# Biosecurity and Food Security: Spatial Strategies for Combating Bovine Tuberculosis in the United Kingdom

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**Abstract**

Concern over the spread of infectious animal diseases has led to attempts to improve the biosecurity behaviour of farmers. Implicit within these behavioural change strategies are different geographies of knowledge that enact different versions of disease. Some versions are fixed whilst others attempt to live with disease by accommodating difference. This paper explores how these different strategies fare in attempts to promote biosecurity to farmers. The paper compares farmers' responses to 'high-risk' and 'population' strategies of biosecurity behaviour change in relation to bovine Tuberculosis (bTB) in cattle. Drawing on quantitative assessments of biosecurity and farmer interviews, the paper suggests that biosecurity behaviour change initiatives that draw on locally situated practices and knowledges of disease are more likely to have an impact on biosecurity behaviour than those which attempt to standardise biosecurity and disease. Through a process of constant tinkering and rewiring biosecurity to fit local social and ecological conditions, approaches like the high risk strategy represent one way of living with the uncertainties of disease. It is argued that thinking more broadly about the nature of disease should lead policy makers to re-evaluate the purpose of disease control and their approaches to it.



**Keywords:** Biosecurity; Food Security; Bovine tuberculosis; Geographies of Knowledge; Behaviour change; Animal Disease

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## Introduction

A focus on the security of agriculture has not only led to critical analyses of food security, but also the parallel concern of biosecurity – the incursion of infectious disease or disease vectors and their impact upon farmed animals, crops, wildlife and humans. The global movement of exotic diseases, such as Highly Pathogenic Avian Influenza, the emergence of new diseases such as the Schmallenberg virus, and the continuing impact of existing infectious diseases have all heightened concerns about biosecurity. Biosecurity breaches have the potential to revise notions of global economic space, limiting access to global agricultural markets through restrictions placed on the mobility of animals and food products. But the social consequences of managing disease outbreaks are also best avoided: the impact of the 2001 outbreak of Foot and Mouth Disease was felt not just emotionally by farmers (Convery et al., 2008) but also by other sectors of the rural economy (Bennett & Phillipson, 2004).

It is therefore no surprise to see Governments attempting to control and improve biosecurity on farms and other agricultural spaces. Enforcement of animal health regulations provides one method, but the emergence of neoliberal styles of animal health governance (Enticott et al., 2011) and an ideological reluctance to regulate are leading to new approaches which attempt to alter the animal health behaviours of farmers, just has been tried with human health campaigns. Whilst this raises questions surrounding the effectiveness of these methods, it also raises a series of questions about the very meaning of animal disease within preventive biosecurity interventions. As Law and Mol (2011) argue, practices of disease management enact different “versions” of disease, which are constructed through quite different geographical practices of knowledge production. The complexity of disease management has also led to critiques of current logics of disease eradication and an advocacy of attempts to find ways of ‘living with disease’ (Law, 2006 ; Bingham & Hinchliffe, 2008 ; Donaldson, 2008 ; Mather & Marshall, 2011). In these approaches, attempts to accommodate difference, imprecision and multiplicity, and develop “looser gathering[s] of expertise” (Hinchliffe, 2007) are preferable to those which seek to purify spaces and maintain strict boundaries around singular versions of disease. In the light of recent biosecurity breaches, these approaches to managing disease may appear “compelling” (Mather & Marshall, 2011), yet the concept of living with disease is also vague and ambiguous because “it is not clear what living with disease means or how a loosely coherent program might translate into a workable approach to animal health” (Mather & Marshall, 2011). What are the loose arrangements of expertise? How can they feature in the new strategies of behavioural change? And do, for example, farmers respond better to these approaches compared to those that rely on standardised and tighter versions of disease and expertise? These are questions that this paper sets out to examine.

In linking concerns of behavioural change with ideas of living with disease, the paper explores how two different attempts fare in attempts to promote biosecurity to farmers. Specifically, the paper compares two different strategies for encouraging biosecurity measures: the ‘population strategy’, which provides broad advice across a whole population, and the more personalised and individual ‘high-risk strategy’ in relation to the management of bovine Tuberculosis in the United Kingdom. The paper suggests that these strategies’ inherent knowledge practices and geographies have considerable implications for the uptake of biosecurity behaviours but also for understandings of disease and biosecurity.

