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THE ECONOMICS OF ANIMAL HEALTH:
DIRECT AND INDIRECT COSTS OF ANIMAL DISEASE OUTBREAKS

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Summary: *Animal disease outbreaks have been shown to cause major economic losses over the centuries and are the reason for the existence of significant investments in animal health services across the world. Data are required on both production losses and the costs of interventions to disease presence or risks in order to allow economics to guide resource prioritisation and allocation to improve the health and welfare of animals under the care of people. This paper presents data available on the impacts of disease outbreaks across the world through a survey of national veterinary services of member countries of the World Organisation for Animal Health (OIE).*

Overall the survey and the descriptive analysis demonstrate the interest of the member countries on the use of economics in animal health, yet there is a paucity of data on direct and indirect costs of animal diseases. This needs to be addressed so that economic analysis can bring greater value to animal health decision making in terms of: (1) justification of existing and requested resources for animal health; (2) identification of global imbalances of resources for animal health; (3) prioritisation of resources between animal diseases; and (4) improved allocation of resources within specific disease control programmes.

In order to achieve these outcomes from the economic analysis of animal disease, it is recommended that three practical actions are initiated. Firstly, education in the use of economics of animal health by veterinary undergraduates, postgraduates and current professionals is improved through better curricula and materials. Secondly, a programme is established that will begin to generate a dataset on the global burden of animal diseases which would include production losses, control costs and impacts on trade and wider economic impacts. Thirdly, a programme is initiated that regularly captures investments in animal health education, research, infrastructure and critical coordination activities. Point 1 will give the profession confidence to engage in discussions on resource use and allocations. Points 2 and 3 will generate datasets that will allow real time prioritisation of diseases and the ability to assess the productivity of veterinary services at a geographical, species and policy level.

Keywords: *Animal health; Economics; Disease outbreaks; Resource allocation*

1. Introduction

At the 83rd General Session of the OIE held in May 2015 the technical item “The Economics of Animal Health: Direct and Indirect Costs of Animal Disease Outbreaks” was confirmed. The area of animal disease impact has been under increasing discussion in part through the recent scale of impacts of diseases such as foot and mouth disease (FMD), highly pathogenic avian influenza (HPAI) and classical swine fever (CSF). In addition, the increasing pressure on public sector budgets and the need to have well-functioning animal health systems require careful thought on how to develop business cases for investment in animal health. In many respects this requires information around the losses due to disease impacts and also the costs of our reactions to the presence or risk of disease.

The economics of animal health is a recent subject area (Rushton, 2009) and one that continues to evolve. Much of the economic analysis of animal health to date uses cost-benefit analysis to either justify disease control programmes or to examine the economic returns on past animal health investments. Yet even these activities lack any standardisation of approach and are not published with a regularity that would lead to improved methodologies, data availability or quality. There is also a significant gap highlighted by McInerney (1996) on the need to think about animal health as an economic problem that involves a balance between production losses caused by disease and the control costs incurred to manage the disease. Tisdell (2009) supplemented this economic perspective with the need to recognise fixed cost investments in core veterinary service activities such as education, research and coordination. Since these seminal ideas were published there has been a small number of studies looking at individual disease impacts at a national level (Bennett, 2003; Bennett & Ijeplaar, 2005; Lane *et al.*, 2015). There has also been a major study that has attempted to capture the loss of animals due to specific diseases (World Bank, 2011) utilising OIE WAHID data and FAOSTAT population estimates. These have been supported by OIE's work to understand the current strengths of national veterinary services through the Performance of Veterinary Services (PVS) system. From this background there is an emergence of data and information that should provide the basis for better animal health decision making, yet these studies have been carried out in different time periods utilizing differing methodologies. In addition some of the studies carried out remain unpublished. There is the need for more systematic approaches to the direct and indirect costs of animal disease outbreaks and a part of this process is to understand what data and information is currently available.

Therefore a questionnaire was designed to capture data and information on animal disease impacts at a national level and how this is used to generate decision-making processes. The current paper describes the data collection tool used, how it was distributed and the collection and analysis of the data. A discussion of the main issues produced by the results of the analysis is provided with recommendations on how the use of economics can be improved in order to help animal health decision making.

2. Questionnaire

The questionnaire was designed to cover different aspects of disease costs which are as follows:

- Section 1 covered the structure of the national veterinary services collecting data on overall costs, staffing and specific disease management programmes.

- Section 2 collected the costs of control of disease outbreaks since 2000.

- Section 3 collected the production losses caused by the transboundary diseases that were endemic in countries.

- Section 4 covered the wider impacts of disease on trade and the general economy.

- Section 5 requested data on who carried out the economic analyses and who used the information that was generated and for what reason. Data were also sought on the need for education and publications of disease impacts in terms of costs and trade.

The questionnaire was translated into French and Spanish and sent to the 180 OIE Member Countries. The data were collected between mid-December 2015 and mid-February 2016, with the data stored in an Access database. Descriptive analysis was performed using Excel.

Additional data used in the analysis

Comments in French and Spanish were translated into English by native speakers of those languages. Where member states provided costs and impacts in local currencies these were converted to US dollars using the currency exchange data extracted from OANDA (www.oanda.com) on 12 February 2016. Denominator data on animal populations were extracted from FAOstat (faostat3.fao.org) which includes population estimates for 2014.

3. Responses from OIE Member Countries

Of the 180 OIE Member Countries that were sent the questionnaire, responses were received from 118[1] with an overall response rate of 65%. Figure 1 shows the geographical reach of the returned questionnaires and a complete list of countries responding to the questionnaire can be found in Appendix 2.

