 2007). They used an outcome tree to illustrate the disease process for a specific foodborne pathogen. See Figure 3 for an illustration of an outcome tree used by Kemmeren et al. (2006). In this diagram, each block in the tree represents a health outcome. An analyst may estimate and present costs and consequences for one individual for each outcome, or at the population level, by multiplying the costs by the incidence or prevalence of each outcome. Adding each of the costs associated with each outcome gives an estimate of the total current and future costs accrued over a specific period.

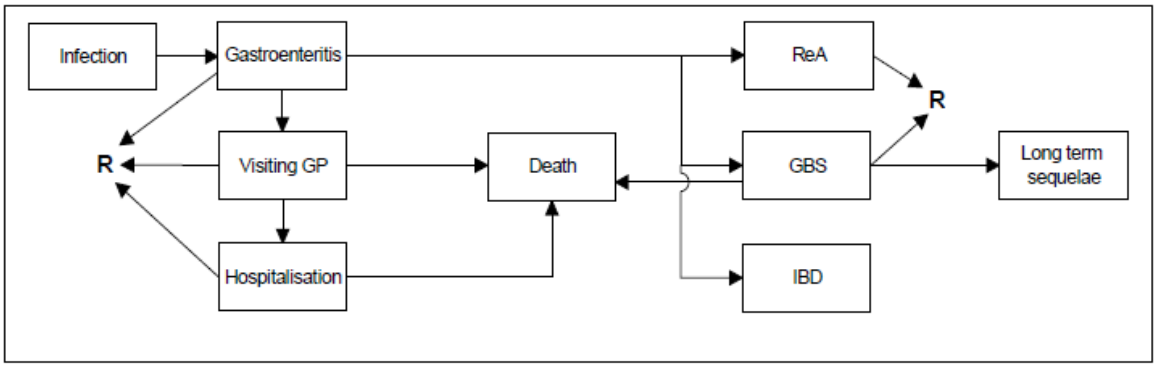

Figure 3: Outcome tree *Campylobacter*-associated gastroenteritis and sequelae (Kemmeren et al., 2006) GP = general practitioner; R = recovery; ReA = reactive arthritis; BGS = Guillain–Barré syndrome; IBD = inflammatory bowel disease

At the minimum, the consequences of disease can be presented as numbers of cases of illness with or without further descriptors of disease severity or sequelae. Consequences of disease presented this way

are often used to provide semi-quantitative rankings in priority studies (Peterson et al., 1996, Krause and Working Group on Prioritization at the Robert Koch Institute, 2008). Typically, more elaborate approaches are used. These include the use of DALYs/QALYs/COI/WTP among others and are described below.

4.2.2 DALYs/QALYs/COI/WTP

Several approaches to estimate the monetary and non-monetary impacts of zoonotic diseases extend beyond numbers of cases of disease. Impacts incur burdens and costs to the individual, the family (loss of functioning, payment for use of services, pain, suffering, death), to government and the private sector, (e.g. as funder of medical services), and to businesses (e.g. loss of productivity due to days off work). Before a decision can be made about which approach to use, the range of impacts of illness that could be included in the overall estimation needs to be considered because methods differ in how they handle consequence information.

Of the burdens listed above, all can be presented in monetary terms. Although it is arguable whether pain, suffering, loss of functioning and loss of life are fully captured when presented in dollar terms, having a common measure allows morbidity and mortality associated costs of different hazards, and cost-effectiveness ratios across different schemes and interventions to be more easily compared. To make trade-off decisions, it helps if these values are rendered in a common currency, so that the judgments are consistent and commensurate. Usually, value is expressed in dollars, providing opportunities to deploy a range of standard economic techniques (e.g. to elicit WTP, hedonic pricing) used in cost–benefit analysis (CBA) (see Section 4.4). Some analysts argue that it is cognitively easier and more reliable to achieve the same goal by avoiding the translation into dollars. Cost-effectiveness analysis can be used for these analyses. If more than one axis of value is involved, forms of multi-criteria decision analysis can be employed that are mathematically equivalent to CBA but that may make it easier for experts and stakeholders to identify, understand and interpret the trade-off points between criteria (Keeney, 2002, Gregory et al., 2005, Hammond et al., 2006).

Personal disease burdens on individuals may be presented as non-monetary summary measures of health status and considered alongside other costs (e.g. productivity loss). Two popular summary measures (often referred to as measures of utility) include disability adjusted life years (DALYs) and quality adjusted life years (QALYs). These have been used to provide a measure of the number of healthy years lost to illness (DALYs accrued due to illness, or QALYs lost due to illness). All other impacts listed above are typically presented in dollar terms using direct or indirect methods of measurement. See Table 2 for a summary of these typical impacts and how they can be estimated.

Table 2: Summary of approaches to the costing (monetary/non-monetary) of personal disease burdens

Impact	1.Utility measures (DALY/QALY)	2. Cost of illness (COI) ($)	3. Willingness to Pay (WTP) ($)	4.Human Capital /Friction Cost Approach ($)
Loss of income	✓	✓	✓	
Pain and discomfort	✓		✓	
Anxiety and depression	✓		✓	
Loss of functioning	✓		✓	
Use of healthcare	✓	✓	✓	
Death (loss of life years)	✓	✓	✓	
Loss in productivity	✓	✓	✓	✓

The approaches to estimating the monetary or non-monetary costs and consequences of illness outlined in Table 2 include the use of use measures such as the DALY or QALY (Approach 1 in Table 2), direct measures of the monetary cost of illness in (Approach 2), and indirect measures of cost of illness derived from techniques to elicit Willingness to Pay (WTP) (Approach 3). Other approaches are limited in the type of costs that they include in their estimation. These include the human capital and friction cost approaches (Approach 4), techniques used in COI studies. They are limited to measuring the loss in productivity in $ terms associated with an illness. The COI approach does not include costs associated with pain and discomfort, anxiety and depression, or loss of functioning, while the DALY/QALY utility approaches do not explicitly include the costs associated with use of health care services, or loss of productivity though these may be reflected in how individuals rate their quality of life, and potentially lead to double-counting[2] (Applied Economics, 2010b). WTP is used to derive the value of a statistical life (VSL) and can also be used to place a dollar value on a DALY or QALY (e.g. see Food Standards Australia New Zealand 2010).

[2] The issue of double-counting is discussed in more detail in Section 5.

See Figure 4 for an illustration of the linkages between the approaches described in Table 2. Human capital and friction cost are considered to be techniques within the COI approach and are not included as separate entities in Figure 4.

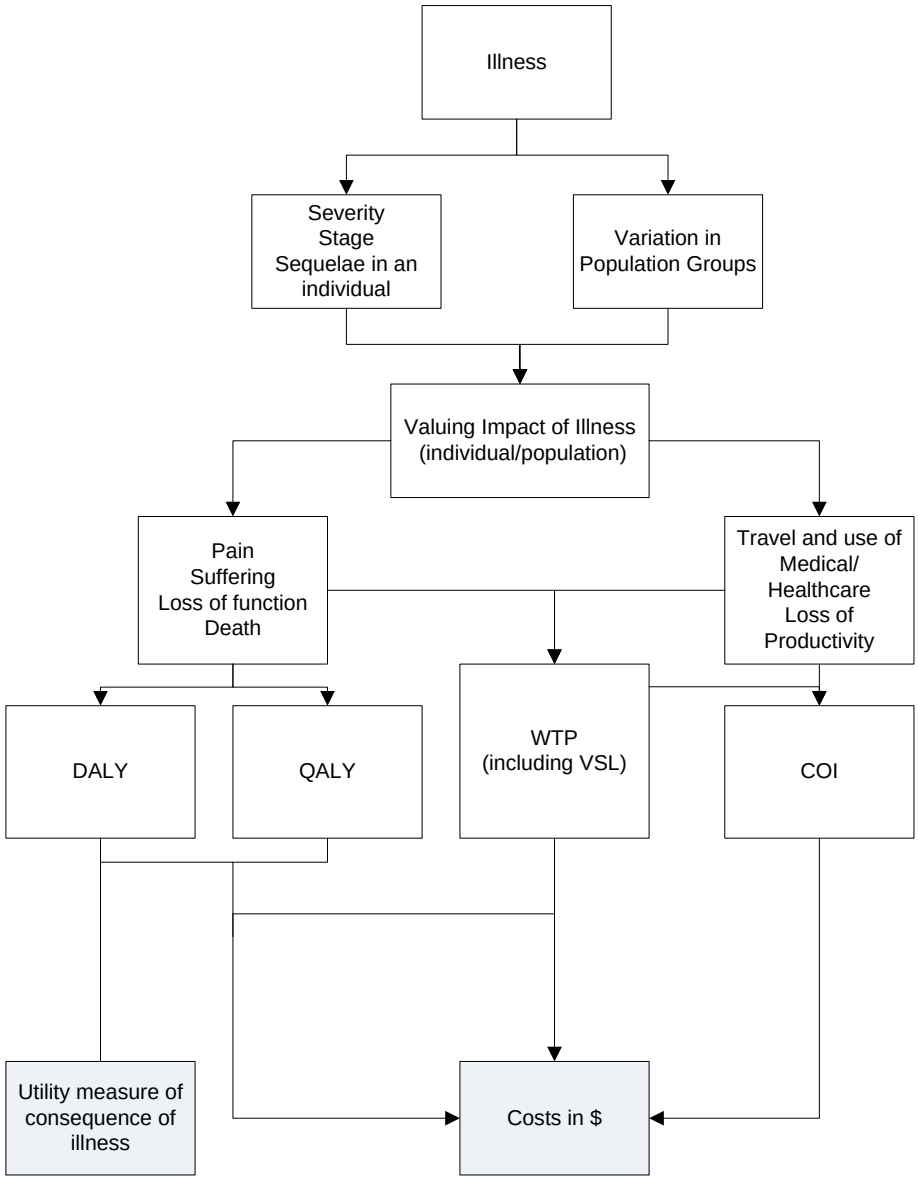

Figure 4: Approaches to costing illness

Utility (DALY/QALY) measures and monetary costs (from COI studies, or WTP) can be included together in an overall summation of the impact of a disease on a population.

4.2.3 DALYs and QALYs

Although an illness might have an impact on the number of years lived (mortality), it might also have an impact on the quality of years lived. Disability adjusted life years (DALYs) were developed by Murray and Lopez for the 1990 Global Burden of Disease project (Murray and Lopez, 1996a) and have since been used as a measure of burden of disease on healthy years lived in Australia (Mathers et al., 2000), and elsewhere (WHO, 2008).

One DALY is equivalent to the loss of one year of full health (WHO, 2008). The DALYs for a particular illness are calculated by adding the years of life lost (YLL) (based on an expected length of life) and the number of years lived with a disability (YLD) for each case of illness or symptom of illness weighted for that disability (WHO, 2008).

DALY = YLL + YLD

YLL (individual level) = standard life expectancy at age of death (years)

YLL (the population level) = number of deaths X standard life expectancy at age of death (years) (WHO, 2008)

YLD (individual level) = duration of the disease X disability weight factor (years)

YLD (the population level) = number of incidence cases X duration of disease X disability weight factor (years) (WHO, 2008)

If an illness does not have a mortality component then the DALY corresponds to the numbers of years lived with disability, weighted by the severity of that disability. Disability weights within a scale of 0 to 1 are used where 1 = death and 0 = perfect health.

According to Essink-Bot and Bonsel (2002 p.449) 'disability weights are needed if the severity of the consequences varies *between* diseases, and, *within* a disease, between various stages of the same disease, *and* if it is considered necessary to take these differences into account'. To estimate the consequences of zoonotic diseases on the number and quality of life years, it is necessary to take these differences into account.

A DALY can be presented for each case or for a given population by multiplying the DALY for an individual by the incidence or prevalence of the disease. Level of burden can therefore be presented at the level of the individual or population.

