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Loss of production and animal health costs in assessing economic burden of animal disease

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Summary

This article focuses on identifying the loss of production and costs (or lack thereof) associated with livestock health as well as animal disease externalities, with the intent to estimate economy-wide burden. It limits its scope to terrestrial livestock and aquaculture, wherein economic burden is predominately determined by market forces. Losses and costs are delineated into both direct losses and costs and indirect losses and costs, as well as *ex post* costs and *ex ante* costs. These costs include not only private expenditures but also public expenditures related to the prevention of, treatment of, and response to livestock disease. This distinction is important because a primary role of government is to mitigate externalities. The article then discusses market impacts and investments. Finally, it provides selected examples and illustrative observations and discusses future directions for research and application.

Keywords

Animal – Burden – Costs – Diseases – Expenditures – Externalities – Health – Human – Losses – Markets.

Introduction

A primary motivation for this article is to summarise the existing knowledge and information gaps in assessing the global burdens of animal diseases and how these economic burdens are distributed across value-added supply chains [1-3]. The article focuses specifically on identifying the losses in production and costs of livestock health and animal disease externalities, with the intent to estimate economy-wide burden. Specifying losses (e.g. morbidity and mortality) distinct from production is essential as loss relationships have different outcomes and properties than do production functions, while specifying costs is necessary to fully identify economic burden [2]. The authors limit their scope to terrestrial livestock and aquaculture, wherein the economic burden is predominately determined by market forces, and do not consider companion animals or wildlife. Consequently, the framework is laid out by economic principles of production, losses and costs, market forces and failures, trade and welfare economics [2,4-6]. The article also discusses information and data required to assess total economic burden from losses and costs due to animal health and livestock disease externalities, which are often sparse or missing in many countries across the world (e.g. Schrobback *et al.* [7]). When data are sparse or missing, alternative means by which to elicit loss and cost data, such as use of non-market data, are also suggested. Finally, the article provides selected examples and illustrative observations, then addresses some empirical issues and future directions for research and application. The overall intent is to improve understanding for policy-makers regarding the importance of production loss and cost data in estimating economic burden for more informed decision-making and the importance of measuring the impacts of those decisions.

Background

The general approach to assessing the economic burden of animal disease, common in economics literature, is to use supply-and-demand relationships to provide a framework with which to analyse trade outcomes and to assess economic burden of diseases at equilibrium prices and quantities [2,8]. The authors maintain that supply is derived from profit maximisation of the firm [9,10], and also that consumer demand is derived from utility maximisation subject to a budget constraint with the standard assumptions under classical duality theory and consequent properties [9,11]. Hence, optimisation, rather than advocacy, is the driving objective of this approach, allowing economic efficiency to enter into the burden assessment. Drawing from the theory of welfare economics, principles of economic surplus are applied to measure the well-being of firms along a supply chain and the well-being of consumers, an approach that, in practice, requires changes in market equilibrium prices and quantities from a baseline to identify the values of the requisite counterfactual scenarios [2,6,12,13].

Profit maximisation is an appropriate metric for live animal production and processing to assess economic burden in a market setting [2,5,14,15]. There are several reasons for this. First, profit in animal agriculture reflects revenues from product sales less production costs for smallholders and commercial operators alike. Operators both small and large, and at any stage of the supply chain, must make non-negative economic profits over the long run to stay in business. Second, profit is the difference between revenue and costs. Losses due to morbidity dictate reductions in productive output, and these are reflected in revenue decreases, while costs adjust according to treatments [2]. Third, livestock are considered capital assets; as a result, the value of an asset is determined by its equilibrium market price [7,16]. Hence, losses in livestock due to mortality result in losses in asset values. In all, changes in profit plus changes in asset value reflect the net change in direct economic burden for the live animal producer [2,5,6,15]. Finally, the field of welfare economics identifies changes in profit maximisation – and not simply changes in supply – as a metric consistent with the concept of economic welfare for a firm and for society [2,5,6]. For example, instances of oversupply in milk are common in agricultural production (say, from increases of productivity). Yet, in some circumstances, more milk does not necessarily improve the welfare of the producer. Rather, instances of oversupply of milk can coincide with lower prices, such that revenues are less than costs of production. Hence, profits are negative, and it is the profit metric that is consistent with decreases in economic welfare to the producer. The upshot is that the economic burden of livestock disease and animal health is translated through profit, and not some other *ad hoc* value or quantity, as an appropriate metric.

