Preface

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The burden of disease has implications that extend beyond the impact of disease on individual health and welfare. A typical initial consequence of this burden is an effort to determine how to respond in terms of mitigating and containing the threat. Despite such efforts, however, when disease occurs on a wide scale, with a large health impact on many individuals, its burden can influence the shape and destiny of societies. For example, the plague – a zoonotic disease transmitted from rodents to people – had dramatic effects on the populations of Europe. It killed so many that land went unused, and some historians believe the lack of people led to labour shortages, which created incentives to invest in labour-saving devices and initiated the Industrial Revolution. Similarly, the arrival of Europeans to the Americas brought new diseases, such as smallpox, which decimated populations and reduced wood burning to such an extent that the reduction in carbon dioxide levels affected the climate. In an animal context, the presence of diseases, such as trypanosomiasis caused by tsetse flies, limits which species can be kept and explains why cattle farming is limited in many parts of Africa. The presence of disease may also lead to restrictions on trade and movement of animals that impact society. The most apparent in today's trading system is the presence or absence of foot and mouth disease.

If diseases can have such dramatic impacts on how societies evolve, what is known about the quantification of the burden of diseases overall? Human disease burden has been a major area of interest for centuries, with interest fluctuating in accordance with the evolving value of people in society. It became an academic area of study over 50 years ago. This led to the emergence of approaches to measuring health and also to quantifying levels of health using either quality-adjusted life years or the corollary,

disability-adjusted life years (DALY). What health is and whether it can be measured remain contentious issues. However, most agree that measurement concerning human health is needed in three types of scenarios: 1) at the individual patient level, to understand when a person is getting worse or better from a condition and to guide clinical action; 2) to quantify the overall consequences of health in order to guide investments and actions in health care; and 3) to have an outcome that can be measured against costs of interventions to guide judgements within a constrained budget [1]. Human health has largely relied on the DALY as a metric to measure health loss, yet some are also interested in and pursue the use of cost of illness methods, which take into account not just the loss of health from the individual, but also the related consequences for health care and human capital – mainly due to reduced workforce productivity – and the broader consequences for society and the environment. One advantage of the DALY is that there is no need to place a value on a human life; it simply captures the loss of health in years lost due to premature death or disability during life. Placing a value on human life creates issues with regards to equity, regardless of the ethical and moral issues of placing a price on life.

Animal disease burdens have also been of great interest, but there has been little consensus over how to measure these burdens. McInerney caused controversy by stating that animal disease was an economic problem with biological constraints [2]. This view was represented in a simple conceptual model in which production loss was weighted against animal health expenditure to define what level of disease is acceptable in society. Tisdell challenged this model, as it failed to recognise fixed-cost investment in the animal health system, which includes investments in people, technologies and infrastructures that underpin the production loss/expenditure model [3]. More recently, Hennessy and Marsh revisited these conceptual models with a mathematical representation of loss and mitigation costs of animal disease [4]. Therefore, the burden of animal disease has a reasonable theoretical basis, but there is still no coordination of work to comprehensively estimate the burden of disease, although occasional studies have been produced on specific diseases (Knight-Jones and Rushton [5], Blake *et al.* [6], Bennett [7]). What is generally agreed is that diseases that affect livestock and farmed aquatic animals have an economic dimension that cannot be ignored and that must be considered when measuring the burden of animal diseases.

With this background, the World Organisation for Animal Health (WOAH) included a technical item on the costs and benefits of animal diseases and their management at the 84th General Session in May 2016 [8]. The discussion revealed that very few

governments had information on the economic impact of animal diseases. Even fewer had readily available information on the costs of mitigation actions. WOAH Members passed Resolution No. 35 to recognise this gap in data and information and to request that WOAH support the development of methods to look at the global burden of animal diseases [9]. In the following years, meetings were held with experts in human and animal health, economics and data science at the WOAH headquarters in Paris to agree on whether to initiate burden of animal diseases work and, if so, what such a programme would do. At one of these meetings, Michele Cecchini said to Jonathan Rushton (scientific editors of this thematic issue), 'Jonathan, the question should not be whether the burden of animal disease work is needed; it should be why it has not been done before'. Given the importance of farm animals on land and in water, Michele's comments are all the more relevant. Land use is dominated by the animals kept for food, fibre and power, and water areas are increasingly being managed to raise aquatic species. These larger populations are at constant risk from biotic and abiotic factors that affect the length of their lives, the quality and performance of the animals and, consequently, the health and well-being of the people who depend on them and the environment in which they are raised. The burden of animal disease affects people in many ways, and its measurement will support how these animals are viewed in society and develop mitigation pathways that reflect societal values. Yet, the burden of animal disease also has broader and multifaceted implications for the environment: diseased animals have poorer productivity, which leads to a higher environmental footprint and contributes to environmental degradation and biodiversity loss that could potentially be avoided.