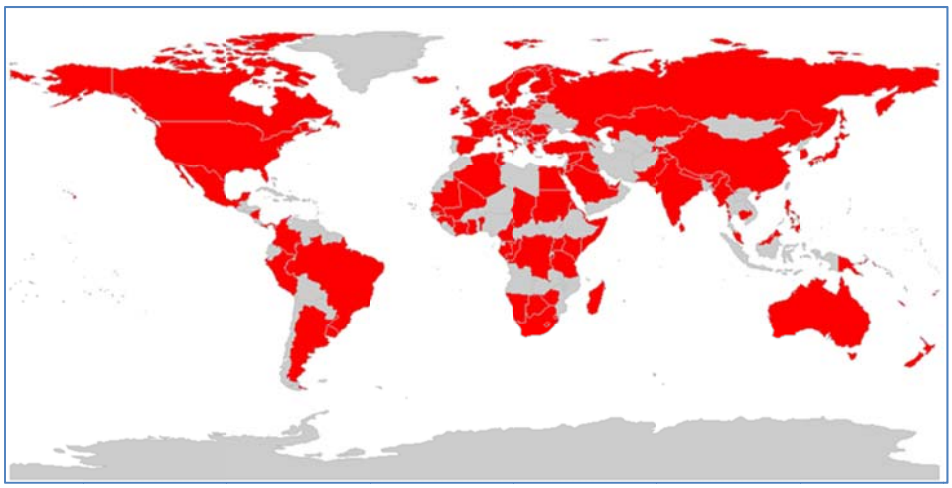

Figure 1. Countries that completed and returned the questionnaire[2]

In terms of the coverage of the questionnaire by livestock populations 80% of the global livestock units are represented by the countries who have returned data (Fig. 2).

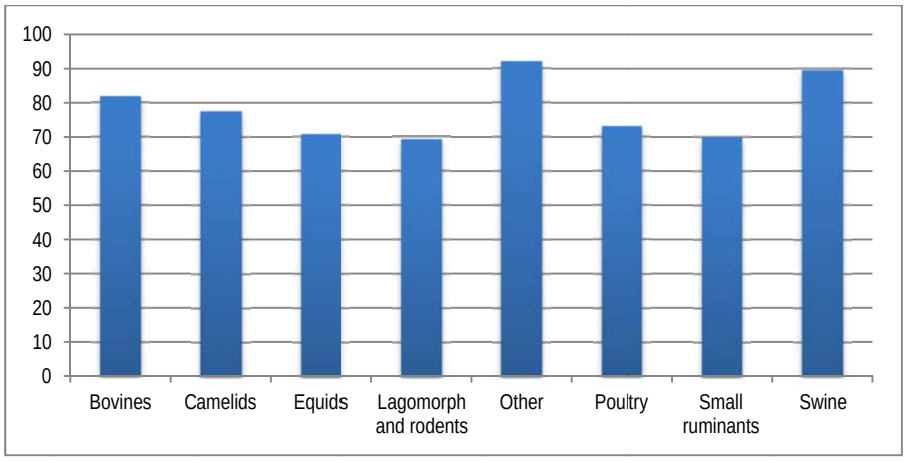

Figure 2. Proportion of the livestock groupings by the countries who returned the survey

Three quarters (15 out of 20) of the top twenty countries with bovines replied to the survey, 13 out of 20 of the top small ruminant and poultry countries and 18 out of 20 of the top swine population countries.

There was a relatively low response of returns from SE Asia, parts of East and West Africa and a major country in the Middle East which affected the level of coverage for poultry, small ruminants and bovines. However, the survey has both a good geographical reach and also a good coverage of the major livestock species.

1 India and Bangladesh returned the forms too late to the included in the data analysis

2 Bangladesh returned the questionnaire at a point when it was impossible to include their data in the analysis.

3.1. Costs of the veterinary system and disease management programmes

The initial part of the questionnaire collected data on the costs of the veterinary service, the personnel employed in the service and data about the ongoing specific disease control programmes. These investment aspects can be considered the underlying fixed cost of the veterinary service system which has been recognised by OIE and economists (Tisdell, 2009) as being so important in the effective implementation of transboundary disease management events.

a) Veterinary personnel and overall cost of the veterinary system

All countries provided the data on the number of veterinarians and veterinary assistants. It was estimated that there was a total of 722,105 veterinarians, 328,572 veterinary assistants and 407,785 other support staff. When combined with the number of livestock units (LSUs) in each country, approximately a third had less than 1,000 LSU per veterinarian and a half had less than 2,500 LSU per veterinarian. As can be seen in Figure 3, a further third of countries had over 10,000 LSU per veterinarian. This staffing issue was improved with the inclusion of the veterinary assistants but the overall pattern of personal to livestock was similar. Overall from the member states who replied there are 2,369 LSU per veterinarian and 1,628 LSU per veterinarian and veterinary assistant. The ideal staff ratio is difficult to define and would require further analysis of the value of animals, the role of companion and sporting animal medicine and the salary levels of staff (Fig. 3).

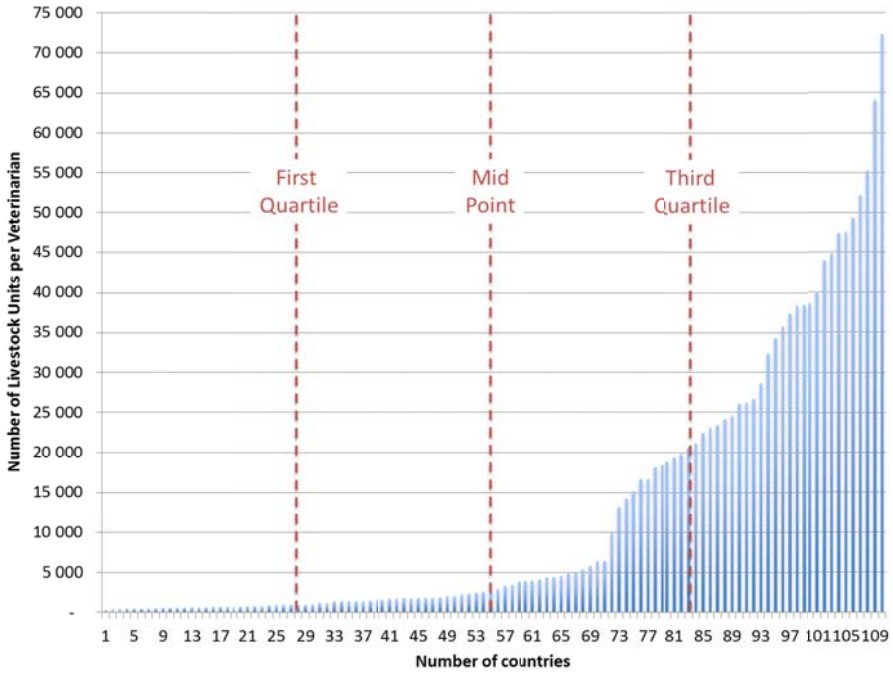

Figure 3. Estimated amount of expenditure on animal health (USD per LSU per year) for the countries who reported costs