More generally, assessing livestock disease burden is different from assessing the same for human health [1,17]. Livestock lifespan is dictated by market forces, such that metrics like disability-adjusted life years (DALYs) that are generally applied to human health are not sufficient to assess the economic burden of farmed animals in a value-added supply chain. Livestock are farmed animals that provide livelihoods to households across the world. Therefore, losses and costs that arise in both the production and the trade of animals and animal products along the value chain to consumption are key components in assessing the economic burden on those households. Under competitive markets, well-defined techniques exist to monetise both benefits and costs of mortality and morbidity outcomes in animal value chains that contribute to burden [2,6]. Under non-market circumstances, in which prices are not reported or not available, one can apply experiments to monetise an individual's willingness to pay (WTP) to avoid a human health risk or an animal health risk (e.g. Goldberg and Roosen [18], Pendell *et al.* [19], Alolayan *et al.* [20]).

It is reasonable to measure the social burden of market failures (e.g. responses to disease externalities and interventions), as well as the distributional impacts from trade embargoes, on economic agents vertically along the supply chain from firms to consumers [21]. For animal agriculture, wherein live animal producers exchange with traders or buyers, and animals are slaughtered and processed with capacity utilisation and scale economies, driving market outcomes, the impacts along the supply chain are particularly important to understand [22]. These costs include not only private expenditures, but also public expenditures related to prevention of, treatment of and response to livestock disease. This is important because a primary role of government is to mitigate externalities, including animal diseases. For example, this framework has been applied to assess the economic burden of foot and mouth disease (FMD) in livestock in the United States of America (US) [10,23], Mexico [24], Australia [25] and Canada [26]. In the context of livestock disease and animal health, Marsh *et al.* [6] and Hennessy and Marsh [2] provide guidance on welfare economics, economic surplus, present value and discounting.

One can extend this approach to a One Health framework integrating both animal and human health to assess the economic burden of zoonotic diseases [27]. For instance, Pendell *et al.* [19] assess the economic impacts of a hypothetical Rift Valley fever outbreak in the US. Rift Valley fever is a zoonotic disease endemic across much of the world. In livestock, it can lead to abortions, haemorrhages and death, while in humans it can lead to illness, blindness and death [28]. Pendell *et al.* [19] assessed not only the economic impacts on agricultural producers and consumer demand, government costs of response, and costs and disruptions to non-agricultural activities in the regions, but also human health (morbidity and mortality) outcomes. Specifically, they estimated WTP to monetise illness and blindness and applied the value of statistical life to monetise loss of life. Rahman [29] also applied a One Health approach to assess the dual burden of anthrax in Tanzania, estimating WTP for illness in both humans and livestock.

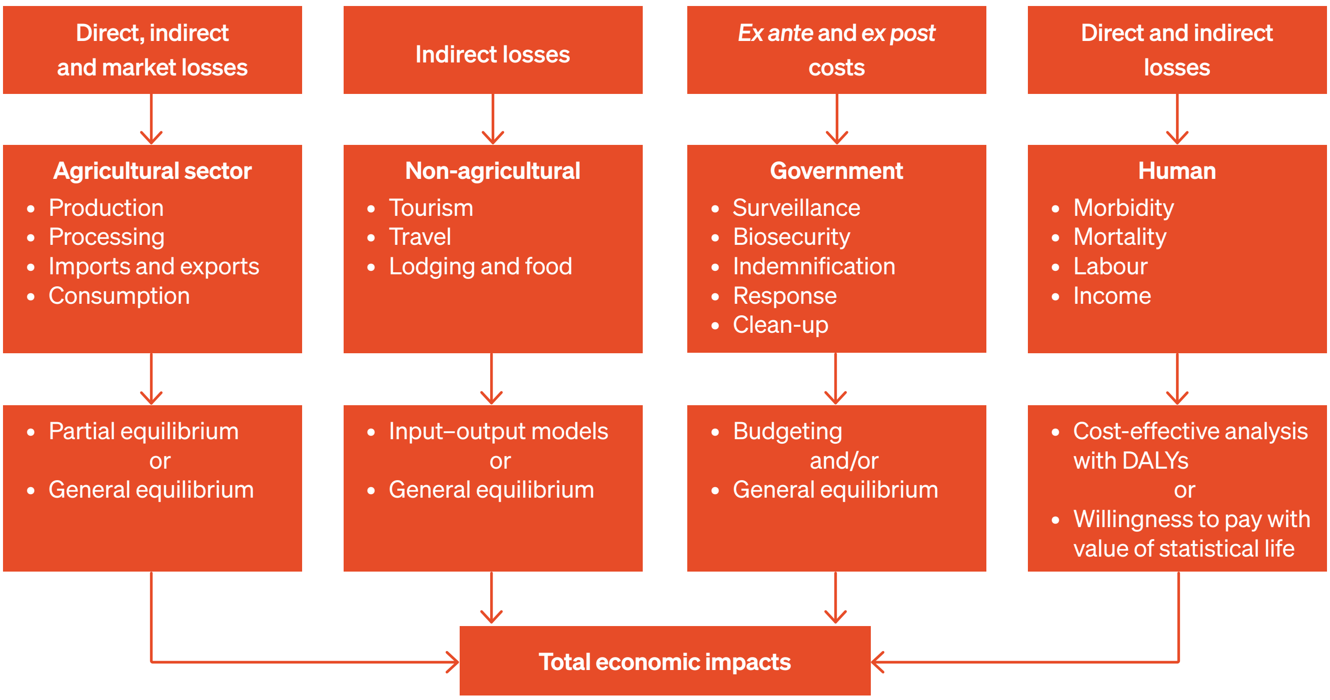
In all, economists can and often do monetise the consequences of events or policies into a single monetary unit that is readily comparable, scalable and useful for measuring changes in efficiency (the size of the economic pie) and examining equity (the distribution of the economic pie) [5,30]. This approach also allows for disaggregation of the distribution of private and public benefits and costs vertically along the supply chain, as well as horizontally across different markets [13]. In this manner, economists measure who is burdened and how much.