**Animal disease and behavioural change**

Governments have always been interested in changing people’s behaviour – some more forcefully than others. Regulation has occupied a central role in achieving public benefits, but increasingly it has been seen to provide a poor fit with prevailing neoliberal political ideologies. Instead, methods of behaviour change rooted in ‘libertarian paternalism’ – popularised in Thaler and Sunstein’s (2007) book ‘Nudge’ – have become increasingly popular as they mesh well with political values of free choice and light touch regulation. One example of this was the establishment in 2010 of the Behavioural Insights Team within the UK Government's Cabinet Office to advise on and implement ideas from Nudge. The Nudge approach to behavioural change advocates subtlely guiding free choice towards options with better outcomes (e.g. ones that are healthier), rather than forcing them through regulation. A central concept to guided choice is what Thaler and Sunstein term 'choice architecture' – often the physical design or layout of any given environment. This can refer to establishing what are the most effective default settings in these environments. But nudge is not simply a form of environmental determinism: it may include other ways of structuring guided choice such as tapping into social norms or finding the best channels to communicate advice. In many respects, these activities are nothing new, particularly in public health and preventive medicine (Bonell et al., 2011). For example, researchers have invested a lot of time evaluating the effectiveness of different strategies of preventive medicine (Marteau et al., 2011).

The same themes apply to animal health. As Enticott et al (2011) explain, the governance of animal health is shifting towards a neoliberal model of "cost and responsibility sharing". In the UK this involves the Government attempting to restructure a longstanding relationship with agriculture and the veterinary profession in which it previously acted as a guiding partner in the management of animal disease, building veterinary capacity, and defining what diseases were important to manage. Instead, the Government has increasingly sought to devolve the costs and strategic direction of animal disease management to farmers and landowners. As part of this, the UK Government has paid increasing attention to nudge-like methods of changing farmers' behaviour in order to comply with animal disease regulations and improve biosecurity (see for example: Defra, 2012). In this respect, a crucial issue facing the promotion of biosecurity is whether some behavioural change strategies work better than others and understanding what drives farmers' acceptance of biosecurity practices (see for example Heffernan et al., 2008 ; Nerlich et al., 2009 ; Palmer et al., 2009 ; Ellis-Iversen et al., 2010). However, for geographers the turn to behavioural change for biosecurity is significant in other ways. Firstly, it reveals how different strategies rely on different geographies of knowledge. Secondly, these different knowledge geographies begin to present alternative versions of animal disease, raising questions over how it is possible to manage disease.

That different geographies of knowledge are implicit within behavioural change strategies and impact upon behaviour has been made most explicit in studies of the public understanding of science (Wynne, 1992). Similarly, epidemiologists such as Rose (1992 ; 1985) recognised that different strategies of preventive medicine have different geographies of knowledge which could be crucial in determining the uptake of the advice contained within them. Rose suggested that there are two main spatial strategies for preventive medicine: the population approach where the strategic focus is a sick population, and the 'high risk' strategy where the focus is sick individuals. The population approach focuses on the causes of incidence of ill health in order to control the determinants of incidence and lower the mean level of risk by changing societal norms. In practice it involves the large-scale communication of general and precautionary lifestyle advice, drawn from large scale quantitative analysis of risk factors. This scale of knowledge provides a significant drawback similar to the ecological fallacy, or what Rose calls the 'prevention paradox' – that is 'a preventive measure which brings much benefit to the population [but] offers little to each participating individual' (Rose, 1985: 38). This arises because the population strategy 'offers only a small benefit to each individual, since most of them were going to be alright anyway' (ibid.). As a result, these strategies become demotivating for both patients and physicians as 'success is marked by a non-event' (ibid.).