Quality of life years (QALYs) are typically used as a measure of healthy years gained in cost-effectiveness or cost-utility evaluations of specific interventions or policies. In these studies the number of QALYs gained as a result of an intervention is measured. However, QALYs *lost* as opposed to QALYs *gained*, have been used to measure the impact of an illness on the number of years in full health, and are similarly weighted using a scale of 0 to 1, but with 0=death, and 1= full health, the reverse of that used for DALYs.

Although QALYs and DALYs were developed for distinctly different purposes (QALYs for assessing the impact of interventions on the quality of life years gained and DALYs for measuring burden of disease on disability adjusted life years), the US Food Safety Consortium Report on Priority Setting for Foodborne and Zoonotic Pathogens suggests that both utility methods are suitable as measures of disease burden for foodborne illness (Batz et al., 2007).

There is some debate in the literature about the interchangeability of these two measures. Sassi (2006) argues that 'although QALYS and DALYs stem from the same broad conceptual framework, they are not interchangeable, as they are partly based on different assumptions and different methodologies…' (Sassi, 2006, p407). However, Sassi's argument is more concerned with the replacement of QALYs with DALYs in intervention studies rather than with the replacement of DALYs with QALYs in burden of disease studies. In relation to intervention studies, the potential DALYs saved for a particular policy option can be used (see example; Haby et al., 2006). Hence, the purpose of the burden of disease data needs to be considered when choosing which Health Adjusted Life Year (HALY) to use.

It is important to understand the 'systematic differences between the two measures' (Sassi, 2006) if QALYs are to be considered for to measure burden of disease. Sassi (2006) and Gold et al. (2002) provide an excellent overview of QALYs and DALYs in measuring burden of disease (Sassi, 2006, Gold et al., 2002). Together they highlight differences in the methods used to derive disability/quality weights - both in the type of stakeholder groups used to make value judgments about their perceived burden of disease and the technique used for deriving weights from them; whether the weights consider age, time preferences (discounting), co-morbidities, and different disease severities; and the different life tables used to determine life expectancy (from which life years lost are derived). See Table 3 for a summary of the differences between each of these characteristics.

Table 3: General differences between QALY and DALY

Characteristic	**QALY**	**DALY**
Attachment of utility	Health states[3]	Disease
Weights typically used	General population Patient groups	Experts[4] Community groups
Weight preferences typically used[5]	Standard gamble (SG) Time-trade off (TTO) VAS Existing summary measures of health status (e.g. EQ-5D, HUI, SF)	Person trade off (PTO)[6] +/- VAS[7]
Age-weighting function option	No	Yes (an option)
Time discounting option	Discrete	Continuous
Co-morbidity option	Yes	Yes[8]
Life tables	Observational and clinical studies Standard population life expectancy tables	Standard life expectancy tables in country specific populations

[3] Health States from which QALYs are derived include Health Utilities index, Quality of Well-Being Scale (QWB), EQ-5D (EuroQol), and the Health and Activity Limitation Index (HALex), and derivates of the SF-36.
[4] Expert panel (GBD Study), Community (GBD, 2010 to be published 2012).
[5] The option is there to use other valuation methods. These are typical methods.
[6] GBD Study 1990.
[7] Dutch weights (Stouthard et al. 2000) derived from a combination of PTO and Visual Analogue Scale (VAS)
[8] Gold et al. (2002) argues that Disability States in DALYs do not 'take account of comorbid conditions'. However, the Australian BoD studies considered co-morbidities in calculating YLL (See Mathers et al. 2000).

(Essink-Bot and Bonsel, 2002) described the valuation methods for determining DALY or QALY weights. These include the time trade-off (TTO), standard gamble (SG), person trade-off (PTO) and visual analogue scale (VAS).

The TTO method involves asking people what they would be willing to sacrifice in time (e.g. years) in their current health state to be restored to a (shorter period) of perfect health. This method is a popular technique for determining QALY weights. The SG technique involves asking respondents what they are willing to sacrifice in risk of immediate death for perfect health (see Figure 5). Along with the SG, a potential drawback is that the use of this approach may be culturally determined, with some cultures or value sets repudiating any kind of implicit gamble.

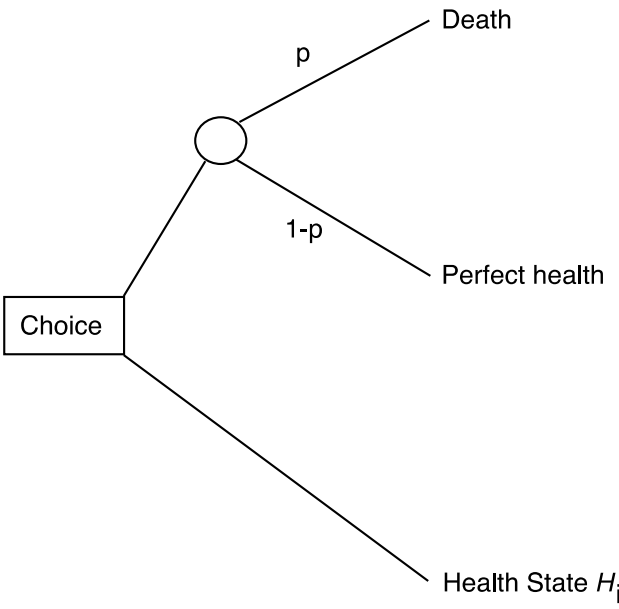

Figure 5: Illustration of the choices made in Standard Gamble Technique (Source: Burgman, M.A. (2005) *Risks and Decisions for Conservation and Environmental Management*. Cambridge University Press, Cambridge)

PTO involves asking respondents what they would be willing to sacrifice in lives of some people in order to provide health benefits to other people (Nord, 1995). VAS involves asking respondents to position the strength of their preference for a given health state on a scale between full health and death. One of the reported strengths of this scale is its ease of use (Essink-Bot and Bonsel, 2002). However, a weakness is

that results tend to show 'relatively high VAS disability weights for relatively mild conditions' (Essink-Bot and Bonsel, 2002).

Weaknesses of the trade-off techniques are that they are relatively difficult to perform by people without specific training and they are not suited to short-duration diseases (Essink-Bot and Bonsel, 2002). On the other hand, they are useful because they can be used from the perspective of the 'third person' - that is, the respondent doesn't need to have experienced the disease or health state (Essink-Bot and Bonsel, 2002). This allows the valuing to be undertaken by health experts. In their review, Gold et al. (2002) suggest that values for health states are 'fairly consistent across groups in general', but that some studies have shown poor correlations (e.g. Slevin et al., 1988).

The downside of these methods is they are subjective and can be influenced by the context of the health state being 'weighted' and its associated risk factors, the framing of the questions used to prompt a response (Fischoff et al., 1982, Gilovich et al., 2002), respondent selectivity bias, and the personal values and preferences of individual respondents (e.g. general population or disease specific respondents). To avoid reliance on any one technique or stakeholder group, and where possible, a random, stratified sample of value-based assessments should be aggregated into a community or population assessment. For example, DALY weights were derived from expert panels in the Global Burden of Disease study (Murray and Lopez, 1996b). However, to gather input from a broader 'cross-section of respondents spanning diverse cultural, environmental and demographic circumstances' a research consortium[9] has been leading a significant revision of the global burden of disease method, whereby disability weights are being re-estimated for a set of about 230 sequelae of disease and injury causes (Salomon, 2010).

4.2.3.1 QALY or DALY to measure burden of zoonotic disease?

Which of the QALY or DALY measures is the most suitable for zoonotic diseases given that a large number of diseases need to be considered, data are typically scarce, and many of the diseases are novel, so that few people have direct experience with their symptoms? In relation to the weighting methods used and described above, if the disease is rare in the community and/or has complicated or long-term sequelae (e.g. vCJD), then weights derived from the patient or community are less likely to be based on a comprehensive understanding of the extent of the true impact of the disease and for this reason the health states should be carefully described. Weights derived from expert 'medical' panels may be more

[9] The research consortium includes Harvard University, Johns Hopkins University, University of Queensland and the World Health Organization.

appropriate, particularly if the objective is to maximise net social benefit over many diseases and social contexts.

An alternative, more common and cost-effective approach to developing DALY weights specific to a population, is to use existing DALY weights derived from other populations (which use trade-off scales and expert panels). Examples of available weights are the Global Burden of Disease Study derived disability weights[10] and the Dutch weights (Stouthard et al., 2000)[11]. For those diseases or sequelae that are not represented in either of these sources, an alternative approach used by the Australian and Victorian Burden of Disease studies (Mathers et al., 2000) could be used, which adapted the methods used in the Global Burden of Disease Study (GBD). The Australian Burden of Disease studies differ to the Global Burden of Disease Study (GBD) in that calculations of YLL used Australian projected life expectancies, did not use age weights; considered co-morbidities; and used Dutch disability weights (Mathers et al., 2000) for conditions prevalent in developed countries, supplemented by weights used in the GBD study for other health states (Victorian Department of Health, nd).

Some weights for diseases were not available from the Dutch or GBD studies. To overcome this, the Victorian Burden of Disease Study estimated provisional weightings for disease states that had matched health outcomes defined in the EuroQol (EQ-5D+) using regression analysis (Victorian Department of Human Services, 2005). The Victorian Burden of Disease Study also asked experts to extrapolate weights for some mental disorders. In the Australian Burden of Disease Study, weights for some conditions were derived from Dutch weights of 'like' conditions. For instance, in developing disability weights for rubella, (for which none were available in the GBD or Dutch Studies) the analysts used measles disability weight of 0.152 and a duration of one week (AIHW, 2007).

DALYs seem a useful approach for measuring the burden of zoonotic diseases for the reasons outlined above, but QALYs are seen by some researchers to be useful for measuring the burden of foodborne illnesses (Batz et al., 2007). If resources were available to develop weights, then QALY weights that are typically derived by trade-off methods from the patient perspective could be developed. QALY weights can be developed directly from specific patient groups, using a utility instrument and 'stock' QALY weights (Mortimer and Segal, 2008). They can also be derived from experts or modelled.

[10] Disability weights have been derived from the original GBD 1990 study, GBD 2010 study is revising existing disability weights and should be available 2013. Note GBD 2004, used a combination of GBD 1990, Dutch, and GBD 2004 disability weights.

[11] Dutch weights: 52 diseases (175 disease stages) used a similar methodology to the global burden of disease weights, but used more detailed disease stages/severities weightings. Each disease stage was defined using modified version of the EuroQuol.

A number of arguments exist for using DALYs rather than QALYs for burden of disease studies. Gold and colleagues suggest that QALYs and DALYs should be used for their original purpose. Although each has proved 'serviceable for their initially intended uses' (Gold et al., 2002; p130) when these uses extend beyond their original purpose in relation to population health burden of disease (DALYs) and medical care intervention effectiveness studies (QALYs), interpretations may lead to invalid conclusions. Gold et al. refer to a previous study of theirs (Gold and Muenning, 2002) that interchanged the two utility instruments for disease burden estimation, and observed differences in both the estimates and the rank order of the illnesses ('differing priorities') across diseases and socio-demographic groups. These variations were reported to be due to inherent differences in the valuing methods used to derive the DALY and QALY weights (e.g. time trade off, person trade-off), the populations sampled (e.g. health professionals v representative community sample) and the incorporation of co-morbidities (Gold and Muenning, 2002). It is unclear from the results of this study which of the two measures provide the most accurate estimates and rank orders of burden of disease. However, it is clear that the same HALY measure should be used when comparing burden across diseases or across population groups.