These initial steps towards the Global Burden of Animal Diseases (GBADs) programme led to proposals being funded by the Bill and Melinda Gates Foundation, the United Kingdom Foreign, Commonwealth and Development Office, the Australian Centre for International Agricultural Research, the International Development Research Centre, the Irish Government and the Brooke Foundation. GBADs' activities, in contrast to similar efforts in human health, began with country case studies, with a strong focus on Ethiopia and related work in Indonesia, Ireland and Senegal.

At a central level, GBADs began with the development of a simple model to look at the populations at risk and an estimation of the loss in production and expenditure on animal health, followed by attribution of the burden by causes of ill health. These farm-level or financial analyses essentially look at negative productivity shifts, and this information has been used in sector and economic models to understand how the economy is affected

and who suffers from the presence of animal diseases. Figure 1 presents the framework's structure.

Initial application of this model has been questioned due to data gaps and inadequate documentation and standardisation of methodological issues. One of the most challenging areas not yet fully addressed is that data on mortality in livestock species are not easily accessible, with even the definition of mortality not yet standardised, as many animals are slaughtered to salvage their value as meat rather than being allowed to die naturally. GBADs includes many different terrestrial and aquatic species that are kept in different production systems. The varied production systems around the world reflect the differences in prices for inputs and outputs. However, methods to classify these production systems are limited and rarely reflect how data are captured on animals at risk, their performance and the levels of disease they experience. In private sector data on performance and disease, these elements tend to be captured in separate datasets that are difficult to combine. From an economic analysis perspective, the prices of animals and livestock products are not easily accessible. These issues have been largely overcome in the initial stages of GBADs through pragmatism and acceptance of uncertainties. Overall, GBADs works on the basis that 'an estimate is better than no estimate' and the frameworks developed will encourage the capture and reporting of better data.

If little or no data and information exist concerning the burden of animal diseases, how are decisions made on large-scale investments in animal health or, indeed, on day-to-day questions of surveillance, prevention and control measures? Despite a systematic process to look at animal disease burdens, many will state that much has been achieved through rules of thumb (heuristics) that have focused on contagious disease problems, leading to the eradication of rinderpest and widespread management of diseases such as Newcastle disease, classical swine fever and foot and mouth disease. In the background, the livestock industries have developed innovative systems of nutrition, production and processing that have generated greater supply of livestock products at prices that are lower than overall inflation rates. Yet the sheer scale of livestock and farm aquatic species means that decisions on the health of these animals have much wider impacts than in the past in terms of possible transmission of diseases to people, livelihood changes and consumer access to nutritious food. These issues merit the development and implementation of more systematic animal disease burden estimates to guide investment and support allocation of resources.

Therefore, this issue of the *Scientific and Technical Review* on GBADs provides information on the global extent of the programme and what it has achieved so far. There has been strong engagement with governments in different parts of the world, and interestingly, this engagement has revealed that it is not just the burden estimations that are of interest in GBADs' work. Information on the populations at risk is critical for governments underwriting the presence or risks of infectious diseases, or private companies supplying animal health technologies and services or processing livestock products. To make investments at scale, there is a need to understand both how big the populations are and the levels of animal disease burden. These investments should be targeted at cost-effective and beneficial actions that GBADs aims to support. Evaluations of past and future animal health policies and strategies require GBADs data to be effective.

This issue of the *Review* also focuses on the progress made so far in the GBADs programme in terms of methods and data flows, allowing the data and information generated to be explored. It also gives a view of the associated work in human and crop burden estimations. The work is ongoing, and there is a need to strengthen the global estimations, to present data and information in accessible forms and to place the burden of animal disease in a One Health framework.

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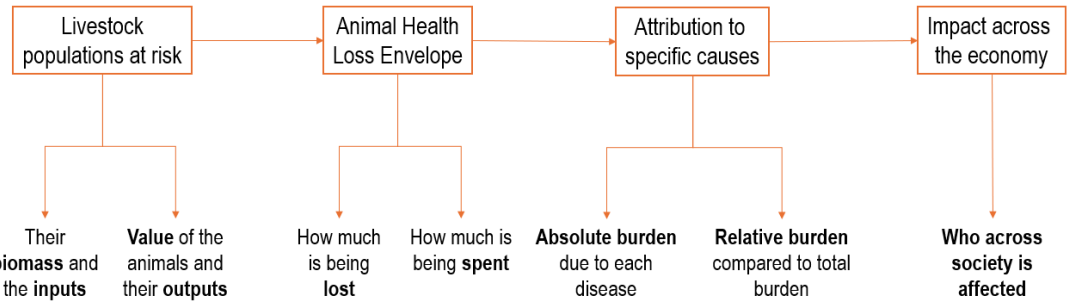

Figure 1

Global Burden of Animal Diseases analytical structure

Modified from Rushton *et al.* [10]