13 The Economic Evaluation of One Health Interventions

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Chapter Overview

Elevator pitch

Understanding the economic value of One Health is crucial for making decisions on One Health investments. In this chapter, you will learn about the basic principles of economic evaluations of One Health. You will discover what is needed to design these evaluations using a One Health lens and how the information can be used to prioritize resource allocation and justify investments in One Health. This will equip you with skills to help make a compelling case for sustainable and impactful One Health implementation.

Book objectives the chapter relates to

☐ 1. Understand what One Health and Ecohealth mean
☑ 2. Think in a One Health and Ecohealth way
☐ 3. Apply One Health and Ecohealth in their professional and personal life
☐ 4. Know how to share One Health and Ecohealth knowledge
☐ 5. Integrate One Health and Ecohealth knowledge actively
☑ 6. Acquire or enhance core One Health competencies

One Health competencies covered

☐ 1. Effective communication
☐ 2. Collaborative and resilient working
☑ 3. Systems understanding
☐ 4. Transdisciplinarity
☐ 5. Social, cultural and gender equity and inclusiveness
☐ 6. Collective learning and reflective practice
☑ 7. One Health concepts
☐ 8. Theoretical and methodological pluralism
☑ 9. Harnessing uncertainty, paradox and limited knowledge

After working through this chapter, you will understand what to consider when planning a One Health economic evaluation and how this information can be used in decision making for One Health implementation.

Learning outcomes

1. Understand the basic principles of economic evaluation of One Health initiatives.
2. Know what to consider when conceptualizing a One Health economic evaluation.
3. Discuss the economic evaluation results and how to use them for decision making on One Health investments.

Summary

In this chapter, you explore the basics of economic assessments in One Health initiatives addressing key questions such as why these assessments are important for One Health implementation and what they entail. You learn about how to conceptualize economic evaluations of One Health and delve into the costs and benefits associated with One Health interventions, covering tangible and intangible costs, market prices of resources, and the evaluation of benefits over time. You get to know various economic evaluation methods that can help to provide insights into how these methods quantify the economic value of interventions. Furthermore, you engage with different metrics and valuation approaches and how to address the challenge of uncertainty through sensitivity analyses, ensuring robustness in your conclusions for decision making. Finally, you learn about wider dimensions including different economic paradigms, financing and funding.

13.1 Introduction

One Health has gained significant momentum in recent years as a holistic approach to address complex **health** challenges spanning humans, animals, plants and the **environment**, emphasizing the narrative that the interconnectedness of these domains causes cascading effects of benefits or problems in other **sectors**. Numerous proof-of-concept studies showcase the **effectiveness** and added **value** of One Health initiatives (Pitt and Gunn, 2024). While much of the initial focus of economic evidence of the **One Health approach** was on **zoonotic diseases** and food safety, there is now growing evidence of the benefits of applying One Health to tackle global development concerns such as antimicrobial resistance (AMR) and environmental pollution (Destoumieux-Garzón *et al.*, 2018). For instance, there is a strong, documented investment case that shows that the value of reducing air pollution is substantial, as it not only benefits human health but also has positive implications for animal health and overall environmental **sustainability** (Manisalidis *et al.*, 2020; Pansini and Shi, 2022).

After the COVID-19 pandemic, with the increasing recognition of One Health's potential, there has been a corresponding rise in funding and financing opportunities for such initiatives. Governments, international organizations, philanthropic foundations and private sector entities are showing greater interest in supporting One Health initiatives. This trend reflects a broader acknowledgment of the interconnected nature of health challenges and the need for collaborative, multisectoral solutions (FAO *et al.*, 2022; Lefrançois *et al.*, 2023; The World Bank Group, 2023).

Despite the progress made, however, challenges remain in fully realizing the potential of One Health through sustainable, long-term and dedicated investments. While there is ample evidence supporting certain aspects of One Health initiatives, gaps exist in demonstrating the added value and return on investment across One Health domains more broadly. Addressing financing and funding challenges is essential for the long-term sustainability of One Health activities. Efforts to strengthen economic arguments, expand evidence across diverse One Health domains, and secure sustainable financing mechanisms are key to advance the One Health agenda and achieve meaningful **impact** on global health and **wellbeing**.

Thus, economic **evaluations** are critical in the One Health implementation cycle as a tool for decision making (Drummond *et al.*, 2015). As resources are limited, they help us to make the best use of them to satisfy our needs. For instance, a government decision maker may wonder what projects or programmes to invest in when they have a budget available for One Health initiatives and a particular epidemiological situation; should they opt for a rabies eradication programme, a blue-tongue vaccination programme, a brucellosis surveillance programme, or maybe a programme to decrease **biodiversity** loss or non-communicable diseases? A mixed group of **stakeholders** working in a wider programme may wonder about investments through private–public partnerships. A private industry actor, such as a vaccine producer, might be interested in the potential financial return on the vaccine development. An NGO involved in conservation might be interested in knowing what the value is of preserving a certain species.

Knowing that the economic value of what we decide to do is given by what we give up – in economics, this is called '**opportunity cost**' (Palmer and Raftery, 1999) – economic evaluations should, therefore, help us to obtain from One Health initiatives an added value when comparing the benefits to the costs.

13.1.1 Economic evaluations in the One Health implementation cycle

When looking at our One Health implementation cycle, we are interested in two big questions. The first question revolves around assessing whether our One Health initiative is economically acceptable and offers sufficient benefits (both monetary and non-monetary) to justify the resources invested. This requires robust economic evaluations tailored to different One Health contexts and interventions. The second question pertains to the financing mechanisms for One Health initiatives. Identifying sustainable funding sources, fostering partnerships among stakeholders, and exploring innovative financing models should help to ensure the long-term success of a One Health initiative.

While the principles outlined are applicable to any type of One Health initiative, we are focusing on One Health interventions here, as a wider coverage of different types of One Health initiatives would go beyond the scope of this chapter.

In the implementation cycle (Fig. 13.1), the economic evaluation links to establishing intervention options where we identify the possible alternatives for achieving the objectives defined. Sometimes, this might just be a

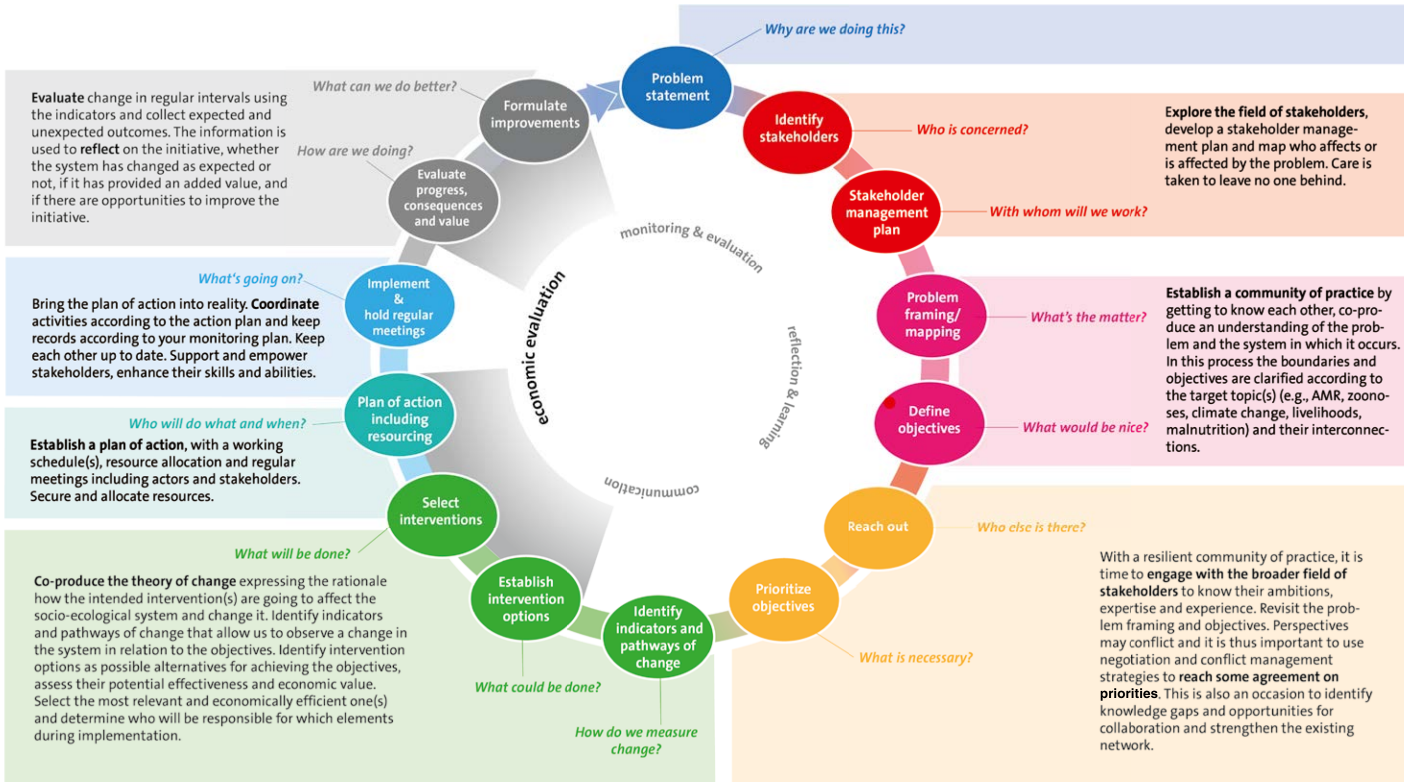

Fig. 13.1. Economic evaluation comes in at various steps of the One Health implementation cycle including the assessment of intervention options, when planning the implementation, and during and after implementation with the aim to find out if the initiative is likely to or has generated economic value.

single intervention, but we might often find a package of interventions (e.g. rabies awareness campaign combined with vaccination of dogs and people). The economic evaluation can be structured based on the participatory approach taking place to define the problem, objectives and possible interventions, and the associated **Theory of Change** (ToC). The selection of the intervention to be implemented should be informed not only by technical considerations, but also by the economic value of these interventions. From an economic point of view, an intervention is acceptable when the resulting benefits outweigh the costs. This can be established in an *ex-ante* (or prospective) analysis to inform the selection of interventions and ensure that sufficient funds are allocated to it. The latter may necessitate the generation of funds through various investment channels and partnerships. Once the intervention is implemented, economic evaluation *ad interim* (while the intervention is ongoing) can be used to determine whether we are on track or need to implement corrective measures. Furthermore, economic evaluation may take place after an intervention has gone through a first phase of this cycle in a process of *ex-post* (retrospective) evaluation that allows us to capture both the progress and unintended consequences (both positive and negative) and determine the value achieved for the investment made. This information then helps to think about a new phase or cycle, reflect on lessons learned, explain variations from the original planning and formulate improvements (Pearce *et al.*, 2006).