Only 50 of the countries who returned the questionnaire provided specific data on the costs of the veterinary service. Of these countries a total of USD 4 billion was estimated to be spent annually with USD 3.1 billion of this amount coming from public sector budgets and only USD 0.5 billion from private sector funds. The figures indicate a greater investment in animal health from the State and would not seem to match earlier published work in this area for a country such as the United Kingdom where private animal health expenditure was estimated to be greater than public expenditure in the livestock industries (Gilbert & Rushton, 2014).

Overall it is estimated that the amount spent per livestock unit ranged between USD 0.06 to USD 934.32 with an overall average of USD 6.80 per LSU per year. However a quarter of the countries who reported expenditure spent less than a USD 1 per LSU and half of the countries less than USD 4.00 per LSU per year (Fig. 4).

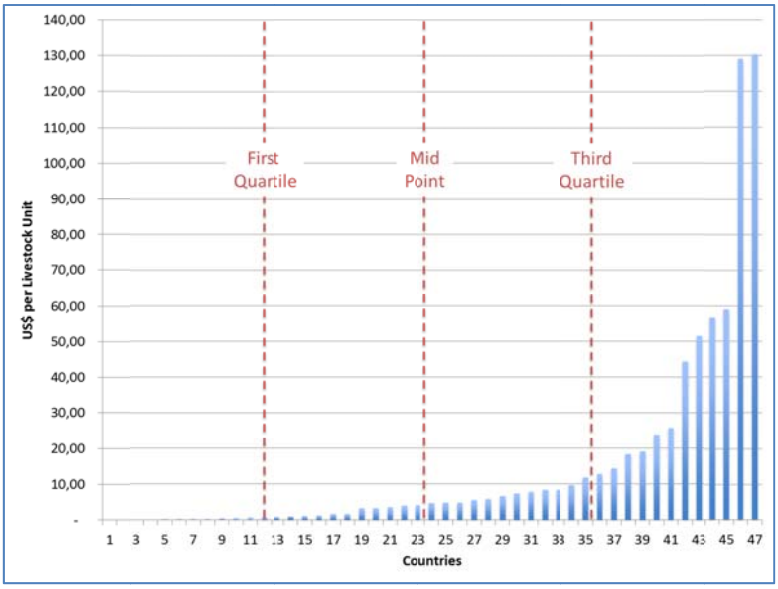

Figure 4. Estimated amount of expenditure on animal health (USD per LSU per year) for the countries who reported costs

Three countries which are very dependent on imports reported very high expenditure per animal unit and were excluded from the data presented in Figure 3. These countries had very small livestock populations and are dependent on imports from other countries to satisfy their meat, milk and egg demands. It is likely that their expenditure on animal health relates to food safety activities and monitoring the animal health of the countries from where they import livestock products.

b) *Countries with specific disease control programmes*

A majority of the countries (105 out of 117) reported having specific disease control programmes. A quarter had more than 7 specific disease programmes and nearly three quarters five or more programmes. One country reported 29 specific disease programmes and three countries only one (Fig. 5).

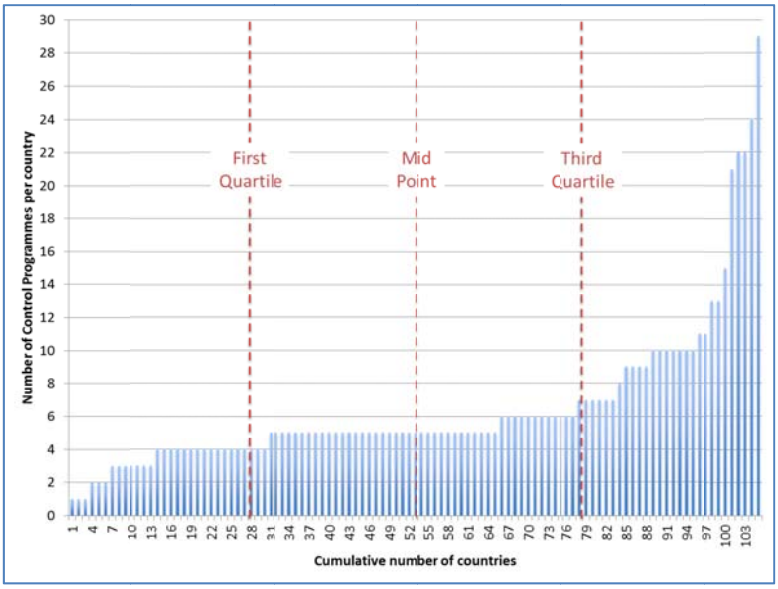

Figure 5. Number of specific disease programmes per country

The countries reported a total of 682 specific disease programmes, approximately half had programmes for brucellosis, avian influenza and FMD. Three quarters of the programmes were for just seventeen diseases (Fig. 6). In the top list food borne and zoonotic diseases are important, yet there is an absence of *Campylobacter*. In specific animal diseases, peste des petits ruminants (PPR) was only reported to have a specific programme in 24 countries despite this being a problem in approximately 80 countries.