One thing to note is the use of severity weights in deriving DALYs for diseases with different stages or severities of illness. Although it is preferable to use them, according to Essink-Bot and Bonsel (2002, p. 452) 'there is no use in deriving disability weights for detailed disease stages if there is nothing to multiply them with, that is, if corresponding epidemiological data on the frequency of occurrence of these stages is not available. The level of detail and reliability of the disability weights should approximately equal that of the epidemiological data'.

Different sources of epidemiological data may provide different estimates of disability weights. Melse et al. (2000) present an example that illustrates how disability weights for hearing impairment based on cases in medical practices might be more severe than those based on hearing impairments detected in population surveys. This raises the issue of generalisability of disability weights across settings or disease severity classes when deciding whether to use disease specific or population based weights.

Both QALYs and DALYs may incorporate age-weights which give 'greater value to years lived in young adulthood and less years lived at the beginning and end of the life span'(Gold et al., 2002), and discounting, which is based on societal preferences of a healthy year now rather than in the future (Essink-Bot and Bonsel, 2002). Arguments for their use are discussed by (Gold et al., 2002), (Melse et al., 2000) and (Bognar, 2008). The initial Global Burden of Disease project (1990), disability weights were age-weighted (Melse et al., 2000), while the Dutch disability weights and the Australian DALY studies were not. In relation to discounting, the Australian burden of disease studies and the Global Burden of

Disease study used discounting (WHO provides DALYs with and without discounting for transparency), while the Dutch disability weights were not discounted.

Looking at effects, and therefore discounting, over time, is critical for assessing costs especially when modelling impacts which may be both short and long term (e.g. the impact of BSE on blood donation, and the consequent impact on the supply of blood services). However, there is no clear consensus on age-weighting, uniformly or non-uniformly. Age-weighting has been reported to lead to double-counting since DALYs incorporate degrees of premature death (based on current age at mortality and life expectancy) (Bognar, 2008). It has also been described as failing to capture important elements of 'productivity' (if productivity loss is the justification for its use) and '…introduces too much into measures which attempt to reflect only one dimension of well-being – the impact of health [or ill health]' (Bognar, 2008; p187).

Co-morbidity weights can also be considered in burden of disease studies. Although the Global Burden of Disease Study did not consider co-morbidity weights, the Australian Burden of Disease and Victorian Burden of Disease studies did, the latter incorporating co-morbidity weights for mental disorders, injuries and non-fatal disorders of old age (Victorian Department of Human Services, 2005).

4.2.3.2 Studies using QALYs and DALYs in foodborne and zoonotic diseases

Most studies of the burden of foodborne and/or zoonontic diseases used DALYs in their estimations. Applied Economics *Guide to Estimating the Cost of Foodborne Disease and Evaluating Regulation of Food Production* (2010) (FSANZ, 2010) did not specifically recommend DALYs or QALYs to measure the burden of disease, but it presented an example that used DALYs.

The DALY was used to determine the annual cost of foodborne illness in Australia for the Australian Government Department of Health and Aging (Abelson et al., 2006), and was also used in the Dutch study of the disease burden and costs of enteric pathogens (Kemmeren et al., 2006). However, the Foodborne Illness Risk Ranking Model (FIRRM), developed by Batz et al. to compare the relative burden to society of foodborne pathogens in the US, relies on QALYs (Batz et al., 2004). In reflecting on the different QALY and DALY methods used for studies of the burden of foodborne illnesses, Mangan et al. (2010) concluded that the choice of measure was largely driven by the background and working environment of the scientists, rather than explicit value judgements of which measure is better (Mangan et al., 2010).

Some studies only focused on life years lost, without the quality component (e.g. life years lived with disability). Benedictus et al. (2009) estimated the cost-effectiveness of Bovine Spongiform Encephalopathy (BSE) intervention strategies on the number of human life years lost/saved (Benedictus

et al., 2009). The cost-effectiveness of all BSE interventions ranged from 4.3 million euros per life year saved in 2002, to 17.7 million euros in 2005 (Benedictus et al., 2009). If their study included wider measures of burden (e.g. life years lived with disability, direct health care costs), then the costs associated with this burden would have been greater.

4.3 COST OF ILLNESS

Cost of illness (COI) studies provide estimates of the costs, in monetary terms, of the burden of illness and have been used by many Government agencies both in Australia and overseas (Australian examples include: Stephenson et al., 2000, Collins and Lapsley, 2008, Walker et al., 2003).

In the estimation of dollar costs associated with an illness, COI studies can include direct costs associated with the diagnosis, treatment and rehabilitation or management of an illness; indirect healthcare related costs (e.g. travel to health services, waiting, informal carers, house fittings); and indirect non-healthcare related costs (e.g. loss to productivity, and those costs to other economic sectors). COI studies typically only include direct costs to health and loss to productivity. Indirect non-health costs that might include impacts on the wider economy are typically omitted. As a consequence, the full economic impact of illness is underestimated because COI studies do not consider the general equilibrium costs to the economy.[12]

Akobundu et al. (2006) reviewed 365 published COI studies and found the direct health care costs of illness generated in these studies included (in order of highest to lowest frequency): emergency department/hospital services, outpatient/physician services, drugs, diagnostic procedures/laboratory tests, other healthcare services (e.g. nursing home and long-term care facilities, community health, home health care), and least of all, allied health services (e.g. physiotherapy, psychological services, occupational therapy). Again in order of highest to lowest frequency, direct and indirect non-health care costs considered included patient loss of productivity, care giver/informal care opportunity costs, transportation, and home re-modelling (Akobundu et al., 2006).

[12]The Monash general equilibrium model simulates the indirect effects of different disease scenarios (e.g. future HNIN epidemic) on the non-health sectors (Verikios et al. 2010). While this method could be useful in identifying the indirect effects of zoonotic diseases, its use in COI studies would depend on the ease with which these indirect effects can be costed in monetary terms.

COI studies only include the 'tangible' costs that can be readily and transparently quantified in dollar terms and do not normally include the 'intangible' costs associated with the personal individual burden of illness such as pain, suffering, and loss of functioning. These burdens of illness can be valued using the DALY or QALY summary measures described earlier (FSANZ, 2010) and are sometimes presented alongside COI monetised costs but are not considered part of the COI study protocol. The burden of illness can also be considered in terms of WTP (see later).

It is outside the scope of this report to describe how to undertake a COI study.[13] It is recommended that the standard text by Drummond (2005) provides a framework for assessing costs in COI studies. Rather this report highlights those aspects that would need careful consideration if using this approach in the estimation of the monetary cost of illness associated with zoonotic pathogens. In their review of COI studies, Akobundu et al. (2006), and later Clarbaugh and Ward (2008) found varied approaches employed across the studies (Clabaugh and Ward, 2008). Clabaugh and Ward suggested that policy-makers should be wary of the methods used to derive cost estimates in the absence of an agreed set of standards to guide the design of COI studies. Australian researchers Larg and Moss (2011) developed a guide to the critical evaluation of COI studies. They undertook an examination of the appropriateness of the various COI methodological options for particular study purposes and disease types and described a number of methodological options for COI studies that require careful consideration when developing the study protocol (Larg and Moss, 2011). Options for consideration include the following:

- Prevalence- versus incidence-based approach
- Top–down or bottom–up approach
- Inclusion and exclusion of costs
- Method for measuring costs due to loss of production

The guidelines by Larg and Moss (2011), along with the earlier reviews by Akobundu et al. (2006) and Clabaugh and Ward (2008) have informed the following discussion about the most suitable COI approach for the estimation of the monetary cost of zoonotic diseases. It is recommended that these sources be examined for a more detailed account of the methodological issues concerning COI studies.

[13] See Drummond (2005). This is a standard textbook that provides a framework for assessing costs in COI studies.

4.3.1 Prevalence- versus incidence-based approach

Incidence-based studies estimate life-time costs of illness for new cases of illness. In contrast, prevalence-based studies estimate actual costs of illness of all cases over a defined period (e.g. 12 months), regardless of the date of onset. Prevalence-based methods are said to be the most popular because case-fatality rate and course of illness data are not needed (Segel, 2006).

Data collection and analysis methodologies differ considerably between prevalence and incidence-based approaches in the studies reviewed by Clabaugh and Ward (2008). Prevalence-based studies used cross-sectional data, while incidence-based approaches more commonly used linked data (e.g. insurer claims data) that allowed new cases to be identified and followed over the course of illness (Clabaugh and Ward, 2008).

Prevalence-based approaches in COI studies are considered to be the most suitable for assessing total current monetary burden of a health problem (Larg and Moss, 2011). However, given that it would be preferable to estimate life-time costs of illness associated with zoonotic diseases, the incidence-based cost to illness could be the most appropriate approach. Incidence-based costs can, however, be derived from annual prevalence-based data. According to Segel (2006) 'Lifetime costs can be calculated from annual costs, assuming a steady state of disease incidence, progression, survival rate, and treatment, but the estimates may not be as accurate as using actual longitudinal data on the full course of the illness because of potential future changes in medical care technology and other assumptions' (p9).

Since many zoonotic diseases cause temporary/acute ill health (immediately after exposure or after a latent period) followed by full recovery (e.g. cutaneous transmission of Anthrax, ornithosis), or death (e.g. Australian bat lyssavirus, Hendra virus), incidence and prevalence methods are likely to yield similar results. However, some zoonoses (e.g. brucellosis and Q fever) can have chronic relapsing clinical signs and symptoms that last for years. Although length of life may not be reduced for some of these diseases, quality of life can be severely affected.

For estimating the lifetime monetary costs of illness associated with zoonotic diseases using the incidence-based approach, longitudinal data could be obtained from retrospective or prospective observational studies of exposures in Australia or other countries (if exposures have not occurred in Australia) and modelled to obtain lifetime costs if the illness attributed to the zoonotic agent has consequences beyond the life of the study. If exposure to the zoonotic disease has not occurred in Australia and there have been no cases of illness attributed to the zoonotic agent, then data on the progression of disease, healthcare utilisation, and days off work etc. would need to be collected from new

cases that arose during a predefined year, and the costs estimated. If cases occurred in another country, then costs related to the Australian setting would need to be extrapolated by linking healthcare resource use and productivity losses in these countries to Australian health care costs.

Prevalence-based approaches, which can also be performed retrospectively or prospectively (Tarricone, 2006), would involve undertaking a cross-sectional study of cases, and identifying the cost per case over a particular period (e.g. the past 12 months). If there are no cases in Australia, data on the use of health services, productivity losses etc. would need to be collected in countries where there have been cases, and these data could be extrapolated to Australian health care costs and context. If secondary data from other countries are to be used, the choice of incidence- or prevalence- based approaches will depend on the nature of the data available, noting that incidence-based costs can be modelled from prevalence-based costs (Larg and Moss 2011; Segel 2006). It would be difficult to undertake primary data collection in other countries, although research partnerships could be set up to collect the relevant data for COI estimations.

4.3.2 Top–down versus bottom–up approach

COI studies are distinguished by the starting point of data analysis. For the top–down approach, analysis begins with use of health care at the population level, and travels downwards to identify the fraction of healthcare resource use that is attributable to a disease or its component co-morbidities. The cost allocations are based on these fractions, the sum of which provides the total population cost of illness (direct health care costs only) for the particular disease. If this approach were used in a COI study of a specific zoonotic disease, then the total healthcare expenditures for a disease of interest for all causes would be collated. Costs attributed to zoonotic agents could then be calculated from the fraction of the disease (for all causes) that could be attributed to the agent. This would be done for all health care expenditures related to the zoonotic disease, the sum of which would give the total population cost of the condition (direct health care costs only). The accuracy with which disease may be attributed to zoonotic agents creates uncertainty in the estimation.

