

ANIMAL HEALTH AND WELFARE: A CASE STUDY OF SCIENCE, LAW AND POLICY IN A REGULATORY ENVIRONMENT.

DAVID CARSLAKE¹, JOHNATHAN CAVE², WYN GRANT³, JUSTIN GREAVES³, LAURA GREEN¹, MATTHEW KEELING⁴, JOHN McELDOWNEY⁵, GRAHAM MEDLEY¹, and HABTU WELDEGEBRIEL²

¹*Department of Biological Sciences, University of Warwick, Coventry CV4 7AL*

²*Department of Economics, University of Warwick, Coventry CV4 7AL*

³*Department Politics, University of Warwick, Coventry CV4 7AL*

⁴*Department of Mathematics, University of Warwick, Coventry CV4 7AL*

⁵*School of Law, University of Warwick, Coventry CV4 7AL*

ABSTRACT

This paper considers, through a multidisciplinary study, the management and regulation of animal health and welfare when taking account of the biological and epidemiological characteristics that determine control. The paper considers how science informs the analysis that contributes to the management and governance of animal diseases. This is a timely study as DEFRA, the central government department responsible, is engaged in an active consultation on the question of cost sharing and regulation of animal diseases. DEFRA has introduced a draft Animal Health Bill, which includes the creation of an Animal Health Organisation, an independent regulatory agency for animal health and welfare. Such an independent agency will help address the importance of scientific advice and its inclusion in the decision-making by policy makers. The paper also addresses the role of science and scientists in the collaboration with lawyers, economists and political scientists in the setting of criteria for policy makers. The research used in writing the paper is from a project that embraces different disciplines and engages with how science, law and policy may be evaluated in the case study of animal diseases. The conclusions draw together the strands of analysis across the various disciplines and are intended to set the agenda for future research in this area. This may also inform the approach eventually adopted by the Government in the current discussion of the creation of the Animal Health Organisation.

INTRODUCTION

Disease in farmed livestock can be considered as anything that affects an animal's well-being and welfare. Generally, there are considerable differences between the management of infectious diseases and non-infectious diseases. Infectious diseases are caused by a pathogen, a transmissible organism; examples include bovine tuberculosis, Johnes' disease, bovine viral diarrhoea and mastitis in cattle, swine fever, swine vesicular disease and porcine reproductive and respiratory disease in pigs, blue tongue and foot rot in sheepⁱ. Pathogens may be specific to one livestock species or may affect many species. Non-infectious diseases are caused by the management of the animal, e.g. poor physical resources such as lying on hard concrete surfaces, which causes foot and limb injuries in all livestock species kept in such conditions or poor diet, leading to deficiencies that cause metabolic diseaseⁱⁱ. In this article we first define what we mean by disease and discuss some biological and epidemiological characteristics that determine control. We go on to examine the management of animal diseases and what characterises their assessment and the regulation.

Finally, we consider how science and policy might best be brought together and incorporated into the Government's the design of a new independent regulatory body for animal health and welfareⁱⁱⁱ, the Animal Health Organisation (AHO) proposed in the draft Animal Health Bill (see below). Our analysis is that such an independent regulatory body should address how interdisciplinary approaches^{iv} are best combined to promote effective control of animal diseases, protect animal health and improve regulation. These are the main issues discussed in this paper. The challenges^v addressed in the paper are part of a general collaboration to facilitate the understanding of relevant science from an interdisciplinary perspective. Interdisciplinary work fosters collaboration and mutual understanding of complex many faceted problems that policy makers and decision makers need to examine to ensure effective management of animal health and welfare.

DEFINING ANIMAL DISEASES: A BIOLOGICAL AND EPIDEMIOLOGICAL APPROACH

Infectious and Non-infectious diseases

A fundamental difference between infectious and non-infectious diseases is that infectious diseases are transmitted between hosts and spread through populations via direct and indirect contact^{vi}. In contrast, non-infectious diseases occur when there is an adverse factor outside the host species. Consequently, the risk of an individual animal acquiring an infectious disease is dependent on the infection status of others in the population, whereas an individual's risks of a non-infectious disease is independent from each other^{vii}. Generally, both infectious and non-infectious diseases cluster within farms (i.e. the on-farm incidence is higher or lower than chance when compared with the population of interest) because both the management and physical conditions and the presence of an infectious animal vary between farms. However, the presence of a non-infectious disease on one farm does not influence its presence on a neighbouring farm whereas it might for infectious disease^{viii}. The independence and non-independence of farm risks influences the regulation of diseases, which is discussed further below.

The Biology of Infectious Diseases: Introduction of a Novel Pathogen

No infectious disease exists everywhere all the time, so that there are farms, regions or nations that are free of some pathogens, either by deliberate action or natural circumstances. Such infection-free populations are at a particular risk of an epidemic since all the constituent individuals are susceptible to infection. A pathogen initially invades a naïve population of susceptible individuals (in this case, farmed animals or livestock) by one or more of several likely routes and infects susceptible individuals causing an epidemic, defined as an increase in disease above the expected level (note that for a novel pathogen the expected level of disease is zero). These individuals might or might not show clinical signs of disease which in turn might range from a few days of ill health to death. For those individuals that do not die the next stage of the process might be recovery and life long immunity to that particular (strain of) pathogen, recovery and partial immunity (i.e. they can be infected again) or a carrier status where the individual remains infected for life and is permanently or occasionally infectious to hosts^{ix}.

Persistence of a Pathogen

A pathogen persists in a population by infecting a continuing supply of susceptible hosts. Pathogens have many characteristics, including manipulating their

host or environment, to facilitate persistence. Once the initial susceptible population has been exposed to a novel pathogen the proportion of the population that is susceptible declines and so constrains disease to a lower prevalence. An endemic disease is one in which each infected individual infects on average one other susceptible individual. Typically, when a new pathogen enters a naïve population disease is more severe, or at least perceived to be more severe, than after it has been in a population for many cycles of infection. Thus a pathogen present in a population as an endemic disease often appears to be a mild disease or is present at a relatively low prevalence or both. Such a disease does not always cause an obvious financial cost to the farmer, but we argue below that this is principally due to accommodation and mitigation of endemic disease by farmers, the agricultural industry and regulatory systems.

The Spread of Infectious Diseases

Pathogens are an extremely varied group of organisms, relying on their hosts to provide energy, shelter etc. and cause injury to their hosts in the process. Pathogens vary in the number of host species they can infect and the number of routes through which they can be passed to other susceptible hosts. They also vary in their clinical presentation and severity of disease caused, the duration of infectiousness of a host, their survival outside a host and whether the host mounts a full immunity to the infection and whether this immunity is life long. We also now know that whilst we refer to pathogens by a name which often derives from a clinical or pathological characteristic, for example influenza or foot and mouth disease, that there is a great diversity of strains of the causative pathogen. Pathogens vary and mutate and use this as an evolutionary mechanism for survival^x. All these biological facets of a given pathogen influence how each disease is controlled.

Whilst the transmission of infection between individuals within a population is critical for invasion and persistence, for livestock disease, there is an additional level of spread. Farmed livestock are typically kept in relatively small populations (herds or flocks), although the distribution of herd sizes is skewed with the majority being very small populations (backyard and small holders) and a relatively few very large populations with sizes, in the United Kingdom, of several hundred cattle, several thousand pigs or sheep or hundreds of thousands of poultry. These populations have

some contact with each other forming a metapopulation, i.e. population of populations. Contact arises through movement of animals, personnel and equipment. Consequently, how a pathogen invades and persists in the metapopulation, not just the individual herd, is of great importance for regulation and management.