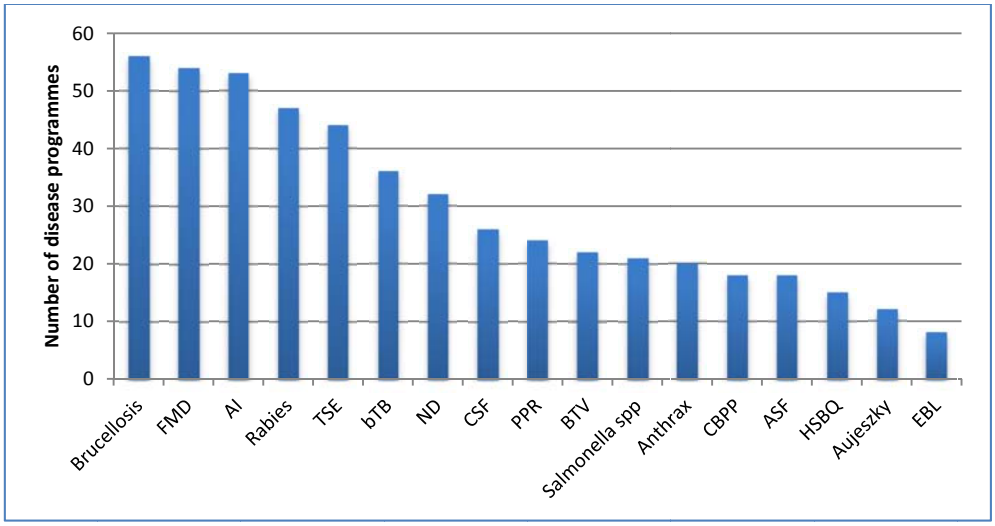

Figure 6. Number of specific disease programmes by disease
(a further 172 specific programmes were indicated)

Approximately half of the disease control programmes recorded (379 of 682) had data on the annual expenditure. The most expensive programmes were for FMD and bovine tuberculosis with an average expenditure of USD 35.9 and 20.9 million respectively. In programmes with an average annual expenditure of greater than USD 1 million per year one was for sea lice and two related to bee health. Brucellosis despite being the most significant in terms of number of countries had a relatively low average annual expenditure (Table 1).

Table 1. Average annual cost of disease control programmes by type of disease

Disease	Number of programmes that reported expenditure	Average annual cost per programme (million USD)
FMD	28	35.9
Bovine tuberculosis	24	20.9
Varroa	2	6.0
Sea lice	1	3.2
RVF	2	3.2
Brucellosis	37	3.0
BVD	4	2.6
Trichinella	1	2.4
TSE	31	2.3
ASF	8	2.0
PPR	11	1.8
Aujeszky	7	1.5
Tick control	3	1.5
Salmonella spp.	12	1.4
Newcastle disease	11	1.4
Rabies	29	1.2
Bluetongue virus	19	1.2
CSF	16	1.2
Bee disease	1	1.1
Q fever	1	1.0

Approximately half of the disease programmes (368 out of 682) reported involved cost sharing with the private sector.

c) Information on specific disease control programmes

When asked whether the disease programmes were for disease that were endemic, sporadic or not present in the countries the level of expenditure based on the returned data was similar for disease that were endemic and not present, USD 95 and 99 million respectively. These data were skewed by the major costs of managing endemic bovine tuberculosis (USD 49.6 million) followed by *Varroa* (USD 6 million) and African swine fever (ASF) (USD 4.3 million). For the costs of disease programmes where countries were free FMD (USD 81.9 million) was the major cost. The costs of the programme diseases that were sporadic was USD 35 million with the major disease issues being bovine tuberculosis (USD 5.3 million), Aujeszky (USD 3.1 million), transmissible spongiform encephalopathies (TSEs) (USD 2.9 million) and ASF (USD 2.2 million).

3.2. Control costs of a major disease outbreak

a) Countries who have suffered a major disease outbreak since 2000

A majority of the responding countries (101 of the 116) reported that they had had a major disease outbreak since 2000. There were 358 reported disease outbreaks, a quarter of these were due to avian influenza (AI) and two thirds were caused by just five diseases AI, FMD, CSF, Newcastle disease and ASF (Fig. 7).

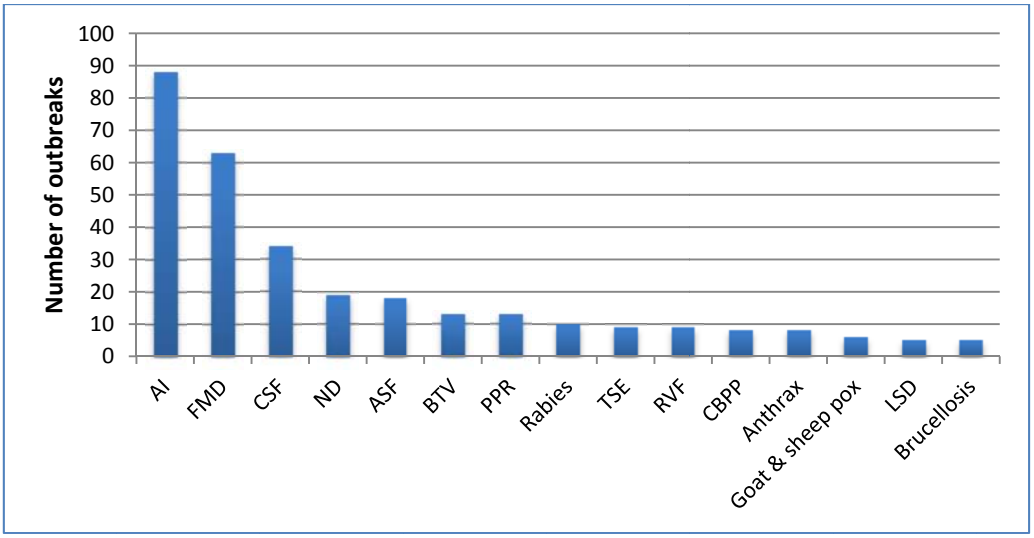

Figure 7. Number of disease outbreaks reported by disease
(a further 50 outbreaks were indicated)

b) Major disease outbreaks reported with type and costs of control activities

Of the 358 outbreaks reports only 128 had information on the costs of the outbreaks. These 128 outbreaks reported costs that summed to USD 12.1 billion since 2000. Two thirds of these costs were attributed to five TSE outbreaks alone and a further 20% of the costs were caused by 33 outbreaks of avian influenza (Fig. 8). On more detailed inspection of the data, one of TSE outbreak in one country led to a cost of USD 6.95 billion, or over half of all the reported costs of outbreaks reported since 2000.