In contrast, the bottom–up approach starts at the case of disease and estimates the direct and/or indirect costs (healthcare and non-healthcare) attributed to each person's resource use. Data on real cases or from other sources (e.g. published unit costs or charges, or published observational studies) are used to construct hypothetical cases that are used to 'assign resource use and productivity loss to individuals' (Larg and Moss, 2011). Mean per-person costs may then be multiplied by incidence or prevalence of disease (attributed to zoonotic agent) to calculate total population costs of illness (Larg and Moss, 2011). This approach is suitable for a COI study of zoonotic disease. Box 1 illustrates a top–down approach used

by the Australian Institute of Health and Welfare in estimating disease costs (AIHW, 1998), and how this approach compares to the bottom–up COI approach.

According to Larg and Moss (2011), bottom–up approaches (also called person-based methods) are likely to be more comprehensive and provide better opportunities to identify differences in frequency of healthcare service use, and isolate costs specifically attributable to the disease of interest compared with top–down approaches. The bottom–up approach would also be useful for identifying differences in the duration and intensity of health service use.

The top–down approach tends to depend on the availability and quality of data that can be used to allocate service use to specific diseases or co-morbidities. Consequently it has limited scope in capturing all costs associated with complex diseases (Larg and Moss 2011). However, top–down approaches may be better suited to highly prevalent conditions compared with bottom–up approaches (Large and Moss 2011). Most zoonotic diseases are unlikely to be highly prevalent in humans — another reason to use bottom–up approaches in COI studies when measuring morbidity and mortality related monetary costs. Larg and Moss (2011) argue that the bottom–up approach is suitable for prevalence-based costs, incidence-based costs, and productivity costs, while the top–down approach is suitable only for prevalence-based costs.

The econometric (Segel, 2006) or incremental approach (Akobundu et al., 2006) is sometimes included within the bottom–up approach or is described as a separate approach all together. It compares the incremental difference in costs between a population with the disease and a group without the disease. Regression analysis and/or matching is used to address potential confounders (e.g. age, gender, risk factor)(Segel, 2006). Larg and Moss (2011) suggest that this approach is not as important when there are few co-morbidity related costs or when these are negligible compared to the primary condition which might be the case for many zoonotic diseases. They also point out that although regression

Box 1. A top–down approach was used in the AIHW Disease Costs and Impact Study (DCIS) (AIHW, 1998). This approach started from the top, by using known aggregate expenditure data on health care and apportioning these data to disease categories using Australian hospital morbidity data, casemix data, Medicare data , and other relevant survey data (AIHW, 1998).

In contrast, to implement a bottom–up approach the treatment costs of specific diseases would have to be calculated (or modelled) by combining actual (or modelled) costs for a cohort of patients who have that disease (AIHW, 1998). According to the AIHW, the bottom–up approach might produce more accurate estimations of the true costs of health expenditure, but its rationale for using the top–down approach is that it ensures consistency of estimates, complete coverage of all diseases, and that cost estimates for individual disease and age–sex groups would, together, 'add to the known total health expenditures' (AIHW, 1998) .

techniques are useful for adjusting for confounding in bottom–up approaches, the relevant data on covariates are not always available. Akobundu et al. (2006) suggest that matching and regression techniques that rely on a comparison group may not pick up all potential confounders. It cannot be assumed that the two groups are randomly selected and therefore similar for all factors apart from disease status. They suggest that these techniques are less prone to bias for conditions that are not influenced by genetics, lifestyle choice and risk preferences (Akobundu et al., 2006). Examples they use to illustrate this are Lyme disease, malaria and influenza. They argue that these conditions are less likely to occur through any conscious behavioural choice and are consequently more likely to occur randomly within the population (Akobundu et al., 2006). This might also be the case for some zoonotic diseases.

Larg and Moss (2011) define as 'specificity' the precision with which the costs are due solely to the condition of interest. They define 'sensitivity' to be the ability to capture the full extent of the effects of the condition (e.g. frequency, duration and intensity of health care use). For top–down approaches specificity relies on the accurate allocation of costs to diseases, the use of relative risks of disease or use of health care services for individuals with the problem, and the prevalence of the health problem used to calculate Population Attributable Fractions (PAFs).

The accuracy of PAFs depends on the relative risk estimates, which can vary widely between studies. PAFs may not account for diseases that are not directly caused by a zoonotic disease, but that might be aggravated by it, thereby reducing the sensitivity of the cost. Although PAFs are not always used in top–down approaches (e.g. Box 1), the accuracy of the allocation of health service expenditure to a specific disease (specificity) and any interacting risks or associated impacts (sensitivity), is highly influenced by the quality of data.

Bottom–up approaches, particularly for diseases or conditions which are likely to have co-morbidities that have high healthcare costs, can use matching and regression techniques to provide greater 'capacity to isolate the costs specifically attributed to the disease in question' (Larg and Moss 2011, p. 663). In the rare instance where zoonotic diseases could include illnesses with complex co-morbidities or sequelae of different disease states, statistical techniques may build confidence in the specificity of the costs to the illness of interest.

In relation to whether a top–down or bottom–up approach be used in COI studies, the points raised above strongly suggest that a bottom–up approach is more suitable for measuring monetary burden of illness due to zoonotic diseases. This conclusion is supported by Tarricone (2006) who asserts that COI studies 'need to be bottom–up and [that] the top–down approach has to be definitely abandoned' (Tarricone, 2006).

However, there are others who consider top–down approaches preferable. Batz et al. (2007) in their method for priority-setting for foodborne and zoonotic diseases in the US, implemented the top–down approach by using surveillance data on zoonotic illness and then tracing these illnesses back to the food origin. They argued that the top-down approach is preferable for 'big-picture comparisons of foodborne risks', but is 'inadequate to isolate the causes of illness along the farm-to-table pathway' (Batz et al., 2007).

In the case of infectious diseases due to zoonoses, one of the difficulties with the bottom-up approach may be the allocation of costs incurred to any one disease which are not unique to that disease. For example, a particular service might serve a number of infectious diseases and apportioning the costs between the diseases would be difficult.

On a practical level, top–down costings are often undertaken as data are often more readily available and less costly to collect. Given the data requirements and time taken to conduct the study it would be more costly to use bottom–up costings. However, given the potentially significant investments in disease management associated with zoonotic diseases, now and in the future, the investment in data is likely to be justified in terms of the accuracy in the estimates of costs obtained.

4.3.3 Inclusion/exclusion of costs in COI studies

It is important to consider the costs that are to be included and excluded from any COI study. In determining which are to be included, the perspective of the 'payer' needs some careful thought. Are the costs to be borne by society in general, the health system/health sector, third-party payers, business, government, patients or the family? If an analysis takes a societal perspective, then all direct and indirect costs would need to be considered. From the health systems perspective, only treatment costs would need to be considered. Although health sector perspectives often exclude the clients and their families as well as government (as third-party payer) and thus exclude their perspective and the costs borne by them), some analyses of the health sector have included these. There is no standard list of what not to include or exclude when adopting particular perspectives. As Segel (2006) points out, the purpose of the analysis determines the perspective. For the estimation of costs due to zoonotic diseases, decisions are likely to require a relatively broad social perspective. That is, analyses should include the perspective of the patients and their families, government, businesses (e.g. loss of productivity), and the wider society. Whichever perspective is adopted, it is possible and usually useful to present the costs separately for each (Segel 2006).

In their review of 52 US COI studies that estimated direct costs Clabaugh and Ward (2008) found approximately half represented a societal perspective, and one third the perspective of the employer or insurance-based health care provider (Clabaugh and Ward, 2008). The perspective of government as third-party payer was presented in less than one tenth of the studies (4/52), the caregiver/patient in around one twentieth (3/52). None reflected the perspective of the health care system (Clabaugh and Ward, 2008). Of the COI studies reviewed, Clabaugh and Ward found that many had focused on a sub-set of total health care expenditures rather than all expenditures associated with a particular disease or illness. This review made it clear that the appropriate perspective should be identified in COI studies, that all relevant costs should be included within the chosen perspective (s), and that these be explicitly stated (Clabaugh and Ward, 2008).

There are some unresolved issues in COI studies. For instance, how should we measure the lifetime cost of those who die prematurely? We should include the consumption saved from these early deaths as a saving to be subtracted from the direct and indirect costs while alive and the lost production from the early death. Saved consumption would include the consumption of health care avoided as well as general consumption. Of course, other formulations are possible. Whatever COI model is employed, it should at least be standardised among applications and jurisdictions, to ensure the comparability of analyses.

As mentioned above, COI studies typically only include direct costs to health and loss to productivity and that indirect non-health costs that might include impacts on the wider economy are typically omitted. As a consequence, the full economic impact of illness is underestimated because COI studies do not consider the general equilibrium costs to the economy.[14] These consequences could be substantial. For instance Lee and McKibbin (2004) reported that 'Most previous studies on the economic effects of epidemics focus on the disease-associated medical costs or forgone incomes resulting from disease-related morbidity and mortality, but the most significant real costs of SARS have been generated by changes in spending behaviour by households, and firms in affected countries...having wide-ranging general equilibrium consequences for the world economy that can lead to economic losses well in excess of the traditional estimates of the cost of disease" (p113). In relation to SARS, entire populations within countries affected directly by SARS and those not affected, had changed their behaviours, subsequently influencing demand

[14]The Monash general equilibrium model simulates the indirect effects of different disease scenarios (e.g. future HNIN epidemic) on the non-health sectors (Verikios et al. 2010). While this method could be useful in identifying the indirect effects of zoonotic diseases, its use in COI studies would depend on the ease with which these indirect effects can be costed in monetary terms.

for goods and services (e.g. consumption demand in areas such as tourism, restaurants, air travel) and costs associated with screening and prevention. Lee and McKibbon estimated that the global economic loss from SARS for Hong Kong alone was 2.63 percent of GDP (Lee and McKibbin, 2004).

While different COI purposes may require the adoption of different perspectives, the societal perspective is the most comprehensive because it includes direct and indirect costs. As well as being useful for determining the cost of the impact of disease due to zoonoses, and comparing these costs with other zoonotic and non-zoonotic diseases, the societal perspective is recommended for cost-benefit and cost effectiveness analyses.

4.3.4 Costs associated with loss in productivity

Batz et al. (2007) in their summary on Priority Setting for Foodborne and Zoonotic Pathogens for the US Food Safety Research Consortium, suggest, contrary to above, that the methods for valuing costs in COI studies are fairly similar, apart for the estimation of productivity costs (p. 22). Loss of productivity, which is an indirect non-health care cost, can be transformed to monetary costs using one of two techniques: the human capital (HC) or the friction cost (FC) method.

The HC method calculates the loss of potential paid and/or unpaid production losses but the FC method calculates loss of production losses until the worker is replaced (friction period). In the human capital approach, 'in case of permanent disablement or premature death at a specific age the total productive value (or income) from that age until the age of retirement is counted …' (Koopmanschap et al., 1995). Arguments against the HC method include that it overestimates actual economic losses because it assumes a society of full employment 'the loss of each affected person cannot be offset by another worker…' (WHO, 2009; p117) that would reduce the loss to productivity costs. Each of these methods is summarised in Table 4 along with their strengths and limitations.

Table 4: Methods for costing loss of productivity (mortality or permanent disability)

Method	Description	Strengths	Limitations
Human Capital Method	Loss of potential paid and/or unpaid production losses	Perspective of patient, family and business. Can include the value of household work (Hodgson, 1988)	Possibly overestimate costs in an economy with less than full employment (Tarricone, 2006) Assigns higher values for some groups than others unless assume same labour productivity for everyone (WHO, 2009)
Friction Cost Method	Loss of production losses until worker replaced (friction period)		Increased costs difficult to attribute to a particular disease (WHO, 2009) Does not capture diminished performance at work (WHO, 2009) Costs generated from the perspective of industry/business Needs data on income and friction period (Segel, 2006) Friction period may change depending on macro-economic climate (e.g. unemployment rate) (Tarricone, 2006) Employers use of 'internal reserves' until replacement is difficult to quantify (Segel, 2006)

To value unpaid and informal care a number of approaches are available: replacement or market value, functional value, opportunity cost, and self-valuation. For a detailed description of these, see Larg and Moss (2011). The Monash University study (Verikios et al., 2010) that explored the macroeconomic impact of pandemic influenza A H1N1 in Australia, demonstrated how the impact on labour force productivity in economic terms can be modelled. Perspectives that consider loss in productivity are critical to the assessment of the costs of zoonotic associated morbidity and mortality. Further information on modelling in relation to zoonotic diseases is presented in the Section 5.