STRATEGIES FOR THE CONTROL OF INFECTIOUS DISEASES

The first infectious diseases to be eliminated^{xi} from the United Kingdom, namely contagious bovine pleuropneumonia (CBPP) and rinderpest, were recognised during the 18th century by the distinct clinical signs that were observed in diseased animals. Elimination was possible because these diseases (later known to be infectious diseases) only occurred in cattle, so they were host specific, did not survive outside the host in the environment and cattle were not infectious for a prolonged period before disease occurred. So, by killing animals diseased with CBPP and rinderpest these pathogens were eliminated. To keep the diseases out of the United Kingdom, legislation was introduced to prevent the movement of livestock or their products (milk, cheese, meat or hides) into the United Kingdom.

Such elimination strategies were initiated in the mid 1700s when there were no vaccines or successful treatments, and elimination was the optimal way to maintain healthy livestock, and they continued for over a century. Sheep pox, rabies and foot and mouth disease were all eliminated and kept out of the United Kingdom using these measures. Elimination was successful biologically because of the nature of the pathogens targeted but the distribution of the hosts – relatively small isolated herds / flocks and the amount of contact between them – probably also aided both elimination and stamping out of re-introduced disease. There were no alternatives other than elimination and prevention of re-introduction to control these diseases at this time, and there must also have been a societal and political willingness to achieve this control.

Disease Labels: Endemic and Exotic and their Consequences

An infectious disease that is not present in a country is described as exotic, i.e. exotic to that country, whilst a disease that is present in a country is described as endemic. These are political definitions or labels for a disease and are constructed. Diseases (pathogens) are not *per se* exotic or endemic, for example foot and mouth

disease is exotic in the United Kingdom but endemic in many parts of the world. Once this labelling has occurred, the political debate is framed around it, particularly in terms of how involved government should be in tackling the disease. Typically exotic diseases have more political debate, more legislation and more estimates of economic impacts of introduction or control than endemic diseases. Endemic diseases are regarded more as part of the livestock landscape, to be accommodated and mitigated against rather than controlled through concerted effort. This situation is self-reinforcing, so that relatively little research is conducted on endemic disease, and their economic and welfare burden is relatively undefined so that the impetus for control is not as great as for exotic disease.

The label a disease carries determines the control that the disease receives and so it's biological and economic behaviour in a population changes. One disease for which the political history has been described is foot and mouth disease^{xii} (FMD). After initial introduction, FMD was eliminated (removed) from the United Kingdom in the late 1800's. From that time the pathogen has repeatedly entered the United Kingdom through introduction of infected animals, animal products and accidental release from United Kingdom laboratories. All political effort was towards keeping FMD as an exotic (i.e. non-endemic) disease. This drove the biological research agenda which targeted characterising the FMD virus, so that we are now able to identify where a particular incursion of virus came from. It also drove the biological agenda away from developing good vaccines that might have resulted in control of FMD through mass vaccination. As Woods points out in relation to foot and mouth disease^{xiii} “[It] is simplistic to assume that the present-day image of FMD as a terrible plague emerged because it was obviously correct.” That is, we could have control by other means than exclusion.

The diseases that are not present in the United Kingdom now have been excluded for historic and practical reasons and we can consider them in distinct categories that are not necessarily biological. They include zoonoses (affecting man) e.g. *Brucella abortus*, rabies, and economically important disease e.g. rinderpest, foot and mouth disease and warble fly and additionally, diseases that are clinically indistinguishable from more important diseases, e.g. swine vesicular disease (which has clinical signs that are not distinguishable from FMD). It is quite possible that if

some of these diseases were present in the United Kingdom now they would be managed differently, possibly by vaccination. For example, bluetongue was exotic to the United Kingdom until it was introduced in 2007; consequently its control in England is being managed through a voluntary vaccination programme with vaccine production costs under written by government, but farmers electing to purchase vaccine to vaccinate their stock. It will be interesting to observe the transition of bluetongue from the exotic to endemic category. We anticipate that this will be marked by a reduction in research funding, a reduction in government concern and an acceptance and accommodation of its existence by the livestock industry as a whole.

Scientific understanding and technical knowledge are needed to control a disease and economics can give us an estimate of the costs and benefits of control. However, these factors may be overruled by a political decision that is opportunistic rather than being evidence-based. The point Woods^{xiv} makes about FMD control could also be applied to other diseases:

‘it was ... an ideological affair that was closely bound up with the role and status of science in society, the accountability of government bodies and Britain’s international standing.’

Endemic diseases are themselves categorised by further political labels. These include zoonotic diseases, economically important diseases, welfare related diseases and production diseases. These labels do sometimes have some biological meaning but the category in which a disease is placed is not without contention (see below). In particular, diseases perceived to be a public health risk (to humans) attain high political importance, especially those that can lead to an illness requiring hospital treatment or that is potentially fatal. For example, bovine spongiform encephalopathy (BSE) resulted in governmental reorganisation (the formation of the Food Standards Agency and DEFRA out of MAFF^{xv} was largely precipitated by the perceived failure to manage the epidemic), and high expenditure. Currently, there is debate regarding the relationship between Johne's disease in cattle and Crohn’s disease in humans, and whether they have the same infectious cause; *Mycobacterium avium* subsp. *paratuberculosis*^{xvi} (MAP). Johne's disease is regarded as a typical endemic infection, i.e. a production problem for the dairy industry. However, MAP is found in milk and if the public perception that MAP is a cause of Crohn’s disease strengthens then the

status of Johne's disease will change. Note that it is only the perception that need change, not that scientific evidence to strengthen, although there is probably some correlation between the two.

Endemic diseases that are not a risk to public health are left to the control of the individual farmer with varying degrees of industry involvement and support. This is an area where there is a clear regulatory gap. There is no clear legislation, little political interest and few estimates of economic impact. Such categorisations of diseases are not immutable and may change over time. An example of this is bovine viral diarrhoea (BVDV). Initially this virus was named after it was associated with an episode of diarrhoea in cattle of 3- 4 days duration. Cattle were infectious for a few days, made a full recovery and had life long immunity. The virus spread was uncontrolled and many herds became infected. Many years later it was realised that the same BVDV virus was responsible for spontaneous abortions in cattle and death in a small proportion of young cattle. These young cattle are immunotolerant to the virus and shed it onto the environment for many months / years before ultimately dying from immune failure. This is the route for persistence of BVDV virus. Infection with BVDV can be diagnosed with a relatively simple blood test and disease can be controlled with a vaccine.

In the mid 1980s the Scandinavian countries moved towards elimination of BVDV. It was argued that the economic impact of BVDV was far greater than was apparent on any one farm and that the behaviour of the virus and availability of diagnostic tests lent it to elimination. These countries approached control through segregation of herds free from BVDV and gradual elimination of BVDV from infected herds through vaccination and culling. By 2005 BVDV was notifiable in seven ^{xvii} European Union (EU) countries and BVDV was added to the OIE [Office International des Epizooties] list of diseases ^{xviii}. Thus interventions by international entities, including EU but also international organisations, especially the sanitary and phytosanitary rules of the World Trade Organisation (WTO)^{xix}, may become more significant over time, influencing domestic decisions. These developments alter the pressures for control and may result in important changes relating to BVDV control in the United Kingdom.

Animal Welfare

Historically, the framing of disease (including its categorisation) and disease control has been driven by public health and productivity. Since the 1960's, the health and welfare of the animals themselves has become an important component influencing disease control. Gunn *et. al.*^{xx} draw attention to the way in which the EU agenda has changed to emphasise public goods provision, including animal welfare, and this creates a different context within which political definitions are constructed. In future, the question may not be is this disease endemic or exotic, but what harm does it cause to farm animal welfare? This leads to a different political issue: what is animal welfare and how can it be improved? There are lobbies who consider that animal welfare is different from animal health, i.e. the emotional and mental welfare of animals is a different from physical health, although the two are related (Table 1). DEFRA make a distinction^{xxi}, e.g. lameness in dairy cows is a welfare disease whilst mastitis (inflammation of the udder) is a production disease. Both diseases occur because of the way we farm dairy cows but the diseases have been labelled politically with the different categorisations welfare and production.

