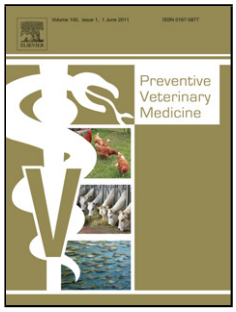
Accepted Manuscript



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PII: S0167-5877(16)30632-8
DOI: http://dx.doi.org/doi:10.1016/j.prevetmed.2016.11.020
Reference: PREVET 4151

To appear in: *PREVET*

Received date: 13-7-2016
Accepted date: 30-11-2016

Please cite this article as: Rushton, Jonathan, Improving the use of economics in animal health – Challenges in research, policy and education.Preventive Veterinary Medicine http://dx.doi.org/10.1016/j.prevetmed.2016.11.020

Improving the use of economics in animal health – *challenges in research, policy and education*

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Abstract

The way that an economist and an animal health professional use economics differs and creates frustrations. The economist is in search of optimizing resource allocation in the management of animal health and disease problems with metrics associated with the productivity of key societal resources of labour and capital. The animal health professional have a strong belief that productivity can be improved with the removal of pathogens. These differences restrict how well economics is used in animal health, and the question posed is whether this matters. The paper explores the question by looking at the changing role of animals in society and the associated change of the animal health professional's activities. It then questions if the current allocation of scarce resources for animal health are adequately allocated for societies and whether currently available data are sufficient for good allocation. A rapid review of the data on disease impacts – production losses and costs of human reaction – indicate that the data are sparse collected in different times and geographical regions. This limits what can be understood on the productivity of the economic resources used for animal health and this needs to be addressed with more systematic collection of data on disease losses and costs of animal health systems. Ideally such a process should learn lessons from the way that human health has made estimates of the burden of diseases and their capture of data on the costs of human health systems. Once available data on the global burden of animal diseases and the costs of animal health systems would allow assessments of individual disease management processes and the

productivity of wider productivity change. This utopia should be aimed at if animal health is to continue to attract and maintain adequate resources.

Keywords: animal health; economics

Introduction

A strict definition of economics would be the *study of the use of scare resources with competing demands*. The starting point when using an economic approach would be to develop an understanding of the allocation of resources in the system of interest, in order to:

- Describe current allocation of resources;
- Determine if the allocation is optimal; and
- Assess if the reallocation will lead to a situation closer to optimality.

Within this analytical framework it should be recognised that at the time of any assessment there is a given set of technologies. This does not negate that there may well be better technologies available that are yet to be discovered, and government policy and powerful companies influence that discovery. An economic analysis also needs to have a given set of prices for the resources used and produced, which could be set by the market through supply and demand with many buyers and sellers who have good information in a timely manner. However, it is very likely the prices will be influenced by government policy and/or sheer power by dominant buyers and/or sellers of the resources. An aspect often overlooked is the institutional environment, which include the rules laid down by society for any transaction or process, be it consumption or production, and include the enforcement of these rules. This powerful combination of rules and enforcement influence the measure of optimality that is held so dear in economics.

Economics in the way described does not have a context, it cuts across all things that society is involved in. The stepwise process of looking at an aspect of society from an economic perspective does not universally occur when using economics for animal health issues. At a policy level it is common that animal health specialists define the boundary of the system, and frequently this relates to the biology of specific diseases. In the extreme this is formalised as a list such as notifiable diseases, accompanied by societal strategies to manage a disease or a group of diseases. The animal health specialist defines the disease list and the process of managing the diseases without reference to economic context or impact. The economist is brought in to justify the focus on this disease either to determine the impact assessment of the disease and/or to determine if the strategy is economically profitable. Figure 1 contrasts the approach of the economist and the animal health specialist.

The differences in approach are characterized by an:

1. Economic approach adding value through a search for optimality; and
2. Animal health approach adding value through advocacy.

The distinctions indicated are not black and white, and there will always be grey areas, but differences do exist and they create frustrations. The economists are looking for ways in which overall productivity can be modified and improved, whereas the animal health professionals are convinced that productivity can be improved by removing pathogens of animals and improving health and welfare of those animals. Part of the difficulty is the definition of productivity, those familiar with literature in agricultural economics recognize that it is not a simple matter of measuring a limited number of outputs divided by a limited number of inputs, yet economists often use figures that relate to returns to labour or capital input. These productivity measures are not ones used in either animal health or in animal production, the latter tends to use proxies such as production per animal or land unit for capital, but rarely are returns per labour unit derived or used (Nix, 2016).

If productivity can be agreed there are also differences of opinion on what is optimal. Those familiar with McInerney's work (1996) will understand that a point of economic optimality may exist in the allocation of resources for animal disease management which would allow a level of disease to persist. McInerney controversially stated that animal health is an economic problem not a technical one, his view has some merit, yet it fails to understand that the underlying relationship between disease losses and control costs are set by technical solutions and the economic optimality is influenced by the technical relationship (Doll and Orazam, 1984; Boehlje and Eidman, 1984). In this setting animal health professionals are constantly searching for technologies and approaches that lead to removal of pathogens, so they are influencing the technical relationship and modifying it.