4.3.5 General critique of the COI approach

Tarricone (2006) reiterated the argument made by others (Shiel et al., 1987, Drummond et al., 1986) that when COI s are used to set priorities, they may give priority to those diseases that are more costly due to the already large amount of resources allocated to them. This could be a problem if the allocation of resources has been inefficient. Tarricone presented a counter argument to this, saying that COIs can inform decision-makers about the resources utilised and if they have been inefficiently allocated, this can be remedied (Tarricone, 2006).

General strengths of the COI approach, according to the WHO Guide to Identifying the Economic Consequences of Disease and Injury (WHO, 2009), are that it is simple to implement with modest data

and technical requirements (e.g. use of secondary data that is easily accessible), and that costs can be disaggregated by type or for different perspectives (e.g. individual, government). However, weaknesses include the limited ability of the COI technique to compare results across studies because of the different approaches used, and that it fails to measure those intangible individual/family costs such as pain, suffering and loss of functioning. They also rarely, include direct non-health care related costs. Whether this is due to difficulty in their identification or costing is unclear.[15]

In their reviews, Akobundu et al. (2006) and Clabaugh and Ward (2008) presented a number of issues with the way COI studies were implemented that include:

- Reliability was not always assured
- Invalid estimates due to:
  - The process for identifying costs associated with an illness
  - Attributing the wrong costs or not including relevant costs
  - A lack of transparency regarding cost data; and
  - Adjustments made for co-morbidity/disease severity.

Akobundu et al. (2006) found that the COI methods adopted in the studies reviewed were not always appropriate for the disease setting, and that the differences in the methods led to significant variations in cost estimates between similar study settings. COI studies are very sensitive to the values they are based upon, and unless a sensitivity analysis is provided, it is difficult to assess their reliability and validity. Clabaugh and Ward (2008) suggested that policy-makers should be wary of the methods used to derive cost estimations in the absence of an agreed set of standards to guide the design of COI studies. The authors present a general list of 'disclosure and technical' standards that they believe should be established for these studies to promote their interpretation and replication, and comparisons between studies. Another useful published resource is the guide to evaluating the appropriateness of methodologies used in COI studies by Larg and Moss (2011).

[15]There are methods available for forecasting or identifying potential indirect non-health care costs[15] of disease risks (e.g. H1N1) – See Monash Equilibrium Model (Verikios et al. 2010).

4.3.6 Studies using COI in foodborne and zoonotic diseases

The Dutch study of the disease burden and costs of enteric pathogens by Kemmeren et al. (2006) used an incidence-based bottom–up approach[16] and adopted the societal perspective in the COI component of the study. The study measured direct health care and non-health care costs, and indirect non-healthcare costs (e.g. loss to productivity) but did not include indirect health care costs ('future savings in health care costs in the life years lost due to premature death'; Kemmeren et al., 2006; p12). The study used the friction-cost approach to measuring the monetary costs of loss of productivity due to illness. Costs of cryptosporidiosis and giardiasis in the Netherlands were also estimated in an associated study (Vijgen et al., 2007)

The US Food Safety Research Committee's Foodborne Illness Risk Ranking Model (FIRRM) is a decision-making tool that 'quantifies and compares the relative burden to society of 28 foodborne pathogens' (Batz et al., 2004). The COI component of their model included medical costs of illness and productivity losses, using the human capital approach, with estimates for both drawn from previous studies.

The US FIRRM model starts with the use of surveillance data, community studies and published literature to derive incidence of illness (cases) and associated health states and outcomes. It assigns likelihoods and costs to each to each outcome, implying a bottom–up approach. It then follows with a top–down approach by tracing incidence downward, using attributable fractions, to identify the food origin, similar to the Dutch study by Kemmeren et al. (2006). Thus although this model states that it uses a top–down approach, it seems to be only partially top–down. A fully top–down approach would have involved starting at the level of health service use and expenditure, narrowing down to identify the proportion due to a particular health outcome, and from this, using attributable fractions to identify the proportion due to a zoonotic agent and further again to food origin.

The Economic Research Service of the US Department of Agriculture developed a Foodborne Illness Cost Calculator (USDA, nd-b) that uses an incidence-based approach to their COI method similar to that used in the FIRRM model — and derived from methods described elswhere (Buzby et al., 1996). The calculator includes direct health care and indirect non-health care costs. The calculator also uses QALYs to estimate burden of illness and converts QALYs to $s using the value of a statistical life derived from WTP. These approaches are described elsewhere in this report.

[16] Although the bottom–up approach is used, they later use these costings to further narrow down the costs attributed to food pathogen using a top–down approach. They used 'food attributed fractions' based on outbreak and case–control studies, and expert elicitation (Kemmeren et al. 2006).

Rayner and Scarborough (2005) implemented a crude top–down method for quantifying the burden of food-related ill health in the UK (including cardiovascular disease, cancer, diarrhoea, nutrient deficiencies, and dental carries)(Rayner and Scarborough, 2005). The authors used WHO (Ezzati et al., 2004), Australian (Mathers et al., 2000) and European (NIPH, 1997) estimates of the population attributable fraction of all illnesses due to food to calculate the overall proportion of all DALYs that are food related. The estimate across the three studies ranged from 10 to 15%. The researchers then used this figure (10%) to estimate a proportion of all health care expenditure associated with food related diseases in the UK. See Table A1 in Appendix 1 for a more detailed listing of the costs included and the methods used for these and other COI studies of foodborne diseases.

4.4 WILLINGNESS-TO-PAY

Willingness-to-pay (WTP) measures (directly or indirectly) the amount individuals would be willing to pay to improve health or reduce the risk of illness. The amount in dollars that people are willing to pay to avoid an illness is considered to correspond to the monetary value of that illness. This approach is useful for including mortality, morbidity and other 'intangible' costs in a monetary valuation. When asked what people will be willing to pay to avoid an illness, they implicitly consider all possible effects of that disease on their lives, consequently including a range of intangible costs in their valuing of that illness (Drummond et al., 2005). Thus WTP, in the context of valuing a particular health state, assesses not only what people would be willing to pay to avoid a health state, but also to avoid the productivity losses and future health care costs that go with that health state (Drummond et al., 2005).[17]

[17] Drummond et al. (2005) note that to avoid double-counting, the respondent needs to be told explicitly which costs they should consider (e.g. income) arising from the disease.

4.4.1 Techniques used to elicit WTP

Willingness to pay can be measured using one of two techniques (See Table 6): revealed or stated preference techniques.

Table 6: Techniques used to elicit WTP

WTP Method	Description	Strengths	Weaknesses
Revealed preferences (based on actual consumer choices) (Drummond et al., 2005)	Actual trade-off choices	Uses existing data (e.g. wages accepted for risk of injury at work)	Relies on real world situations and availability of data (Batz et al., 2007) Presumes rationale process reveals societal values (Drummond et al., 2005)
Stated preferences (survey methods)	Asking what a person is willing to pay for... (hypothetical situation)	Community, or expert panel Can be applied to any risk reduction or adverse health effect	Elicits response to hypothetical scenarios - questionable reliability (Hausman, 2012) Resource intensive and costly

Revealed preferences can be derived from hedonic wage analysis (which measures what income workers are willing to trade in risk) or hedonic price analysis (which measures what people are willing to pay for items to reduce risks) (Abelson, 2007). Stated preferences can be derived from contingent valuation approaches (asking people what they are 'willing to pay for a defined health benefit or a reduction in health risk') or by choice modelling (e.g. asking whether people are willing to pay an amount in dollars more for A than B) (Abelson, 2007). For a detailed description of these approaches, see Abelson (2007), Buzby et al. (1996), and (Australian Safety and Compensation Council, 2008).

WTP estimates can be developed by using one of these techniques outlined but either approach is resource-intensive (Batz et al., 2007). To overcome this, WTP estimates can be derived from existing (previously published) estimates (Batz et al., 2007). Unfortunately, they are not available for all health states and are unlikely to be available for new and emerging zoonotic diseases.

4.4.2 Advantages and Disadvantages of WTP

The advantages of the WTP approach include:

- It overcomes a disadvantage of COI approaches in that it allows the 'intangible' costs, that are otherwise not valued, to be translated into a monetary form and included in the overall cost estimation.
- It provides a way of providing a value, in dollar terms, for a reduction in risk of illness and its associated morbidity and mortality consequences.

The disadvantages of the WTP approach include:

- Intangible costs are implicitly valued. As a consequence, it is difficult to know to what degree people consider each of the various 'intangible' costs when determining what they would be willing to pay for a reduction in illness or risk of illness.
- Individuals value from their own perspective (Segel, 2006) so accuracy, reliability, and the potential for bias are difficult to determine.
- A WTP approach can be complex, time-consuming, and resource-intensive (Mangan et al., 2010).
- There is often a lack of discrimination between duration and severity of illness (Applied Economics, 2010b).

The arguments against the use of contingent valuation methods for estimating WTP have strengthened over the years despite efforts to address its associated problems. Hausman (2012) goes so far as to argue that contingent valuation should not be included in policy analysis as it does not provide a good basis for informed policymaking (p44). A recently published review of empirical evidence on contingent valuation (on environmental issues) reinforces the problems of hypothetical response bias that can lead to overstatements of value so that 'what people say is different from what they do" (p44), and large differences between willingness to pay to avoid a negative outcome and willingness to receive in payment in order to accept a negative outcome (Hausman, 2012), despite efforts by others to rationalise the gaps between these.

4.4.3 WTP and Value of a Statistical Life

The WTP approach can be used to assess what people are willing to pay to avoid an illness, as well as to avoid the risk of premature death. The latter is often referred to as the value of a statistical life. The value of a statistical life (VSL) is sometimes referred to as the value of risk reductions (VRR) (Hensher et al.,

2009) and is measured using the WTP approach. It refers to 'what an average individual in a population is willing to pay to avoid the risk of premature death' (Mangan et al., 2010) or as stated by the Australian Government's Office of Best Practice Regulation (2008) 'is an estimate of the financial value society places on reducing the average number of deaths by one' (OBPR, 2008). The value of a life lost is also used to determine the economic burden of mortality, and can be based on the human capital approach, where it represents the present value of future earnings foregone with premature death (Buzby et al., 1996). The clear advantage of the VSL approach (using WTP) is that it measures, in dollar terms, what people are willing to pay for a reduced risk of premature death, as opposed to the use of productivity losses (e.g. Human Capital Method) in COI studies to place a value on mortality[18].

The numerical VSL estimate derived by WTP is influenced by a number of factors. Values ranging from $0.5 m up to $50 m in 2000 US dollars (Bellavance et al., 2009) and $3m to $15 m in 2004 Australian dollars (Abelson, 2007) have been reported. Bellavance et al. (2009) analysed 37 studies from nine countries and observed a large variability in the VSL values generated. They found this variability was largely due to differences in method. For instance, they found that the VSL was influenced by the nature and source of the risk, the inclusion or exclusion of worker's compensation and insurance compensation, and the population under study (e.g. wealthier people generate higher VSLs). They also found that VSL-generated values were influenced by the country, year of publication, and race. The authors highlighted the importance of using appropriate methods and the need either to use representative samples or adjust the values to the target population (Bellavance et al., 2009).