Losses and costs

Economies face both losses and costs due to disease and health events. It is commonplace to delineate losses and costs into both direct losses and costs and indirect losses and costs, as well as *ex post* costs and *ex ante* costs [31]. The authors adopt and acknowledge this perspective and extend it into a One Health framework for zoonotic diseases. Before going into detail on losses and costs, the article highlights how these are applied in wider economic assessment, as well as the information and models used for doing so.

Figure 1 provides an overview of how losses and costs due to livestock disease and animal health may be applied in a wider economic assessment. First, losses and costs are identified, collected and/or estimated from the literature or from output of an epidemiological model. These estimates are then entered as direct exogenous shocks to production (e.g. changes in morbidity or mortality of livestock), to demand for products (e.g. changes in consumer demand) and/or to trade (e.g. changes in trade status or embargoes) into an economic equilibrium model to estimate changes in markets (prices and quantities). Economic outcomes from equilibrium models vary with the exogenous shifts applied at different stages of the value chain [32]. As such, the losses and costs may induce changes in broader economic outcomes (e.g. gross domestic product, income), in government expenditures (e.g. response costs) and in the economic burden on human health (e.g. morbidity and mortality). The sum of these impacts is total economic impact. Paarlberg *et al.* [21] and Pendell *et al.* [19,23] provide examples of how losses and costs have been applied in assessing livestock disease outbreaks in the US. For the interested reader, Pritchett *et al.* [33] provide an overview of modelling approaches in assessing livestock disease and animal health events.

Underlying the losses and costs are maintained information and additional data on livestock inventories, market structure and firm behaviour, human population and culture, and institutional structures of the region of interest that are necessary to predict outcomes of wider economic scenarios. Equilibrium models encompass this information and data in a systematic structure of the economy. These models are then used to simulate counterfactual scenarios to evaluate alternative events, and the outcomes of those scenarios in turn are



DALYs: disability-adjusted life years

Figure 1

Illustrative losses and costs in burden assessment for economic impacts on livestock disease

Source: adapted from Pendell *et al.* [19,23]

used to better plan resource use, mitigate risk and capitalise on opportunities. More specifically, livestock inventories and livestock products produce revenues, while livestock themselves are capital goods that produce asset values for the household or firm. Perhaps surprisingly, significant gaps in these data exist across the world [7] (see Table I for additional details and observations). Market structure dictates the supply chain, and firm behaviour dictates patterns of substitution among goods and efficiency of resource use. Human population and culture are key determinants of demand for livestock and livestock products. Market structure and demand are typically captured in the configuration of equilibrium models. For example, equilibrium displacement models capture this behaviour with price, income and substitution elasticities, as well as other relationships and constraints, as specified in the model [21]. Government institutions are key in determining public expenditures and determining efficient and sustainable trajectories of economic growth. Partial equilibrium models often budget government expenses outside the model, while general equilibrium models such as the Global Trade Analysis Project model include governments as an economic component within the model [34].