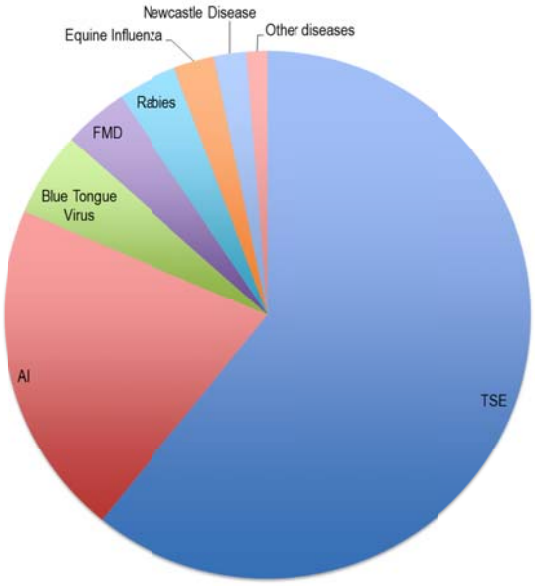

Figure 8. Proportion of outbreak costs reported by disease since 2000 (total costs were USD 12.1 billion)

The average length of the outbreaks for TSE was well over ten years (142.6 months) with only tick control having a longer period. Essentially the programmes for TSE have become institutionalised and cause major costs across the livestock sector. The most expensive diseases in terms of costs per month were rabies and equine influenza outbreaks with approximately USD 37 million costs per month. A further seven diseases were reported to cause costs of a million dollars or more per month (Table 2).

Table 2. Average monthly costs of disease outbreaks by disease

Disease	Number of outbreaks	Average duration (months)	Cost per month (million USD)
Rabies	2	6.0	37.5
Equine influenza	2	4.0	37.2
TSE	5	142.6	10.3
Avian influenza	33	9.2	8.3
Newcastle disease	10	10.3	2.3
FMD	21	10.9	2.1
Bluetongue virus	10	36.7	1.7
Q fever	1	36.0	1.1
Swine vesicular disease	1	24.0	1.0

Approximately two thirds of the costs of the disease outbreaks (228) were shared between the public and private sector. Respondents reported that for 91 outbreaks costs were borne entirely by the government.

3.3. Production losses of the disease outbreaks

a) Countries with endemic transboundary diseases

Seventy (60%) of the member states who responded stated that they had an endemic transboundary disease and just over two thirds had more than one endemic transboundary disease. The most commonly reported endemic transboundary diseases were FMD (28), PPR (28), Newcastle disease (19), ASF (15), contagious bovine pleuropneumonia (CBPP) (15), brucellosis (14) and lumpy skin disease (11) out of a total of 187 reports of endemic transboundary disease.

b) Impact on production of endemic transboundary diseases

The data collected on the populations at risk and the estimations of the losses through morbidity and mortality did not generate anything of value and a different approach would be needed.

3.4. Trade and other impacts of transboundary diseases

a) Countries whose trade has been affected by transboundary diseases

Just over half the countries (68 out of 116) that had had a transboundary disease outbreak experienced problems with international trade, with a total of 168 outbreaks of disease. Italy, Sweden and the United Kingdom reported the most outbreaks that affected trade and the most frequently trade related diseases were AI, FMD, Newcastle disease, TSE, ASF, CSF and bluetongue virus (Fig. 9). These seven diseases alone accounted for 74% of the outbreaks with a trade impact.

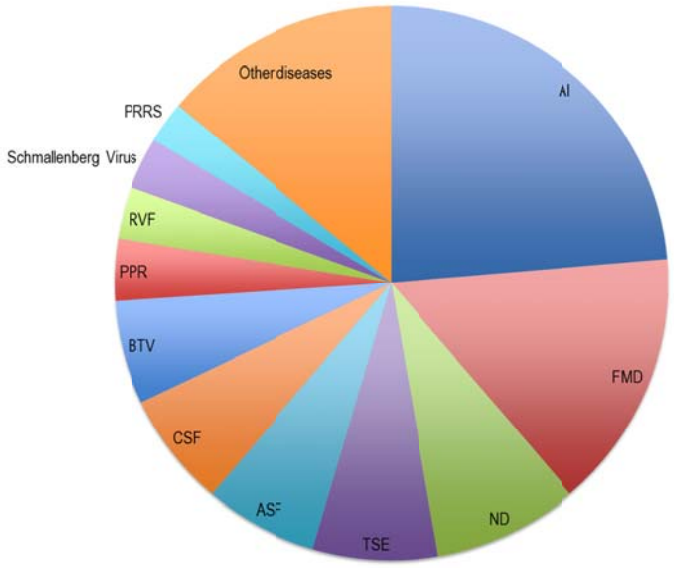

Figure 9. Proportion of outbreaks that were reported to affect trade by disease

The actual costs of the trade losses were not reported for all disease outbreaks with only eight diseases that caused trade losses having quantitative data on estimated losses. The impact varied considerably by disease and a summary is presented in Table 3.

Table 3. Trade losses reported during the outbreaks of specific diseases.