Davison et al (1989 ; 1991 ; 1992) argue that the population approach actually encourages dysfunctional health behaviour and link this failure to the scale of medical knowledge. They show that the public develop their own knowledges of ill-health through experience and personal observation of people known to be unhealthy and their circumstances. These observations generate explanatory hypotheses which challenge or support suspected medical understandings of illness (Davison et al, 1991). The overall effect is to construct an image of an unhealthy person – a 'candidate' – which helps people make sense of their risk of becoming ill, and predicts or explains illness. The prevention paradox is an inherent part of the candidate system because many other factors are involved in illness causation than are recognised in health promotion. The inability to handle fine grained detail leads to the recognition that rules are fallible and there will be exceptions – a gap filled by the role of bad luck and chance. Moreover, this broad scale knowledge is said to enhance these beliefs as the identification of more and more risk factors labels more and more behaviours as pathogenic, leading to the recognition of more and more exceptions. The ironic consequence is therefore 'that these cultural concepts are given more rather than less explanatory power by the activities of modern health educators, whose stated goals lie in the opposite direction' (Davison et al., 1991: 16).

By contrast, the 'high-risk strategy' places preventive medicine in a more localised and contextual environment. The approach deals with sick individuals by providing appropriate interventions relevant to those individuals who have been identified as 'at risk' following medical screening. The communication of risk and the identification of actions usually occur on a one-to-one basis, so that advice can be personalised and tailored to situational factors. The high risk strategy also helps to address these social concerns by providing a more proximate and trusting relationship compared to the distant relationship and impersonal form of communication within the population approach. The immediacy of the doctor-patient relationship enhances trust through the ability to 'talk things over', receive comfort and the ability of 'good doctors' to recognise patients' feelings, communicate and listen. Thus, in studies of public health, research has also shown that people with a high-risk of developing genetic conditions found comfort in talking to experts and fellow patients about the uncertainty of genetic screening, providing ways of coping with concerns about chronic risk (Kenen et al., 2003 ; Parsons et al., 2000). These affective and emotional dimensions to the doctor-patient relationship are crucial in stemming the erosion of trust that may have built up over time (Gilson, 2003). Even when the consequences of medical uncertainties are laid before patients, trust can persist out of recognition of these complexities or an inevitable need to have faith in medicine, or 'charismatic authority', at some point in one's life (Lupton, 1997 ; Lupton, 1996). This is not to say that there are not problems with this approach: the doctor-patient relationship may not always be so productive. Moreover, it is expensive, does not deal with the root causes of ill-health, only protects those who are already vulnerable to illness and requires individuals to change their lifestyle contra social norms (Rose, 1985).

In emphasizing the way solutions are moulded by context, the high risk approach is similar to other theories of health promotion, as well as resonating with the broader concept of living with disease. Firstly, other theories of health promotion stress the need to understand the local social and ecological contexts of human behaviour (Stokols, 1992). This helps create interventions that are locally situated and culturally compelling because they create a sense of community ownership and are matched with local priorities (Panter-Brick et al., 2006). Here there are similarities to approaches to resolving environmental challenges facing farmers. In agriculture, the complexity of both the social and ecological environment means that 'there are no single problems, no single solutions, no single extension strategies, and no best medium that extension should solely recognise' (Vanclay, 2004: 214). As farmers are work with different farming rationalities, finding a way of engaging with all of them at once remains a challenging task. Instead, appreciating the range of these different farming rationalities and styles and adapting to them may be crucial in generating appropriate behavioural changes (Pannell et al., 2006 ; Fairweather & Klonsky, 2009). Elsewhere, Henke (2000) describes how these adaptive behaviours are essential to the experimental spaces in which agriculture operates. As Henke describes, the variables involved in farming mean that farmers cast doubt on universal knowledge derived from systematic trials of new technologies, crops or practices. Instead, they find ways of improvising within experimental methods, based on their own and others' understandings, in order to provide meaning to the complex natural, social and technological relations in which they are embedded.

Secondly, the kinds of accommodations and situational rewiring required in the high risk approach have broader parallels with the concept of living with disease. However, unlike the picture of disease in Rose's description of the high risk approach, the very nature of disease – its ontology – is challenged by ideas of living with disease. To begin with, the importance of accommodation and flexibility in managing disease – the central point of the high risk strategy – is apparent in studies of biosecurity. Mather and Marshall's (2011) account of an outbreak of avian influenza in Ostriches in South Africa provides one example of this. Here, at least in one region of South Africa, the disease was managed using "local experience with the disease and an understanding of how avian influenza affects ostrich populations" (p.162). In practice, this meant farmers attempting to boost the immunity of ostriches during stressful periods, whilst vets adapted a "one size fits all" culling policies in recognition that locally, ostriches had previously withstood the disease. Instead, flocks were culled only where infection was seen to multiply. Here we find what we mean by 'living with disease': a recognition of the complexity of disease and its environment, that disease may manifest itself differently across space, and that more nuanced and open forms of prevention, rather than those which are closed and static, may be required to deal with it effectively.