While the primary focus here is on live animal production, losses and costs can also arise vertically upstream or downstream of live animal production in the value-added supply chain (Fig. 2) or horizontally across economic sectors. For instance, losses and costs may arise upstream in sourcing inputs (e.g. labour) and downstream in the processing of commodities and distribution of products (e.g. infected animals and/or contaminated carcasses) [19,21,23]. Alternatively, examples of horizontal sectors are the pharmaceutical [35] and tourism sectors [19,23,36]. On the human health side, observations from the COVID-19 pandemic are particularly insightful, as both losses and costs due to human disease and health arose during the pandemic [37]. Barrett *et al.* [38] argue that the major agri-food system disruptions from COVID-19 originated predominately in the retail market from demand-side shocks caused by workplace closures, with labour shortages throughout the value chain. The Global Burden of Animal Diseases (GBADs) programme [1,17] implements approaches to provide information on direct productivity changes for live animal producers through its Animal Health Loss Envelope, as well as the indirect economic impacts of livestock disease and animal health through partial and general equilibrium models.

Direct losses

Direct losses are losses from physical output (morbidity) and

Table I

Livestock disease burden data requirements, availability, gaps and observations across countries

Term	Requirements	Availability	Gaps	Observations
Direct losses and costs	Production output quantities and prices; production input quantities and prices; morbidity and mortality estimates; livestock inventories, replacements and prices	Production for primary output (meat, milk, eggs, etc.) and prices; production inputs and prices for feed; livestock inventories and prices	Production inputs for capital, labour, energy, animal health, land and resources; costs for draught animals; replacement numbers and prices; morbidity and mortality estimates (a)	Systematically collect input data akin to crop agriculture; morbidity and mortality estimates by species and disease akin to human health; costs for draught animals; replacement numbers and prices by species
Indirect losses and costs	Production outputs, inputs and prices along supply chains for processors, wholesalers and retailers	Sparse input and output data exist for processing, wholesaling and retailing across sectors (b)	Data gaps in outputs and inputs of firms between producer and consumer (a)	Improve systematic collection of data along supply chains; especially for animal agriculture
Trade data	Domestic and international trade data	Supply and demand data, import and export data (c)	Inspection and quarantine data; embargo data (c)	Multiple sources provide access to national and global trade data
Public expenditure	*Ex ante*: biosecurity, surveillance, stockpiling *Ex post*: response, clean-up and recovery; as well as research and development, engagement	Data may be collected *ad hoc* and reported internally to government agencies	Data are often not collected, confounded with other public expenditure data, not reported or not available for public use (d)	Systematically collect public and private expenditure data akin to human health; standardise collection of national accounts, and have open access to data

(a) Data usually generated at firm level, but not necessarily available at national or global level for every species
(b) Selected input–output and equilibrium models provide multipliers, elasticities, social accounting matrices and other parameters at regional or national levels; usually available but not necessarily free
(c) Data usually reported at regional or national level and aggregated to global level, but not at disaggregated firm level
(d) Public expenditure data usually not available at firm or global levels but may be collected at regional or national level. Private expenditure data generated at firm level, but often not reported or not available at national or global level