The focus of this chapter is on explaining the basic steps of an economic evaluation in alignment with the One Health implementation cycle. It refers to the problem statement, stakeholder engagement, prioritization, systems mapping, implementation and monitoring and evaluation steps discussed in Chapters 10, 11 and 12, and makes use of these foundations to explain what we need to consider in the economic evaluation. Emphasis is also placed on valuation approaches and the challenges of measuring certain One Health outcomes. Finally, we spend some time thinking about how these analyses link to funding and financing and what more complex analyses will look like.

13.2 Economic Evaluations of One Health Interventions

Economic evaluations assess alternative One Health interventions by comparing their respective costs and consequences across the different sectors involved.

Figure 13.2 shows the main characteristics of two alternative surveillance programmes and associated interventions to mitigate bovine brucellosis in the dairy farms of a given area. Bovine brucellosis is a One Health challenge due to its multi-species impact, zoonotic potential, economic ramifications and the necessity for a collaborative approach (Pal *et al.*, 2017; Buttigieg *et al.*, 2018; Franc *et al.*, 2018; Ghanbari *et al.*, 2020). It affects various animals, including cattle, sheep and wildlife, while posing risks of transmission to humans through direct contact or consumption of contaminated products. Its economic consequences can be far-reaching

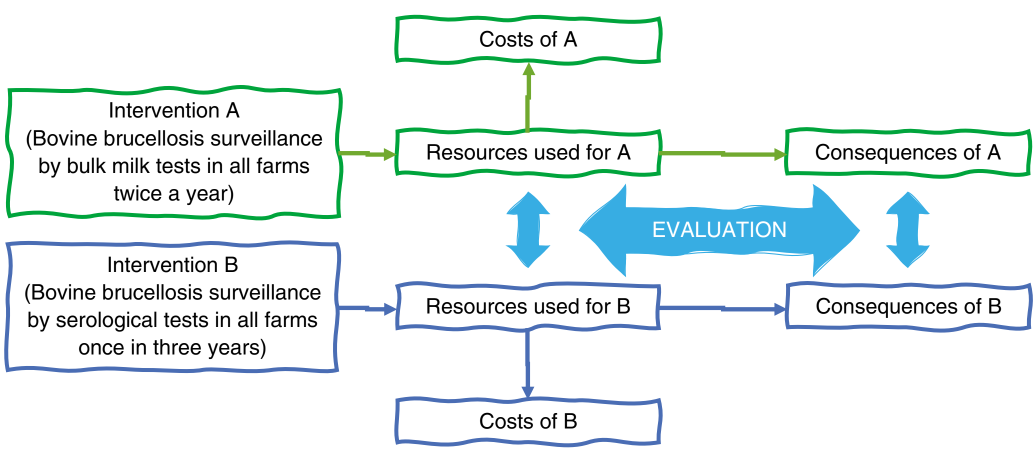

Fig. 13.2. Main characteristics of two surveillance and intervention options against bovine brucellosis in the dairy farms of an area and elements subject to economic evaluation.

and span reduced productivity in livestock, trade limitations and human health impacts. Addressing brucellosis requires coordinated efforts between veterinary or agriculture, public health and wildlife management sectors, emphasizing the interconnectedness of health across species and the importance of a holistic One Health approach (Buttigieg *et al.*, 2018; Moriyón *et al.*, 2023). We will use the example of this disease throughout the chapter to illustrate the principles covered.

One of the alternative surveillance options of Fig. 13.2 involves indirect testing of bulk milk samples from all the farms in the area twice a year, followed by serological testing of suspected herds and animals. The alternative surveillance option tests serological samples from all dairy cows every three years. Positive animals are culled, and positive farms are isolated to avoid infection of other animals and to reduce the risk to people and wildlife. The identification of the aetiological agent in the organs of culled animals triggers a sanitization protocol for the farm.

Both programmes require resources, such as skilled personnel, transportation, laboratory infrastructure and materials, which have associated costs. Each programme also has consequences in terms of reduced risks of infections in animal and human populations. The economic evaluation process involves comparing the costs and the consequences of the two alternative programmes to determine which gives the most benefits at the lowest cost.

What economists consider a 'full' economic evaluation requires two conditions: the first is that there must be at least two alternative interventions to be examined (knowing that a situation with no intervention can be one of the alternatives); the second condition is that both the costs and the consequences of all the alternatives are analysed (Pearce *et al.*, 2006; Drummond *et al.*, 2015). From this point of view, if the analysis is limited to one intervention, it is not an economic evaluation in the conventional sense but merely a description of costs, results, or both costs and results (Table 13.1). An analysis considering multiple alternatives but only evaluating their consequences is an evaluation of effectiveness, which allows the identification of the intervention that produces the best effects for the intended objective (see Chapters 10–12). Alternatively, if only costs are examined, we have a cost analysis (CA), which identifies the intervention implementable at the lowest costs compared to the alternatives. Descriptions of cost and results, evaluations of effectiveness, and CAs are partial evaluations. When we examine two or more alternative interventions, assessing the costs

Table 13.1. Partial and full economic evaluations (authors' own elaboration based on Drummond *et al.*, 2015).

Alternatives examined	Analysis of costs and/or consequences and type of evaluation	Partial or full evaluation
One intervention only	Only the consequences are examined: • Description of the results produced	Partial evaluations
	Only the costs are examined: • Description of costs	
	Costs and consequences are examined: • Description of costs and results	
Two or more alternative interventions	Only the consequences are examined: • Evaluation of effectiveness	
	Only the costs are examined: • Cost analysis (CA)	
	Costs and consequences are examined: • Cost-minimization analysis (CMA) • Cost-effectiveness analysis (CEA) • Cost-utility analysis (CUA) • Cost–benefit analysis (CBA)	Full economic evaluations

and the consequences of each, we conduct a full economic evaluation.

There are several types of full economic evaluations. When the effects of the alternatives under consideration are the same, the best solution is the one entailing the lowest costs and is identified through a cost-minimization analysis (CMA) (Rai and Goyal, 2018). When the effects of the alternative interventions are different and can be compared through a physical parameter (e.g. gains in terms of fewer infections or deaths in the human population, fewer days of hospitalization, less livestock culling, fewer animals dying, reduction in air pollution, etc.), the cost-effectiveness analysis (CEA) indicates the solution that provides the best result at the lowest cost or at a higher cost deemed acceptable. For example, a more expensive solution that guarantees fewer infections than the alternative one may be preferable if the additional costs do not exceed what the decision makers consider spendable for that outcome (Briggs *et al.*, 2006; Diamond and Kaul, 2009; Glick, 2015a).

In evaluations related to human health, when the alternatives are compared in terms of the quality of human life provided over time through specific indicators such as the Disability-Adjusted Life-Years (DALYs) and the Quality-Adjusted Life-Years (QALYs), we have a cost-utility analysis (CUA), which prefers the solutions achieving the best quality of life for the longest time at the minimum cost or with costs deemed affordable (Robinson, 1993; Coons and Kaplan, 1996; Nuijten and Dubois, 2011). For animal lives, new metrics are becoming available that are similar to the DALYs and QALYs, such as Welfare-Adjusted Life-Years (WALYs) (Teng *et al.*, 2018). A cost–benefit analysis (CBA) evaluates all the costs and outcomes of the examined alternatives in monetary terms. In this case, the best solution is the one that generates the highest net present value (NPV), i.e. the highest difference between all the benefits and the costs produced over time expressed in terms of present values[1] (Sunstein, 2005; Pearce *et al.*, 2006; Glick, 2015b; Guerriero and Pacelli, 2020).

In our brucellosis example, we are focusing on a full economic evaluation using a One Health lens where we are looking at two interventions in the animal sector, but with consequences in other sectors. We could of course expand this to have, for example, a package of interventions (with integration points) in both the human and animal sectors with consequences in both. However, for the sake of simplicity and covering basic principles, we are starting with the animal sector example and later show you how to expand this to add more complexity and One Health aspects. The underlying concepts of One Health evaluations and the use of CMA, CEA, CUA and CBA are described in detail in Canali *et al.* (2018) and Häsler *et al.* (2021); we suggest that you refer to these chapters for more information on how to conduct these analyses. Here, we provide a basic coverage of the main steps involved in these analyses and spend some time discussing valuation approaches.

But before doing so, we want to discuss how to conceptualize economic evaluations given the complexity of One Health problems and their solutions. Note that economic evaluations, particularly in the context of healthcare and public health interventions, are often associated with neo-classical economic theory due to their emphasis on efficiency, rational decision making, and resource allocation based on CEA or CBA. **Neo-classical economics** is a school of economic thought that emphasizes the role of individual rational behaviour, market mechanisms and the efficient allocation of resources to maximize societal **welfare** (Pigou, 1920; Kelman, 1981; Hansson, 2007; Glick, 2015b). There are other schools of economic thought that can be relevant to One Health; a short overview of three selected ones is provided in Box 13.1.

13.3 The Challenges of Designing and Conducting Economic Evaluations of One Health Initiatives

Economic evaluations of complex One Health initiatives pose significant challenges due to the inherent complexity and dynamic nature of these initiatives. One of the primary difficulties arises from the diverse and dynamic outcomes that we often see associated with One Health interventions. Unlike traditional healthcare interventions with relatively clearly delineated outcomes, such as reduced mortality or improved quality of life, One Health initiatives often target multifaceted problems involving human, animal, plant and environment dimensions and it is not uncommon that we face **trade-offs**. Thus, economic evaluations of One Health need to deal with a wide range of outcomes across various sectors, making it

Box 13.1. Three selected alternative schools of economic thought with relevance for One Health

Ecological economics: Ecological economics emphasizes the interconnectedness of human economies with the natural environment. It highlights that economic activities are embedded within and dependent on our planet's **ecosystems**, which provide essential resources and services that sustain life and economic activities. It acknowledges the finite nature of natural resources and the ecological limits of the planet. It advocates for meeting present human needs without compromising the ability of future generations to meet their own needs. This involves adopting practices and policies that promote resource conservation, reduce pollution and waste, and promote regenerative approaches to economic activities, such as de-growth, green growth and circular economies. It focuses on the importance of clean air and water, biodiversity, soil fertility, climate regulation, and other ecosystem functions that directly or indirectly contribute to human wellbeing and economic prosperity. Furthermore, ecological economics challenges traditional measures of economic progress, such as Gross Domestic Product (GDP), by advocating for alternative indicators that reflect broader wellbeing and the health of the environment. This includes metrics like Genuine Progress Indicator (GPI), Ecological Footprint, and measures of social and environmental resilience (Martinez-Alier and Schlupmann, 1987; van den Bergh, 2001; Baumgärtner *et al*., 2008).

Doughnut economics: Doughnut economics is a concept developed by Kate Raworth that proposes a new economic model centred around social and planetary boundaries (Raworth, 2017a, b). It can be seen as a sub-set within the wider framework of ecological economics. The essence of doughnut economics lies in creating a balance between meeting the needs of people without overshooting the Earth's ecological limits. The 'doughnut' represents two concentric rings: the inner ring represents the minimum social standards that everyone should have access to (such as food, water, healthcare, education), while the outer ring represents the ecological ceiling beyond which human activity risks damaging the planet (such as **climate** change, biodiversity loss, pollution). The goal is to operate within this 'safe and just space for humanity', ensuring social **equity** and environmental sustainability. Doughnut economics encourages rethinking traditional growth-focused models and emphasizes sustainable development that respects planetary boundaries and promotes wellbeing for all. The goal of downscaling is met with several challenges related to the behaviour of **complex systems**, dealing with trade-offs and difficult questions in decision making and agreeing on goals when considering different scales (Turner and Wills, 2022) – all aspects that the One Health approach can help us address.