Non-Infectious Disease

Additionally to these categorisations, the management, regulation and policy related to non-infectious and infectious diseases differs and the responsibility for a non-infectious disease is with the immediate carer who can influence their occurrence by changing the herd / flock environment. The limitation for reduction of non-infectious disease has been entirely economic, with the cost of improving a herd's environment having to be less than the financial benefit gained either through increased productivity or increased market value of the final product. Although farmers have different approaches to the amount of extra income that they use to improve the living conditions of their livestock. More recently in the United Kingdom, laws and codes^{xxii} have been introduced to guide farmers on minimum standards for the environment of farmed livestock that are aimed at reducing non-infectious diseases and ensuring that livestock have some or all of the five freedoms used to define good animal welfare. Some of the legislation^{xxiii} in the United Kingdom is more prohibitive than in any other country in the world, e.g. it is illegal to house

pregnant sows in individual stalls (crates); they have to be kept in groups. The pig industry generally considers that this legal requirement makes them less able to compete on the international market.

THE GOVERNANCE OF ANIMAL DISEASE: HOW ANIMAL DISEASES ARE CURRENTLY MANAGED AND HOW MANAGEMENT HAS ARISEN

In broad terms it is possible to distinguish between three forms of governance of animal diseases.

1. Action taken by the individual livestock keeper.

This action depends on a number of factors, of which the most significant might be: whether the farmer can readily detect the disease in the animal / herd; whether the disease has obvious economic impact relative to the value of the animal / herd and its products; the likelihood of re-infection into the herd (although this often ignores the fact that new strains introduced might be more virulent than existing strains); whether a treatment is readily available and whether it is affordable. In practice, the livestock keeper's decision will also be influenced by the advice that is available. Veterinary surgeons are presumed to be an important source of such advice, but other sources might be other farmers, breed societies and farming organisations^{xxiv}.

Particular to infectious disease is that farmers are not independent in terms of the risk of disease and the impact of interventions. One farmer's management (or mismanagement) of an infectious disease affects other farmers' livestock by reducing (or increasing) their risk of exposure to the pathogen. This is not only a farm to farm issue; the risk of infectious disease transmission is influenced by hauliers of food and livestock and livestock products, humans who move between farms, and the use of markets that disseminate animals and potentially their pathogens. That is, there are many actors to consider when attempting control of infectious diseases.

2. Self-regulation by a group of farmers but without government intervention.

Action taken by the individual livestock keeper might be undermined by inaction or actions by other farmers. Hence, there is a classic collective action and free riding situation (i.e. the best action for a farmer depends on what other farmers are doing). For example, if all farmers are vaccinating against BVDV, then the rational action for any individual farmer is to cease vaccination since he is protected

by the action of the others. There is also a clear ethical component in relation to farmers who take actions (at a cost to themselves) from which other farmers benefit (so-called ‘first movers’). Farmers might attempt to overcome this by banding together voluntarily to regulate a disease in a defined geographical area. This may be easiest to achieve in a geographically isolated area such as an island. These activities may be facilitated and in part organised by veterinarians (either in practice or in academic institutions). Government may encourage such actions, but offer no tangible support.

Interestingly, we know of no examples where such governance has developed spontaneously amongst dairy farmers, and several examples where attempts to develop such governance, through industry or veterinary leadership, have had, at best, muted success (e.g. BVDV in Shetland, the United Kingdom and EU) ^{xxv}.

Understanding why collective action to control endemic cattle disease in the United Kingdom is rare would be a major step forward in developing governance of endemic cattle disease. The question of co-ordination between farmers is discussed further below.

3. Government intervention

A range of policy instruments have been used at different times to manage and assist control of some diseases at a national level. These include: culling of affected animals with compensation to the owner or of affected wildlife considered to be a disease reservoir; control of animal movements; research into the transmission of diseases and their treatment; provision of vaccines below cost price and creation of bodies to provide advice and mediate between conflicting interests and perspectives. In the case where a pathogen has a wildlife reservoir, some form of public (government) control is likely to be critical, especially if the reservoir species has legal protection, as in the case of badgers and bovine TB.

MOTIVATIONS FOR GOVERNMENT INTERVENTION

Motivations for government led control arise from the impact of the disease on humans and animals and the nature of the pathogen. Public health was a major driver for action on bovine TB in the 1930s. A Medical Research Council reported stated: “2,000 human deaths each year may be ascribed to bovine tuberculosis derived from cows’ milk, and at least 4,000 (a most conservative estimate) fresh human cases

infected with bovine tuberculosis probably occur”^{xxvi}. This particular route of infection is largely overcome by pasteurisation, although transmission could occur through an aerosol or consumption of raw milk from an infectious animal. Bovine TB is therefore no longer a major zoonosis, but this has not diminished political interest in the disease. This may in part suggest the importance of ‘path dependency’ effects resulting from the initial classification of a disease, and in the case of bovine TB the role of international legislation. It would also, of course, be a serious animal disease if it returned to its early 20th century levels when 30 per cent or so of cattle died from bovine TB.

Other factors include the political costs of taking / not taking action on the disease; in particular, whether key stakeholder groups hold positions for or against intervention. The economic impact of the disease, including its impact on international trade, is also a major driver. This seems to have been important in relation to FMD^{xxvii} but less so for Johne’s disease or BVDV. Johne’s disease was one of the four diseases included in the wartime scheme known as the Panel Scheme or Four Diseases Scheme^{xxviii} and it was recognised as a disease that “has presented a serious problem in our cattle herds for many years’ leading to considerable loss. This may suggest that the disease ought to have been tackled earlier. The fact is, however, that it has no public health significance”^{xxix}. The prevalence of the disease is now much lower, but this probably has more to do with changes in cattle demography (especially reduced life expectancy) than concerted action.

It is important to have a readily usable and reliable diagnostic test for a disease and some strategy for treatment, e.g. through vaccination. In the case of bovine TB, an effective vaccine has been promised for a long time, but is yet to be achieved because of the nature of the pathogen / host interaction. We also lack uncontested knowledge about the reservoirs for transmission of bovine TB and persistence in the environment. ‘Johne’s disease presents several problems; carriers are difficult to identify; much effort may be required to reduce the spread of disease, and there is no effective treatment or wholly effective vaccine.’^{xxx} In the case of BVDV the technical tools and knowledge for elimination are available, but it has not been accorded a high priority in England.

The political costs of controlling a disease include the public expenditure costs of the measures taken; the time taken by decision-makers (ministers and civil servants) in reaching decisions; personal abuse or threats to those taking the decisions; and the political costs in terms of unfavourable publicity and criticism by stakeholder groups. All these elements have been present in the case of bovine TB^{xxxii}. The public expenditure costs of attempting to manage the disease over a seventy-year period have been, and remain, considerable. It is estimated to cost approximately £1 billion between 2008 and 2013 and ‘takes up 40 per cent of the Animal Health Agency’s resources.’^{xxxiii}. Considerable ministerial time, up to prime ministerial level, has been taken up with the issue and special working groups have had to be formed by the civil service. Those involved in reports and other studies have been subjected to considerable hostility and personal abuse, including threats against them. Media treatment of policy has been generally highly critical and there has also been outspoken criticism by stakeholder groups, including a private prosecution launched against a minister. The whole topic is highly politicised in an emotional fashion because measures to control the disease have involved the killing of badgers, a highly valued wild animal. The management of bovine TB may be characterised as one of policy failure^{xxxiii}. The high political profile has also influenced research into bovine TB hugely with many years of work, post the 1970 discovery of TB in a badger carcase, funded only on badgers and a strong belief that this was the area where research was needed. Only since the Krebs’ Report in 1996^{xxxiv} has research into cattle been highlighted to obtain a more rounded portfolio of research (ISG etc) and provide scientific evaluation. In contrast, Johne’s disease and BVDV have had a very low political profile.