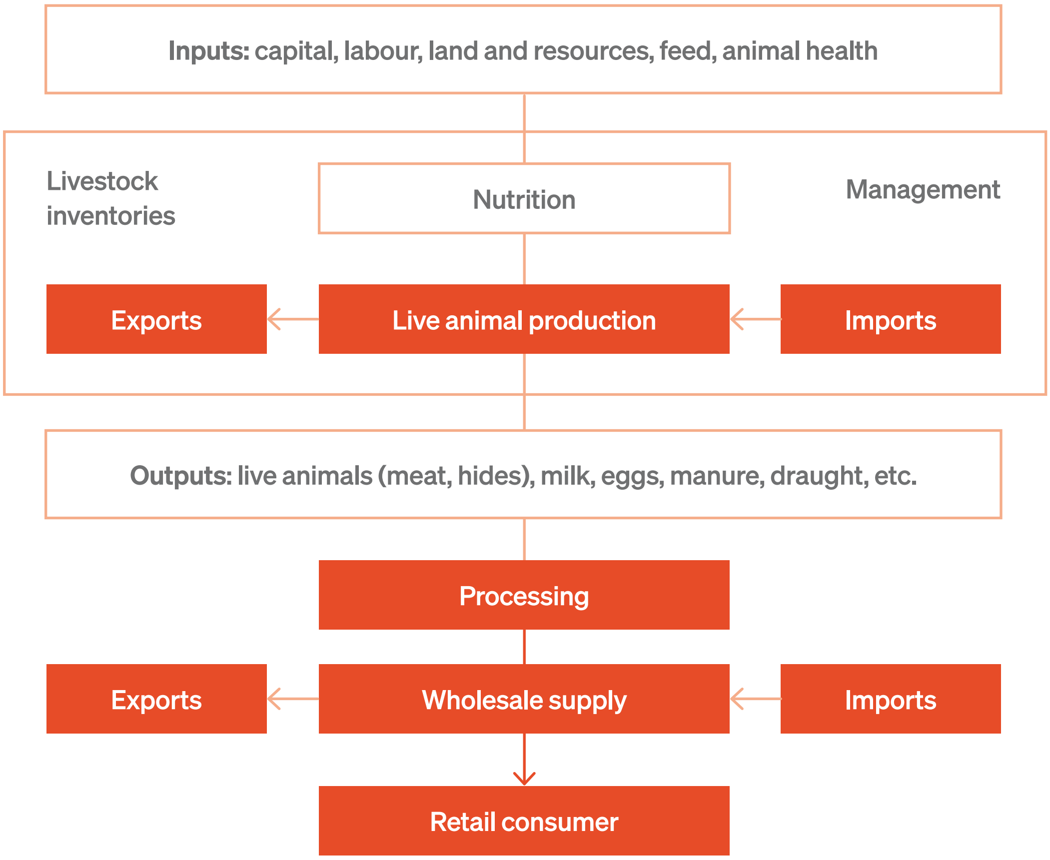


Figure 2

Vertical market model of livestock production and value-added supply

assets (mortality). On the upstream part of the supply chain, for livestock production these could be, for example, from the reduction in meat or milk output or loss of livestock itself [39]. Peterman and Posadas [40] reported direct economic impacts of fish diseases. On the downstream end of the supply chain, a direct loss could be from an adverse consumer reaction to a food safety outbreak (e.g. *E. coli* contamination in meat products) in the retail market [41,42]. Costs for direct losses are often quantified by changes in market input and output quantities with fixed market prices [15]. If market prices are not sensitive to a disease outbreak or health event, then this is appropriate. Otherwise, for wider economic effects, when applying equilibrium models, the direct losses are quantified with changes in both quantity and prices [4,10,23]. The GBADs programme estimates direct financial effects on the live animal producer in the form of the Animal Health Loss Envelope, which calculates changes in revenue and livestock assets with fixed prices plus changes in input expenditures [15].

It is relevant to point out and emphasise that direct losses can arise horizontally in other sectors of the economy outside of agriculture. For example, consider quarantine impacts on tourism. Blake *et al.* [36] estimate that the direct losses to tourism following the 2001 FMD outbreak in the United Kingdom were equal to the losses in the agricultural sector, excluding the producer compensation from the government. Pendell *et al.* [23] have also recognised and calculated tourism impacts from hypothetical FMD outbreaks in the US.

For human health, direct losses caused by COVID-19 arose from people dying from COVID-19 or suffering short-term illnesses or long-term health consequences. DALYs, a nonmonetary measure of morbidity and mortality applied to assessment of human health burden along with cost-effective analysis, are often applied in the context of human health [43]. Direct losses and costs for humans can also be monetised by economists with WTP or cost of illness (COI) to assess morbidity, or with the value of statistical life to assess the loss of human life [18,20,44]. In the case of Rift Valley fever, Pendell *et al.* [19] estimated WTP to avoid illness (US$ 1,525 per adult) and blindness (US$ 75,833 per adult), and the value of statistical life to monetise death (US$ 8,160,000 per adult) based on Viscusi and Aldy [44]. Rahman [29] reports direct animal or asset losses to anthrax in a hyper-endemic area of Eastern Africa, the Ngorongoro Conservation Area of northern Tanzania. Households' willingness to contribute to prevention and treatment measures for humans and livestock was driven by the effectiveness of those measures and the severity of infection in humans.