Feminist economics: Provides a critical lens that examines economic theories and practices through the prism of **gender equality** (see Chapter 9) and **social justice**. At its core, it challenges the traditional economic model's **assumptions** and methodologies (Nelson, 1995), which often overlook or undervalue the contributions and experiences of women and marginalized groups. One key aspect of feminist economics is its emphasis on recognizing and valuing unpaid labour, such as caregiving, household work and community support, which are predominantly shouldered by women (Antonopoulos and Hirway, 2010; Benería *et al*., 2015; Winders and Smith, 2019; Stevano *et al*., 2021). This perspective sheds light on the hidden economic contributions that sustain societies but are often ignored in conventional economic analyses (Mair, 2020). Feminist economists also highlight the intersectionality of gender with other axes of identity like race, class and sexuality, acknowledging that individuals experience economic systems differently based on their unique social positions (Antonopoulos and Hirway, 2010). Moreover, feminist economics advocates for policies and interventions that promote gender equality, economic empowerment, and inclusivity in decision making. This includes initiatives to address pay gaps, enhance access to education and employment opportunities for women, and challenge discriminatory practices within economic institutions. By centring social justice, equity and diversity in economic discourse and policy making, feminist economics aims to create more inclusive and sustainable economies that prioritize the wellbeing and agency of all individuals, irrespective of their gender or social identities (Razavi *et al*., 2012; Braunstein, 2015; Bachelet, 2022).

challenging (but not impossible!) to capture and quantify their full impacts comprehensively.

Furthermore, the multisectoral nature of One Health adds layers of complexity to economic evaluations. One Health initiatives typically involve collaboration and coordination among diverse stakeholders from public health, veterinary medicine, environmental science, agriculture and other sectors. Each sector may have distinct priorities, metrics and methods of assessment, making it difficult to integrate economic data and analyses across sectors. This multiplicity of perspectives and outcomes complicates the task of assigning economic values to different aspects of One Health interventions. It is important to consider explicitly the One Health elements and structures of an evaluation if we want to determine the added value of One Health (Auplish *et al.*, 2024).

Economic evaluations often use monetary terms, and these may not adequately capture the full spectrum of outcomes and impacts associated with One Health interventions. The potential intangible benefits of such interventions, such as **ecosystem services**, social equity improvements or resilience enhancement, are challenging to quantify in monetary terms despite knowing that these benefits have value to communities and society. Additionally, **data** availability and quality for economic evaluations in One Health can vary widely, especially when dealing with interconnected systems and long-term effects. For example, when effects on the environment are considered, the benefits often reach far into the future and questions of intergenerational values and equity must be considered.

Addressing these challenges involves developing and adapting the evaluation frameworks and methods that can accommodate the diverse outcomes, perspectives and uncertainties inherent in One Health initiatives. Collaborative efforts among economists, public health experts, environmental scientists and other stakeholders are crucial for advancing methodological tools, data collection strategies and analytical techniques tailored to the complexities of One Health. By improving the capacity for economic evaluations in One Health, decision makers can better understand the value proposition of these initiatives and make informed investment choices for promoting global health, sustainability and resilience. We will revisit these challenges later, but for now look at the different steps of capturing the costs and benefits of One Health interventions.

Task: Thinking about the brucellosis intervention from Fig. 13.2, list any consequences that you can think of resulting from these two interventions covering livestock health, agriculture, wildlife and public health sectors.

Example answer 1: For a context, where brucellosis is endemic and transmission to people directly through animals or milk is a common occurrence, we might think about the following:

- Livestock health: Reduction in brucellosis prevalence among dairy cows due to removal of infected animals would be a positive aspect and contribute to improved overall health of dairy herds with fewer disease outbreaks.
- Agriculture: A positive effect would be increased productivity in dairy farming as infected cows are removed, preventing further spread, thereby contributing to more economic resilience of the sector. On the negative side, there could be economic losses for small-scale farmers due to culling of infected cows.
- Wildlife: A positive effect could be the reduced risk of transmission to wildlife species sharing habitats with infected cattle.
- Public health: A positive effect could be the decreased transmission of brucellosis to humans through consumption of contaminated milk or direct contact with infected animals and improved public health outcomes with fewer brucellosis cases among the population.

Example answer 2: For a context, where brucellosis has been eliminated and the intervention focuses on maintaining the situation of freedom from disease, the consequences may include the following:

- Livestock health: The testing might lead to the detection of some rare cases of brucellosis in dairy cows that may lead to slaughter of some animals. On the positive side, there might be a good reputation of the sector for having eliminated the disease and keeping it away.
- Agriculture: With the detection and removal of (few) positive animals if a reintroduction occurs, there can be some economic losses to the animal owners. On the positive side, the wider sector benefits from the disease absence.

- Wildlife: A positive effect is the limited risk of transmission to wildlife as brucellosis is largely absent in livestock.
- Public health: A positive effect is the very low risk of human brucellosis cases due to effective control measures and eradication efforts. Improved confidence in food safety and reduced public health concerns related to brucellosis transmission.

From this and the previous sections you know the main challenges of performing economic evaluations by comparing costs and consequences of alternative One Health initiatives. In the next section, we are going to discuss how we can put values on these elements and compare them.

13.4 What are the Costs and Benefits of One Health Interventions and How Do We Evaluate Them?

When individuals experience a decrease in their wellbeing, they incur a cost. The resources, skills and time used to fulfil given needs cannot be used to satisfy other needs. This trade-off or sacrifice is the cost incurred by pursuing a particular activity. Additionally, any suffering, discomfort, pain or reduction in wellbeing experienced by an individual is also considered a cost. When the wellbeing improves (e.g. less human disease, better livestock welfare, more biodiversity), the reduction of the negative effect transforms into a benefit. The magnitude of the benefit that we can achieve through an intervention gives us an upper limit of how much we can invest to achieve these benefits and break even (a break-even point is a term commonly used in economics and business to describe the point at which total revenue equals total costs, resulting in neither profit nor loss). In other words, an investment is economically worthwhile if the investment costs are recovered by the resulting benefits.

In One Health, the costs may be borne by different **actors** and the benefits may include both private and public goods. A **PRIVATE GOOD** is both excludable and rivalrous in consumption and includes most consumer products, such as food or clothing typically bought and sold in markets. A **PUBLIC GOOD** is non-excludable and non-rivalrous in consumption, i.e. consumption is open to all and if one individual consumes it, there is still availability or benefits for others, e.g. public parks or clean air. Public goods often have positive EXTERNALITIES, i.e. the impact of an economic activity that affects third parties who are not directly involved in the activity and whose interests are not taken into account in the market price, meaning their benefits spill over to society as a whole beyond those directly consuming or paying for goods or services.

13.4.1 Market prices of resources

How do we value what we have defined as costs? The materials, work time, and skills we use for One Health interventions are generally available on the market. **MARKET PRICES** are indicators of the availability of these resources and the competition for their use among economic operators in their activities. Then, market prices show how much the resources in a One Health intervention are worth. This cost reflects what we give up by not using those resources for other possible purposes.

13.4.2 Tangible and intangible costs

When implementing an activity, the costs related to resource use for which market prices can be identified, such as fuels, energy and other utilities, raw materials, consumable and durable goods, facilities, personnel and professional services, are defined as **TANGIBLE COSTS** (measurable costs that can be quantified in monetary terms). Their assessment is based on information on technical parameters (how much energy, how many materials, how much labour, what kind of facilities, etc.) and price data.

We have also seen that the occurrence in individuals of suffering, discomfort, pain or reduced wellbeing is a cost. To estimate these costs, we cannot refer directly to market prices. For this reason, costs originating from non-market goods are defined as **INTANGIBLE COSTS** and are estimated by analysing the behaviour of individuals through a range of methods. In the context of the evaluation of One Health initiatives, we often also consider the intangible costs related to animal welfare losses in farms (Bozzo *et al*., 2019; Alonso *et al*., 2020) and those related to losses in the 'non-use' values of environmental goods. The latter refers to the value individuals attribute to keeping in existence an environmental good even though there is no actual, planned or possible use of it (see also Section 13.7 on valuation later in the chapter). People's value could stem from the concern for the good itself (e.g. a threatened landscape or animal species), a feeling of responsibility for it (existence values), or a sentiment that the good should be available to others (altruistic value) or future generations (bequest value) (Pearce *et al*., 2006).

Methods for estimating intangible costs are based on the assessment of individuals' willingness to pay[2] (WTP) to avoid the associated welfare losses. They include revealed and stated preference methods, which derive values based on observed behaviours or stated opinions of individuals respectively (Whitehead *et al*., 2008). This makes it possible to attribute monetary values to intangible costs: an example is the social cost of carbon used specifically for environmental intangible costs (Nordhaus, 2017). The concept of the 'intrinsic' value affirms that environmental goods have value in themselves independently of human preferences and WTP (Attfield, 1998; Batavia and Nelson, 2017). However, this notion cannot be incorporated into evaluation procedures that attribute values to assets based on objective criteria and people's WTP (Pearce *et al*., 2006). In other words, when we assume that the value of an environmental good is not related to individual preferences, we do not know how to quantify this 'intrinsic' value objectively in monetary terms.

13.4.3 Direct and indirect costs of an intervention

Direct costs are those directly related to the implementation of an intervention, for example:

- employment of health and administrative personnel;
- use of medicines, vaccines, supplements, medical instruments, personal protective equipment, etc.;
- use of health facilities, laboratories, health equipment, vehicles, etc.;
- third-party services (insurance, rental of vehicles and equipment, banking services, consultancy, etc.);
- monitoring and evaluation to track the progress and effectiveness of the intervention; and
- activities and processes in the environment, such as construction, planting, or habitat restoration efforts.

Indirect costs are those that arise as a consequence of the implementation of the intervention; typical indirect costs are the so-called productivity losses when people and animals are affected, but there are also other types of indirect costs:

- time spent by workers or community members participating in or supporting the intervention instead of their regular activities or jobs;
- temporary declines in animal health and productivity or welfare due to side effects of the intervention;
- trade disruptions in the agricultural or animal production sector caused by the intervention; and
- impact on local businesses or industries due to changes in environmental regulations or interventions, such as restrictions on fishing or logging.

13.4.4 Resources that do not exhaust their functionality with use

There are resources that exhaust their utility with use, such as medicines, electricity, fuel for vehicles, disinfectants, detergents, hours of work, which once used cannot be reused at other times. Therefore, their value in use corresponds to the price we pay to buy them.