It might be expected that a cost-benefit analysis could be conducted to determine the economically optimum level of control for any disease, as is done for human disease by the National Institute for Health and Clinical Excellence (NICE). In the light of such an analysis, a social planner might decide to live with the disease if the cost of elimination outweighs its benefit^{xxxv}. However, the impact of any intervention is unknown at the outset (although the probabilities of its possible outcomes can be predicted), so that stating an objective to eliminate, especially by a particular date, has a clear risk of failure, which will have political and economic

consequences. On the other hand, a clear, politically-articulated, date-stamped intention has been suggested to be critical for success of eradication of human disease, despite the fact that the date for eradication is continually moved^{xxxvi}.

What is evident is that decisions about animal disease management are highly political, although more so in relation to some diseases than others. Although technical advice from vets and other scientists is an important component of the decision-making process, that advice is viewed through a political lens which involves a calculation of the costs and benefits to decision-makers of action or inaction.

Once a disease is eliminated, that is removed from a defined region, resources are required to prevent its re-introduction into the region. Once a pathogen is eliminated, the perceived threat to productivity and welfare is greater, and may be actually greater since immunity to infection will be lost. Such prevention measures are required until the pathogen is eradicated from the globe. These resources include border control and trade barriers that may control any likely source of animal / animal product or human traffic that could lead to accidental or deliberate re-introduction. The use of trade barriers that are likely to control animals or animal products or even human traffic are problematical. Trade barriers between countries may limit the markets addressed by farmers and consequently reduce their bio security incentives^{xxxvii}.

Consequently, excellent monitoring and accurate testing are required to prevent re-entry of a pathogen and rapid response is required if a re-introduction occurs to prevent the pathogen becoming endemic again. There is a critical timeframe within which this response has to occur and be successful before the pathogens mechanisms for persistence occur and elimination becomes much more difficult.

COORDINATION SUCCESS AND COORDINATION

Disease elimination results in a public good^{xxxviii}. However, it involves commitments by producers that are difficult to monitor even in the presence of regular monitoring and of financial incentives provided by the public veterinary service. For instance, Great Britain has been following a policy of paying compensation to farmers who report certain types of disease occurrence in their stock (see, for instance, SVS, 2006 for sheep scrapie related payments). However, such compensation has not

resulted in total elimination of the diseases for which the scheme works. Kuchler and Hamm^{xxxix} make a similar observation in relation to compensation payment to encourage elimination of sheep scrapie in the US for the period, 1952-1992. It is not that farmers do not respond to such incentives; they do, but there are other incentive structures at work which counter the effect of such a compensation scheme. In particular, it should be noted that such compensation schemes incentivise reporting, but not elimination – without other measures, the infected animal has a protected value.

Hennessy makes the point that farmers have the incentive to make commitments that, if implemented simultaneously by a critical mass, have the potential to eliminate a disease from a country but only if they believe that others also have the incentive to act. In a market where such a belief is missing, however, an individual farmer might not foresee benefit, but only a cost, from a private action to eliminate disease from their own farm. This produces a situation where the disease remains endemic and some farmers have to contend with a risk of herd infection from neighbours' herds. This points to the importance of signals that indicate the level of commitment among farmers to eradicate disease. According to Hennessy^{xl} one way of making such signals available to farmers is through coordination of farmers' efforts which can be achieved, if, for instance, the level of effort expended by individual farmers on disease control is monitored over time and made publicly available.

Thus, farmers face a coordination problem; both elimination and non-elimination could exist as equilibrium behavioural *conventions* but the efficient outcome may emerge only if it is possible for farmers to commit to contingent (or matching) behaviour or if elimination is not only efficient but *risk-dominant* – in other words if it takes more simultaneous errors or shocks to undermine the elimination regime than the non-elimination regime. This, in turn, may depend on the (social) network structure linking farmers (which e.g. reinforces 'good' behaviour) and the epidemiological network linking their herds (which determines the fragility or otherwise of progress towards elimination in local areas). Additionally, robustness depends on the correlation of these two networks; a favourable local epidemiological situation may produce demonstrable success which encourages the diffusion of elimination behaviour (or ambitions) through social networks. Conversely, a

favourable social climate (e.g. a cluster that lies also at the heart of the epidemiological network) can change underlying infectivity and thus encourage other parts of the social network to evolve towards elimination.

Hennessy^{xli} argues that farmers in close geographical contact are more likely to believe in (and implement) effective coordination than farmers with small farms that are dispersed as they stand to gain more – both from improved market access and from enhanced productivity as a result of disease eradication. As the above makes evident, one explanation for why a certain disease will exist in one country as endemic emanates from failure to coordinate farmers' and government's efforts to eradicate the disease. Some evidence of these processes can be found by comparing livestock species. The pig and poultry industry in United Kingdom is configured very differently from the sheep and cattle sectors, with the consequence, we argue, that disease control is significantly more co-ordinated in pig and poultry sectors..

International Trade

Diseases differ between countries in terms of presence, prevalence and impact. Countries which have eliminated a disease (or in which it was never endemic) have a comparative advantage in international trade because, all else being equal, they can trade a larger volume of animal products and have a smaller excess burden associated with the disease^{xlii}. Given the economic alignment in international trade, those countries which have not yet eliminated the disease have a relatively lower incentive to avoid engaging in animal trade that facilitates the re-entry of the disease to countries with disease-free status. In this particular case, unless countries with disease-freedom coordinate with those who have not declared such a freedom, they will find it difficult to maintain freedom indefinitely. Therefore in the same way that coordination of farmers' efforts plays a significant role in ensuring disease elimination at the local level, so coordination of countries' efforts plays a role in ensuring regional elimination and global eradication. Such a global coordination is difficult to achieve unless there are international organizations which set disease control standards and enforce them^{xliii}. The formation of the World Organization for Animal Health (OIE) was a result of such calls for standards and enforcement, and, as

a consequence of this coordination, the global eradication of rinderpest has been imminent for a number of years.

REGULATING ANIMAL DISEASES

The classification of disease as eradicated, exotic or endemic, especially for economically significant diseases, is complex and more quantitative than qualitative. It also may give rise to legal implications in terms of controls and procedures. A disease may be classified from (at a minimum) epidemiological, political, policy, legal and economic perspectives. Moreover, the classification may be limited in time, location^{xliv}, species, strain, managed vs. wild populations, etc. Social scientific (e.g. legal, policy, political and economic) classification may further need to distinguish between reality, an assessment based on sufficient validated evidence, and/or beliefs and expectations (which themselves vary in incidence and prevalence).

Analysis of animal diseases in terms of prevention and cure is interlinked with the question of how best to regulate animal health. DEFRA has been actively engaged in a number of consultations and deliberations. Beginning with the inquiry into the foot and mouth outbreak in 2001 under Sir Iain Anderson^{xlv}, there have been a number of working parties and public consultations, some of which are ongoing^{xlvi}. There is currently a Consultation on a new independent body for Animal Health concluded in June, 2009 with the government's response expected at the end of the year. Designing the most appropriate regulatory regime for animal health and welfare requires careful consideration to ensure the "right fit" between the design of the best regulation and the requirements for animal health and welfare^{xlvii}. It is clear from the Government's consultation process that there are a number of goals in the regulation and governance of animal health. These are to:

- Reduce the overall levels and total costs of animal diseases;
- Ensure that investment in disease prevention and management is effective, efficient and economical;
- Share costs between main beneficiaries and risk managers;
- Improve confidence of the livestock industry and that of other stakeholders in the way disease risks are managed.

It is clear that sharing costs and introducing any form of independent regulator will substantially alter the largely self regulatory nature of the current arrangements. Cost sharing is likely to mean that livestock owners gain financial responsibilities that were hitherto largely held by government through subsidy and support. This will empower livestock owners awareness but also require a much more open debate and informed decision-making; a substantial departure from the lobbying stance taken by stakeholders in the past. The Government has an expectation that any new regulatory structure will have the following benefits^{xlviii}

- ensure more independent and better informed decision making;
- increase the involvement of livestock awareness amongst farmers and other key stakeholders;
- provide incentives to reduce the cost of managing disease;
- provide incentives for better risk management and;
- ensure greater financial transparency and accountability in the livestock industry.