The fact that there is a difference between economic and animal health approaches can lead to frustrations, but does this matter? A pragmatic approach to animal health with minimal use of economics in many cases has worked with diseases such as rinderpest with its global eradication, and a number of diseases that have been eliminated from large populations of animals. In addition the animal health status of populations under the control of people has improved markedly.

The question this paper sets to answer is whether there is a need for a shift in how we do business with regards animal health. It will explore this through thinking about change - animal populations, their health status and societal responses to animal health challenges. It will initially look at the changing role of animals in society, and then discuss how the health and health systems for our animals have responded. Within this context the paper will explore what would be needed from a data collection and analysis perspective to improve overall management of disease and animal health issues in the future. The conclusions will reflect on the education, research and policy challenges to achieve positive change. Overall the paper will present arguments on the need for data capture and analysis systems that allow prioritisation.

Material and methods

The paper is a thought piece based on the author's experiences of living and working as a dairy farmer's son followed by 25 years of working in livestock development and animal health issues. During the professional period he has worked in academia in the UK, for a governmental development agency in Bolivia, an international organization at a global level which was challenged by an animal health crisis, and he has been involved throughout this time in giving strategic advice at national, regional and international levels. More recently the approaches that the author has used have broadened to look beyond the farm level and think of the sector and the societal impacts with particularly reference to the use of methods such as value chain analysis to capture the complexity of the food system (Rushton, 2009; Taylor and Rushton, 2011). Throughout the author's experience there has been a strong feeling of frustrations of vets with economists and economists with vets, and this spurned the need to examine how economics was taught in the veterinary curricula globally with a project – NEAT – investigating both the current trends and the needs (Jackson et al, 2015; Waret-Szkuta et al, 2015).

This very personal basis of the paper is supplemented by data from specific projects and also with the analysis of secondary data.

Results

The changing role of animals in society

The first species to be domesticated was the dog followed by goats, sheep, cattle, pigs, poultry (Essig, 2015). Very few species have been domesticated (Diamond, 1997) as the process requires specific characteristics which can be identified as:

- Diet – the efficiency of turning vegetative matter into meat;
- Growth rate – the ability to grow quickly;
- Ability to breed in captivity;

- Relatively easy disposition;
- Tendency not to panic; and
- Well defined dominance hierarchy with the ability to have a leader imprinted on their group.

The process of domestication for grazing animals is likely to have been different from scavenging species such as the dog, pig, poultry. Grazing animals were probably hunted then managed whereas the scavenging animals probably followed humans and then were incorporated into societies (Essig, 2015).

These domesticated species were originally useful in many ways with the dogs providing protection and assisting in hunting, and the grazing animals collected energy from grasses and browse not accessible to humans to generate milk, wool, fat, meat, skins, bone. The scavengers also searched and ate food not accessible to humans to generate fat, meat and eggs. Animal fat in many societies was a critical aspect of cooking. Species such as equines, cattle, buffalo and camels provided power to cultivate land and for transport, with horses being a critical aspect of warfare. These useful species have been moved to new continents as humans have moved and have replaced many native species in the process. Overall the role of animals up until approximately 200 years ago was to harvest energy sources in the environment to produce food and clothing and to provide power.

With the discovery of coal and oil the role of animals began to change. There was less need for animals to generate power and harvest energy from the wider environment. The change accelerated around a hundred years ago with the widespread use of the combustion engine. It has accelerated again around fifty years ago with the intensification of cropping systems, and in particular with the advances in cropping technology where grain yields increased. The overall importance of animals has led to drastic changes in the populations of the useful species, particularly equines where the rise of the combustion engine to transport goods and people has

led to a rapid reduction in populations. Figure 2 provides an example of the changes in the Australian horse population over the last 100 years.

Alongside the changes in the role of animals in society has been an increasing tendency for people to live in urban centres, and for the overall human population to increase (Gerland et al, 2014). With people moving from the rural areas there has been a separation between people and livestock through the process of urbanization. There has also been a food system system change as animals are raised, slaughtered and processed out of sight of urbanized people. Livestock products are found in shops and have been heavily processed before urban consumers buy and consumer them. In general the number of people who handle livestock are very few, and are a very small proportion of a country's population. The livestock products generated in these systems are consumed by everyone, and are increasingly seen as commodities that are to be generated as economically efficiently as possible. The animals themselves are increasingly kept in intensive systems, fed grain based concentrated diets brought to them and kept in high population densities. The value – price – of these animals is dictated by the demand of the consumers and the means in which they are kept. The production systems and their associated value chains have become very efficient and the livestock have reduced in value relative to other goods in society. This change in relative value has accelerated over the over the last 50 years, driven in part by the way the food system rewards people. In the OECD countries the pattern has been to reduce the number of livestock farms and to increase the herd or flock sizes in a drive to increase labour productivity and to reduce costs of unit production. The extremes are dramatic with UK dairy farms reducing from 35,000 to 10,000 in a period of 25 years and herd sizes increasing from 75 to 125 during that time with no impact on level of production (Figure 3 and 4).

Livestock have become invisible in many societies and as the name implies are simply a live form of stock, hence livestock, to be invested in and managed, they have become depersonalized and devalued during the recent rise of the urbanized elites.