The Australian Office of Best Practice Regulation (OBPR 2008) has produced a guidance note that outlines a method for VSL estimation to be used for the purposes of regulation. According to this note, the estimate of the VSL is $3.5 million in Australia and the value of a statistical life year is $151 000. This estimate is based on the work by Abelson (2007)[19]. The VSL represents an average and is based on a healthy person living for another 40 years (OBPR, 2008).

According to Abelson (2007), VSLs previously used in Australia include $1.57 m (NSW Roads and Traffic Authority in 2005), $1.36m (based on COI WTP) by Commonwealth Bureau of Transport Economics in 2000, and $2.5 m based on earlier recommendations (Abelson, 2003) that have been used

[18] According to Hensher et al. (2009) the greater focus on VSL compared with human capital methods in cost–benefit analysis has resulted in higher 'benefits for risk avoidance'. This has resulted in a higher social net benefit of safety policies justifying a greater allocation of resources to road safety interventions that previously were not seen to be socially profitable [http://sydney.edu.au/business/__data/assets/pdf_file/0007/25675/itls_wp_09_03.pdf]

[19] Abelson (Access Economics) has previously concluded that the VSL range lies between $3.7 m and $9.6 m, and adopted a mid-range estimate of $6.5 m). However the figure of $3.5 m used by OBPR, as recommended by Abelson (2007), is drawn from estimates in Europe.

by the Australian Government Department of Health and Ageing in estimating the 2006 annual cost of foodborne illness in Australia (Abelson et al., 2006). Many of these differences are partly due to the methods used in the estimations (e.g. human capital, revealed preferences, and stated preferences). VSLs derived from revealed preference methods have been found to be slightly lower than those using stated preference studies (Australian Safety and Compensation Council, 2008)[20].

Although the VSL can be estimated for individual regulations, interventions or risk sets, the OBPR argues that this is likely to be too resource-intensive to be undertaken for individual regulatory proposals (OBPR, 2008). The Office recommended that departments and agencies use the values of $3.5 million indexed by annual CPIs to the current year (cf the preceding estimates measured in 2007 dollars) and discounted for future years (OBPR, 2008).

Risk management involves estimating the reduction in future consequences that result from interventions imposed now. To estimate the benefits of risk avoidance strategies implemented now for morbidity or mortality that could occur in the future (e.g. zoonotic diseases, climate change), the potential incidence of mortality in the future would need to be modelled. Using the VSL to estimate total mortality-related costs at the population level would require multiplying the discounted VSL by the number of deaths.

Compared to the non-monetary DALY that incorporates a mortality function, the VSL approach is better suited for cost–benefit analysis[21]. Despite this, the DALY or QALY have been monetised using the VSL/WTP approach for use in economic analyses.

4.4.4 Monetising DALY/QALYs using WTP

Another use of WTP is to determine the amount people are willing to pay for a DALY or QALY. A number of economic analysts have published methods for monetising a QALY using the WTP approach (Pinto-Prades et al., 2009, Baker et al., 2010, Mauskopf and French, 1991). Mauskopf and French (1991) used previously published estimates of WTP to avoid particular illnesses and multiplied these WTP-derived dollar costs with the QALYs lost due to a particular foodborne-disease associated health state. For example, a previous WTP estimate to avoid chronic bronchitis ($18 500) was multiplied with the QALY weight 0.0493 (derived from Relative Utility Weights for the Rosser and Kind Health Status Index) to give the dollar value of one full QALY of $375 254 (Mauskopf and French, 1991). For premature death,

[20] Examination of 244 VSL studies across more than15 countries, showed a revealed preference approach mean VSL of A$9.6 m, with a median of $7.5 million) and a stated preference approach (mean of $11.2 million, median of $7.9 m) in 2006 Australian dollars (Australian Safety and Compensation Council, 2008).

[21] Some health economists firmly believe that CBA is the gold standard in economic evaluation techniques as it allows comparisons across different government programs.

they used the dollar value of avoiding a future case of premature death (WTP) of $5 million at age 40 derived elsewhere (Moore and Viscusi, 1988) and multiplied this by the QALY.
Pinto-Prades et al. (2009) reported a feasibility study into the estimation of a monetary value for a QALY (MVQ). They used two different survey WTP methods to assess how proportional the WTP was to health gains measured in QALYs. They found that the MVQ varied inversely with magnitude of health gain. They noted large variations in the estimates of the MVQ. They recommended further research to understand the sources of variability better (Pinto-Prades et al., 2009).

Baker et al. (2010) also reported a feasibility study that trialled a method for placing a dollar value on a QALY. Instead of asking people to value QALY gains or losses directly, they asked people to value avoidance of some states of illness (via WTP). They elicited a QALY for those states and then combined the two results to assign money values to the QALYs (Baker et al., 2010). For instance, using a convenience sample of 409 people, they asked each person what they were willing to pay to avoid different durations of head pain or stomach illness. Each person was then asked to value each state using the standard gamble (SG) technique, in which they had to scale each state between 0 and 1 (0=death, 1=full health). These results were combined to estimate a dollar value (derived from the WTP) for the QALYs (derived from SG) associated with each state. The authors recommended further investigations into key elements of the approach before trialling the method on a larger scale.

The Australian Government Office of Best Practice Regulation guidance note on VSL, suggests that the quality of life year component as opposed to just mortality can be incorporated into the VSL, if one considers it to equate to 'the value of a year free of injury, disease and disability'. Disability weights[22] can be used to adjust the VSL. The guidance note (OBPR, 2008) uses the example of an amputated foot with a disability weight of 0.3, equating to 30% of a VSLY or $45 300 per year using the OBRP recommended VSLY of $151 000 (0.3*$151 000)[23].

How useful would monetising a DALY/QALY be for the estimation of the burden of disease? As stated earlier, DALYs gained due to illness or QALYs lost due to illness can be used in the final presentation of an overall impact of disease analysis or can be further costed in monetary terms. Applied Economics' *Guide to Estimating the Cost of Foodborne Disease and Evaluating Regulation of Food Production* (Applied Economics, 2010b) describes how these can be translated to costs in dollar terms using an approach similar to that recommended by the OBPR (OBPR, 2008). To calculate the cost of utility, the

[22] OBPR suggests the use of the Australian Institute of Health and Welfare published disability weights

[23] In 2007 dollars

amount that people are willing to pay (WTP) for a year in good health (value of a life year or VSLY) is multiplied by the utility (DALY/QALY) for a particular health or disease state (Applied Economics, 2010b).

For instance, the total cost (TC) of the DALY in dollar terms would extrapolate to:

> TC=ΣDALYs x $151 000 for life year in good health (Applied Economics, 2010b) (based on Australian VSLY, OBPR, 2008).

An indirect way of monetising the DALY is to calculate the WTP to avoid an illness using the DALY weight. This was done by Abelson (2006) to calculate the annual cost of foodborne illness in Australia. Abelson used the following equation to calculate what people are willing to pay to avoid an illness:

> WTP= disability (DALY) weight x duration of illness in days x the value of a day of good health (VSLD derived from WTP)

The US Department of Agriculture, Economic Research Service's Foodborne Illness Calculator (USDA, nd-b) also provides a method for converting health disutility value to dollars.

Baker et al. (2010) support monetizing Health Adjusted Life Years (HALYs). They contend that deriving a value to a preference based QALY, for instance, would have potential value in allowing greater consistency in cost-benefit analysis across a broader range of public health and safety policies 'and in a way which better reflects the values of the people who are paying for, and benefiting from, those policies' (Baker et al., 2010).

A number of different methods for estimating a monetary value for a HALY have been trialled and require further research and refinement (Pinto-Prades et al., 2009, Baker et al., 2010). However, if a HALY is converted to monetary costs as undertaken by Abelson, the DALY/QALY and its dollar value should be presented separately for transparency and to assist in its interpretation.

When considering the use of VSL directly or in transforming life years lost to a monetary value, the nature of its genesis needs to be acknowledged. According to Sussman et al (2008), the VSL 'allows valuation economists to focus on how people respond to and implicitly value mortality risk in their daily decisions, rather than attempting to value the lives lost, *per se*' (Sussman et al., 2008: p132).

4.5 INTEGRATING SEMI-QUANTITATIVE/QUANTITATIVE INFORMATION

Different methods to rank the propriety of diseases (e.g. for foodborne illness) assess potential threat and/or level of importance according to different criteria. There are many approaches for combining information on the burden and costs of illness for particular diseases (Mangan et al., 2010). Mangan et al. (2010) note that attempts to integrate the different forms of data for priority-setting involve both semi-quantitative and quantitative methods. One approach is to assess diseases according to set criteria, then score and subsequently rank their importance. Of the five priority-setting studies summarised in Table 7 that used semi-quantitative scores for ranking diseases, only one used a utility measure (QALY) (Horby et al., 2001). This study was the only one that also used a monetary measure of the burden of disease (costs to the individual, health providers) to rank diseases. In the other studies, measures of burden of disease were largely confined to measures of incidence, severity, and mortality or case-fatality rate. One study included a categorical measure of discomfort or intensity of gastrointestinal symptoms. In contrast, those studies that used fully quantitative criteria for ranking risk of diseases used a number of monetary and non-monetary measures of burden of disease, and other non-health consequence measures.

Table 7: Summary of some studies using semi-quantitative or fully quantitative methods for priority-setting (The criteria shown in bold are the measures of disease burden used in the process)

Reference	Country	Scope	Semi/fully quantitative	Criteria
(Krause and Working Group on Prioritization at the Robert Koch Institute, 2008)	Germany	Infectious Diseases	Semi	**Incidence** **Severity** **Mortality** Outbreak potential Trend Emerging potential Evidence for risk factors/groups Validity of epidemiological information International duties and public attention Evidence for pathogenesis Preventability Treatability **Case fatality rate**
(Horby et al., 2001)	Australia	Communicable Diseases	Semi	**Age, and sex-related morbidity and mortality** **QALYs lost** **Social and economic impact (individuals, organisations, health care providers)** Potential threats Health gain opportunity Public concern and confidence
(Peterson et al., 1996)	US	Meatborne Zoonotic Agents	Semi	**Population group affected** **Cases/year** Perceived/actual seriousness **Case fatality rate**

Reference	Country	Scope	Semi/fully quantitative	Criteria
				Duration of illness **Intensity/discomfort of GI symptoms** Detected using current inspection procedures Multiply or infectious levels in beef Infectious dose Percent prevalence in final product
(Sumner et al., 2005)	Australia	Red-meat microbiological hazards	Semi	**Hazard severity** **Population susceptibility** Frequency of consumption Proportion of consuming (%) Total population Proportion of raw product contaminated Effect of processing contamination rate (%) Post processing control Increase required to cause infection/intoxication Effects of preparation before eating on hazard **Estimated cases per annum**
(Ross and Sumner, 2002)	Australia	Foodborne illnesses	Semi	**Hazard severity** **Susceptibility of the consumer** Frequency of consumption Proportion of population consuming Size of population consuming Size of population of interest Proportion of product contaminated Effect of hazard reduction process Potential for recontamination
(Kemmeren et al., 2006)	Netherlands	Foodborne pathogens	Quantitative	**DALY** **COI: direct health care and non-health care costs, indirect non-health care costs** **Trends in incidence and prevalence** Food products involved Effectiveness of prevention measures Perceptions
Batz et al. (2007) (Batz et al., 2004)	US	Microbiological foodborne hazards	Quantitative	**Cases (symptom, severity, medical attention required)** **Hospitalisations** **Deaths** **Cost of illness (medical costs and productivity losses)** **WTP to avoid illness** **QALY loss**
(Hensen et al., 2007)	US	Foodborne pathogens	Quantitative	**Public Health (burden of disease)** • **Number of illnesses** • **Hospitalisations** • **Deaths** • **Trend analysis of incidence** • **DALYs** • **COI** Consumer Risk Perceptions and Acceptance Market level impacts Social sensitivity

There is value in estimating total cost or burden of imported zoonotic diseases in monetary or non-monetary terms. This report has not considered dimensions such as societal or political perceptions of hazard or risk associated with import-related decisions impacting on the introduction of zoonotic disease. Some of the studies outlined in Table 7 included these 'other dimensions' (e.g. international duties and public attention, public concern and confidence). Some of the studies also included such dimensions as preventability or health gain opportunity as criteria for determining priorities. In determining priorities it is important to consider the policy options (and their costs) and the likely impact of these options on the illness.