This account reflects how disease management practices can vary at local scales and reveals how geographically uneven and fractured single global approaches to biosecurity can be in practice. But drawing on Law and Mol (2011) we can also see how the practices associated with living with disease enact one of many different ontological versions of disease which are performed through different biosecurity practices. For example, in relation to Foot and Mouth Disease, Law and Mol define three broad approaches in which vets attend to the diagnosis of this disease: epidemiology, laboratory science, and clinical practice. In making these distinctions, different versions of disease are constructed – not because they take a different perspective of disease – but because they configure and are configured by different materials, qualities, time and spatial relations. Thus, in distinguishing between different disease practices, epidemiology seeks to establish disease in universal ways whilst others such as clinical practice seek to adapt to local presentations of illness. Here there are similarities here with the high risk strategy: Law and Mol refer to attending to the local and the accommodation of the variable as "tinkering", a skill which predominates in the mode of clinical practice: "In clinical work various uncertainties have to be entertained at the same time. And since so many variables are variable, the clinic works not by fixing reality but in a chronic process of tinkering or (if the term can be stripped of its perjorative connotations) of doctoring…Thus, clinical time is characterised by shifts, simultaneities and ongoing adaptations" (p.12).

This analysis of the multiplicity of disease is important because it opens up ontological questions of the management of animal disease. As Law and Mol insist, these questions are a matter of ontological politics: what it means for "facts" to be established. Enactments of different specific versions of reality have consequences. By foregrounding some, others are marginalised, but as Law and Mol ask: "which version of reality deserves to be foregrounded and worked with?" Their conclusion appears to be that which "come[s] with a repertoire marked by adaptability [attuned] to specific local needs and circumstances" (p.14). Broadly at least, these are practices common to the notion of living with disease and the high risk strategy rather than the population strategy where disease is fixed rather than fluid. But what is less clear is how such a situated and indeterminate approach to managing to animal disease can be built into behavioural change techniques aimed at improving biosecurity. What methods would be required? How would farmers respond? These questions are the focus of the remainder of this paper, specifically in relation to one disease – bovine tuberculosis.

**Bovine Tuberculosis in the United Kingdom**

Bovine tuberculosis (bTB) is a zoonotic bacterial infection that can be passed between animals and humans by consuming infected food. In the UK, it is commonly found in cattle and wildlife, specifically badgers. The disease was first recognised as an animal and public health problem at the end of the nineteenth century. Infection was connected to the consumption of infected milk and meat. At its height in the 1920s, approximately 50000 human cases of bTB were recorded annually, killing 5% of those infected (Waddington, 2006). Since then, a range of public and animal health measures have been progressively implemented – for example, milk pasteurisation and meat inspection – such that now the risk to humans is judged to be very low (Health Protection Agency, 2009). Continued government intervention is instead largely required to meet international trading legislation and mitigate the social and economic effects upon farmers.

In cattle, however, the disease has been described as the most challenging and complicated animal health problem in the United Kingdom. Although eradication of the disease in cattle was virtually achieved in the 1960s (MAFF, 1965), from the 1970s cases began to rise steadily. In 2009, over 25000 cattle were slaughtered due to bTB infection. The disease is concentrated in the west and south-west of England and West Wales. Although much of the spread of the disease may be attributable to farming practices, managing the disease is made complicated by the involvement of badgers as a disease host and vector. As an iconic and culturally significant animal in the UK, protected from harm by law, government-led badger culling strategies aimed at reducing bTB have been disrupted by public protest and ceased completely in the 1990s (Enticott, 2001). Subsequent scientific study into the effects of badger culling as a disease control strategy found that benefits were outweighed by negative effects (Independent Scientific Group (ISG). 2007).