Pets and sporting animals

Despite this removal of livestock from a majority of people's lives, humans remain zoophilic. The desire of societies to see wild animals is strong and the link with animals that people can look after has increased through pets that are cared for like friends and family (Jones, 2003). In addition, sporting animals such as horse and dogs, are part of the entertainment economy and are linked to major parts of the economy. Others animals, such as horses and zoo animals, are involved in tourism. The economic activity associated with pet care has become so important that countries around the world collect specific data to estimate its contributions to GDP. In the case of the UK it represents 0.5% of GDP, which contrasts sharply with the knowledge that primary agriculture is 0.7% of GDP in this economy. In general pets, leisure and sporting animals have a high individual value, and this value appears to be increasing as people in urbanized setting fill their time and use their money to take great care of their important animals.

Summary of the animal role changes

The changes in the role of animals have been dramatic in the last two decades leading to changes in resources use to look after animals. Pets and sporting animals have individual attention with: increasingly sophisticated healthcare; specialised diets and clothes, toys, treats. While livestock are increasingly confined, raised, slaughtered and processed in large groups. It is a societal paradox that one group of animals – livestock - have become separated from people and their value has reduced whilst another group – the pets and leisure animals – have seen a dramatic increase in their individual value. These changing values leads to the role of animals

constantly evolving with some of changes being demand driven and others relating to supply process changes.

How the health of our animals has changed and how the animal health systems have responded

The beginnings of the profession - the importance of the horse

The veterinary profession emerged with people who specialised in maintaining the health of horses (Wilkinson, 1992; Jones, 2003). This was demanded from rulers who needed armies for invasion or protection, but it is also reflection of the relative value of animals for example in 1867 in Australia a heavy horse was worth ten times a breeding cow (Durack, 1959 page 79). As discussed above the importance of the horse decreased over time with the widespread use of the combustion engine.

The initiation of veterinary systems - food, food systems and disease

The changes in human population in OECD countries and the migration of people to urban centres shifted the demand for food and the shape of food systems (Delgado et al, 1999; Rushton, 2009; Rushton et al, 2010). There were modifications of production and marketing systems and the emergence of disease threats – rinderpest, FMD, CBPP plus a range of zoonotic issues (Greger, 2007; FAO, 2013). This creates a societal demand for control measures and government investments in state services – jobs and work for vets!

And more recently - ongoing problems with emerging disease

The increases in human populations and shifts of location are ongoing – new diseases are still emerging. This is not just in Africa and Asia, let's not forget that many of the major problems have come from Europe and North America e.g. BSE, PED. So there are demands for veterinarians in understanding disease in populations – epidemiology and in public health. And

because epidemiology relates to how people behave it calls for an understanding of economics and social science – subjects that study why people do what they do.

More recently - rising importance of pets

The urbanised affluent people are separated from livestock, yet are increasingly attached to pets. They have money and are willing to use it to improve the health of their animals. Therefore there has been an increase in demand for pet care and vets have responded to these changes. Most vet time is spent on these animals and their high individual value has led to an expansion in the demand for veterinary services for pet animals (Brown and Silverman, 1999). The pet healthcare and the associated nutrition and accessory sales have attracted the interests of the finance world. Many places are seeing investors buy veterinary practices and pet businesses developing into corporate entities. And there are vets who have worked together to generate a franchise system. The size of these new businesses is large compared to previous practice models, the role of the vet has changed.

On livestock health

Animals kept for the production of meat, milk, eggs, wool – livestock are managed in groups. Their healthcare is dependent on the skills and knowledge of farmers, vets and scientists. There is great dependence on antimicrobials and immunological agents. Individual animal attention is rare and the overall demand for specialised veterinarians is small, particularly in the intensive pig and poultry systems. The one area of large animal veterinary medicine that continues with individual animal care is the cattle dairy sector where individual animal value is significant.

The veterinarian and their changing roles

Vets are increasingly part of large business activities that serve the pet sector. There is also demand for veterinary skills at a societal level or in a large population management role with demand for veterinary public health work. This reflects the changing wealth, demands and

preferences of people in society. People's use of animals has changed and as a consequence their use of vets has also modified (Jones, 2003).

Is there a balance across our health systems? Is the focus within the animal health systems correct?

From an economic perspective the shift of the animal health professionals to species that have greater value makes sense. Yet from a wider societal perspective where livestock dominate so many resources such as land and water and potentially have major health implications in terms of pathogen and nutritional burdens there could be questions raised on the balance of the allocation of scarce animal health professional skills. It raises questions of:

- What is known across species in terms of biomass change?
- What is known across health systems in terms of costs?
- What does the resource allocation across health systems look like?
- How do these allocations relate to: overall biomass of species; the use of species in terms of land and water; and disease generation – currently and the future.

It is widely known that domesticated animals make up around two thirds of the biomass of humans and animals combined, and that the livestock dominate this domesticated species category (see Figure 5).