For resources such as buildings, medical and laboratory instruments, health equipment, vehicles, furniture and hardware, which do not exhaust their functionality with use and can also be used beyond the specific intervention we are evaluating, it is necessary to estimate the COST OF DEPRECIATION in the context of the intervention considered. For example, the depreciation cost of a vehicle used by the public veterinary service to collect samples for the alternative surveillance options, outlined in Fig. 13.2, can be calculated with the formula:

$$C_{int} = \frac{NV}{TT} * T_{int}$$

Where:

NV = price of purchasing the vehicle as new (e.g. a minivan, price: US$40,000);

TT = estimated total time of use of the vehicle by the public veterinary service until its decommissioning (e.g. 10 years);

T_{int} = estimated time of use of the vehicle for the interventions:

6 months per year in the case of intervention A (bulk milk testing in all farms twice a year);

1 month per year in the case of intervention B (serological testing in all farms once in three years).

C_{int} = cost of depreciation of the vehicle for its use in the interventions:

for intervention A (bulk milk testing in all farms twice a year) = ($40,000/10 years) * 6/12 = $2000 per year;

for intervention B (serological testing in all farms once in three years) = ($40,000/10 years) * 1/12 = $333 per year.

Task: Assuming the vehicle of the above example is used for an average annual distance travelled of 30,000 km, estimate the depreciation cost per km travelled.

Answer: The annual depreciation cost of the vehicle is calculated by dividing the NV ($40,000) by the estimated total time of using the vehicle (10 years), which results in an annual depreciation cost of $4000 per year. Next, we calculate the depreciation cost per kilometre travelled. We know the vehicle travels an average annual distance of 30,000 km. We calculate the depreciation cost per kilometre by dividing the annual depreciation cost by the average annual distance travelled, i.e. $4000/30,000km = $ 0.1333/km.

13.4.5 Benefits

Contrary to costs, anything that causes an increase in an individual's or population's state of wellbeing determines a benefit, for example:

- a decrease in the state of suffering, discomfort, pain, or the induction of a state of greater pleasure or satisfaction in an individual;
- improved water quality, increasing biodiversity, and providing recreational opportunities enhancing the overall wellbeing of the community and ecosystem;
- increasing crop and animal yields to ensure a stable food supply, reducing hunger and malnutrition;
- generating more equitable education opportunities promoting empowerment of disadvantaged groups; and
- saving resources in satisfying a need so that they can be allocated to meet other needs as well as productivity improvements.

Benefits assessment generally follows the same logic and classifications seen for costs regarding tangibility, direct and indirect correlation to the implementation of the intervention, distribution over time (see below), and application of methods to determine their value.

13.4.6 The evaluation timeframe, values over time and discounting

The timeframe of an evaluation is the period over which the costs and consequences of an intervention are assessed. It should cover the time needed for the intervention to develop all its relevant impacts regarding the use of resources and wellbeing creation. Typically, this goes through a first phase in which most of the investments necessary for intervention implementation are deployed, with dominance of costs over benefits. In the second phase, the intervention runs at its ordinary capacity with operating costs being incurred, and benefits often prevailing.

Therefore, resource consumption and effects of a One Health intervention develop over time, and the same happens for the costs and benefits that the intervention produces, which is a problem for economic evaluations because values generated at different moments are not directly comparable.

Getting a benefit of $1000 today is better than getting a benefit of $1000 in one year's time and supporting a cost of $1000 in one year's time is better than disbursing such an amount today, because money available now is worth more than the same amount in the future due to its potential earning capacity. Therefore, to compare benefits and costs occurring at different moments, it is necessary to convert them to present-day values, a process called **discounting**:

$$PV = \frac{FV}{(1+r)^t}$$

Where:

PV = present value;

FV = future value;

r = discount rate;

t = time

Discounting gives account of time preference of individuals. A classical problem is that a future value discounted at present appears to us smaller the later in time it occurs, and the higher the discount rate is. Figure 13.3 illustrates the distribution over time of the net values created by a One Health intervention that extends its relevant impacts over 20 years. Net investments of

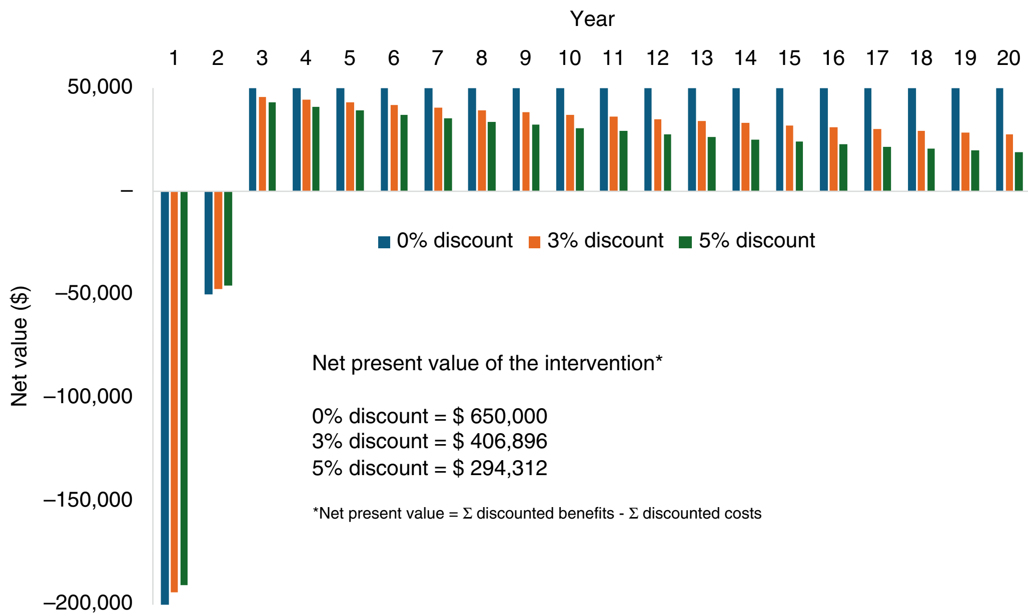

Fig. 13.3. Distribution over time of the net values created by a One Health intervention over a 20-year timeframe calculated at different discount rates (0 %, 3 % and 5 %), and respective net present values (see details in the text).

$200,000 and $50,000 are planned in the first two years. The intervention brings an annual net benefit of $25,000 between the third and the twentieth year.

These values have been discounted at different rates:

- 0%, i.e. no discount applied (blue bars in the graph);
- 3% discount (orange bars in the graph);
- 5% discount (green bars in the graph).

The graph highlights the difference between the annual values when discounted at different rates and the further away from the start of the project in time. Figure 13.3 also shows the intervention's net present value (NPV), i.e. the difference between the sum of all the discounted benefits and the discounted costs accumulated over time. Not applying discounting, the intervention achieves a net present value of $650,000. With a discount rate of 3%, the attractiveness of the intervention decreases considerably to an NPV of $406,896. If we apply a discount rate of 5%, the NPV is $294,312.

The choice of the discount rate can, therefore, significantly influence the final economic judgement on an intervention:

- In the case of health interventions, reference is made to the so-called 'social time preference rate' or 'social discount rate', generally indicated by government authorities for projects that have public utility implications (Zhuang *et al.*, 2007). They can be lower than market rates to reflect societal preferences for intergenerational equity. The WHO suggests applying in health assessments a discount rate of 3% (Tan-Torres Edejer *et al.*, 2003). The European Commission often uses a range of 3% to 5% for CBAs related to public investments, including environmental projects.[3]
- Financial discount rates are used in financial analysis to evaluate investments, projects or assets from the perspective of investors or businesses. For interventions operated with private financing (for example, in the agriculture sector), a reference can be the rate of return of alternative investments in the private sector.

The social discount rate emphasizes societal values and intergenerational equity, while the financial discount rate focuses on maximizing financial returns and investment decisions.

Discount rates proposed by governments for public interest initiatives vary significantly across countries and over time for the same country. Zhuang *et al.* (2007) analysed the different approaches public authorities adopted in different countries. Following the mentioned WHO suggestion, as well as the advice of the US Panels on Cost-Effectiveness in Health and Medicine, the 3% discount rate is often used for evaluations concerned with global health (Basu and Ganiats, 2016; Haacker et al., 2020).

Discounting future values related to environmental assets is deemed to underestimate the potential damage to future generations from the current use of natural resources; this is called the 'Tyranny of Discounting'. Many environmental interventions, such as conservation projects or pollution reduction efforts, generate benefits that accrue over extended time periods, sometimes spanning generations. Discounting these benefits at standard rates can diminish their perceived value in present terms. Another argument is that some environmental changes, such as species extinction or habitat destruction, are irreversible or have long-lasting consequences and that discounting may not adequately capture the irreversible nature of these losses. Proposed alternatives to the supposed unfairness of discounting towards future generations are the adoption of zero discounting or discount rates that diminish in the far future for economic evaluations involving the environment (Broome, 1992; Pearce *et al.*, 2003; Polasky and Dampha, 2021). These approaches want to induce incremental savings of natural resources by the current generation to safeguard the prosperity of future generations. However, zero discounting implies that future values are accounted the same as current values by neglecting individuals' time preference, which does not fit with human behaviour. Moreover, the zero-discounting perspective entails that there are no limits on how many future generations are entitled to benefit from current savings, creating relevant paradoxes, including inequity regarding the possibilities of improving the conditions of the most disadvantaged populations within the current generation (Pearce *et al.*, 2003, 2006).

Over the last decades, researchers have found that time-declining discount rates align better with the behaviour of individuals compared to the conventional practice of discounting at a constant rate over time (Hansen, 2006). The human attitude of discounting future values has been attributed to **uncertainty** about the future or the economy. In contrast, the application of time-declining discount rates addressing intergenerational equity is rooted in a prescriptive approach stemming from environmental ethics and climate-change policies. Despite this considerable difference – and other shortcomings related to the logic consistency of time-declining discounting when concretely applied (Hansen, 2006) – the two approaches could opportunistically find some convergence (Pearce *et al.*, 2003; Hansen, 2006; Polasky and Dampha, 2021).

13.4.7 The evaluation point of view

What is a cost for the government is often not a cost for an individual patient or farmer. Moreover, the interest of the entire national community is not necessarily the same for a specific region, territory or health facility.

The 'point of view' or 'perspective' considered in economic evaluation is relevant. For example, two alternative viewpoints are adopted in the economic assessment of health interventions that have public interest implications (Hurley, 2000; Brouwer *et al.*, 2008; Drummond *et al.*, 2015), namely:

- Given the available resources, the 'societal' point of view pursues the maximum interest for the whole community of reference; this is the 'welfarist' approach.[4] One solution is better than another if it increases someone's wellbeing without damaging anyone else (or providing compensations for those supporting damages);
- The point of view of the health structure that provides the service is the position of an institution that, with the budget assigned, must optimize the services to which it is committed in quantitative and qualitative terms, under the hypothesis that the institution's decision makers act in the interest of the community: this is the 'extra-welfarist' approach.

In the first case, the judgement on the convenience of an intervention should also consider the possible alternative uses of resources in society's sectors other than the One Health sectors. In the second case, the choices about the intervention directly concern the management of the specific institution or service.