Disease	Reports	Average duration (months)	Loss reported (USD)			
			Minimum	Maximum	Total	Average per month
AHS	1	72.0	2,472	2,472	2,472	34
AI	7	85.1	-	51,120,000	8,815,816	103,585
Bluetongue virus	1	21.7	25,700,000	25,700,000	25,700,000	1,186,154
FMD	6	23.5	1,306	14,604,600	3,040,031	129,152
Newcastle disease	3	4.4	33	5,629	3,225	733
RVF	3	37.0	199,126	135,768,000	57,390,642	1,551,098
Schmallenberg virus	2	40.0	2,328	462,050	232,189	5,805
TSE	5	69.3	723,100	665,252,000	157,209,171	2,267,440

A number of countries indicated that the losses caused by a disease outbreak continued to have an impact on their trade with some saying that they never regained their original markets. Seven countries reported that trade was still affected after a disease outbreak had ended and that their previous markets had not been regained. Five countries had ongoing outbreak situations that were affecting trade. Four countries indicated how long it took to re-establish trade links with a minimum of 21 days and a maximum of 50 months. One country also indicated that a disease outbreak lead to a 20% reduction in their livestock trade.

In addition to the trade in the species and their associated products affected by the disease, some diseases were reported to have an impact on products that were either partially related or not related to the disease outbreak. The issues raised are shown in Table 4.

Table 4. Trade losses reported during the outbreaks of specific diseases

Country	Disease	Other goods affected
Australia	AI	Rendered poultry meals, pet food
Botswana, Peru, United Kingdom, China (Rep. pop. of)	FMD	Hides and skins; Fishmeal; Genetics; Straw
Brazil, United Kingdom	TSE	Meat and bone meal; Ruminant by products including pet food; Processed animal protein
Finland, France, Germany, Sweden	Schmallenberg virus	Genetics
Germany, Italy, Sweden	Bluetongue virus	Genetics
Kuwait	Glanders	Live horses
Lesotho	Anthrax	Wool and mohair
South Africa	African horse sickness	Live horses
South Africa	Rift Valley fever	Wool

b) Countries whose trade has been affected by transboundary diseases suffered by other countries

Half of the member states (63) who responded to the survey indicated that they had had problems with their trade due to neighbouring or trading partners having transboundary diseases. A total of 128 different outbreaks were reported with regards this type of trade issue with avian influenza (42), FMD (20), ASF (19), TSE (10) and BTV (10) being the most commonly reported issues.

Nearly 60% (76 outbreaks) of the outbreaks caused a negative impact on the trading of the countries, whereas only 9 outbreaks were reported to be positive to a country's trading position. The longest recorded duration due to a neighbour or trading partner having a transboundary disease was four years and shortest was one month (PPR). A summary of the impacts of transboundary disease in neighbouring or trading partners is shown in Table 5.

Table 5. Comments on the impact on trade due to transboundary disease in neighbouring or trading partner countries

Diseases	Country	Overall impacts
AHS EI Theileria FMD	Mauritius, New Caledonia, Fiji, Maldives	Negatively affected live animal imports
AI Aujeszky BTV FMD	Algeria, Egypt, Nepal, Pakistan, Tanzania, Argentina, Australia, Fiji, Maldives	Negative impacts on: - supply of livestock products; - input supplies particularly DOCs - genetic material
TSE	Australia	Increase in the costs of production

ASF FMD	Belgium; Cyprus; Czech Republic; Denmark; Finland; France; Hungary; Ireland; Italy; Malta; Spain	Lost export markets
FMD RVF	Mauritius	Increased risks of disease entry
AI ASF ND PRRS	Australia; Bhutan; New Caledonia, Norway	Short and medium term positive impacts on exports of products and genetics

c) Other impacts due to transboundary diseases

A little less than a third of the countries (33 out of 116) reported that a major animal disease outbreak had generated impacts across the livestock food system, and with some impacts in the wider economy. Thirty of these outbreaks were avian influenza and eleven were FMD. These two diseases accounted for half of the diseases that caused widespread impacts.

d) Specific aspects of the other impacts due to transboundary diseases

A majority of the outbreaks were reported to cause an impact on the livestock input and processing industries and only a minority to have wider impacts on aspects such as tourism (Table 6).

Table 6. Reported impacts of the major disease outbreaks across the economy

	Impacts on:		
Response	Inputs	Processing	Tourism
Don't know	7	3	11
No	7	7	48
Yes	61	62	13
NULL	3	6	6

Only six countries[3] reported the type of analysis performed to estimate the overall wider impacts of the disease outbreaks with a total of 16 analyses carried out. Half of these were for avian influenza, two for FMD and two for TSE. Partial equilibrium models were used in the estimates of impact in the USA for avian influenza, Porcine Epidemic Diarrhoea virus (PEDv) and TSE. Italy used consequential losses models for the analyses of avian influenza outbreaks. Other countries did not specify the methods used.

3.4. Economic analysis and the use of disease impact information on decision making

a) Type of economic analysis performed

A majority of the respondents indicated that economic analyses were either regularly carried out or carried out on an *ad hoc* basis. The responses were similar for preventive, endemic and outbreak disease measures. Around a third of this analysis involved in house teams with some involvement of academics and consultants and the most important user of the information was the veterinary services. The way the information was used was split reasonably equally between advocacy, justification and resource allocation (Fig. 10).