Per person it is estimated that there are approximately 0.38 livestock units or 190 kilos per person. This is equivalent to three chickens, a third of a sheep or goat, a fifth of a cow, a seventh of a pig and a tenth of a cat or dog. Very little biomass is now occupied by the terrestrial wild mammals (Smil, 2013) and the world is dominated by humans and their pets through the use of land and water either directly by themselves or indirectly through the domesticated animals largely kept for the production of food and fibre.

The unit of measure for this comparison is metabolic weight, which is not an economic measure. If metabolic weight was used to allocate animal health resources then many more vets

would be employed to help to care for livestock. If the unit of measure used is changed to a monetary value, an economic metric, then humans and their pets become far more important. For example a human fatality in the UK would be valued at £1.635 million on an assessment of railway investment (Department for Transport, 2015) or as a measure of between £20-30,000 per QALY when carrying out a cost-effectiveness analysis for the UK government (NICE, 2016). The average value of livestock unit as measured by the value of a beef cow or dairy cow would be in the region of £1000 to 2000. Given that humans are only around 0.3 of a livestock unit this implies that a human livestock unit is valued at least £60,000 and at the highest at £4.7 million.

At the extremes this valuation means a society such as the UK have adopted a relative value of humans to livestock is between 60 to 4,700. These relative values matter in terms of resource allocation between species and our attitudes towards domesticated animals in general. The values also express an overall opinion of society of the worth of different types of animals in society and affect our choices in terms of how they are managed, slaughtered and consumed.

Land, water and the environment

With the decreasing value of livestock there has been an associated increase in their numbers and an increase in the level of production per animal. These changes have led to concerns about:

- **Land use** – it is estimated that two thirds of land is dedicated to livestock (Wirsenius et al, 2010)
- **Water use** – agriculture takes between 70% and 90% of the freshwater (Comprehensive Assessment of Water Management in Agriculture, 2007) and a third is used on livestock (Gerben-Leenes et al, 2013)
- **Environmental** emissions with livestock being a major source of methane and indirectly CO2 emissions and local pollution (FAO, 2006).

In addition it is known that two thirds of human diseases come from animals and this has recently increased to three quarters of emerging diseases being from animals (Cleaveland et al, 2001; Woolhouse et al, 2005; Jones et al, 2008). The way livestock are kept has increased concerns about animal welfare (Norwood and Lusk, 2011, Marchant-Forde, 2015). From a food system perspective livestock products are modified and handled before being sold and this has opened up new problems of adulteration of products due to the complexity of the food system (Wei and Liu, 2012). In the more recent times concerns have been raised on the use of antimicrobials in livestock and the potential associations with antimicrobial resistance (Rushton et al, 2014; Landers et al, 2012; Price et al, 2015; Van Boeckal et al, 2015).

The metrics used to allocate animal health resources are skewed by the values society places on livestock, pets and humans. A more powerful measure would appear to be needed given that many issues arising from livestock are inadequately managed, yet the resources to address these problems are not available.

What is known about the losses and costs of disease?

Disease impacts can be conveniently broken into losses caused by a disease in the species affected and the costs of control of the disease (McInerney et al, 1992; McInerney, 1996, Rushton et al, 1999). At a global level what is actually known about these two sides is presented in Table 1.

The balance of information on losses due to disease and health problems is very much in favour of what we know about human health. Given the way society values humans relative to livestock and wildlife this is not very surprising, economic logic would assume that the health of more valuable aspects of society would attract investments in the understanding of these. The attempts to look at animal disease impacts have been limited to one global study that had very limited resources and was entirely dependent on global level databases (World Bank, 2011). The framework for the study of animal disease followed closely the global burden of disease

work (Murray et al, 2012) with an estimate of the livestock units lost due to premature death of animals or impaired ability to reach maturity in an optimal time. The estimates of losses in both human and animal health are gross measures of loss, they do not take into account the need for resources of humans or animals saved which is the basis of the national level studies carried out at a national level (Bennett, 2003; Bennett and Ijeplaar, 2005; Lane et al, 2015).

On the cost side there are very good models of capturing expenditure on healthcare for humans with well established data lines held by the national office of statistics (OECD et al, 2015). In addition as mentioned earlier there are data lines for pet healthcare also by the national office of statistics which is now established in OECD and poor countries (World Bank, 2015). General animal healthcare costs for the livestock sector are in some countries available through the OIE PVS, but these data are collected in different time periods and with different methodologies (Civic Consulting, 2009; Rushton and Jones, 2016).

When combining the data available between the human and animal health care there is a balance of approximately 9.7 million doctors trained in human medicine (Henry J. Kaiser Family Foundation, 2015; WHO, 2016) and the author estimates that there are approximately 1 million veterinarians globally. The distribution of the veterinarians is not even across the globe or across the production systems (Rushton and Gilbert, 2016). Data on actual expenditure for human health indicates that in 2011 US$ 1 trillion was spent across the world, there were no similar figures for animal health. However, animal health medicines market is estimated to be a fortieth of the human medicines market (Animal Health Institute, 2015). There appear to be imbalances across the health system and within the animal health system.

Imbalances across the species

Human healthcare systems absorb a majority of the resources. Similarly pet healthcare absorbs significant animal health resource. The current resource allocations would appear not to reflect concerns about the resilience of livestock food systems; disease emergence/re-emergence;

animal welfare; and environmental impacts. Is the allocation of resource across the health system optimal? We do not have the data to answer this question.