In the context of One Health, the costs and benefits associated with interventions can vary depending on the perspective adopted. Unlike traditional health evaluations, where costs for the public health service may not directly impact individual patients or farmers, One Health interventions often involve interconnected systems where costs and benefits extend beyond the health sector alone.

Consider, for example, a vaccination programme targeting **zoonotic diseases** in both human and animal populations. From a societal perspective, the 'welfarist' approach seeks to maximize overall wellbeing across all sectors of the community. This perspective considers not only the health benefits but also the broader societal impacts, such as economic productivity, environmental sustainability and social equity. In this view, an intervention is deemed favourable if it increases overall wellbeing without causing harm to any sector and considers potential trade-offs between One Health sectors and other societal needs.

Task: Using the brucellosis example with interventions to be applied in an endemic context, work through the different steps as outlined in this section and for each step write down what you would consider in your analysis.

Example answer:

- Market price of resources: Consider the cost of resources such as vaccines, diagnostic tests, personnel and medical equipment based on market prices. This will allow you to estimate the costs of the intervention accurately.
- Tangible and intangible costs: By analysing both tangible and intangible costs, direct and indirect costs, we can get a more complete picture of the economic burden associated with the two options. Evaluate tangible costs like extra labour needed or labour lost when people are sick, medicines and facilities used, and costs for the culling of animals as well as the costs incurred for personnel (veterinarians, technicians) involved in testing of the animals. Both programmes might lead to productivity losses for farmers owing to time spent handling testing procedures and culling. Restrictions on animal movement due to positive tests could also lead to indirect costs. The tangible costs can be estimated using market prices for personnel, testing materials and equipment. Moreover, consider intangible costs such as animal welfare losses when livestock get ill, environmental non-use values (see Section 13.7 on valuation), and societal wellbeing impacts. Both interventions involve culling infected animals, which can be a source of stress and suffering for the animals. This can be considered an intangible cost. Estimating the intangible cost of animal welfare is challenging. We cannot directly use market prices, but we can consider studies that assess people's WTP to reduce animal suffering in farm settings.
- Resources that do not exhaust their functionality with use: Estimate costs related to resources that retain functionality over time, such as buildings and medical equipment, considering their use beyond the specific intervention.
- Benefits: Assess benefits in terms of reduced disease burden, increased productivity, societal wellbeing, improved animal welfare and environmental benefits.
- The timeframe of the evaluation: Define the time over which the One Health intervention deploys its relevant consequences in terms of the use of resources and impacts on humans, animals and health of the environment. Note that the timeframe for proposed interventions affects the inclusion of benefits. Longer timeframes can be more useful to see environment health benefits, but if timeframes are too long, the results become much less certain.
- The values over time and discounting: Apply discounting to compare costs and benefits over time, considering the present value of the intervention and the choice of discount rate based on public or private financing perspectives.
- The point of view of evaluation: Consider the evaluation perspective, whether it is from a social viewpoint aiming for maximum community or sector benefit or if it is an intervention that benefits society more widely. In some cases, it may also be of interest to include the perspective of a specific health facility managing its resources optimally (e.g. a chain of veterinary practices involved in brucellosis control).
- Applying the framework: This information, along with the potential benefits (improved animal health, reduced public health risk), can be used to conduct a CBA and determine the most cost-effective programme for controlling brucellosis in the specific context.

13.5 Combining Different Metrics and Decision Parameters

The main methods of economic evaluation do not substantially differ in considering costs, which are always expressed in terms of monetary values, but rather in the ways in which the consequences of the interventions examined are compared. Even when the comparison is made with reference to non-monetary effects, such as in the CEA and CUA, these effects should be discounted. Table 13.2 provides an overview of how the different

Table 13.2. Types of economic evaluations for One Health interventions, parameters for the evaluation of costs and consequences, and published examples on brucellosis.

Type of evaluation	Costs	Consequences	Description and decision parameters	Examples on brucellosis
Cost-minimization analysis (CMA)	Monetary values	The examined alternatives have identical health effects expressed with the same indicator	Compares the costs in monetary terms of alternative interventions that have equivalent outcomes. Aims to identify the least costly option among equally effective alternatives.	Cost comparison of two surveillance strategies on cattle with the same diagnostic accuracy in a brucellosis officially free area in Northern Italy (Aragrande *et al*., 2020).
Cost-effectiveness analysis (CEA)	Monetary values	The examined alternatives have different health effects expressed with the same indicator in natural (physical) units	Compares the costs and health outcomes of alternative interventions calculating the cost per unit of outcome achieved to identify the most cost-effective solution. The alternatives are compared through the incremental cost-effectiveness ratio (ICER, see in the main text).	The sensitivity in detecting brucellosis and the costs of the French surveillance system for the disease are compared to those of 19 alternative surveillance scenarios (Hénaux and Calavas, 2017).
Cost-utility analysis (CUA)	Monetary values	Different effects expressed in terms of better health status of individuals over time	As in CEA (often CUA is also considered to be a type of CEA), except for the outcomes that are always expressed as individuals' quality of life over time with specific indicators, e.g. disability-adjusted life-year (DALY) or quality-adjusted life-year (QALY).	Cost-utility comparison in terms of cost per DALY averted between two testing methods, namely the Febrile Antigen Brucella Agglutination Test (FBAT) and the Rose Bengal Test (RBT) in Kenyan hospitals (Alumasa *et al*., 2021). Comparison of different test-and-slaughter strategies for brucellosis control achieving different levels of livestock culling for cattle and sheep in Armenia (Anyanwu *et al*., 2024).
Cost–benefit analysis (CBA)	Monetary values	Effects expressed in monetary values	Considers the monetary values generated over time by alternative interventions in terms of both costs and the benefits to identify the solution that generates the highest net present value (NPV, see Section 13.4.6). Other parameters for decision in CBA are the benefit–cost ratio (BCR) and the internal rate of return (IRR). There are also parameters that do not use discounted values, such as the pay-back period (PBP).	Cost–benefit evaluation of a proposed improved annual mass vaccination programme for sheep and goats targeting all animals older than 3 months with the Rev. 1 vaccine, compared to a current annual programme vaccinating only female animals between 3 and 6 months of age in Northern Iraq (Al Hamada *et al*., 2021). Comparison of different test-and-slaughter strategies for brucellosis control achieving different levels of livestock culling for cattle and sheep in Armenia (Anyanwu *et al*., 2024).

Continued

Table 13.2. Continued.

Type of evaluation	Costs	Consequences	Description and decision parameters	Examples on brucellosis
Mixed analysis	Monetary values	Effects expressed in monetary and non-monetary values	A mixed One Health analysis that combines both cost-effectiveness analysis and cost–benefit analysis and looks at effects in multiple sectors.	For the human population, an incremental cost-effectiveness analysis to compare the cost and health effects of a vaccination programme with current practice. Combined with a cost–benefit analysis for different vaccination strategies in livestock. Consideration of reduced transmission from livestock to people (Roth *et al.*, 2003). From a societal perspective, the value of reduced disease in humans, households and animal production outweighed the total intervention costs and the $ per DALY averted became negative.[5]

types of economic evaluations can be applied using different brucellosis examples.

For the CBA, an important parameter informing decisions between the examined interventions is the NPV described in Section 13.4.6. Other parameters used in CBA are the benefit–cost ratio (BCR) and the internal rate of return (IRR). The BCR of an intervention is calculated by dividing the sum of its discounted benefits by the sum of its discounted costs, as follows:

$$BCR = \frac{\sum discounted\ \ benefits}{\sum discounted\ \ costs}$$

An intervention creates a positive value (i.e. NPV > 0) when the BCR > 1. Between alternative interventions, we should prefer the one with the highest BCR. If two alternatives have the same NPV, the one that implies the lower costs is better, and this can be detected with the BCR.

The IRR is the discount rate that results in an NPV equal to zero. It can be calculated based on the equation:

$$\sum discounted\ benefits = \sum discounted\ costs$$

Between alternative interventions we should prefer the one with the highest IRR.

All three decision criteria are ideally considered in decision making. The IRR has the advantage of avoiding the choice of the discount rate to be adopted in the valuation. However, the literature advises against its use as the main evaluation parameter of an intervention, as it is influenced by the distribution of costs and benefits over time and has several accounting drawbacks: e.g. it is possible for an intervention to have more than one IRR or even no IRR at all (Pearce *et al.*, 2006).

There are also decision parameters for CBA that do not make use of discounted values. One is the pay-back period (PBP), which is the time needed to recover the initial investment of the intervention with the generated net benefits. For example, if an intervention requires an initial investment of $1 million, and generates net benefits of $100,000 per year, its PBP is ten years. Between alternative interventions, we should choose the one with the shorter PBP.

Regarding CEA and CUA, the cost-effectiveness of alternative interventions is compared through the incremental cost-effectiveness ratio (ICER), which expresses the difference in costs related to the difference in effectiveness between the alternatives:

$$ICER = \frac{C_N - C_O}{E_N - E_O}$$

Where C_N and C_O are the costs of the new intervention and the old (existing) alternative, and E_N and E_O are the respective effects.

The ICER expresses the cost-effectiveness of N compared to O. If N is less expensive and more effective than O, it should be preferred. If it results in being more costly and less effective, it should be rejected. If it is more costly but also more effective than O, the decision maker should establish if the incremental effect of N justifies its incremental cost, according to a cost-effectiveness threshold that, in a societal perspective, sets the maximum willingness to pay of society for such an improvement.

For details on how to conduct the different analyses summarized in Table 13.2, please refer to Canali *et al.* (2018) and look at the references provided with illustrative examples. Here, we are now moving on to think about how to combine different effects in these economic evaluations.

Learning questions: Building on the example above and the different effects that you identified, think about how these outcomes could be measured and how they would be included in an economic evaluation. Would they all have the same metric? Would they all have the same weight? Why?

Example answer:

- Improved animal health productivity can be measured through indicators such as disease incidence rates, animal mortality rates, reproductive success and livestock productivity metrics (e.g. milk yield, weight gain). In the economic evaluation, improved animal health productivity would involve assessing the costs of veterinary services, disease prevention measures, animal husbandry practices, and access to quality feed and healthcare. The benefits can be assessed in terms of increased income from livestock products, reduced healthcare expenses and overall economic gains for farmers.
- Improved human health resulting from the interventions can be measured through various indicators such as changes in disease incidence and prevalence, morbidity and mortality rates, healthcare utilization patterns including hospital admissions and primary care visits. Also, qualitative assessments can be used such as quality of life surveys and patient feedback to determine metrics such as QALYs and DALYs. The interventions also come with healthcare associated costs that need to be considered.
- Biodiversity gain can be measured using ecological metrics such as species richness, habitat diversity, ecosystem stability and presence of indicator species. In the economic evaluation, biodiversity gain would involve assessing the costs associated with conservation efforts, habitat restoration and biodiversity monitoring. The benefits can be assessed in terms of ecosystem services provided, such as pollination services, soil fertility, water purification and carbon sequestration.
- Social **empowerment** can be measured through indicators such as increased participation in decision-making processes, enhanced **knowledge** and skills among community members, and improved access to resources and opportunities. The economic evaluation can assess the cost of **capacity-building** programmes, community training sessions, and infrastructure development aimed at empowering individuals. The benefits can be measured through factors like increased community resilience, reduced social inequalities and improved overall wellbeing.
- Each outcome would require different metrics for measurement due to their unique nature (social, ecological and economic). For example, social empowerment may use qualitative and participatory methods, while biodiversity gain may rely on ecological surveys.
- The weights assigned to each outcome in the economic evaluation would depend on various factors such as the project goals, stakeholder priorities and societal values. For instance, in an area with high biodiversity importance, biodiversity gain may be given more weight, whereas in a community facing social challenges, social empowerment may be prioritized. These weights would reflect the relative importance and impact of each outcome on the overall success and sustainability of the One Health intervention. They can be determined with the community of practice and stakeholders set up during the implementation cycle.