In this complicated policy environment, and without other means such as a useable vaccine, the UK Government's Department for Environment, Food and Rural Affairs (Defra) has relied on its regulatory powers of testing and slaughtering infected cattle. Whilst this approach may seem to reflect a universal version of bTB achieved through epidemiological or laboratory science, there are also elements of living with disease found in these practices. Enticott (2012) for instance shows how modes of clinical practice are employed when testing cattle for the disease rather than modes of epidemiology. Whilst these practices demonstrate flexibility, they also involve breaking Government guidelines. In general, therefore, attempts to manage bTB have revolved around fixed notions of disease. This is evident in attempts to encourage farmers to voluntarily improve their biosecurity to prevent bTB by, for example, fencing off badger setts, storing cattle feed securely, adopting other husbandry techniques and checking the health status of cattle before purchasing new stock (Defra., 2007b ; Defra., 2007a) . In order to generate behavioural change, these risks have been communicated to farmers through leaflet campaigns, as well as personalised advice from vets. There is, though, limited evidence surrounding the efficacy of many of these interventions, not least in terms of how they might be physically implemented on a farm and fit with the daily routines and practices of farming (Enticott, 2008b). Given this uncertainty, it seems likely that not only will biosecurity be unevenly implemented according to farmers' experiences of living with disease, but that those methods of behavioural change that engage with the uncertainties and varied experiences of living with disease are more successful.

**Evaluating biosecurity practices**

The remainder of this paper explores how approaches that are more open to difference fare in relation to the promotion of biosecurity. It begins by reviewing evidence on population style approaches before turning attention to an example of the use of the high-risk approach to deal with bTB.

*The Population Approach*

In Enticott (2008a), the theoretical impact of a population strategy approach to bovine tuberculosis is examined. These findings are briefly summarised here to allow comparison with the high-risk approach. Drawing on qualitative interviews with 61 farmers in areas at high risk from bTB, Enticott argues that, just as in public health, farmers' understandings of disease and biosecurity interact with advice from population strategy initiatives – in this case a set of leaflets issued by Defra (2007a ; 2007b) – to produce behaviour that is contrary to the goals of policy makers. In this case, farmers created 'candidates' for bTB for farmers, cows and badgers based on their first-hand experiences of the disease and by sharing these accounts with other local farmers. This candidate system helped to retrospectively explain why farmers had suffered a bTB breakdown and/or to predict who is likely to go down with bTB based on other farmers' management practices, where they sourced replacement stock and/or their farming ability.

As many of the elements of this system were common to risk factors communicated within the population approach, it was suggested failure to implement biosecurity advice was not a result of a knowledge deficit, but factors connected to the geography of knowledge within the population approach. Whilst the population approach provided generalised and universal advice, at a local level, they farmers suggested that disease was uncertain and complex. The generic advice contained within the population strategy conflicted with their experiences of bTB. Observations of unwanted and unwarranted cases of bTB confirmed that the universal rules of the population approach provided no guarantees of avoiding bTB. Farmers judged to be excellent by their peers would be just as likely to suffer from bTB as those judged to be poor farmers, or following high-risk practices.

Equally, exceptions to biosecurity rules within the population approach provided further proof that general rules were problematic. Farmers pointed to unwarranted survivals and deaths of cattle from bTB: where it was likely that cattle-to-cattle transmission should have occurred but did not, farmers used these cases to demonstrate that theories of cattle-to-cattle transmission were uncertain and provided no guarantees. 'Closed herds' – herds that breed all their replacement stock – were prominent in other examples of unwarranted deaths. According to the general risk factors within Defra's advice, closed herds were less likely to suffer from bTB. Farmers though pointed to numerous examples of closed herds and other examples of good farming or 'good farmers' that had suffered from bTB breakdowns to demonstrate the limitations of universal biosecurity practices and the difficulties of inspiring behavioural change with broad-scale knowledge.

Whilst the population approach attempted to suggest universal rules, these experiences came instead to characterise the bTB candidate system as fallible, in which disease incidents were dependent on luck. Set against these exceptions to the rules, the population approach did not encourage biosecurity but instead inspired a sense of fatalism in which nothing could be done to prevent animal disease. Reluctance to follow universal guidelines therefore led to a reliance on farmers' own 'lay epidemiologies' of disease management. In practice that meant illegal badger culling; missing or delaying bTB tests; and ignoring biosecurity regulations, such as isolating bTB infected cattle. Farmers were discouraged from buying from herds in low risk bTB areas because the stress of moving cattle long distances could make them susceptible to bTB. Restocking from areas with high bTB was seen as safer because of beliefs in immunity and susceptibility gained by cattle living in high risk areas.