An economic framework to provide information for animal health decision making

An economic framework that provides information for animal health decision making needs to have data on the animal health and welfare burden. Defining how this is measured requires more careful thought that simply counting the number of extra animals or greater levels of product which would be a gross measure. For an economic framework the estimates of change in losses need to include the net measure of animals and product less the extra feed and general investment required for such changes. On the costs there needs to be estimates of the costs of surveillance, prevention and control measures of livestock diseases, health and welfare problems, plus an estimate of the impacts on trade if the disease leads to bans of movement of animals and products.

Animal health & welfare burden

To estimate the animal health and welfare burden requires scale data and there is the need for animal populations. The way in which FAOSTAT is currently being updated with the hope that these population data are both more accurate and also represent more carefully the production systems in which terrestrial livestock are kept and in which aquatic species are maintained. To maintain these data in ways that allow such analysis also requires further efforts at a national level to ensure that populations are estimated and that the production system changes are captured.

In addition to the population data, there is a need for classification systems. The current classification systems promoted in the mid 90s based on land use (Sere and Steinfeld, 1996) bear little relationship to how population data are currently captured either at local, national or global level. This needs to be addressed and it is hoped that the FAOSTAT modifications will

recognize this disconnect between classification, capture and analysis. Many of the current papers based on these early classification systems will always be fraught with difficulty.

With the population and classification there is a process of scale and the separation into categories that represent differences in the use of livestock and the overall use of inputs. To make good estimates of animal health and welfare burdens there needs to be data on production parameters such as mortality, fertility and offtake rates and critical inputs in order to estimate the productivity and efficiency of the systems (Baptista, 1987; 1992; James & Carles, 1996). These provide an ability to examine the net change in output from a livestock system with a change in disease or welfare levels rather than simple estimates of change of the gross output.

In general there are comprehensive data on populations and production parameters for the intensively managed livestock systems such as pigs, poultry and dairy cattle in OECD countries. These data may also exist in other geographical regions but the coverage is patchy. In general the less extensive production systems in most countries and particularly in developing countries have limited data. These are normally represented by the main grazing species – cattle, buffalo, sheep, goats and camels – where the main purpose is largely the gathering of forage that would be difficult or expensive to collect using machinery and human labour. There are also some scavenge based systems dominated by pigs and poultry that continue to be important in most parts of the world for poor people, yet represent a very small proportion of livestock biomass overall. Yet the proportion of animals in the extensive grazing based systems continues to be high and in both scavenge and grazing systems there are continue to have problems with transboundary and zoonotic diseases. Overall there is a desperate need for the study produced by Otte and Chilonda (2002) that summarized what was known in the late 90s about production parameter data. Similar efforts were made in 2000s for South America (Rushton and Viscarra, 2004), North Africa and Asia but these documents never reached a stage of widescale publication and have not been updated.

Data are also needed on disease presence. Whilst transboundary animal diseases have some data, data on endemic diseases are sparse and/or inconsistent even in OECD countries, and data on health and welfare issues are largely absent. There is a need for agreed models for the analyses with population models that reflect systems of production producing agreed metrics in terms of changes in animals and outputs with a relationship to key inputs used.

Data capture and storage remain problematic and research is needed on modelling approaches. In general there is a strong need for a cadre of people need to be educated to perform the work around the area of assessing livestock populations and their positive and negative impacts.

The costs of surveillance, control & prevention

There is some capture of expenditure of the public sectors on animal health, but it is not consistent or frequent. There is capture of private expenditure in pet healthcare through national statistics departments. It is rare to see data on private expenditure on livestock health (Gilbert & Rushton, 2014).

Core investments in animal health

There has been a slow, yet increasing, understanding of the need for core investments in animal health. This recognises the need for money – public and private – to support:

- Education – vets, livestock owners, pet owners
- Research – antimicrobials, immunologicals
- Coordination – managing resource use across the public, private and NGO sectors

Animal health systems need this core investment both in periods of quiet and to respond to periods of crisis. Core investment is likely to vary according to animal population, animal use and societal attitudes. Research is required on the size of this core investment for an effective animal health system.

Market distortions and market shocks due to animal disease

Market data on livestock products. Information on the impact across the food systems. Assessment of market impacts at all levels from input suppliers, production, processing, retailing and consumers. Good reference work for market shocks would be from Longworth et al (2007) for the AI outbreak in The Netherlands.

At a micro-level

Animal health and welfare burdens once available can be used as a basis for outcome measures. Animal health system costs will affect animal health status and burdens. For specific animal health programmes it would be possible to develop a library of cost-effectiveness measures and cost benefit analyses, which should allow the development of production surfaces and a more thorough investigation of optimal points of intervention.

At a sector level

Animal health & welfare burdens by country and by region will highlight the level of problems in the animal population. Linking these to overall costs of animal health systems should help to identify where resource use is ineffective and inefficient. Assessment of the effectiveness of the overall animal health system should be possible.