You will see from the activity above that there are important considerations and decisions to be made when it comes to the combination of diverse outcomes. Using our example of two interventions for brucellosis in dairy farms, we now present the hypothetical results of their application in a region recording 100 human cases annually.

Task: Given the two interventions summarized in Table 13.3, considering a period of 10 years, and a discount rate of 3 %, calculate:

- The NPV of the two interventions from a societal perspective and from the viewpoint of the national health service, and indicate the best solution; and
- The ICER per averted human case of the two interventions with respect to the current situation from a societal perspective and from the viewpoint of the national health service and indicate the best solution.

Answer:

The subscripts A and B indicate interventions A and B, respectively, and the figures highlighted in bold indicate the preferred intervention from an economic point of view.

Net present value:

- Societal perspective: **NPV_A $29,378,019**; NPV_B $26,968,236.
- Health service perspective: **NPV_A $20,165,400**; NPV_B $18,101,090.

Incremental cost-effectiveness ratio:

- Societal perspective: **$ICER_A$ $–43,050** per DALY; $ICER_B$ $–41,058 per DALY (for both solutions the ICER is negative, which in this case means that both generate a benefit per DALY averted).
- Health service perspective: **$ICER_A$ $–29,550** per DALY; $ICER_B$ $–27,558 per DALY (for both solutions the ICER is negative, which in this case means that both generate a benefit per DALY averted).

Table 13.4 shows the costs and benefits for the two interventions A and B as compared to the current situation. Note that the benefits (both monetary and non-monetary) can be estimated directly using the averted costs, i.e. no comparison with the current situation (i.e. the baseline) is needed.

Table 13.5 shows the calculated net present value and the ICER for both options A and B. Here, the total monetary value calculated was compared to the DALYs averted. Because the NPV is already positive, the DALYs averted are an additional benefit, adding to the monetary benefit that is created in the livestock sector. One DALY equates to a year of healthy life lost, i.e. averted DALYs constitute a benefit. Here, we are now facing a situation where we are seeing a benefit for each DALY averted. As explained in the note cited previously (note 5), this can be difficult for decision makers to understand and it may make sense to present this outcome in a different way.

We often see situations where there is a net cost and the averted DALYs are used to decide whether an intervention is economically worthwhile. Hence, we might

Table 13.3. Results stemming from a hypothetical *ex-ante* economic analysis of two new intervention options (to replace the current one) for brucellosis in dairy farms in an endemic region where 100 human cases are annually recorded, with resulting benefits in human and animal populations. One of the two options will substitute the current farm control strategy of the public veterinary service.

Item	Intervention A	Intervention B
Total cost of the current farm control strategy of the public veterinary service ($/year)	20,000	20,000
Transportation costs of public veterinary service staff with the new farm surveillance system ($/year)	25,000	7,000
Costs of sample collection in dairy farms by the public veterinary service with the new farm surveillance system ($/year)	23,000	145,000
Laboratory testing costs by the public veterinary service with the new farm surveillance system ($/year)	8,000	56,000
Averted farm costs for suspected animal culling and farm sanitation protocols with the new farm surveillance system ($/year)	800,000	770,000
Averted costs for human healthcare and hospitalizations by the public health service with the new farm surveillance system ($/year)	2,400,000	2,310,000
Averted costs of productivity losses for human cases with the new farm surveillance system ($/year)	280,000	269,500
Number of averted DALYs with the new farm surveillance system (DALYs/year)	80	77

Table 13.4. Overview of the different costs and benefits, both monetary and non-monetary, over a time period of 10 years, discounted and undiscounted.

Years	1	2	3	4	5	6	7	8	9	10
COSTS										
Current control strategy cost ($)	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Transportation costs + sample collection + laboratory testing for A ($)	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000	56,000
Difference in costs current and A (i.e. the extra costs of A compared to current) ($)	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000
Discounted difference in costs (i.e. the extra costs of A compared to current in present value terms) ($)	**34,951**	**33,933**	**32,945**	**31,986**	**31,054**	**30,149**	**29,271**	**28,419**	**27,591**	**26,787**
Transportation costs + sample collection + laboratory testing for B ($)	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000	208,000
Difference in costs current and B (i.e. the extra costs of B compared to current) ($)	188,000	188,000	188,000	188,000	188,000	188,000	188,000	188,000	188,000	188,000
Discounted difference in costs (i.e. the extra costs of B compared to current in present value terms) ($)	**182,524**	**177,208**	**172,047**	**167,036**	**162,170**	**157,447**	**152,861**	**148,409**	**144,086**	**139,890**
BENEFITS										
Societal perspective A										
Averted farm costs + averted human health costs + averted productivity losses ($)	3,480,000	3,480,000	3,480,000	3,480,000	3,480,000	3,480,000	3,480,000	3,480,000	3,480,000	3,480,000
Discounted benefits societal perspective ($)	**3,378,641**	**3,280,234**	**3,184,693**	**3,091,935**	**3,001,879**	**2,914,445**	**2,829,558**	**2,747,144**	**2,667,130**	**2,589,447**
Health service perspective A										
Public health perspective: Averted costs for human healthcare and hospitalization ($)	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000
Discounted benefits health service perspective ($)	**2,330,097**	**2,262,230**	**2,196,340**	**2,132,369**	**2,070,261**	**2,009,962**	**1,951,420**	**1,894,582**	**1,839,400**	**1,785,825**
Societal perspective B										
Averted farm costs + averted human health costs + averted productivity losses ($)	3,349,500	3,349,500	3,349,500	3,349,500	3,349,500	3,349,500	3,349,500	3,349,500	3,349,500	3,349,500

Continued

Table 13.4. Continued

Years	1	2	3	4	5	6	7	8	9	10
Discounted benefits societal perspective ($)	3,251,942	3,157,225	3,065,267	2,975,987	2,889,308	2,805,154	2,723,450	2,644,126	2,567,113	2,492,343
Health service perspective B										
Public health perspective: Averted costs for human healthcare and hospitalization ($)	2,310,000	2,310,000	2,310,000	2,310,000	2,310,000	2,310,000	2,310,000	2,310,000	2,310,000	2,310,000
Discounted benefits health service perspective ($)	2,242,718	2,177,397	2,113,977	2,052,405	1,992,626	1,934,589	1,878,241	1,823,535	1,770,423	1,718,857
Human cases averted										
Intervention A (DALYs)	80	80	80	80	80	80	80	80	80	80
Discounted values (DALYs)	78	75	73	71	69	67	65	63	61	60
Intervention B (DALYs)	77	77	77	77	77	77	77	77	77	77
Discounted values (DALYs)	75	73	70	68	66	64	63	61	59	57

Table 13.5. Net present value and ICER for options A and B calculated for a ten-year time period using the values shown in Tables 13.3 and 13.4. The preferred option using economic criteria is highlighted.

Net Present Value (NPV)	Across 10 years	
Societal perspective	A	B
Total discounted costs (Sum Years 1 to 10) ($)	307,087	1,603,678
Total discounted benefits (Sum Years 1 to 10) ($)	29,685,106	28,571,914
NPV societal perspective ($)	**29,378,019**	**26,968,236**
Health service perspective		
Total discounted costs (Sum Years 1 to 10) ($)	307,087	1,603,678
Total discounted benefits (Sum Years 1 to 10) ($)	20,472,487	19,704,769
NPV health service perspective ($)	**20,165,400**	**18,101,090**
INCREMENTAL COST-EFFECTIVENESS RATIO (ICER)		
Societal perspective		
Difference in costs (intervention option compared to the baseline) ($)	–29,378,019	–26,968,236
Total discounted effects (Sum Years 1 to 10) (DALYs)	682	657
Cost per averted DALY ($/DALY)	**–43,050**	**–41,058**
Health service perspective		
Difference in costs (intervention option compared to the baseline) ($)	–20,165,400	–18,101,090
Total discounted effects (Sum Years 1 to 10) (DALYs)	682	657
Cost per averted DALY ($/DALY)	**–29,550**	**–27,558**

see a situation where the benefits from the livestock sector are not sufficient to recoup the investment and the benefits in humans decide if the investment is worthwhile. Let us look at this with an illustrated (hypothetical) example: if intervention B produced a net cost of say $–1,034,566 and we compared that to the DALYs averted, then the cost per DALY averted would be $1576. To know if this is good value for money, we could aim to find a cost-effectiveness threshold. Many health economic evaluations use specific thresholds to determine whether an intervention is cost-effective. These thresholds can vary by country and health system but are often benchmarked against a country's GDP per capita or specific policy targets. For instance, the World Health Organization (WHO) has suggested that interventions costing less than three times the GDP per capita per DALY averted are considered cost-effective, while those costing less than the GDP per capita per DALY averted are considered highly cost-effective.

13.6 The Problem of Uncertainty and Sensitivity Analyses

Economic evaluations of One Health interventions are based on assumptions about the accuracy of the information, reference data and the occurrence of certain events in the future (e.g. incidence of diseases, availability of resources, prices of materials to be used, etc.). The concrete usefulness of an evaluation depends on the correctness and the occurrence of these assumptions. Each evaluation is therefore affected by uncertainty: it represents a probable, but not certain, situation.

13.6.1 Sensitivity analysis

Economic evaluations are subject to **sensitivity analyses** to address uncertainty that make it possible to assess the extent to which an evaluation outcome is sensitive to variations in the parameters used for calculations (e.g. epidemiological indicators, quantity of resources to be used, reference prices, etc.). In other words, it is a question of seeing if the outcome of the evaluation is confirmed in the presence of possible changes in the values of the parameters adopted, especially those that appear more uncertain.

Deterministic and probabilistic sensitivity analyses:

1. Deterministic sensitivity analyses, on the one hand, consist in varying a specific parameter (univariate) or a set of relevant parameters (multivariate) of the evaluation, then the results are examined to verify the impact of these changes on the initial evaluation.
2. Probabilistic sensitivity analyses, on the other hand, tend to incorporate uncertainty within the evaluation process.

In a probabilistic analysis, first, we define the statistics (i.e. type of distribution, mean, standard error) of the relevant parameters of the evaluation model. On this basis, a new value is randomly extracted for all the model parameters to calculate a new evaluation outcome for the intervention that will be different from the result of the baseline evaluation. Available software can easily repeat this process thousands of times and randomly produce thousands of possible outcomes, of which one part will indicate the achievement of the intervention goal and the other will not. This allows estimating the probability of a successful intervention outcome by integrating uncertainty into the evaluation procedure.