The regulatory proposal is to transfer DEFRA's current animal health policy responsibilities to a new regulatory body. The new body is likely to have a Regulatory Board with the Government Chief Veterinary Officer as an adviser employed by the regulatory body. Decision making is intended to be based on the best evidence and a proportionate response to risk, balanced by costs and benefits.

A number of aspects of the proposed regulatory body are to be continued as is currently the case within DEFRA, such as the doctrine of ministerial accountability to Parliament and public funding through public funds as a grant in aid. There is, however, an expectation, on the part of the Government, that there should be accompanying funding for the regulatory body to support 50% of the costs of tackling exotic disease outbreaks. The Government's agenda to create a regulatory agency provides an important opportunity. In terms of animal health and welfare, it is essential to locate scientific advice at the heart of policy making. In that respect the key proposals are that:

- Animal health and welfare policy will be the responsibility of an independent board;
- The Chair and Chief Executive of the proposed new regulatory body will make decisions about how to tackle disease outbreaks based on advice from the Chief Veterinary Officer. This will include advice on vaccination and controls over animal movements;
- The decision-making and policy making underlying strategies to control exotic diseases are transparent and open.

The above proposals are worthwhile. Their significance is that if properly implemented it will be possible for scientific advice to be at the heart of decision making. Consequently there is also a reasonable prospect of providing better coherence in how animal health policy responsibilities are reached and communicated to the public. One of the key elements of the new proposals is that welfare policy is to be made “... balancing a wide range of different societal interests, and taking into account ethical as well as scientific concerns”^{xlix}. This will also include close working relations between DEFRA and the new regulatory body. There must also be appropriate and effective communication with farmers. It will also have to engage with the public and the public interest. How are scientific decisions likely to be made? The Consultation Paper is clear as to the principles that should govern the operation of the new regulatory body. These are:

- Action informed by the best available scientific evidence and advice;
- Decisions and actions should be consistent, clear and proportionate to the risk; pay due regard to costs as well as benefits to those affected by them; take into account Government’s wider objectives, particularly related to welfare; and assist better regulation;
- Action should be independent of special sectoral interests.

There are also principles of ministerial accountability, the role of EU law and also the significance of value for money through effective and efficient operations.

Establishing the central role for scientific analysis and advice is critical to the success of the new agency. Ensuring that science used in decision making is the best available

scientific evidence and analysis of that evidence requires care and may be partly achieved through peer group review. Sound science is likely to be contested and overshadowed when it is at the centre of policy and economic considerations. It is therefore essential that safeguards are in place to ensure that the science operates in an environment that allows and creates inter-disciplinary collaboration successfully while at the same time allowing public debate and political decision-making to take place. Achieving independence for scientific findings consistent with political agendas is crucial. The recent debate about the role and value of scientific advice on the Advisory Council on the Misuse of Drugs¹ is a cautionary tale of how best to confuse scientific advice with policy decision-making. The advice is advisory and independent based on sound science, leaving the political process to make decisions based on the public interest and government policy.

The European Union and Future Strategy

An important dimension to the discussion of animal health and welfare is the role of the EU^{li}. Generally there are many Community Treaty provisions on agriculture and reform of the Common Agricultural Policy is foremost in the Agenda set since 2000. The welfare of animals was given priority in 1991 but legislation has been slow in coming. This is because animal welfare was regarded as only incidental to the Treaty on European Union and the Treaty of Amsterdam. The steady increase in the size of the EU with the addition of new Member States has forced animal health up the political agenda. It was clear that Member States might work on their own initiative and this has allowed Member States to follow the provision of many general directives on animal health^{lii}. Various Directives^{liii} have concentrated on the transportation of animals and the protection of animals up to the time of slaughter^{liv}. The absence of formal legal authority for the Community to intervene on animal health and welfare left uncertainty as the Commission has waited until the agreement of a Protocol and Declaration annexed to the original Treaties in 1992. The Protocol is advisory only and does not give comprehensive powers to intervene on all aspects of animal health. This leaves matters on animal health and welfare to Member States. However, changes are on the way. Today there is an EU Animal Health Strategy from 2007 to 2013. The Strategy envisages a greater prioritisation of EU intervention including steps to improve economic competitiveness. This also covers setting up and

implementing by Member States an animal health regulatory framework and engaging in disease prevention as part of the overall sustainable development strategy. There are a number of distinct strands to the EU's Animal Health Strategy, as follows :

- Prioritisation of EU intervention;
- A modern and appropriate framework for animal health;
- Better prevention, surveillance and crisis preparedness;
- An increase in attention given to science, innovation and research.

There is an ongoing effort to give attention to each of the points above. The EU makes an important linkage between animal health and welfare and is all-encompassing inviting stakeholders from owners, the veterinary profession and food supermarkets to engage together as part of a co-ordination of animal health and welfare. There is a further linkage between high levels of public health and food safety as well as support for farming and the rural economy. This is aimed at improvements in economic growth cohesion and competitiveness.

The recently ratified Treaty of Lisbon Protocol foresees priority to policies that advance animal welfare. Under the UK Animal Health Act 2006 there are requirements to take all reasonable steps to ensure that the animal's needs are met. Under the Welfare of Farmed Animals (England) Regulations 2007 much of EU regulation and law is codified into domestic law. It is clear that the approach taken by the EU in regulating animal health and diseases has to take account of the general policy direction as well as the legal regime of the EU. Consequently, designing a regulatory regime must meet standards of best practice as well as the EU dimension^{lv}. Progress is likely to be speeded up when the Treaty of Lisbon is fully implemented.

Designing the Regulatory Regime

There are significant regulatory issues at the forefront of animal health and welfare policy strategies. These relate to the independence of the regulators, regulation policy and implementation strategies. The Government's proposal is for the new body to follow the model of the Food Standards Agency and fall within the category of a Non- Ministerial Department. This would mean that funding would be voted directly by Parliament and the new agency would operate through the Treasury

or DEFRA. The advantages of this model are that it provides the Agency with an independence from the sponsoring government department and a direct link to Parliament in terms of accountability and transparency. It is estimated that the costs of the new body will initially be £2 million with running costs of £100,000's annually^{lvi}. There are major issues about funding vaccinations and treatments of diseases and whether an animal insurance scheme might provide animal owners with the requisite protection. In order to secure adequate supervision of animals and disease control, there will have to be a registration scheme. This will be based on livestock keepers providing an annual fee, which will contribute some of the necessary finance to the regulatory agency. Raising levies in this way will provide a link between costs of keeping the animals and the associated intervention to prevent or treat diseases. The basic assumption is that risk management will be inbuilt into the financial scheme. Registration and payments will be interlinked with risk factors associated with the keeping of different animals.

The regulation of animal health and welfare will be connected to a “light touch” regulatory system that follows the Hampton^{lvii} and Macrory Review^{lviii}. The Macrory Review that followed the Hampton Report, was asked to look at the role of sanctions and the functioning of criminal sanctions in regulatory justice. This is a critical part of the regulatory system. Regulators require access to a range of incentives and sanctions in order to be effective. The Macrory Review accepted that the existing use of criminal sanctions for regulatory offences was required. He also recommended that a new punitive regulation system was necessary rather than reliance on simple moral persuasion or good behaviour. He recommended an extension of the range and variety of penalties available to regulators. He adopted the principle that a regulator’s own sanctioning powers should be used rather than requiring recourse to the formalised use of the criminal courts. Macrory’s recommendations were largely accepted by the government. New compliance codes and greater managerial controls are also favoured, in his review, as a way of making the compliance arrangements more effective. The implementation of many of the Macrory Review’s recommendations may be found in the Regulatory Enforcement and Sanctions Act 2008. This underlines the shift beyond the criminal courts for the application of sanctions to regulator based systems of sanctions and enforcement. The

Act underlines the five principles of regulation set out in Hampton; namely that enforcement action should be transparent, accountable, proportionate, consistent and targeted. The impact of the Hampton and Macrory Reports is important in setting the future direction for regulation in the United Kingdom and for the new animal health and welfare agency. The Hampton Report reinforces and encourages a targeted approach to regulation that requires all regulators to perform risk assessments and to adopt an effective, efficient and proportionate response which does not place unnecessary burdens on business. The underlying philosophy is that information should only be sought when required. Intervention should be targeted and not invasive to the detriment of market conditions.