Discussion

Reflections on educational needs, research needs and policy challenges

Understanding and meeting the education challenges in the health system

Much of the animal health education at present is following the money – small animal clinician work. We need a cadre of people who are capable of understanding and describing change in our use of animals, the health of these animals and our responses to their health and welfare. And this cadre also need to be able to identify poor allocations of resource and communicate

these to people with power to change the allocation. Veterinarians need awareness of economics and social science skills to understand and influence change

Understanding and meeting the research challenges in the health system

Research is needed on metrics for animal health and welfare burdens, the capture and analysis of cost data and the associations between health inputs and outputs. This needs to be in social and economic terms. A combination of burden information with costs of the specific programmes will facilitate the identification of weaknesses in the system that need to be addressed by research. Economists and social scientists are needed to support and engage in this research

Understanding and meeting the policy challenges in the health system

A systematic process of collecting, capturing and analysing animal health and welfare burdens will allow prioritising and re-prioritising of these issues. Imagine a flexible list of notifiable diseases. Information on the associations between burdens and costs and who bears the costs and burdens will provide evidence for public policy on:

- Legislation
- Programmes
- Coordination

Policy could become a mix of demand driven responses, and where market failure exists, supply led responses to address poor resource allocation. Policy needs to become more evidence based.

Conclusions

Animal health professionals are currently not working well enough together to allow the generation of information to prioritise animal health and welfare problems. In comparison human health professionals have mechanisms in place to do this. In the larger context animal health professionals and animal productionists need to be aware that changes in animal

production are likely as the sustainability of how we are feeding and managing animals is being challenged. This requires the design of new systems of surveillance and monitoring linked to public and private sector interventions that combine the analysis of health, production, economics and the social aspect of the way animals are kept and used. Figure 6 provides a schematic representation of such a system.

The next steps in animal health and welfare need to draw lessons from human health in establishing estimates of the global burden of human diseases (Murray et al, 1996; Murray et al 2013) and the continuous collection of data on health expenditure (OECD et al, 2015). Both these two aspects provide a basis to prioritise health problems and alter the priorities as burdens change and also the ability to assess the changes in effectiveness and productivity of different types of health delivery policies and programmes. Currently animal health has no similar datasets and this is hampering both the allocation of resources with the animal health sector and the ability to advocate and maintain funding for the core activities of a good animal health system. The key messages from the paper would be summarized as:

- At best animal health professionals are currently being reactive and at worst drifting with what is seen as a given;
- There is a growing need to move to being more proactive in the use of economics in decision making; and
- This requires data and the generation of information on burdens and costs.

This sounds like an ideal world, but human health systems are working towards it and animal health needs to find ways to match their work.

Acknowledgements

Many people have influenced me and helped shape the thoughts expressed in the paper of which Peter Ellis, Andrew James, Joachim Otte and Martin Upton have been fundamental. During my

work at RVC Barbara Haesler, Liz Jackson, Pablo Alarcon, Paula Dominguez-Salas, Betty Bisdorf, Mieghan Bruce and Will Gilbert have been very supportive. Colleagues in NEAT, NEOH, UNE and Sydney University. Liz Redmond and the Rushton family. Thank you to ISVEE for the honour of giving a keynote paper. I want to recognise the support of Norbrook Pharmaceuticals and LCIRAH in the work I carry out.

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Figure 1. Differences between an economic and an animal health approach.

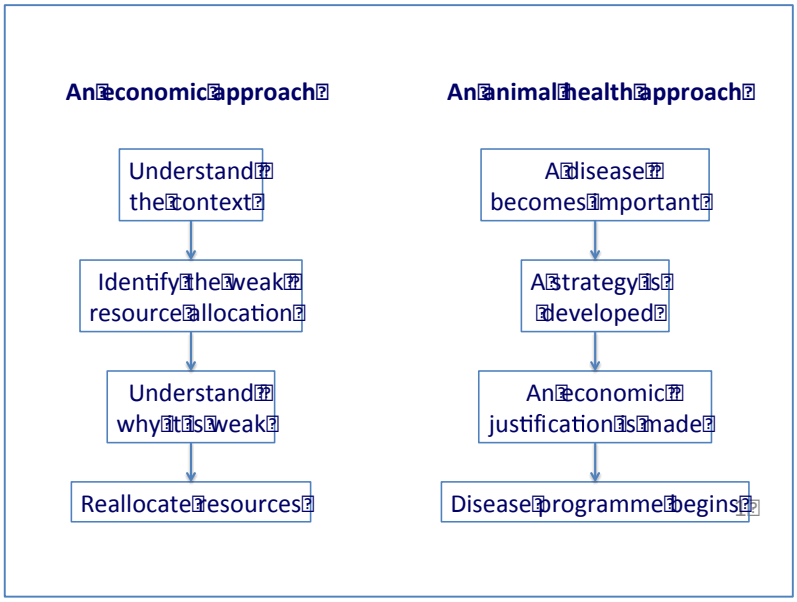

Figure 2. Australian horse population 1885 to 2011 (Australian Bureau of Statistics, 2013)