These actions therefore provided a feedback mechanism to the candidate system creating what Strong (1990) calls an 'epidemic psychology'. That is, the circulation of this knowledge within local agricultural communities reinforces and amplifies their actions as legitimate (cf. Kasperson et al, 2003). Where farmers' bTB problems have been resolved following badger culling or other 'lay epidemiologies', their cases are held up as examples of success – those 'unwarranted survivals' who contravene animal health advice yet whose situation somehow improves.

*The High Risk Strategy*

Enticott's study provides evidence that the geographies of biosecurity knowledge in the population approach, together with its fixed versions of disease, play an important role in affecting the uptake of biosecurity interventions. However, much of this evidence is theoretical and lacks precise measurements of how levels of biosecurity may have changed over time. However, analysis of high-risk strategies may help to confirm these conclusions. One example of such a strategy was developed in 2006 by the Welsh Assembly Government. The project was known as the Biosecurity Intensive Treatment Area (ITA) and ran from December 2006 until March 2008. Its aim was to raise awareness, understanding and, ultimately, uptake of biosecurity interventions on farms. The expectation was that any improvement of on-farm biosecurity would in turn help to reduce outbreaks of bTB.

The ITA was located in West Wales, covering approximately 100 $km^2$. The area contained 176 cattle holdings, but 63% had suffered from bTB the year before the ITA. All cattle holdings in the area were invited to participate in the ITA and open meetings with farmers were held to explain the aims and operational details of the ITA. All farmers were free to choose whether they wanted to take part. Approximately two thirds (107) of all cattle farms volunteered to take part, 27 of which had bTB. Of these, 13 dropped out of the trial due to bereavement or retirement.

The communication of biosecurity advice in the ITA followed the principles of the high risk strategy. Farms that volunteered received two free visits from their vet who undertook a risk assessment of the farm. The risk assessment was based on a Biosecurity Scoring Tool developed in collaboration with vets from seven veterinary practices in the ITA (see Van Winden & Aldridge, 2008). This provided a quantitative assessment of the level of risk faced by farms for 8 key risk factors (see table 1). Vets – usually the senior partner who specialised in farm animals – from each of the practices were trained to deliver the risk assessment. The veterinary practices themselves were relatively small, employing on average nine farm animal vets. Following the first risk assessment, the vet and the farmer agreed on three risk factors that were practical to reduce and could be written into an Action Plan for the farmer. The second risk assessment occurred nine months after the first where the process was repeated. Data from each farms' risk assessment visit were collated within an Excel spreadsheet.

*[Insert table 1 about here]*

In order to gain an understanding of the effectiveness of the ITA, the quantitative risk assessment data was merged with data relating to bTB status and farm size and analysed using SPSS. These data were supplemented with two forms of qualitative data. Firstly, vets were interviewed and work-shadowed as they conducted the risk assessment. Second, 28 longitudinal interviews were conducted with farmers. Interviews took place with 14 farmers after their first and second risk assessment visits. Farmers were selected from a stratified sample of the first round of risk assessment scores. Nine farmers improved their biosecurity over the period of the ITA; for three, biosecurity worsened; and for two there was no change. Interviews focused on the experience of being part of the ITA, but also asked the same semi-structured questions relating to understandings of bTB and biosecurity as were posed to the farmers in the population strategy. These data were analysed in the same manner using NVivo.

Data from the ITA suggest that, empirically, the high-risk strategy can achieve statistically significant improvements in farm biosecurity (see table 2). In the first round of biosecurity assessments, the highest biosecurity score recorded (representing highest risk) was 1544, the lowest was 82 and the mean was 528.39. In the second round, the highest score had fallen to 1407, the lowest had fallen to 71 and the mean had also reduced to 467.55. Comparing individual farms at the start and finish of the ITA reveals a mean level of change of 60.85 in ITA scores (paired t-test: p=.000), an overall risk reduction of 10.69%. The largest reduction in score was 728 (or a 66% reduction).