Indirect losses

Indirect losses are subsequent secondary losses that follow from the initial physical damages. Like direct losses, indirect losses may arise upstream or downstream of live animal production (Fig. 2). Indirect losses may come from transportation or travel disruptions and business interruptions along the entire supply chain, but more broadly include the loss of wages and tax revenue. On the downstream end of the supply chain, there could be an indirect loss translated through higher prices or lower consumer income curbing purchases in the retail market [41,42]. Stress and mental health issues contribute to indirect losses as well [45].

Indirect losses come in many forms and are critical components of an economic assessment. For instance, livestock disease events and subsequent quarantines tend to create spillovers out of agriculture into other sectors of the economy (e.g. pharmaceuticals, transportation, tourism). Blake *et al.* [36] estimated the indirect losses to tourism following the 2001 FMD outbreak in the United Kingdom, finding the indirect effects on tourism 20 times greater than the indirect effects on agriculture. In the case of COVID-19, indirect losses included loss of income and an overloaded human health system [37]. The aquaculture industry also experienced indirect effects due to COVID-19, as discussed in Aarstad *et al.* [46]. Partial equilibrium models generally require explicit inclusion of the sectors in which the exogenous shocks were applied and therefore are not suited to indirect cost assessment like input–output and general equilibrium models [47]. The authors note that general equilibrium models are particularly effective in estimating indirect losses, including estimating spillovers from one sector of the economy into other sectors of the economy. For example, the GBADs programme captured indirect effects of livestock disease and animal health in Ethiopia using a general equilibrium model [35]. From a broader social perspective, indirect losses could also consist of limitations on health through nutrition, education opportunities and future economic growth [39,48,49].

Ex ante and *ex post* costs

Expenditures come in the form of *ex ante* costs and *ex post* costs. *Ex ante* costs are preventive mitigation expenditures prior to an event, such as biosecurity, surveillance and stockpiling costs. *Ex post* costs are mitigation expenditures made during and after an event and during the recovery period, such as response, clean-up and recovery costs.

These costs include private expenditures by firms and public expenditures by governments. Private costs may include expenditures on surveillance, biosecurity and prevention, as well as response, clean-up, recovery and business interruption [50]. Private costs also include asset loss with livestock death. Because a primary role of the government is to mitigate negative externalities [5], public costs include not only preventive expenditures on surveillance, biosecurity and stockpiling in an effort to mitigate disease externalities, but also response, clean-up, recovery and indemnification expenditures [31]. Indemnification expenditures by governments tend to partially offset private asset losses [2]. As such, while private expenditures are intent on safeguarding individual herds, public expenditures mitigate negative externalities and safeguard society.

Several examples are noteworthy. Seeger *et al.* [51] provide comprehensive estimates of *ex post* government costs for the 2014–2015 high pathogenicity avian influenza (HPAI) outbreak in the US, which required $US 879 million in public expenditures to eradicate the disease from poultry production. Total response costs for government and farmers were $US 459 million, of which $US 70 million were farmer costs. Those authors also report cost by response activity and per bird. This study is an exception, as government costs for animal health events are generally not systematically collected and can be difficult to access or are not publicly available. Dorn *et al.* [37] provide examples and estimates for selected COVID-19 costs. Historically, total public expenditures on research and development have been explored by Wohlgenant [12], Alston [13] and Holloway [32].

Market impacts and investment

Market impacts are a particularly important component of livestock burden. Changes in the status of livestock disease or animal health often lead to changes in market outcomes (prices and quantities) for inputs, outputs and assets in both the domestic and international markets (Fig. 2). Such changes could arise via shocks in demand or supply, as well as government-imposed quarantines or trade embargoes or other constraints on the system [19,23,52]. Quantification of market impacts on both prices and quantities typically relies on either partial equilibrium or general equilibrium models of the sector or sectors in the country or region under study [2,6,21,35]. It is standard practice to measure these market impacts by applying welfare measures of economic surplus, such as consumer surplus, producer surplus and asset value [2,4-6,13]. In doing so, changes in revenue for livestock and livestock products in both domestic and international markets, as well as the costs of trade, can be captured from quarantines or trade embargoes [10,19,23-26]. The GBADs programme measures market impacts of livestock disease and animal health translated through the Animal Health Loss Envelope and its attribution [15,35,52].

Additional observations about trade and investment are in order. Since the onset of COVID-19, global supply chains have experienced increased trade costs and reduced labour participation along the supply chain [53]. Moreover, investment in animal and human infrastructure and health was also impacted by COVID-19. Farms, processing firms and other firms increased investment in robots invulnerable to infectious diseases [38]. Adjustment costs arise when farms and firms respond to livestock disease and animal health events in dynamic economic models [10,24-26]; for instance, vaccines were stockpiled after the 2014–2015 HPAI outbreak [54], while investment and adjustment costs expanded during COVID-19 [38].