By way of example, Fig. 13.4A shows the result of a probabilistic sensitivity analysis of a hypothetic CUA comparing the cost utility of a One Health intervention to a no-intervention scenario in a societal perspective. The scattered orange points on cost-effectiveness represent the ICER of the intervention resulting from 1000 random iterations. Most points fall in the first quadrant of the cost-effectiveness plan, denoting a high probability that the intervention is more effective for gained QALYs but costlier than no intervention. A consistent number of points also fall in the fourth quadrant, which indicates the favourable occurrence that the intervention is more effective and less costly than no intervention. Few iterations give an outcome where the intervention is costlier and less effective (second quadrant) or less costly and less effective (third quadrant) than no intervention.

Figure 13.4B shows the cost-effectiveness acceptability curve (CEAC) of the intervention. The intersection of the curve with the vertical axis indicates that the

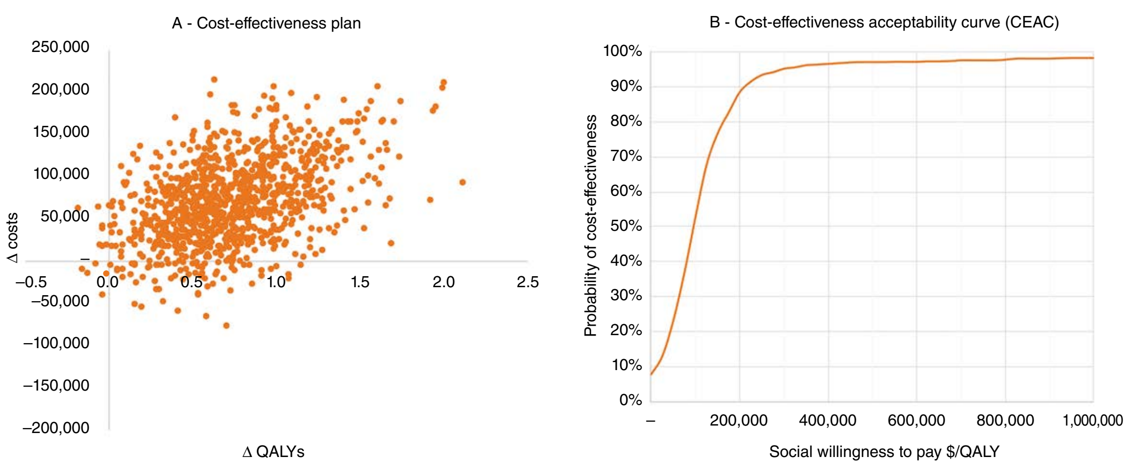

Fig. 13.4. (A) Representation of the probabilistic sensitivity analysis of a hypothetic CUA in the cost-effectiveness plan and (B) the resulting cost-effectiveness acceptability curve (see explanations in the text).

intervention has a 7.8% probability of being more cost-effective than the no-intervention scenario without any additional cost to society. The probability of cost-effectiveness of the intervention increases with the increase of the social willingness to pay for QALY gains. Within a social willingness to pay threshold of $100,000 per QALY, the cost-effectiveness probability of the intervention rises to 52.8% and 88.5% if the threshold is $200,000.

13.7 The Valuation Problem and Approaches to Address it

The previous sections demonstrated the variety of outcomes we may consider and the importance of measuring them for inclusion in economic evaluations. A big topic in One Health nowadays is the value of nature and other outcomes that do not have a market price. The intimate links between biodiversity, various kinds of ecosystem services and One Health have been illustrated in Chapter 7 on biodiversity. This section adds a conceptual reflection on value and valuations, which is particularly relevant for decision making in One Health; for example, when planning development projects or exploiting natural resources or creating projects that affect the social fabric of communities.

13.7.1 Valuation

VALUATION plays a crucial role in various fields of economics (e.g. health economics or environmental economics), but each field approaches it from distinct perspectives and focuses on different aspects. In simple terms, it refers to the process of assigning a quantifiable monetary value to various entities, outcomes or impacts. Valuations play a crucial role in evidence-based decision making, allowing the incorporation of intangible values into economic analyses and thereby ensuring that policies and interventions are aligned with societal values and goals.

Learning questions: What is value? Take a few minutes to think about what 'value' means to you. What has value to you and why? How do you know that something has value? Will this be similar to the value other people attribute to this?

Example answer: Here are two examples – yours may be similar or completely different; there is no right or wrong!

1. *I perceive value based on my personal beliefs and life experiences. To me, value encompasses various aspects depending on my priorities and what brings meaning to my life. For me, wealth, finance and success are important, and provide value in the form of material possessions, financial stability and economic opportunities. Investments, business ventures and financial assets hold significant value in my eyes as they contribute to my financial security, status and ability to achieve my desired lifestyle.*

2. *For me, there is only one thing that really has value, namely nature. My perception of value is deeply rooted in spiritual and environmental considerations. I find immense joy in the interconnectedness of all living beings, the tranquillity of nature, and the harmony of ecosystems. If a tree is unwell, I feel physically sick and I cannot witness the felling of trees, as it breaks my heart.*

Reading these statements and having thought about your own values, you will appreciate that there are many different forms of value and many different value systems. For some people, personal relationships and moments of joy hold great value as they contribute to emotional wellbeing and happiness. Similarly, knowledge and personal growth are valuable as they enrich life experiences and enable continuous learning. Value can also be attributed to tangible items like time, health and financial security, which are essential for overall wellbeing and quality of life. These aspects have value because they contribute to a sense of security, stability and fulfilment.

The perception of value is subjective and influenced by various factors such as cultural background, personal beliefs and life experiences. What holds value for one person may not hold the same value for another. For instance, a painting may hold significant emotional value for an art enthusiast because of its aesthetic appeal and artistic meaning, while others may not find the same level of value in it.

Understanding that value is subjective and can vary among individuals is crucial in appreciating diverse perspectives. It highlights the importance of empathy, open-mindedness and respect for different values and beliefs in interpersonal interactions and decision-making processes.

Given the multitude of perspectives, interests and value systems encountered in transdisciplinary processes, it is difficult to come up with valuations for inclusion in economic evaluations that do justice to the diversity encountered. Also, there are disciplinary silos that contribute to the challenge. In human health economics, valuation primarily revolves around health-related measures and outcomes, such as improvements in health status, life expectancy or quality of life. On the other hand, environmental economics focuses on valuing natural resources, ecosystem services and environmental impacts. This includes assigning monetary values to aspects such as clean air and water, biodiversity conservation, climate change mitigation and land-use changes. Valuation also extends to social aspects, encompassing factors such as social equity, community wellbeing, cultural heritage and human rights. Next, we are going to look at these diverse valuation challenges and then reflect on how to bring everything together and what this means for our implementation cycle.

13.7.2 Ecosystem valuation

Ecosystem services are gains or benefits to humankind derived from surrounding ecosystems. The primary challenge associated with this definition is the concept of 'gains'. A gain, benefit or ecosystem service is more than an objective description of the state, components or processes relating to an ecosystem: it entails an **anthropocentric** valuation of this very state, components or processes. This valuation determines whether a certain ecosystem state, component or process is seen as a benefit, or service that provides some gain. This valuation problem is the normative dimension which is inherent to any effort to identify or quantify ecosystem services. It is also related to the concept of '**environmental health**', which likewise contains an element of anthropocentric judgement about what is considered a 'healthy' environment.

This valuation problem can be broken down into two key aspects:

- How do we assess the value of the ecosystem service? This question becomes particularly relevant when we intend to compare several ecosystem services, or to account for the benefits and losses incurred by different actions.
- From whose perspective is an ecosystem service identified? That is, which stakeholders determine what is to be considered an ecosystem service?

Many standardized approaches to measuring subjectively perceived values have been developed by economists, psychologists and decision-making scientists that are relevant to valuing ecosystem services. Most such approaches are based on the concept of '**utility**'. Utility was first introduced by moral philosophers (Bentham, 1879; Mill, 1863) to designate pleasure or happiness. In this context, utility represents general qualities that apply in similar ways to different people. From the perspective of ecosystem services, this concept of utility thus comes closest to the concept of environmental health as a measure of 'optimal' state of ecosystems.

Modern economics and game theory defined utility as personal and subjective preference order over a set of choices (Pareto, 1923). Importantly, any such preference order is considered subjective, even if it refers to material goods, commodities or natural resources (Baron, 2008). From the perspective of ecosystem services, this definition emphasizes the subjective nature of gains and services that can be derived from ecosystems. By implication, different states of ecosystems could be considered desirable, depending on the utilities attached to them by different individuals. The question of which state of an ecosystem was to be considered 'healthy' would thus become a matter of negotiation or selection between different perspectives.

The concept of utilities was further refined by mathematicians (Von Neumann and Morgenstern, 1953), who developed it into 'expected utilities', which describe the relative preference of choices, the outcomes of which are not known for certain, but are uncertain. The overwhelming complexity of virtually any ecosystem will always make it impossible to base one's choices regarding the environment on full knowledge of the outcomes of different actions. Expected utilities that consider uncertain outcomes are thus a key concept for valuing ecosystem services in One Health initiatives.

The mathematician Herbert Simon and psychologists Tversky and Kahneman reconsidered the valuation concept (Simon, 1957; Kahneman and Tversky, 1979; Kahneman, 2011). Their key insight is humans' limited capability to amalgamate large bodies of information, and uncertain outcomes of extended sets of choices, into clear and consistent preference rankings. Instead, they tend to use incomplete information to make 'heuristic' choices, which can be described as establishing one's preference orders by rules of thumb. This approach may be a good approximation as to how humans and societies tend to value and decide about choices that impact on the ecosystem services that they profit from.

The school of 'bounded rationality' focuses on how to help people making better choices, by considering more available information and reflecting about potential inconsistencies in their preferences (Sent, 2018). One key tool relevant to the valuation of ecosystem services is multi-criteria decision methods, which are promoted and used in various One Health contexts (Hitziger *et al*., 2018). These decision-making support procedures enable the elicitation of values and preferences between several alternative choices through a variety of criteria. In a case study by Aenishaenslin *et al*. (2013) on Lyme disease in Canada, multi-criteria methods are used to analyse stakeholder preferences and impact of disease management interventions along 16 criteria, which include public, animal and environmental health, as well as social, economic and surveillance criteria.

Multi-criteria analysis can incorporate valuations from stakeholders with differing perspectives and objectives. It is the responsibility of the analyst to ensure that all relevant stakeholders are included in the analysis and that the voices of underrepresented and marginalized groups or populations are considered. Valuing ecosystem services using economic models has been criticized as inadequate for incorporating non-utilitarian, cultural or sacred values regarding the environment that are held by many groups of Indigenous Peoples. Some assessment processes for ecosystem services, in particular the IPBES[7] (Pascual *et al*., 2017), have therefore developed an alternative framework for integrating complementary valuations into their assessments. In this framework, the conceptual approach to measuring ecosystem services is used in addition to a holistic valuation of 'nature's gifts'.