Data indicate that the gap between the best and worst biosecurity scores narrowed between rounds 1 and 2. Comparative analysis focusing on farms in the bottom and top quartile biosecurity scores (assessed in round 1) found that during round 1, the mean difference between the best and worst biosecurity scores was 866.90 (p=.000). This decreased to a mean difference of 755.09 in round 2 (p=.000). Analysis of biosecurity scores and bTB status of farms in the ITA also reveals that biosecurity on farms that did not have bTB was better than those that did (p=.001). Amongst the ITA farmers that were interviewed, biosecurity scores fell on average from 552 in round 1 to 490 in round 2.

*[Insert table 2 about here]*

In Thaler and Sunstein's terms, the scoring system created a kind of choice architecture to guide farmers towards better animal health behaviour. One way the scoring system could do this was by establishing norms of "responsible" farming and creating competitive behaviour between farmers to have low scores. In fact, although farmers did compare their biosecurity scores, this was not envisaged at the start of the ITA. Moreover, in some cases, farmers misunderstood the nature of the scoring system. Vets in the ITA recounted how one farmer was pleased that his biosecurity was higher (i.e. worse) than his neighbour, commenting that this was because he had never previously beat him at anything. Whilst this may reveal the potential of establishing biosecurity social norms to generate behaviour change, in this case it revealed flaws in the design of the ITA. Indeed, although biosecurity improved, interviews with farmers and vets did not seem to suggest that the scoring system played a significant role in encouraging better biosecurity. Vets involved in the scheme suggested that some farmers misunderstood the scoring system. Few farmers interviewed could remember their farm's biosecurity score nor did they view them as positive planning instruments, whilst a majority continued to express fatalistic attitudes towards biosecurity and bTB following their assessments. For example, one farmer said:

> 'Yes [the vet] did say something; I can't remember what he said. Well what the hell can we do? The point is so far I might go down next Tuesday but the only thing I can say is I stick to what I've been doing all the years and Im not going to do that way or that way and hope for the best'.

Nevertheless, analysis of interview data reveals three core themes relating to the understanding and adoption of biosecurity advice generated from farmers' risk assessment visits. Each of these three themes is specific to an approach to biosecurity that does insist on universal versions of disease, but its malleability that comes from living with disease. They were evident – to varying degrees – within the interactions between vets and farmers during the ITA. Where they were evident, farmers cited them as beneficial elements of the ITA; where vets did not engage with farmers in these culturally appropriate ways, farmers suggested the ITA was poorer for it. Farmers who implemented all or part of their recommended biosecurity actions spoke of their good relationship with their vet, the need for practical and sensible advice and the value of being able to take time to discuss biosecurity. By contrast, farmers that did not implement the advice complained that it was impractical.

The first theme that links the promotion of biosecurity with ideas of living with disease suggested that an 'alignment of expertise' is important for farmers to implement biosecurity actions. An 'alignment of expertise' requires vets to be able to have an understanding of how farming works and demonstrate their farming competence through their interactions with farmers. This requires vets to discursively demonstrate their knowledge of farming to farmers through a recognition of the situated expertise required to farm effectively. Just as socio-ecological approaches to health promotion suggest, this requires vets to recognise the specificity of each individual farm and match solutions to it, because that is how farmers think about farming. As one farmer commented:

> 'you know some say you should do it one way, some say you should do it another way and you know on different farms we have different ways and different land works for different animals, it's very hard to take a piece of advice from one farmer and apply it to your own farm because it may not suit. You may try it and you think well how did he make it work? Because it doesn't work with us, that's the trouble with farming.'

In this view, the adoption of biosecurity interventions relates to the ability of the vet to 'flexibly' weigh up the limits to biosecurity interventions and identify what is 'practical' and 'sensible' for each particular farm. It is not just natural contingencies that vets need to take into account but also the social, cultural and economic context of the farm and local agriculture. Whilst some biosecurity interventions may make veterinary sense, without the support of the farmer and the wider social environment there is little point suggesting them for they will be rejected. Farmers' for example complained about the penalties in the scoring tool for not cleaning and disinfecting contractors' equipment. They argued that this was not within their control and, if they were to demand it, the contractors would just laugh and not return. It is in these moments then that vets demonstrate their ability to live with disease: a recognition that biosecurity is not a universal object, but requires fitting to different social, natural and technological relations. At the same time, bTB becomes enacted variously on different farms. On some farms, the disease may be rendered docile easily; in others, these associations mean that the disease takes on additional vigour, but a vigour that must be accepted as part of the relations that are essential for farming life.