Discussion

As noted in the introduction, this article has limitations. It focuses on losses and costs needed to estimate wider economic effects from livestock disease and animal health externalities. Its scope is limited to terrestrial livestock and aquaculture and does not include companion animals or wildlife. Finally, its primary focus is on economic surplus and not cost-effective analysis with DALYs.

While not addressed in this article, the topic of adaptation through adjustments in ecological, social or economic systems in response to actual or expected shocks is a critical next step in GBADs or other economic assessments. In this light, and in addition to the above discussion of past research, intertemporal economic equilibrium models that integrate population dynamics, and in which economic agents adjust to historical outcomes, will need past and current population parameters and estimates and/or forecasts of them, as well as assumptions about future changes in technology and preferences [10,24-26]. These models provide short- and long-term outcomes for both economic surplus and the intertemporal redistribution of that surplus to firms and consumers. Moreover, intertemporal econometric models, such as those introduced by Barratt *et al.* [55] and Rahman and Marsh [56], demonstrate statistical approaches to provide data-driven estimates of loss and costs in data-challenged environments. That said, the discussion above provides the basic insights into the data and information required in constructing specific counterfactual scenarios to quantify wider economic effects.

There are additional issues and gaps in the literature on assessing wider economic burden, including framing, specification, stress and mental health, structural change, redistribution, forecasting and interpretation. A selective discussion on non-market impacts and WTP, COI and other issues is provided below, followed by suggestions for future directions.

Non-market impacts

Non-market impacts include social costs to the environment or culture [7,57]. They could also include expected private costs of vaccines under development but not yet on the market [58]. Estimation of such costs or, for example, option value and other non-use values may require complex primary data collection and analysis methods. These methods can include choice experiments (e.g. WTP ensuring breed continuation) or contingent valuation [57,58]. The choice of experimental design and analysis also depends on the specific research question and context, as well as the data units and platforms available for collection [59]. WTP has been used to assess drivers of vaccination preferences and vaccine adoption for a low-value livestock resource, poultry [60-62].

Cost of illness

To place a value on morbidity, two approaches are generally used: COI and WTP [2,19]. The most commonly used approach, COI, is calculated by summing up the direct medical expenses (e.g. expense of doctor's office visit) incurred by individuals and the indirect expenses related to productivity. Although the COI approach is commonly used, it has several shortcomings. Firstly, most COI studies use *ex post* data to calculate expenses. If those data are not available, then it is impossible to use COI data to calculate the expenses. Secondly, costs associated with pain and suffering are ignored. For most individuals willing to pay some amount to avoid symptoms, the COI approach likely under-estimates the true cost of morbidity. As an example of this approach, Rahman [29] has applied WTP and COI to assess zoonotic diseases.

Looking forward

As noted above, large data gaps persist regarding animal populations, as well as mortalities and morbidities of animal populations, worldwide. Sourcing consistent quantity and price data series for many countries across the world also remains a critical problem [7]. In contrast to human health, there is limited information on public and private expenditures and investments in animal health across the world. In the private sector, such information is typically proprietary, often viewed as confidential and generally not shared. In the public sector, limited resources, low priority or little political interest prevent an accurate and precise accounting of these populations and expenditures. In all, continued effort on systematic data collection that is openly accessible, collaboration on that data collection, quality control of the data, standardisation of the data across countries, and leadership to do so are required. Programmes such as GBADs provide a vision and focal point to champion these efforts.

Disease management is difficult given these gaps in the context of disease burdens [1]. Nevertheless, opportunities exist to close these gaps, including taking advantage of private–public data sharing, triangulating known datasets, and exploiting technologies to generate data, such as using crowdsourcing or geographic information system tools to track herd movements. These efforts will require novel methods and analytical tools but will also ensure a bright future for empirical analysis and implementation of theoretical methods and hopefully, ultimately, for policy contributions. For example, new tools are being created to collect private and public expenditure data on animal disease outbreaks [63]. Hennessy and Marsh [2] point out the need for additional work on issues of antibiotic resistance, gender, behavioural economics and institutional failure.