The use of scientific evidence and evaluation in the light touch regulatory regime assumed for the new Agency by the government raises issues about enforceability and effectiveness. There is a strong ethos post Hampton and Macrory that unreasonable or excessive regulation may lead to burdens and costs on the regulated activity. The need for prescription has to be balanced by the use of incentives. Linked to costs and burdens are questions about accountability. Democratic governance requires transparency and public confidence in science and its use by politicians is not high in the wake of BSE, the foot and mouth crisis and perceived high costs and public health concerns over animal diseases. The need for accountability includes:

- high standards in the veterinary profession and public confidence in regulation of the profession, including professional accreditation;
- the accessibility of scientific data and its explanation to the public;
- forms of political accountability that are effective.

Addressing such issues also brings to the fore a long-standing concern amongst critics of regulatory agencies that there is potential for regulatory capture in the operation of the regulator. This may be due to a number of factors such as private interest or lobby groups dominating the operational decisions made by the regulator. This may be particularly the case if one group or sector has a monopoly over the prescription of standards and their enforceability^{lix}. The solution to concerns about regulatory capture is to ensure transparency and openness in decision-making, the registration of vested

interest and the creation of a healthy interface between the different sectors within the regulatory body. There is a key element of consistency in approach in setting and enforcing standards and the enhancement of professional standards within the accountability mechanisms. It is probably impossible to eliminate regulatory capture when the stakes are high amongst farmers, pharmaceutical and chemical companies, veterinarians and supermarkets. Enhancing professional standards may require a close look at the legal regime that accompanies each profession to ensure that professional accountability is strengthened and that codes of conduct are properly enforceable^{lx}.

The Animal Health Bill

On 25th January 2010 the draft Animal Health Bill was published. This is an important Bill as it makes major changes to the role of DEFRA, creates the new Animal Health Organisation (AHO) and amends the Animal Health Act 1981, the main primary legislation in the United Kingdom. The Animal Health Bill contains many of the proposals discussed by DEFRA over the past three years^{lxi}. However, the Bill does not include the arrangements for cost-sharing which are intended to form a separate Treasury Bill. The link between cost-sharing and the new proposed Animal Health Organisation (AHO) are not set out in the current Bill. This leaves open to question the future of compulsory insurance and the operation of a levy to cover exotic diseases and their surveillance. This is seen as a disappointment by many. The EU's Community Animal Health Policy 2007-13 is expected to provide a cost-sharing responsibility for epidemic diseases in 2010. It is important that the cost-sharing requirements are fully addressed for the future.

The link between cost sharing and the AHO is important and any new Bill on cost-sharing must be appropriately connected to the proposals for the AHO. The Bill does contain a number of expectations that any new regulatory structure will have the following benefits^{lxii}:

- ensure more independent and better informed decision making;
- increase livestock awareness amongst farmers and other key stakeholders;
- provide incentives to reduce the cost of managing disease;
- provide incentives for better risk management and;

- ensure greater financial transparency and accountability in the livestock industry.

The Animal Health Bill includes a number of key proposals as follows.

- Part 1 of the Bill provides for an independent Animal Health Organisation (England only)- animal health is a devolved policy area. Many of the functions currently exercised by the Secretary of State are devolved to the new Animal Health Organisation (AHO) and involve amending the Animal Health Act 1981;
- Part 2 of the Bill sets out how the main role of the Chief Veterinary Officer (CVO) for the United Kingdom is brought under the AHO. The CVO (England) will be appointed by the AHO. Legislative functions of the CVO are set out in the Bill including duties and consultation with the AHO and the devolved administrations;
- Part 3 of the Bill covers ancillary powers for the AHO in terms of order making powers and the use of vaccines, testing of animals, collecting samples and slaughter making powers including compensation. There are human rights implications for the Bill (Clauses 27, 43-44, 46-48);
- Part 4 of the Bill contains technical law making powers related to orders and other law making powers. This is likely to provide an important means to regulate the animal health industry in forthcoming years.

The proposed Bill provides the basis for regulating the complex relationship between the government and private stakeholders. The above applies to England only and there are differences in the arrangements for the devolved regions. The devolution of animal health in Wales, Scotland and Northern Ireland provides for the regional devolved administrations to learn from each other and follow distinct policy decisions that are best suited to the needs of their locality. As most of the AHO powers relate to England there is a need for the following:

- transparency in decision-making between the devolved administrations;

- consideration of whether the AHO model should be applied in each of the devolved regions;
- Clauses 37-42 envisage that there are various duties for co-operation (clause 37) and consultation (clauses 38 and 39) and providing information (clause 40).

The potential for co-operation institutionally is provided under clause 14. It is important that there is adequate monitoring of the effectiveness of any co-ordinated action in a clear and transparent manner. It will be important for the future of the AHO that there is good co-ordination, adequate transparency and effective accountability. One of the most important aspects of the proposed Bill is the use of advisory committees and their role in providing specialist information and analysis (see: Clauses 14, 15 and 16 relating to advisory committees and co-operation). How independent are the advisory committees going to be and how is transparency provided overall? There are a number of distinctive features related to animal health that require transparency of advice given by specialist advisory committees. These are:

- the litigation tendencies of various stakeholders within the animal health community;
- the need for public interest to be addressed with transparency supporting the public confidence in the regulatory system;
- the controversial nature of animal health policy. The general remit of the AHO will not cover wild animals which will be kept within DEFRA which retains responsibility for some of the most controversial policy areas such as the policy relating to badgers;
- differences between devolved administrations and ;
- the role of specialist advisors.

The proposed Bill is likely to prove controversial and subject to intense political debate in the coming months. At the time of writing it is difficult to determine whether the Bill will survive the results of the 2010 general election. It will however set the framework for discussion of animal health in the future.

CONCLUSIONS

We have reviewed animal disease from a number of perspectives, but essentially from the implicit presumption that it is, like human disease, a suffering that should be avoided where possible. An alternative approach would have been to consider the value or worth of animals and what is lost by disease. However, we believe that any approach would reveal the same central message: that animal disease and its control involve a complex interaction between biological and human spheres, of which economics, politics and law are key. To argue from an extreme, it is theoretically possible to eliminate most obligate pathogens with current scientific understanding and technology – what is missing is the necessary political will and legal framework. Endemic diseases, especially those that persist biologically and against which interventions could be implemented, persist only because the economic, legal and political frameworks allow them to. These human activities do respond to animal disease, sometimes resulting in elimination of infection, so the “successful” endemic disease is one that (unconsciously) creates its own environment in all spheres. If the ultimate aim is to remove animal disease^{lxiii}, then a system needs to be created that is able to appropriately manipulate the biological, political, economic, legal and social factors. However, control of endemic animal disease typically suffers from two opposing problems. First, it does not have the political profile to attract research and surveillance funding to demonstrate the burden of disease, and its economic impact. Second, this lack of data and knowledge prevent its political profile being increased.

The Government’s Consultation Paper^{lxiv} offers a unique opportunity to set the terms of the relationship between public and private sectors in the financing of the surveillance, detection and prevention of animal diseases. Co-ordination of various policies and strategies is essential if regulation is to be effective. Increasing the scope and variety of regulation over the keeper of animals and the various stakeholders must be accompanied by an extensive “tool-kit” of regulatory ideas and devices. Regulating animal health and welfare through a new regulatory agency brings the potential of a new approach to governance. This will enable stakeholders and the public to be engaged in an important collaboration at a period when science is doubted,

government and politicians are not trusted and various regulators under the light touch regimes of the past have been thought inadequate^{lxv}. The recently published Animal Health Bill 2010 is an important step in the implementation of policy.