3 Cote d'Ivoire, Czech Republic, Italy, South Africa, United Kingdom and USA

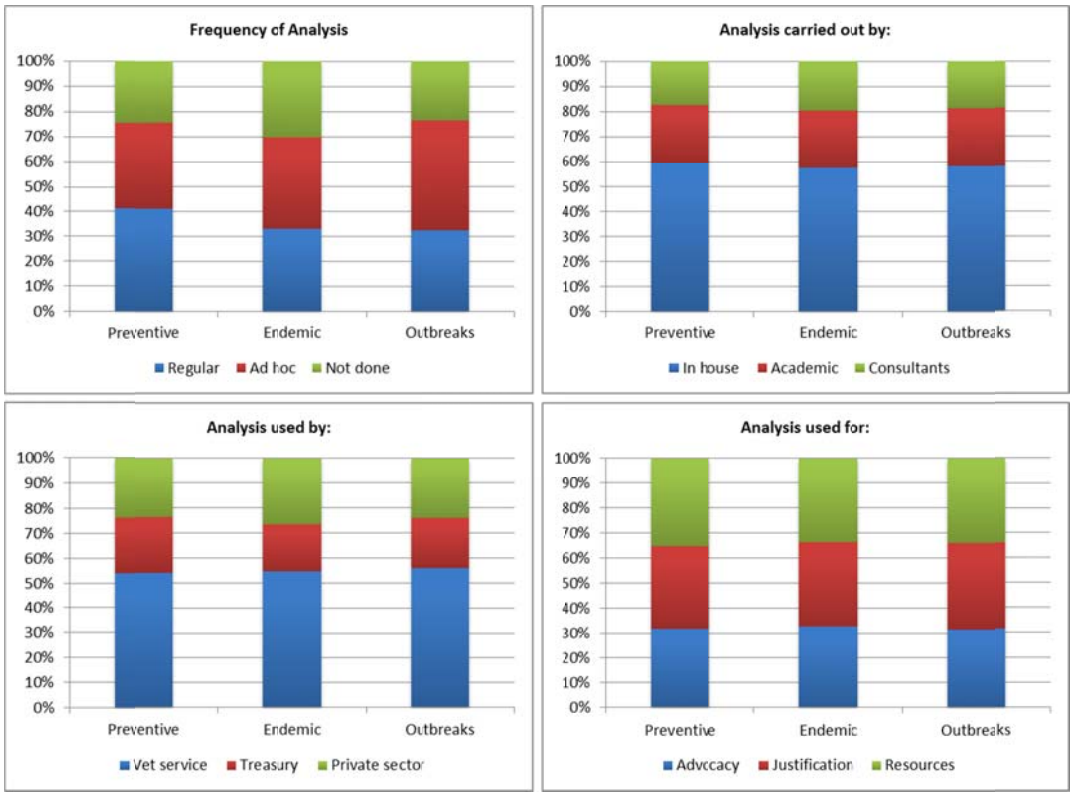

Figure 10. Regularity of economic analysis with an indication of who carries it out, for whom and how the results are used

The data indicate that economic analyses are largely driven by the internal veterinary service and used by them in terms of resource allocation. With well-trained economists within the service this would add value; however, where the analysis is conducted in such ways with limited training and challenge it could well lead to simply keeping the same pattern of implementation.

b) *Availability of experienced and trained people for economic analysis of animal health*

Approximately half of the respondents indicated that they had sufficient resources, people and skills to carry out economic analyses for endemic, preventive and outbreak animal health issues. A further third to two fifths responded that they had insufficient people, resources and skills for these activities.

c) *The need for further education in the economic assessment of animal disease outbreaks and the provision of publications on economic evaluations and trade impacts of animal disease*

A majority of the respondents (92%) would like more education in the application of economics to animal health. Similarly the majority would appreciate regular publications on the economic impacts of animal disease (87%) and on the trade impacts of such problems (89%).

d) *Willingness to discuss the use of economics of animal disease outbreaks and the use of the information in decision making*

A majority of the respondents (92%) would be willing to discuss the use of economic evaluations in animal health policy making and have provided their contact details.

4. Discussion

Whilst the geographical and species coverage of the survey was good, it was disappointing that some of the major livestock producing countries were not represented. Some of these countries have experienced major livestock disease outbreaks in the last fifteen years and their knowledge and information would have greatly enhanced the report.

For the veterinary services investments, all of the countries provided data on the number of animal health professionals, which demonstrated that many areas of the world have limited access to people formally educated to manage animal disease. Only half of the countries were able to indicate the costs of their veterinary services and of those that had this information in hand there was also a wide variation of investment per livestock unit. Both these items of data indicate a general weakness that animal health professionals and economists need to explore further in order to provide guidance on the numbers of animal health professionals and financial investments required per livestock unit. This requires further thought on the value of the animals under the care of the veterinary services, the salaries of the animal health professionals and the net economic value generated per livestock unit in the economies. Therefore it would require a mix of technical information on animal health inputs and the impact on disease management and the economic values of the overall veterinary service.

A majority of the responding countries have specific disease management programmes which require significant annual resources. Many of these programmes were for surveillance and preventive measures as the diseases were not actually present in the country. Only half of the programmes being run globally could provide data on the annual costs of the programmes.

Most countries reported at least one major disease outbreak yet only a third of these outbreaks had quantitative data in hand on the costs incurred. The costs reported summed to USD 12 billion which was skewed by the costs of one disease outbreak in one country that was reported to have cost USD 7 billion. Given the number of countries who did not respond to the survey that have experienced major AI problems in the time period covered by the survey, the data on costs of disease outbreaks should be treated with some caution if it is to be used as an indication of animal disease impacts at a global level.

An attempt was made to collect data on the production losses caused by endemic transboundary diseases. No useful data were generated from this section of the questionnaire. This would indicate that available data to make such estimates are not readily available and the methods to estimate such losses are not a regular part of the economic analysis of animal diseases in the veterinary services. As mentioned earlier this type of work has been done for endemic diseases in the United Kingdom (Bennett, 2003; Bennett & Ijeplaar, 2005) and Australia (Lane *et al.*, 2015) and therefore the paucity of information in this area is not surprising.

Trade and wider economy impacts due to the presence of disease in countries or in the neighbouring or trading partner countries was reported by roughly half of all the responding member states. Quantification of the trade impacts was limited as was the estimates of the wider sector and/or economy impacts. This largely reflects that economic analyses of this nature require existing models of the livestock sectors and/or the wider economy, and economists skilled in the parameterisation of these models to answer the questions with regard to likely impacts. Similarly trade impacts require data on trade flows and analysts familiar with the data and its use to examine impacts.