There is also a critical nexus in animal health, climate change and the environment that is inextricably linked by key inputs and management of animal feed and nutrition [64]. Returning to Figure 2, the supply chain can be expanded upstream to include demand and supply of animal feed, which are translated into nutrition. This is important because the level of nutrition fed to an animal not only impacts animal health, but also impacts methane gas release into the environment from animal production. This illustrates an important production externality. Further examples include the impacts of drought shocks on pastures and croplands, which in turn impact feed and nutrition and then translate into animal health and climate change outcomes. To mitigate these events, consistent policies are needed that cut across animal health, climate change and the environment, as is an understanding of the impacts of such policies. To assess impacts, data on losses and costs are needed.

Financial instruments and mechanisms are becoming more important and more complicated in the agricultural sector. For example, indemnification often arises in animal culling, with the funding for it coming not only from governments, but also from levies collected from producers by governments. Besides indemnification for livestock losses by governments, other financial mechanisms exist or are on the horizon. Firms may bear abatement costs when required to remove and/or reduce undesirable nuisances or negative by-products created during production, such as spillovers of agricultural waste into the environment or greenhouse gas emissions. Climate-smart programmes attempt to address the interlinked challenges of the food system and climate change by identifying incentives for producers to more fully participate in a sustainable manner. Again, to effectively assess the impacts of these programmes, data on losses and costs are needed.

The final point relates to institutional failure, wherein governments themselves face the risk of failure as they are resource constrained, lack incentives, have imperfect or incomplete information and are vulnerable to regulatory capture [65]. Government failure arises where government intervention creates inefficiency and leads to a misallocation of scarce resources. Such failure also includes not collecting relevant data and not publicly reporting it. In the future, constraints, costs of externalities (e.g. the environment and climate change), alternative scenarios and adaptation need to be recognised in assessment and forecasting of the burden of disease.

Les pertes de production et les coûts liés à la santé animale dans les estimations du fardeau économique des maladies animales

T.L. Marsh, D. Pendell, P. Schrobback, G. Shakil & P. Tozer

Résumé

Cet article examine les pertes de production et les coûts associés (ou non) à la santé animale ainsi que les externalités liées aux maladies animales, dans le but d'estimer le fardeau pour l'ensemble de l'économie. L'examen se limite à la production d'animaux terrestres et aquatiques, secteurs où le fardeau économique est principalement déterminé par les forces du marché. Les pertes et les coûts sont répartis en pertes et coûts directs et indirects, ainsi qu'en coûts *ex post* et *ex ante*. Ces coûts comprennent non seulement les dépenses privées, mais aussi les dépenses publiques liées à la prévention, au traitement et aux réponses aux maladies des animaux d'élevage. Il s'agit d'une distinction importante car l'une des fonctions premières d'un gouvernement est d'atténuer les externalités. Les auteurs examinent ensuite les impacts sur les marchés et les investissements. Pour conclure, à partir d'exemples choisis et d'observations illustrant leur propos, les auteurs proposent des voies d'exploration pour la recherche et ses applications.

Mots-clés

Animal – Coûts – Dépenses – Externalités – Fardeau – Humain – Maladies – Marchés – Pertes – Santé.

Pérdidas de producción y costos de sanidad animal en la evaluación del impacto económico de las enfermedades animales

T.L. Marsh, D. Pendell, P. Schrobback, G. Shakil & P. Tozer

Resumen

Este artículo se centra en determinar las pérdidas de producción y los costos (o la ausencia de ellos) asociados con las externalidades de la sanidad del ganado y las enfermedades animales, con el objetivo de estimar su impacto en toda la economía. El ámbito del artículo se limita a la ganadería terrestre y la acuicultura, donde el impacto económico está principalmente determinado por las fuerzas del mercado. Las pérdidas y los costos se clasifican en pérdidas y costos directos e indirectos, así como en costos *ex post* y *ex ante*. Dichos costos incluyen no solo los gastos privados, sino también los gastos públicos relacionados con la prevención y el tratamiento de las enfermedades del ganado y la respuesta ante estas, una distinción que es importante habida cuenta de que una de las principales funciones del gobierno es mitigar las externalidades. En el artículo se analizan a continuación las repercusiones en el mercado y las inversiones y, por último, se presentan algunos ejemplos y observaciones ilustrativas y se examinan las orientaciones futuras de la investigación y sus aplicaciones.

Palabras clave

Animal – Costos – Enfermedades – Externalidades – Gastos – Humano – Impacto – Mercados – Pérdidas – Salud.

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