There may be value in using multi-criteria approaches following the completion of quantitative studies to estimate total cost or burden of imported zoonotic diseases. This is because decision-making processes are never based entirely on quantitative, 'scientific', value-free analysis. The trade-offs between incommensurate values are essentially social decisions. Thus the decision-making process may be enhanced by analysis by expert and stakeholder groups who consider both quantitative data on total cost or burden of imported zoonotic diseases and the societal or political perceptions of hazard or risk. There are numerous approaches to facilitating such interactions that can be tailored to the time and resource constraints of an issue and the context in which the evaluations are made (e.g. Phillips and Bana e Costa, 2007).

5. CONCLUSIONS

The approaches presented in this review are varied in their output, resource intensity and contribution to the quantification of the cost of morbidity and mortality that can be associated with zoonotic diseases. Key considerations in choosing which approach or approaches to use include:

- single or multi-criteria approach
- how the data will be used
- the time and resources available
- contribution of modelling
- equity considerations.

5.1 Single or multi-criteria approach

Each approach presented in this report for costing the impact of disease due to zoonoses provides a different cost perspective and could be presented separately or together (e.g. DALY, COI, one or more of the criteria described in qualitative/semi-quantitative criteria). Structured decision methods such as multi-criteria analysis may be used, if the criteria that contribute to health impact measures can be disaggregated into their individual components. When using integrated approaches, it is important to avoid double-counting by making explicit which costs are included and excluded (Drummond et al., 2005). This can be difficult, since DALY/QALY approaches do not explicitly include the costs associated with the use of health care services, or loss of productivity, although these may be reflected in how individuals rate their quality of life. This is unless, as Drummond et al. (2005) suggest, respondents are told explicitly which costs they should or should not consider in their valuing of a disease state.

5.2 How the data will be used

It is expected, as a minimum, that monetary and non-monetary 'costs' will be used to inform government of the human health impact of zoonotic diseases and their associated costs. It is also expected that these cost data will be used to inform priority-setting for biosecurity risk management. Priorities may be determined by the size of an existing or forecasted impact of an illness on society in comparison to other illnesses — measured in DALYs/QALYs or COI studies. However, in determining priorities for risk management, the policy options (and their costs) and the likely impact of these options on the illness (cost-effectiveness) need to be considered.

The data from the assessment methods outlined in this report could be used to determine the marginal benefit of extending or contracting an existing intervention designed to prevent or eradicate a potential or existing zoonotic disease. To undertake a marginal analysis, one needs to compare the expected 'change in benefits with the costs of the intervention' required to bring about that change, and COI studies typically 'fail on this point by totally ignoring the importance of the margin' (Shiel et al., 1987).

Shiel et al. (1987) argue that 'good epidemiological data on the total consequences of disease may be necessary to aid the identification of possible priority areas, it seems irrelevant to go one step further and place monetary values on these total consequences when policy changes at the margin affect only a small proportion of the consequences' and that ' total costs of illness' can only indicate the benefits of treatment

options if an intervention is capable of totally eradicating or entirely preventing the disease in question'(p. 320).

However, in relation to COI studies it should be possible to model the effect of policy options on an illness and then undertake a bottom up, scenario analysis, to determine the different COI for each scenario, not unlike that done by Verikios et al. (2010). In this way, the marginal benefit to any illness consequences (e.g. loss in productivity) would be considered in the analyses. In addition to a marginal analysis, the cost data derived from the approaches outlined in this report might be considered for use in cost–utility or cost–benefit analyses to inform decisions concerning the adoption of different interventions.

QALYs gained is the 'benefit' measure used in cost-utility economic evaluations of alternative interventions, and, in these studies, it does not rely on any reduction to the costs derived from COI studies. The QALYs gained due to an intervention are usually measured prospectively in cost-utility evaluations. However, processes for setting policy priorities can explore the expected gains in QALYs, based on any estimated QALY impact of illness due to an intervention. These can be derived from past studies or modelling. Although the DALY can be used in a cost-utility approach, it is not typical, for reasons described in the report.

The cost–benefit approach, often viewed as the gold standard in economic evaluations, relies on all outcome measures being presented in dollar terms. Outputs of COI studies are presented in dollar terms and are suitable for cost–benefit analyses. Although QALYs or DALYs are not used in these forms of analyses, they can be if they are converted to dollars. Deriving a value for a preference-based DALY/QALY would have potential value in allowing greater consistency in cost-benefit analysis across a 'broader range of public health and safety policies' and 'in a way which better reflects the values of the people who are paying for, and benefiting from, those policies'(Baker et al., 2010). However, the expected reduction in DALYs or gains in QALYs from different interventions would need to be estimated to do this, and these converted to dollars. Otherwise, converting the DALYs/QALY consequences of an illness to dollars would result in the same problem outlined above by Shiel et al. (1987) for COI studies, where it would need to assume that an intervention option 'is capable of totally eradicating or entirely preventing the disease in question' (p. 320).

The report also outlined that when using COI study findings in a priority-setting process, irrespective of any consideration of alternative policy options, the use of health services and their associated costs might be inflated for a particular illness if significant resources were devoted to this illness from previous priority-setting processes. New resources might also be spent inefficiently. If used in a priority-setting

process, unless care is taken to take these factors into account appropriately the COI data might incorrectly give priority to this illness based on these costs (Drummond et al. 1986).

Another consideration in relation to the use of the cost data is the audience. Although DALYs and QALYs are widely used and accepted within the health sector and among health policy-makers, they are not necessarily used or understood in other sectors. To assist in their interpretation, policy-makers in other sectors would need to be educated about their value as measures of illness consequence. Other sectors may not recognise the QALY/DALY in budgetary decisions. Hence there may be considerable benefits from converting these measures to dollar figures.

5.3 Time and Resources

When determining which 'costing' approach to use, the effort and resources required would need to be considered. The collection of primary data (e.g. deriving individual disability weights, WTP discrete choice experiments, or deriving health service utilisation via a bottom–up approach) may be preferred, but time and resource constraints might limit the potential to do this. Using existing data and tools, if based on reliable data, could produce very usable results.

5.4 The value of modelling

Modelling costs of the impacts of disease uses existing data, some of which are derived from methods described in COI studies (e.g. loss in productivity, health service costs, VSL) and quality-of-life utility measures. Modelling, if data are available, is a cost-effective approach to estimating the costs of the impacts of disease. Collecting primary data is the 'gold standard' but is costly and takes time. The textbook *Decision Modelling for Health Economic Evaluation* (Briggs et al., 2006) outlines and describes methods of decision modelling for economic evaluation. It argues that a sound general model will capture the essentials of underlying biological or clinical processes – examples include the use of viral load in HIV models (biological) or Kurtzhe Expanded Disability Status Scale in multiple sclerosis (clinical) (Briggs et al., 2006). In the Monash University example presented earlier, the modelling of two pandemic influenza A H1N1 scenarios was derived from the classic susceptible–exposed–-infected–-removed model of infectious disease transmission (Verikios et al., 2010). Health-related quality of life weights or costs to states or pathways can be attached to different scenarios.

A good epidemiological model should summarise the important elements of the natural history of a disease, evidence of probabilities of clinical events over time, and differences among patient groups

(Briggs et al., 2006). Models in general can also take into account changes over time, and discounting of costs and effects, that are often very important in economic assessments.

Cohort models focus on the average patient experience but micro-simulation models (sometimes called individual-based models) consider variability between patients (Briggs et al., 2006). Cohort model techniques, as used in the pandemic influenza A H1N1 scenario modelling, that use proportions of populations are less time and resource intensive, but the micro-simulation models (not unlike bottom–up COI approaches) may provide more realistic outcomes. A decision needs to be made to justify the additional cost of the micro-simulation models for potential accuracy gains (Briggs et al., 2006). Micro-simulation models may be better suited to rare cases of zoonotic diseases, where the history and experiences of the few patients can be used to derive the costs and health related quality of life measures (Briggs et al., 2006). For zoonotic diseases with large numbers of cases, cohort model techniques are potentially more cost-effective.

5.5 Equity considerations

The nature and use of a single criterion or multi-criteria to priority-setting will determine the type of approaches used. An equity criterion is not included in the studies outlined in Table 7. Is an illness of greater consequence to those in the population who are least able to manage that illness and its consequences (e.g. loss in productivity, health service costs) or respond to any treatment or intervention to treat or prevent it or its associated sequelae? Equity criteria generally require cost data (monetary and non-monetary) for different groups.

How, if at all, do the approaches described in this report address inequities in populations? What of VSL, and WTP approaches? What about loss in productivity? Are all populations considered to be the same? Do QALY and DALY weights include inequity differentials? According to Essink-Bot and Bonsel (2002), QALYs and DALYs fail to give priority to those who are most sick or disadvantaged. COI studies typically do not present findings at the sub-population level in relation to education, income, etc. However, there are techniques for building equity weights into QALYs and DALYs (Essink-Bot and Bonsel, 2002, Gold et al., 2002), and bottom–up COI studies can account for the different consequences of an illness on the direct and indirect costs for different sections of the population. Loss in productivity measurement approaches (e.g. Human Capital or Friction Cost) can assume that everyone's income potential is the same or alternatively, recognise different levels of income and their source (e.g. social security benefits). Whether or not equity is to be included as a criterion for the measure of consequences of illness – the decision for or against needs to be explicitly stated, and the degree to which each approach used addresses inequities should be assessed.

6. RECOMMENDATIONS

The management of zoonotic diseases typically involves estimating the consequences of new and emerging threats, and comparing the potential costs with those of established diseases. To rank diseases based on their 'burden' on society we recommend the use of DALYs, especially to compare the costs of different illnesses. However the QALYs lost to zoonotic disease could serve use as a measure of burden of disease, if comparisons are to be made between zoonotic diseases only. The potential QALYs gained with alternative policy options could be contrasted with the overall measure of burden. The potential DALYs saved (Haby et al., 2006) for a particular policy option can alternatively be used. Hence, the purpose of the burden of disease data needs to be considered when choosing which HALY to use. Although DALYs and QALYs are widely used and accepted within the health sector and among health policy-makers, they are not necessarily used or understood in other sectors. We recommend educating policy-makers in other sectors about their properties and their value as measures of illness consequence.

We recommend converting health-adjusted quality of life measures to dollar figures whenever decisions are constrained by budget, and when such inputs are required for cost-benefit analyses. If this approach is to be used, the process for translating the DALY/QALY to dollar costs needs to be transparent.

Direct and indirect costs, which are recognised by non-health sector departments, can be measured by using actual expenditure data on illnesses that have occurred previously or modelled, using forecasted levels or scenarios of illness to determine the costs in terms of loss in productivity, health service use, and, as incorporated in the Monash General Equilibrium Model, wider sector impacts. We recommend calculating and including costs due to loss in productivity, and health service utilisation.

When relying on 'past expenditure', the use of health services and their associated costs might be relatively inflated for a particular illness if significant resources have been devoted to an illness as a result of previous priority-setting processes. The COI data, if used in such processes, might then incorrectly give priority to this illness based on these costs (Drummond et al., 1986). These resources might also be spent inefficiently. Instead, we recommend forecasting or modelling illness and determining the 'efficient' or standardised costs associated with that illness.