Placing the best scientific advice available at the heart of animal health and welfare is fundamental to the success of any new regulatory system. This entails prioritising scientific methodology and ensuring transparency so that accountability mechanisms are in place. Cross-disciplinary and collaborative studies are essential. This creates the most appropriate relationships within a regulatory system, and supports professional judgment and responsibility. At the apex of any new regulatory body for animal health and welfare are the political, economic and societal issues that make up decision-making^{lxvi}. At the outset public accountability requires that sound science is openly discussed and available; that political choices are fully explained and justified and that when choices are wrongly taken there is an appropriate feedback to ensure that better decision making takes place in the future. It remains to be seen whether any new legislation, including the proposed new Animal Health Bill will address all the expectations that come from engaging with stakeholders and scientific evaluation.

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NOTES

ⁱ Brownlie, *et.al.* (1987); and Bennett (2003).

ⁱⁱ Goodwin and Vado (2007) and see also Bielza *et.al.*(2008).

ⁱⁱⁱ The framework strategy was set out by DEFRA in 2004 in *The Animal Health and Welfare Strategy* (2004). The strategy addresses animal health and welfare by hoping to make “joint working between industry and government a reality”. This involves making joint decisions over the prevention, control and elimination of animal diseases under the vision of a clear understanding of the roles and responsibilities that define the relationship between industry and government. In 2007, DEFRA published its influential *Responsibility and cost sharing for animal health and welfare: next steps Consultation Paper* DEFRA, December, 2007.

^{iv} Scott (2000).

^v Greaves and Grant (2010).

^{vi} Barrett (2003).

^{vii} One possible exception are the injurious behaviours inflicted by conspecifics, e.g. tail biting in pigs or feather pecking in hens, which might spread in a manner more similar to an infectious rather than a non-infectious disease within a herd / flock.

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- viii Hindmoor (2009).
- ix Turvey (2003).
- ^x There are a very small number of pathogens, including the human diseases measles, mumps and rubella that appear to have much more limited diversity, but these are exceptional.
- ^{xi} Elimination is the epidemiological term for regional removal of a pathogen, but still requiring control to prevent re-invasion. Eradication describes the global removal of a pathogen – smallpox is the only pathogen to have been eradicated.
- ^{xii} Woods (2004), p.101.
- ^{xiii} *Ibid.*
- ^{xiv} *Ibid*, p.101
- ^{xv} Marsden *et. al.* (2010), pp 79-80.
- ^{xvi} Greenstein (2003).
- ^{xvii} Gunn *et. al.* (2005).
- ^{xviii} *Ibid*, p.151.
- ^{xix} Josling *et. al.* (2004), pp. 40-51.
- ^{xx} *Ibid.*
- ^{xxi} The framework strategy is set out by DEFRA in *The Animal Health and Welfare Strategy* (2004)
- ^{xxii} See DEFRA for a list of relevant legislation www.defra.gov.uk and also www.open.gov.uk
- ^{xxiii} See www.parliament.uk
- ^{xxiv} Gunn *et. al.* (2008) and see also Ellis-Iversen and Hoeveveen (2009).
- ^{xxv} Gunn *et. al.* (2008).
- ^{xxvi} Jordan (1933).
- ^{xxvii} Woods (2004).
- ^{xxviii} Ministry of Agriculture, Fisheries and Food (1965), p.97.
- ^{xxix} See Ritchie, J.N. 13 December 1963. National Archives: MAF 287/184 available at <http://www.nationalarchives.gov.uk>.
- ^{xxx} Stott (2005), p.829.
- ^{xxxi} See The Bovine TB Advisory Panels at DEFRA. Consultative Panel on Badgers and Tuberculosis, Independent Scientific Group on Cattle TB, the Bovine TB Advisory Group, the Bovine TB Eradication Group for England.
- ^{xxxii} House of Commons (2008), p.12
- ^{xxxiii} Grant (2009).
- ^{xxxiv} Krebs Report (1997), pp.136-137.
- ^{xxxv} Sumner *et. al.* (2005).
- ^{xxxvi} See *The Eradication of Infectious Diseases* (eds. W.R. Dowdle & D.R. Hopkins), Dahlem Workshop Report. Chichester: John Wiley & Sons.
- ^{xxxvii} A barrier to trade between non-infected countries can lead one of them to trade with an infected country especially if the barrier raises prices above the implicit price of disease risk. If the barrier prevents traffic with all infected countries, the incentives for specific precautions and screening are sure to fall as the perceived and actual risk falls. This may delay the detection of any accidental reintroduction of disease and may slow the response time to take action.
- ^{xxxviii} See for example Table 1.
- ^{xxxix} Kuchler and Hamm (2000).
- ^{xl} Hennesy (2007).
- ^{xli} *Ibid.*

- ^{xlii} Excess burden is defined as a burden beyond the case reports of disease incidence collected by the public health authority if costly disease prevention occurs, see Philipson (1995).
- ^{xliii} Barrett (2007).
- ^{xliv} Market segment, geographical or political region, epidemiological area, etc.
- ^{xlv} Foot and Mouth Disease (2001). *Lessons to be Learned Inquiry Report*, 22nd July 2002 HC 888.
- ^{xlvi} Public consultations were in 2006 and 2007 and there is a United Kingdom Responsibility and Cost Sharing Consultative Forum.
- ^{xlvii} See May (2007); and Scott (2000).
- ^{xlviii} DEFRA. (2009).
- ^{xlix} *Ibid*, p.15.
- ¹ This relates to the sacking of Professor Nutt see *The Economist* 7th October 2009 and see also House of Commons Science and Technology Committee, *The Government's review of the principles applying to the treatment of independent scientific advice provided to government* 3rd Report Session 2009-10 HC 158-I (14th December, 2009) available at <http://www.publications.parliament.uk/pa/cm200910/cmselect/cmsctech/384/384.pdf>.
- ^{li} Radford (2001).
- ^{lii} See the Animals (Scientific Procedures) Act 1986.
- ^{liii} Directive 91/628 as amended by Directive 95/29.
- ^{liv} The Welfare of Animals (Slaughter or Killing) regulations 1995 SI 1995/731; The Welfare of Animals (Transport) Order 1997 SI 1997/1480; and see also Regulation 411/98 and Regulation 1255/97.
- ^{lv} McMahan (2007).
- ^{lvi} *Ibid* and DEFRA (2009).
- ^{lvii} Philip Hampton, *Reducing Administrative Burdens: Effective Inspection and Enforcement Final Report* London: HM Treasury, 2005.
- ^{lviii} See Macrory, R. (May 2006). *Regulatory Justice: Sanctioning in a post-Hampton World: A Consultation Document*. Cabinet Office; London, available at <http://www.bis.gov.uk/files/file45183.pdf> . See also Macrory, R. (November, 2006) *Regulatory Justice: Making Sanctions Effective* Cabinet Office; London.
- ^{lix} Ayres and Braithwaite (1992).
- ^{lx} Dowdle (2006).
- ^{lxi} See Anderson, I. (2002). “ Foot and Mouth Disease 2001: Lessons to be Learned Inquiry Report see <http://archive.cabinetoffice.gov.uk/fmd>.
- ^{lxii} DEFRA. (2009).
- ^{lxiii} There are biological arguments (the “hygiene hypothesis”) that would argue that infection has beneficial effects, and an economic perspective would argue that this should only be an aim if the benefits outweigh the costs. Consequently, the desired outcomes of an idealised animal disease control system are not simply defined.
- ^{lxiv} DEFRA. (2009), p.15.
- ^{lxv} Lodge (2004).
- ^{lxvi} Hampton (2005).
- ^{lxvi} *Supra* n. 58.