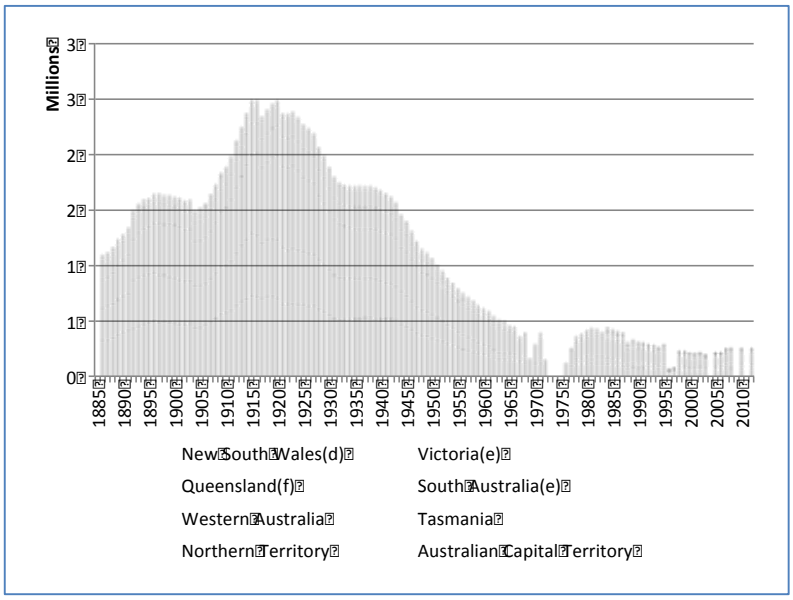

Figure 3 **The number of dairy farmers in the United Kingdom – 1995 to 2013. (reference)**

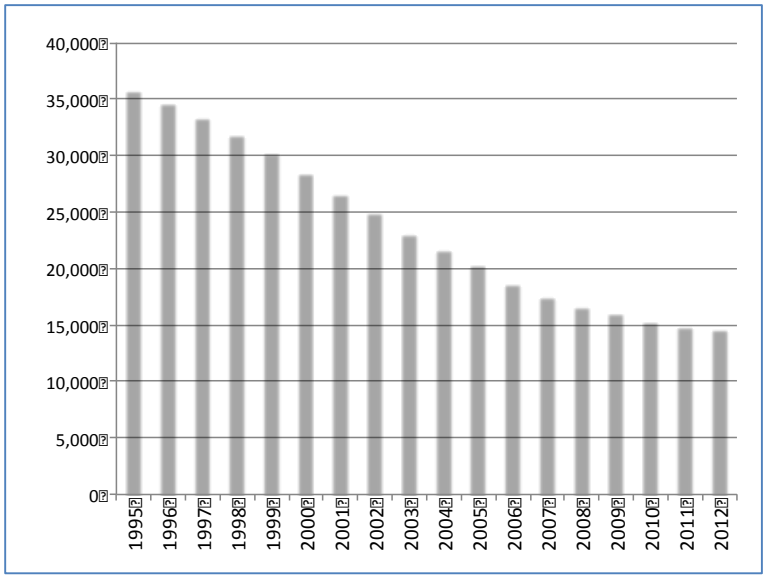

Figure 4. **Average dairy herd size in the UK between 1996-2012 (reference)**

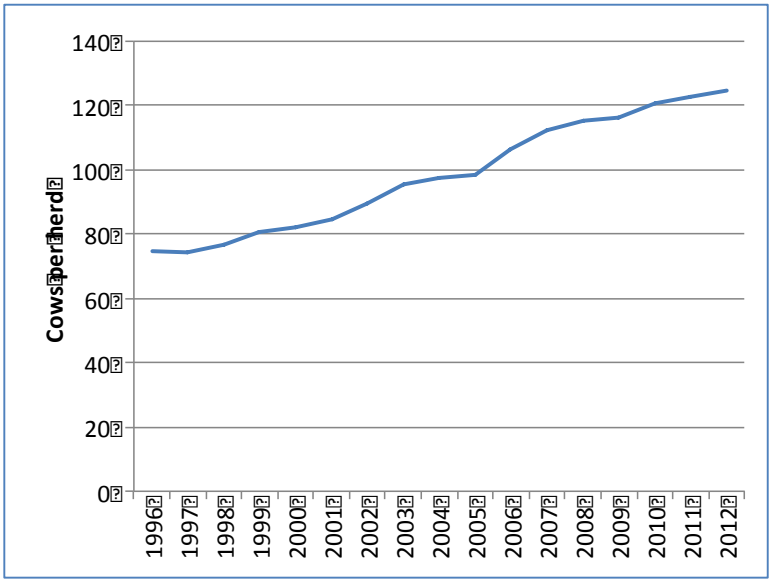

Figure 5 Human and domesticated animals *(in livestock unit equivalents based on FAOSTAT, 2015)*