13.7.3 Social outcome valuation

Social impact assessment (Freudenburg, 1986; Esteves *et al*., 2012; Vanclay *et al*., 2015) and social cost–benefit analysis (Chawla, 1987; Kumar, 2017) are methodologies used to quantify and evaluate social values, addressing issues such as income distribution, access to essential services, social cohesion and inclusivity. Valuation in the social realm aims to highlight the broader impacts of policies, projects or interventions on society, beyond purely economic or environmental metrics, to ensure holistic decision making and sustainable development.

The social aspects are also an important part of what is called the Social Return on Investment (SROI), which is a framework for measuring and accounting for a broader concept of value by incorporating social, environment and economic costs and benefits. It can be seen as an expansion of the CBA described above because it includes environmental and social outcomes more comprehensively, but requires careful consideration of the use of counterfactuals (baselines) and study time horizons (Banke-Thomas *et al*., 2015). Social impacts may, for example, consider improvements in quality of life or social cohesion, enhanced skills and knowledge, or increased access to services and opportunities for marginalized groups. Environmental impacts may be a reduction in environmental degradation or conservation of natural resources and the economic effects may be health service costs saved in animal and human health sectors. Thus, this approach lends itself to One Health, but has not yet been used widely in the One Health community.

13.7.4 Health valuation

Health valuation refers to the process of assigning a quantitative value or monetary value to health outcomes or health-related interventions. It involves assessing and measuring the benefits or improvements in health resulting from specific healthcare interventions, policies or programmes. The most common metrics are QALYs and DALYs to measure the impact on quality of life and overall health status. This valuation helps decision makers prioritize healthcare resources, allocate funding efficiently, and make informed choices regarding healthcare investments based on the expected health benefits and their associated costs.

In animals, many of the effects can be a combination of physical coefficients and market price information. It can include, for example, measuring parameters such as disease incidence and prevalence, mortality rates, physiological indicators of health (e.g. body condition scores) and output (e.g. litres of milk, number of eggs produced per unit of livestock). Multiplying these by the market prices of the animals or the products can give us the magnitude of a certain effect. Like for human health, there are also efforts to come up with behavioural assessments and overall quality of life indicators that allow capturing the welfare of an animal. For example, the Welfare-Adjusted Life-Years (WALYs) for animals reproduce the QALYs used in humans. WALYs aim to measure the overall wellbeing or quality of life of animals, based on both the duration and the quality of their lives (Teng *et al*., 2018). It involves assessing various aspects of animal welfare, such as physical health, behaviour, social interactions, environment and mental wellbeing, and then assigning a quantitative value to these factors. WALYs consider the impact of different health conditions, treatments or interventions on an animal's welfare over time. For example, an animal experiencing chronic pain or suffering from a disease may have a lower WALY score compared to a healthy, well-cared-for animal. By combining measures of welfare with time, WALYs provide a way to evaluate and compare the overall impact of different management practices, treatments or interventions on animal wellbeing, helping inform decisions related to animal welfare policies, veterinary care and ethical considerations.

In terms of integrated metrics, the zDALY provides a metric for zoonotic diseases that spans people and livestock (Torgerson *et al.*, 2018). In the zDALY, the losses from animal disease are converted to a metric using the local gross national income per capita to be able to compare them to human life-years. This allows estimating the time required to earn the income needed to make up for the loss incurred. Based on this, a so-called animal loss equivalent (ALE) is estimated and added to the DALY associated with human disease to give the zDALY (Torgerson *et al.*, 2018).

13.8 Dealing with Additional Levels of Analysis and Complexity

So far, we have looked at how to conceptualize the cross-sectoral interventions and effects when it comes to an example like a zoonotic disease intervention where we may see multiple activities and multiple effects in different populations. We looked at how we can identify and compare the different inputs and the consequences in common types of economic evaluations. These are analyses often used to determine the value of potential investments and help guide decision making. However, there are several other aspects that are important to consider when looking at the economic value of One Health.

Economic evaluations of unintended consequences require a design that allows keeping track of what is happening and incorporating new consequences (both positive and negative) as they emerge in the system. These can then be embedded in retrospective (*ex-post*) economic evaluations. Alternatively, modelling approaches make use of dynamic modelling techniques that simulate complex interactions and feedback loops, aiding in predicting long-term economic implications, such as system dynamics or agent-based modelling. Another approach can be to use scenario analysis to consider wider potential effects.

The Network for the Evaluation of One Health (NEOH) proposed a framework to assess the level of One Health integration of an intervention or an institution operating in the One Health context (Rüegg *et al.*, 2017, 2018a, b). This framework could be helpful to investigate correlations between the economic value created by an intervention and its 'One Healthness' (i.e. the level of One Health). Currently, there are not many peer-reviewed studies available that are targeting this question explicitly. A systematic literature review (Auplish *et al.*, 2024) found only seven studies that looked at the added value of One Health coordination, collaboration, communication or capacities. However, the authors found a good body of evidence from studies that showed that the consideration of effects across sectors may generate a positive return on the investment. Some of these studies explicitly compared a uni-sectoral with a cross-sectoral intervention and thereby demonstrated the added value of One Health. It should be noted that One Health economic evaluations that do not show an added value are still useful because they allow understanding in which situations One Health may or may not generate an added value.

When expanding the scale and complexity, scenario analysis (see Chapters 10 and 11) can be useful to shed light on different options and their potential outcomes. They could refer to different scenarios as elaborated in the implementation cycle, or they could come up during the discussions on how to conduct the economic evaluations. In any case, they include the definition of differing scenarios or alternative futures that could affect the interventions. They could, for example, include different economic conditions, market trends, regulatory changes, technological advancements or environmental factors.

The challenges of dealing with complex systems and non-linear causality in economic analyses are multifaceted. While efficiency is a vital aspect of One Health initiatives, incorporating equity and sustainability aspects is challenging. Economic evaluations typically prioritize efficiency, aiming to maximize outcomes within resource constraints. However, this approach may not adequately address equity concerns or long-term sustainability, leading to potential inequities or unsustainable solutions. Efforts have been made to integrate equity considerations into health-oriented evaluations and incorporate sustainability goals into efficiency measures. Yet, these adaptations can sometimes conflict with the fundamental principles of economic evaluation, emphasizing the need for caution or alternative approaches as alluded to above. More information on this topic can be found in Häsler *et al.* (2021), for example.

Returning to our brucellosis example, the following expansions would be possible for a more comprehensive and in-depth economic analysis:

1. Assessing whether the effect of the One Health integration across sectors, **disciplines** or communities increases the added value of the intervention(s);
2. Conceptualizing the economic analysis at the systems level considering dynamic feedback loops and non-linear effects;
3. Including in the analysis a wide range of effects that span all One Health dimensions including social, economic, health and environment; and
4. Involving an explicit consideration of the value systems, rights and ethics of different groups affected by the intervention and incorporation of their priorities in a participatory way.

It is important to note, however, that these expansions may not be strictly necessary to inform decision making. An economic evaluation always needs to be structured with the decision maker in mind and what their needs are. The results of the economic analysis should be presented to them in an accessible way with clear guidance on how to interpret the results and what to do with them. This is particularly important when seeking to leverage investment in support of the One Health intervention.

13.9 Funding and Financing

There is a need for economic analyses providing information on the return on investment to orient financial resources towards One Health. While the One Health approach has the potential to generate efficiencies and positive outcomes, its implementation does require funding. To investors, it is relevant to understand the impacts and implications of One Health investments.

It is essential to clearly define the scope and objectives of the initiatives, whether focusing on zoonotic disease control, ecosystem health, antimicrobial resistance or food safety. Identifying potential stakeholders, partners and collaborators is an important step because it allows for collaborative funding efforts that leverage diverse resources and expertise from government agencies, NGOs, research institutions, private sector entities and international organizations.

For example, the global cost of emerging diseases has been shown to outweigh significantly the expenses of prevention at the source, highlighting the importance of proactive measures (Bernstein *et al.*, 2022). This has been recognized by the Pandemic Fund,[6] which is a financing mechanism aimed at prevention, response, containment efforts, healthcare infrastructure, research and development of vaccines or treatments, workforce development and other critical interventions. By pooling resources from various stakeholders and countries, the Pandemic Fund aims to enhance preparedness and response capabilities, minimize economic disruptions, and prevent the escalation of health crises into full-blown pandemics as seen during the COVID-19 pandemic.

Detailed budgeting and financial planning aligned with initiative objectives and timelines are essential. This involves developing short-term and long-term financial projections, conducting cost–benefit analyses, and assessing risks associated with funding uncertainties, budget overruns, economic fluctuations and political challenges. Strong grant applications and funding proposals tailored to different funding agencies' requirements are essential when aiming to secure financial support in line with the investor's interests. An awareness of different mechanisms can help you to think about how to prepare and present your investment case, as well as alignment with budget cycles.

Common funding and financing mechanisms include government grants, philanthropic donations, loans, private investments, private–public partnerships and crowdfunding. Another potential new mechanism is the proposed global subsidiary principle, akin to the Global Fund to Fight AIDS, Tuberculosis and Malaria, that could be beneficial for addressing emerging and endemic zoonoses, advocating for collective global support in funding initiatives. Additionally, newer funding instruments such as Development Impact Bonds, which share risk between donors and private investors, offer potential avenues for zoonosis control projects (Häsler *et al.*, 2021).

13.10 Conclusions

In this chapter, you have learned about how we can use economic evaluation to support decision making in the One Health implementation cycle. This information might help you to comprehend how evaluations can be conceptualized and the challenges of working across different sectors and scales. Further, you might have improved your understanding of the limits of economic evaluation and difficulties when trying to combine different paradigms and schools of economic thought in One Health. With this chapter, we have completed the One Health implementation cycle, and you are now equipped with information that helps you to support the different aspects of implementing a One Health initiative.

Acknowledgements

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Notes

[1] A concept called discounting, which is explained later in the chapter.

[2] WTP is an economic concept that represents the maximum amount of money an individual or group is willing to spend to acquire a good or service, or to avoid something undesirable, such as a negative outcome or risk.

[3] https://ec.europa.eu/regional_policy/sources/studies/cba_guide.pdf

[4] A perspective in economic evaluation that focuses on maximizing overall wellbeing or welfare for society as a whole with the goal to assess interventions or policies based on their impact on the welfare of individuals within society.

[5] In One Health cross-sectoral evaluations, when the monetary benefits outweigh the monetary costs, the numerator in the ICER can become negative. The Roth *et al.* (2003) study estimated −373 US$ per DALY averted, which can be difficult to understand for decision makers. Therefore, different approaches have been developed to present these effects across sectors, such as the separable cost method (Roth *et al.*, 2003), the aggregate net cost, the zoonotic DALY (Torgerson *et al.*, 2018) or an integrative CBA. For a discussion of these approaches, see Häsler *et al.* (2021).

[6] https://www.thepandemicfund.org

[7] www.ipbes.net

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