With regards to the people involved in the economic analysis of animal disease it would appear that this is largely driven by in-house groups in the veterinary services and their associated Ministries. The use of the information generated by the economic analysis is also largely for the use of the veterinary services. Given the limited availability of costs of core veterinary services, regular disease programmes, costs of outbreaks and impacts on trade and the wider economy, the capacity to carry out economic analysis would appear limited. The services who responded recognise this and the majority have indicated a desire for further education in this area and for greater access to publications on the use of economic analysis of animal health.

Overall the survey and the descriptive analysis have demonstrated the interest of the member states on the use of economics in animal health, yet there is a paucity of data on direct and indirect costs of animal diseases. A question should be asked whether this matters and what would be the benefit of having more data available on the economic aspects of animal diseases and their management – in short what value would more economic analysis bring to animal health decision making? There are three areas where the authors believe value could be added:

- Well-presented economic analysis are a useful tool in **justifying existing and requested resources** for animal health and welfare with good examples from Australia (Buetre *et al.* 2013), New Zealand (Forbes & van Halderen, 2014) and USA (Pendell *et al.* 2007).
    - Given that the veterinary profession have a critical role in the management of domesticated animals that represent a major proportion of the biomass of animals globally yet have limited resources (see Section 3.1), presenting economic arguments for greater resource should be a priority.
- Economic analysis of resources applied at a global and species level would provide useful information on the **global imbalances**.
    - Many areas of the world continue to have low staffing levels relative to their animal populations
    - Many species, particularly those of poorer people, have poor resource allocation
- Economic analyses of the allocation of resources across the **major diseases** can provide insights into the need for **prioritisation and reprioritisation** of focus over time.
    - A small number of diseases dominate the resources currently available to the veterinary services
    - Endemic diseases that are not transboundary in nature are poorly represented in current programmes, yet these have a critical impact on animal productivity and environmental impacts.
- Economic analysis of **resource allocation** within **specific disease control programmes** can assist in the more efficient use of scarce human, infrastructure and financial resources.

In terms of very practical steps in this area **three recommendations** are made:

1. **Veterinary education** at undergraduate, postgraduate and continuing professional development should include the **use of economics in animal health and welfare**. The materials should be focused on very practical areas of use and understanding the underlying economic concepts of resource allocations.

2. A **pilot project** is established to initiate a **global burden of animal diseases estimates**. Such a project should determine the diseases to be included – transboundary and endemic – and need to include the production losses, control costs and trade impacts of these diseases. Data collection, capture and analysis methods would need to be established. A full project would mirror the global burden of human disease.

3. A **pilot project** is established to collect and summarise data on the **costs of national veterinary services**. Where possible this should include **investments of governments, NGOs** and **private sector** in **animal health education, research and key infrastructure**. A full project would mirror the human health accounting system that was initially published by OECD in 2000 and updated in 2010 and guided by the OIE PVS system.

Point 1 would ensure that present and future animal health professionals can engage in debates on resource use and allocation. Points 2 and 3 would generate panel data that would allow the animal health professionals to assess the changing productivity of resource use in animal health across countries, diseases and between different policy models. Currently these productivity estimates are not available because datasets are not available for economic analysis (building on Civic Consulting, 2009 and Rushton & Jones, 2016).

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APPENDIX 1

Definition of current and new information technologies and animal health settings used in the Technical Questionnaire for the 84th General Session

TERM	DEFINITION
Control cost	All costs associated with the management of disease such as vaccination, culling and compensation, movement control measures
Cost analysis	An economic analysis of the costs incurred by an intervention for disease management.
Cost benefit analysis	An economic analysis that compares the additional costs and additional benefits from a change in animal disease situation over a number of years
Cost effectiveness analysis	An economic analysis that compares the additional costs with a marginal change in a technical outcome from a change in animal disease situation over a number of years
Econometric analysis	The analysis of empirical economic datasets to derive changes in the use of resources and their efficiency of use
Fixed cost	Costs associated to activities such as passive surveillance, coordination, research and education that cannot be assigned directly to a specific disease activity
Prevention cost	Costs associated with reducing the risks of the entry of disease and its early detection once in a population.
Private investment	The resources invested by private companies and individuals to manage a disease problem, or prevent disease
Production loss	The difference between the level of production in a herd or flock without disease and with disease. The measure should also indicate if there has been a change in productivity - inputs required to produce the same product or number of animals
Production parameter	The level of mortality, fertility and the sales and purchase levels for the animals in different stages of production and age
Public investment	The resources invested by the Government in the management of a disease problem
Surveillance cost	The costs associated with the collection of samples and data and the resources and time required to turn these data into information, including the diagnostic costs of samples
Trade impacts	The loss or restriction in markets due to the presence of disease on a population
Variable cost	Costs directly associated with the surveillance, control and prevention of a disease and reflect the scale of the disease outbreak or problem

APPENDIX 2

List of OIE Member Countries responding to the questionnaire

Algeria, Andorra, Argentina, Armenia, Australia, Austria, Bahrain, Bangladesh, Belgium, Benin, Bhutan, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Bulgaria, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Chad, China (People's Rep. of), Colombia, Comoros, Côte-d'Ivoire, Croatia, Cyprus, Czech Republic, Congo (Dem. Rep. of), Congo (Rep. of), Denmark, Djibouti, Egypt, Eritrea, Estonia, Fiji, Finland, France, Gabon, Gambia, Germany, Ghana, Greece, Guinea, Guinea-Bissau, Hungary, Iceland, India, Iraq, Ireland, Italy, Japan, Jordan, Kazakhstan, Kenya, Korea (Rep. of), Kuwait, Latvia, Lesotho, Liechtenstein, Lithuania, Luxembourg, Macedonia, Madagascar, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Micronesia (Federated States of), Moldova, Myanmar, Namibia, Nepal, The Netherlands, New Caledonia, New Zealand, Nicaragua, Norway, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Senegal, Serbia, Seychelles, Singapore, Slovakia, Slovenia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syria, Taipei China, Tajikistan, Tanzania, Tunisia, Turkey, Uganda, United Arab Emirates, United Kingdom, United States of America, Uruguay, Vanuatu, Zimbabwe