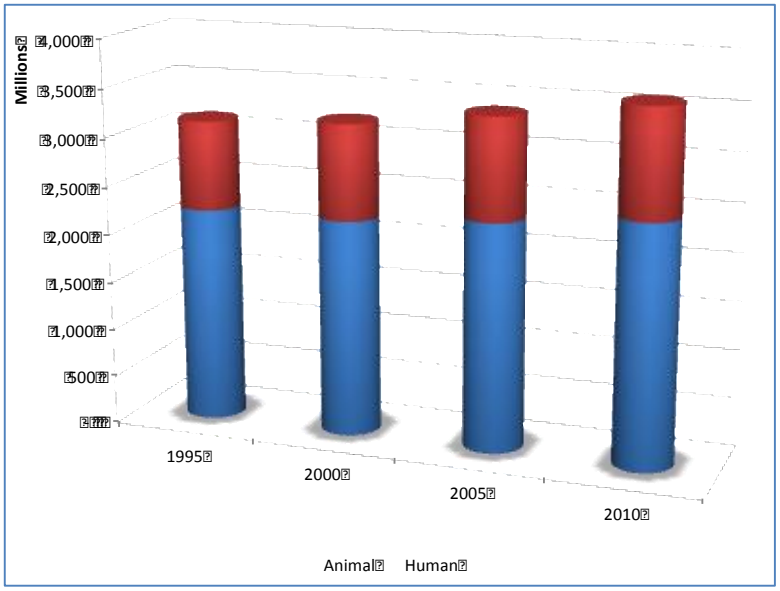

Figure 6. Structures needed for an economic analysis of livestock health and welfare.

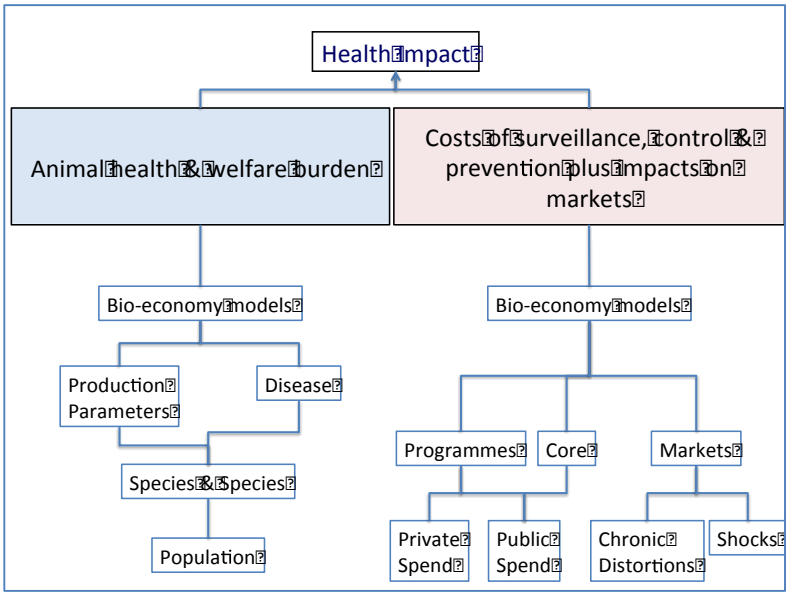

Figure 7. A schematic of an ideal system of animal health delivery with economics and social science embedded.

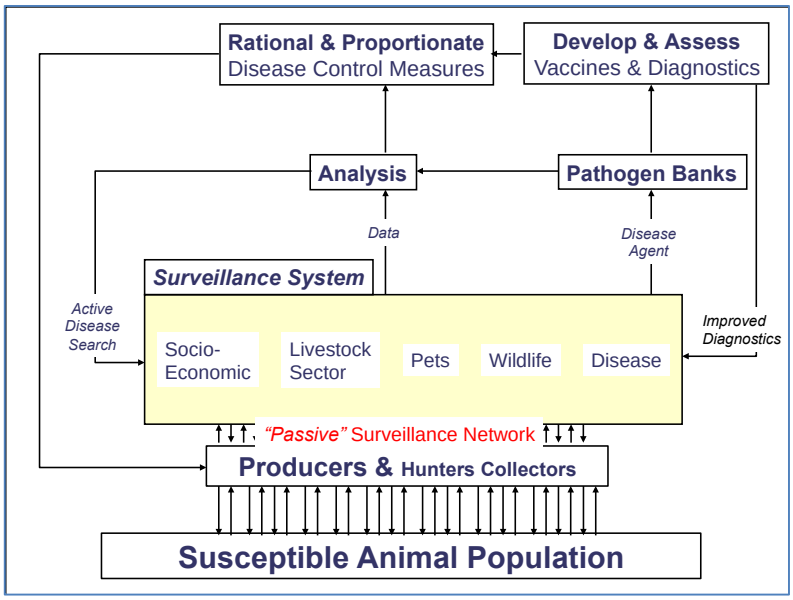

Table 1. Disease impact split between losses and costs of disease management.

Disease Impact			
Losses		Costs	
Gross	Net	Overall health systems	Reactions
Global Burden of Diseases (Murray and Lopez, 1996; Murray et al, 2015)	National studies on diseases in the UK (Bennett, 2003; Bennett and Ijelplaar, 2005) and Australia (Lane et al, 2015)	Human health costs held by WHO and national statistics offices (OECD, 1999; OECD et al, 2013)	Occasional studies looking at the trade impacts of diseases (Longworth et al,
Global Burden of Food Borne Disease (WHO, 2015)		Pet health costs captured by national statistics offices	
World Atlas of Animal Disease (World Bank & TAFS, 2011)		PVS for some countries (for details see OIE webpage)	