A detailed economic cost estimate of the consequences of illness should be undertaken when a significant zoonotic threat is identified. When rapid decision making is necessary and information on the likely costs of an imminent zoonotic threat is needed quickly, policy-makers should use existing local or international cost of illness estimates. A wealth of data is available on the cost of illness due to zoonoses (e.g.

foodborne diseases). When data are not available, policy-makers should use semi-quantitative methods to determine costs.

Gosling et al. (2012) outlined a method using experts to determine the future costs of exotic diseases. They determined point estimates for the costs of minor and major outbreaks, and the probabilities of outbreaks being major for some diseases. This latter quantity is the probability that the consequences of an outbreak will exceed a specified threshold in monetary terms, which qualified the event as 'major'. These estimates were combined and the total expected annual cost estimated. Gosling and colleagues quantified the uncertainty around these cost estimates by eliciting quantiles, fitting distributions and propagating the uncertainties by Monte Carlo simulation. The approach outlined in their study is one of many structured approaches to eliciting expert judgments that may be deployed to substantially improve the accuracy and calibration of expert estimates (Gosling et al., 2012).

Studies adopting semi-quantitative/qualitative measures for priority setting have used estimates of incidence, severity, and mortality or case-fatality rate. Others have included dimensions such as international duties and public attention, and public concern and confidence. Multi-criteria, expert elicited approaches are useful when estimating total cost or burden of imported zoonotic diseases, particularly when time and resources are constrained. Since decision-making can never be based on value-free 'scientific' analysis, the trade-offs between incommensurate values are essentially socially derived. Societal or political perceptions of hazard or risk inevitably intrude. Thus the decision-making process may be enhanced by analysis by expert and stakeholder groups who consider both quantitative data on total cost or burden of imported zoonotic diseases and the societal or political perceptions of hazard or risk. There are numerous approaches to facilitating such interactions that can be tailored to the time and resource constraints of an issue and the context in which the evaluations are made (e.g. Phillips and Bana e Costa, 2007).

The context of managing zoonotic diseases and other biosecurity health risks more generally suggests that monetary and non-monetary 'costs' will inform government policy and decision-making. Priorities may be determined by the size of an existing or forecasted impact of an illness on society in comparison to other illnesses — measured in DALYs/QALYs to which information from other kinds of analyses including COI studies, or multi-criteria analyses could contribute. We recommend that decision-makers consider the costs and the likely impact of policy options through the use of model-based scenarios that estimate the outcomes of alternatives. Potential cost savings for particular interventions may be included in the analyses, involving other economic tools (i.e. cost-effectiveness, cost–benefit or cost–utility

analysis). ‘Preventability’ or ‘health gain’ has been used as a measure in studies using semi-quantitative approaches to priority setting.

Multi-criteria approaches can again be considered at this point as they have the potential to incorporate dimensions other than the costs and burden of disease (e.g. societal views on the acceptability or otherwise of the decisions arising out of the cost analysis).

In summary, it is recommended that:

1. **Burden of disease should be considered as one of a number of measures of the consequence of illness when using cost data (both monetary and non-monetary) to inform the magnitude of the impact of the issue in a priority setting process.** The burden of disease measure is useful when making comparisons with other illnesses, both zoonotic and non-zoonotic.

2. **Strategies should be developed to inform policy-makers in non-health sectors about the properties and value of DALYs and QALYs as measures of consequence of illness and policy effectiveness respectively.** This will assist in the interpretation and use of these forms of data.

3. **Health-adjusted quality of life measures should be converted to dollar figures whenever budgetary decisions are determined by monetary costs and when such inputs are required for cost–benefit analyses.** If this approach (using VSL) is used, the process for translating the DALYs/QALYs to dollar costs needs to be transparent so that policy-makers can identify the source and possible overlap of all costs.

4. **Costs due to use of health services and loss in productivity should be included in any consequence assessment of zoonotic diseases.** Burden of disease provides a measure of only some of the consequences of morbidity and mortality (e.g. premature death and years with disability). Other important consequences of human morbidity and mortality that can be included in COI studies include use of health services and its associated costs, loss in productively, as well as losses to the broader economy.

5. **A multi-criteria approach should be considered** in **the assessment of zoonotic illnesses when decisions are affected by other, non-human health, consequences**. Each approach to costing human morbidity and mortality provides a different cost perspective and can be presented separately, or together. The latter could include a multi-criteria approach to negotiate trade-off points (equivalence points) in relation to these illnesses. The tradeoffs between incommensurate values are essentially social decisions. Thus, the decision-making process may be enhanced by

analysis by stakeholder groups who consider not only quantitative data on total cost or burden of imported zoonotic diseases but also societal or political perceptions of hazard or risk.

6. **Double-counting should be avoided by making explicit what costs are included and excluded if using integrated or multi-criteria approaches to consequence assessment.** When using integrated approaches, it is important to avoid double-counting by making explicit which costs are included and excluded. For instance, the COI approach does not include costs associated with pain and discomfort, anxiety and depression, or loss of functioning , while the DALY/QALY utility approaches do not explicitly include the costs associated with use of health care services, or loss of productivity though these may be reflected in how individuals rate their quality of life, and potentially lead to double-counting.

7. **A bottom–up approach should be the preferred option in any COI study designed to estimate the monetary burden of illness due to zoonotic diseases.** In relation to whether a top–down or bottom–up approach be used in COI studies, the points raised in this report strongly suggests that a bottom–up approach is more suitable for measuring monetary burden of illness due to zoonotic diseases. On a practical level, top–down costings are often undertaken as data are often more readily available and less costly to collect. However, given the potentially significant investments in management of zoonotic diseases, now and in the future, the investment in data is likely to be justified in terms of the accuracy in the estimates of costs obtained.

8. **Modelling should be considered to forecast potential consequences of zoonotic diseases introduced through imports of animals and animal products, or in instances where consequence data in Australia are not readily available.** A lack of consequences data does not preclude estimation of impact of disease. Models can be constructed with regard to costs and effects of different outcome scenarios. Costs linked to different outcome scenarios can be derived from existing data (e.g. loss in productivity, health service costs, VSL) and quality of life utility measures or, if not available for a particular disease outcome, from further modelling. Efficient or standardised costs associated with that illness should be used. Micro-simulation models may be better suited to rare cases of zoonotic diseases, but for zoonotic diseases with large numbers of cases cohort model techniques are potentially more cost-effective.

9. **If the expected costs of a zoonotic threat exceed values that are considered to be 'major', it is recommended that DAFF partner with DoHA/FSANZ or other appropriate organisations, facilitated through a memorandum of understanding (Beale Review Recommendation 41) or other appropriate policy vehicles, to undertake a full economic analysis of the costs related to**

the associated illness. When rapid decision making is necessary local and international data or agreed upon estimates (e.g. government prescribed VSL) should be used when they are available to estimate costs. When local and international data are not available, experts should be used to estimate the magnitude of the consequences of a zoonotic threat. Analysts should use structured elicitation methods to elicit estimates and uncertainties, and should document their approaches.

10. **Decision-makers should consider the likely impact of policy options through the use of model-based scenarios that estimate the outcomes of alternatives.** The amenability of a zoonotic disease threat to intervention should be considered in the priority-setting process. This would require some consideration of the likely cost–benefit of interventions designed to prevent or control a zoonotic disease threat. However, a zoonotic disease threat that is not amenable to an intervention (e.g. that is difficult to control once introduced) would pose a higher risk and may require stricter preventive measures.

11. **Either DALYs saved or QALYs gained should be used as one of a number of measures of policy effectiveness —** see also Recommendation 10.

12. **Equity should be considered in the estimate of consequence of illness.** The inclusion of equity in as a criterion for ranking the priority of zoonotic diseases should be considered. There are techniques for building equity weights into QALYs and DALYs and COI studies can be mindful of the different consequences of an illness on the direct and indirect costs for different sections of the population. Loss in productivity measurement approaches can assume that everyone's income potential is the same or alternatively, recognise different levels of income and their source (e.g. social security benefits).

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APPENDIX 1

Table A1: Description of COI studies of foodborne and other zoonotic diseases

Study	Country	COI Approaches					WTP[24]	Non-monetary Approaches	
		Top–Down/ Bottom–up	Incidence or prevalence	Perspective	Costs	Productivity losses		DALYs or QALYs	Weights
Kemmeren et al. (2006)	Netherlands	Bottom–up/Top–down	Incidence	Mixed	**Direct health care**[25] Medical services (GP consultations, hospitalisations, drugs, rehabilitation and other) **Direct Non-Health Care**: Travel costs of patients, costs for diapers, informal care and patient co-payments **Indirect non-health care**: value of production lost to society. **Indirect health care:** none	FC		DALY	Derived from Public Health Status and Forecast Studies and global burden of disease studies
Batz et al.(2004) (FIRRM)	US	Bottom–up/Top-down[26]	Incidence	Health Service	**Direct health-care costs:** Medical costs	HC	WTP to avoid risk of illness or premature death	QALY	QWB index

[24] HC: Human Capital Method; FC: Friction Cost Method; WTP: Willingness to Pay; GBD: Global Burden of Disease; QWB: Quality Well-being Index; AIHW: Australian Institute of Health and Welfare.

[25] 'The direct health care costs related to a specific pathogen were estimated by multiplying the number of cases requiring health care service (*m*) by the required health care service units per case (*p*) and by the costs per health care service unit (*mc*)', p. 30.

[26] This study used the top-down approach by using surveillance data on pathogen illness and then tracing these illnesses back to the food origin. They state that the top-down approach is preferable for 'big-picture comparisons of foodborne risks', but is 'inadequate to isolate the causes of illness along the farm-to-table pathway' (Batz et al. 2004, p4).

Study	Country	COI Approaches					WTP[24]	Non-monetary Approaches	
		Top–Down/ Bottom–up	Incidence or prevalence	Perspective	Costs	Productivity losses		DALYs or QALYs	Weights
Vijgen et al. (2007)	Netherlands	Bottom–up	Incidence	Mixed	**Direct health care costs:** over-the-counter medicine, cost for medication incl prescription charges, cost per average GP visit, costs for pathogen diagnosis, hospitalisations/day, outpatient visit, subscription fees for specialists **Direct non-medical costs**: travel cost per average GP consultation and per hospitalisation, cost per diaper. **Indirect costs**: average costs of absence from paid/hour, average costs of third person taking care of sick person/hour.	FC	-	DALY	GBD and Dutch weights, (also modelled weights in sensitivity analysis)
Abelson (2006)	Australia	Top–down	Incidence over one year, prevalence of sequelae not due to infections in the current year	Mixed	**Direct health care costs**: hospitalisations, visits to emergency department and general practitioner, use of carers, specialist services, diagnostic testing, pharmaceutical expenses. **Indirect non-health care costs**: Loss of disruption to household activity	HC	WTP to avoid illness (based on VSL and DALYVSL[27]	DALY in $	AIHW (Mathers et al., 1999)

[27] Abelson (2006) calculates WTP to equal severity weight (DALY weight derived from AIHW) multiplied by days of illness, and the value of a day in good health derived from WTP (VSL).

Study	Country	COI Approaches					WTP[24]	Non-monetary Approaches	
		Top–Down/ Bottom–up	**Incidence or prevalence**	**Perspective**	**Costs**	**Productivity losses**		**DALYs or QALYs**	**Weights**
Cressey (2008)	New Zealand	Top–down	Incidence	Societal	**Direct health care costs:** GP consultations, medications. **Direct non-health care costs:** travel costs to and from GP and hospital. **Indirect non-health care costs:** lost production from illness.	HC		DALY[28]	
Rayner and Scarborough (2005)	UK	Top–down	Prevalence	Health Service	**Direct health care costs: All healthcare expenditure**			DALY	

[28] Cressy and Lake (2007) estimated DALYs.