REFERENCES

Ayres I., and Braithwaite, J. (1992). *Responsive Regulation: Transcending the Deregulation Debate*. Oxford University Press; Oxford.

-
- Barrett, S. (2003). Global disease eradication. *Journal of the European Economic Association*, **1**, 591-600.
- Barrett, S. (2007). *Why Cooperate? The Incentive to Supply Global Public Goods*. Oxford University Press; Oxford.
- Bennett, R. (2003). The 'Direct costs' of livestock disease: The development of a system of models for the of 30 endemic livestock diseases in Great Britain. *Journal of Agricultural Economics*, **54**, 56-71.
- Bielza, M., Diaz-Caneja, Conte, C.G., Catenaro, R., and Pinilla, J.G. (2008). Agricultural Insurance Schemes II, Index insurances. *European Commission*, EUR 23392 EN/2.
- Brownlie, J., Clarke, M.C., Howard, C.J., and Pocock, D. H. (1987). 'Pathogenesis and epidemiology of bovine virus infection of cattle' *Annales de recherches Veterinaires*, **18**, 157-166.
- DEFRA. (2009). *Consultation on a new independent body for animal health* available at <http://www.defra.gov.uk/corporate/consult/new-independent-body-ah>.
- Dowdle, M. (ed.) (2006). *Public Accountability: Designs, Dilemmas and Experiences*. Cambridge University Press; Cambridge.
- Ellis-Iversen, J. and Hoegeveen, H. (2009). *Barriers and motivators for zoonotic control on cattle farms*. Society for Veterinary Epidemiology and Preventative Medicine (SVEPM) Annual Conference, pp177-87. Imperial College; London.
- Goodwin, B.K. and Vado, L. (2007). Public responses to agricultural disasters: rethinking the role of government. *Canadian Journal of Agricultural Economics*, **55**, 399-417.
- Grant, W. (2009). Intractable Policy Failure: The Case of Bovine TB and Badgers. *The British Journal of Politics and International Relations*, **11(4)**, 557-573
- Greaves, J and Grant, W. (2010). Crossing the Interdisciplinary Divide Political Science and Biological Science. *Political Studies*, **58**, 320-339.
- Greenstein, R.J. (2003). Is Crohn's disease caused by mycobacterium? Comparisons with leprosy, tuberculosis and Johne's disease. *The Lancet Infectious Diseases*, **3**, 507-14.
- Gunn, G.J., Saatkamp, H.W., Humphry, R.W., and Scott, A. (2005). Assessing economic and social pressure for the control of bovine viral diarrhoea virus. *Preventive Veterinary Medicine*, **72**, 149-162.

Gunn, G.J., Hefferman, C., Hall, M., McLeod, A., and Hovi, M. (2008). Measuring and comparing constraints to improved biosecurity amongst United Kingdom farmers, veterinarians and the auxiliary industries. *Preventative Veterinary Medicine*, **84**, 310-23.

Hampton, P. (2005). *Reducing Administrative Burdens: Effective Inspection and Enforcement Final Report*. HM Treasury; London available at <http://www.berr.gov.uk/files/file22988.pdf>.

Hennessy, D. (2007). Coordinating to eradicate animal disease and the role of insurance markets. *Working Paper 07-WP 45*, Iowa State University; Iowa.

Hindmoor, A. (2009). Explaining Networks through Mechanisms: Vaccination, Priming and the 2001 Foot and Mouth Crisis. *Political Studies*, **57**, 75-94.

Horan, R.D. (2007), "Economics and ecology of managing emerging infectious animal diseases", *American Journal of Agricultural Economics* 89(5): 1232-1238.

House of Commons. (2008). *Badgers and cattle TB: the final report of the Independent Scientific Group on Cattle TB*. Environment, Food and Rural Affairs Committee, Fourth Report of Session 2007-8, The Stationery Office Limited; London.

Jordan, L. (1933). *The Eradication of Bovine Tuberculosis*. His Majesty's Stationery Office; London.

Josling, T., Roberts, D., and Orden, D. (2004). *Food Regulation and Trade*. Institute for International Economics; Washington.

Krebs Report. (1997). *Bovine Tuberculosis in Cattle and Badgers*. DEFRA, HC Deb 16th December 1997 Vol 303.

Kuchler F., and Hamm, S. (2000) Animal Disease Incidence and indemnity eradication programs. *Agricultural Economics*, **22**, 299-308.

Lodge, M. (2004). Accountability and Transparency in Regulation: Critiques, Doctrines and Instruments. In J. Jordana, D. Levi –Faur, eds., *Politics of Regulation: Institutions and Regulatory Reforms for the Age of Governance* (J. Jordana and D. Levi, eds) pp. 124-144. Edward Elgar; Cheltenham.

Marsden, T., Lee, R., Flynn, A., and Thankappan, S. (2010). *The New Regulation and Governance of Food*, Routledge; Abingdon.

May, P.J. (2007). Regulatory regimes and accountability. *Regulation and Governance*, **1**, 8-26.

-
- McMahon, J.A. (2007). *EU Agricultural Law*. Oxford University Press; Oxford.
- Ministry of Agriculture, Fisheries and Food. (1965). *Animal Health: A Centenary 1865-1965*. Her Majesty's Stationery Office; London.
- Philipson, T. (1995). The welfare loss of disease and the theory of taxation. *Journal of Health Economics*, **14**, 387-395.
- Scott, C. (2000). Accountability in the Regulatory State. *Journal of Law and Society*, **27**, 38-60.
- Radford, M. (2001). *Animal Welfare Law in Britain*. Oxford University Press; Oxford.
- Scott, C. (2000). Accountability in the Regulatory State. *Journal of Law and Society*, **27**, 38-60.
- State Veterinary Service. (2006). *National Scrapie Plan for Great Britain: compulsory Scrapie flocks scheme booklet*, available at [http://www.defra.gov.uk/animalhealth/publications/NSPAC/CSFS%20stateaid%20re-notification%20\(v0%203\)%2031%20Jul%2008%20\(3\)%20\(3\).pdf](http://www.defra.gov.uk/animalhealth/publications/NSPAC/CSFS%20stateaid%20re-notification%20(v0%203)%2031%20Jul%2008%20(3)%20(3).pdf).
- Stott, A.W., Jones, G.M., Humphry, R.W. and Gunn, G.J. (2005). Financial incentive to control paratuberculosis (Johne's disease) on dairy farms in the United Kingdom. *Veterinary Record*, **156**, 825-31.
- Sumner, D.A., Bervejillo, J.E., and Jarvis, L.S. (2005). Public policy, invasive species and animal disease management. *International food and Agribusiness Review*, **8**, 78-97.
- Turvey, C.G. (2003). Conceptual issues in livestock insurance. Food Policy Research Institute, Rutgers University, Working Paper No. WP-0503-005.
- Woods, A. (2004). *A Manufactured Plague: The History of Foot and Mouth Disease in Britain*, Earthscan; London.

TABLE 1. Animal Health and Welfare: The Five Freedoms

Animal welfare is defined in many ways but one of the most common definitions is that proposed by The Farm Animal Welfare Council, FAWC, who defined animal welfare in terms of the five freedoms. Disease directly reduces welfare under Freedom 3, but may result from poor welfare under the other 4 freedoms.

The five freedoms are:

1. Freedom from Hunger and Thirst - ensuring access to fresh water and a diet that maintains full health and well-being;
2. Freedom from Discomfort - by providing an appropriate living environment including a rest area, suitable bedding, and shelter;
3. Freedom from Pain, Injury or Disease – implementing management protocols that are based on prevention and in the event of a health issue, ensure rapid diagnosis and treatment;
4. Freedom to Express Normal Behaviour – affording livestock the ability to exhibit normal behaviour by providing sufficient space, adequate facilities and interaction with animal's own kind;
5. Freedom from Fear and Distress – avoiding mental suffering through ensuring adequate conditions and stockmanship.