Secondly – and related to the first theme – farmers suggested that the ITA matched their style of learning and implementing agricultural innovations. Farmers frequently suggested that ‘it was good to talk’ about innovations – whether it be about biosecurity, machinery or feeding. Sifting through information by ‘talking about things’ and ‘mulling things over’ were important aspects to disease management (cf. Sligo and Massey, 2007). Like Henke’s (2000) descriptions of agricultural trials, the ITA opened up a space of experimentation in which disease and biosecurity were not strictly pre-given: they were up for negotiation. The ITA enabled this by providing an opportunity for talk. This opportunity was itself related to the trusting and caring environment established by their ongoing relationship with their vet. As one farmer said: ‘You can never be too safe at the end of the day just for a chat with somebody you can’t go wrong, can you?’. This discursive approach to solving animal health problems also reveals how farmers view agricultural innovation as non-linear. Talking about biosecurity, for example, may not instantly result in a progressive adoption of agricultural innovations as theories of top-down technology transfer imply (Rogers, 1962). Instead, talking may lead to trial and error or ideas may sit unused until an appropriate time when they may suit a farmer’s needs (Vanclay, 2004). Indeed, comparison of interview data and biosecurity scores reveals a complicated relationship between the provision of advice and its implementation. One farmer dramatically improved his biosecurity by following the advice provided but claimed to have done so only so the government could not blame bTB upon farmers. On other farms, biosecurity worsened despite practical advice being offered. However, even here, farmers recognised the value of being able to talk through their problems and build up a stock of knowledge, even though it might not be instantly deployed. One farmer said:

> ‘I didn’t really think the advice I had was particularly helpful but I don’t like to sort of say its been no use at all because you know it’s only by constantly discussing and sort of probing the whole problem that hopefully somewhere we’ll perhaps have a breakthrough and find something that perhaps is missing you know missing in our understanding at the present.’

Finally, forms of 'emotional care' appear to be important in forms of biosecurity that live with disease. As Lupton (1997) suggests, the one-to-one relationship between a patient and doctor can generate a trusting relationship which helps to induce health related behaviour. Farmers argued that an important element of the ITA was being able to speak directly to vets. Farmers said that their vet could 'understand what they were saying' and were 'easy to talk to'. The direct contact with their vet meant that they could be more honest and open when discussing the risks on the farm. For example, one farmer commented that:

> 'if [the ITA] was over the phone…we wouldn't be as interested. It wouldn't be like asking him questions because you think "oh God, what's he doing the other side?"'

The prior relationship between the farmer and vet was also important. Some farmers suggested that their confidence in their vet came from providing help and advice for past problems and helping to resolve the confusions they may have had. Farmers recognised that the physical proximity of the vet in delivering the ITA was important. Not only was it important that they visited the farm, but it was also important that they came from the local area and understood local farming. In other words, for vets to be trusted, they need to have local knowledge. Veterinarian knowledge that came from government vets or through a population style approach was classed as 'distant' knowledge and not to be trusted. For example:

> 'Leaflets I will read it later and it's gone, you find it months down the line when you come to sorting it…it was much better coming from somebody you know, you respect, trust and has a hands-on experience of the problem'

In trusting their vet, farmers believe that they will do their best for them and look after their interests. This relationship of care is no doubt related to vets' surgical skills, but it also relates to their social skills and ability to establish a rapport, as well as their ability to be practical and sensible. The importance of different aspects of 'veterinary care' in encouraging biosecurity (cf. Law, 2010) is therefore related to the first theme of situated expertise.

Thus, although these results are from a small sample and are deserving of further research, the qualitative evidence from the ITA generally suggested that attempts to accommodate and live with the uncertainties of disease provide more compelling reasons to implement biosecurity than the population strategy.

## Conclusion

At the start of this paper we asked whether approaches to behavioural change could accommodate notions of living with disease. In comparing the high risk strategy and population strategies we are able to draw some conclusions about the extent to which these approaches affect farmers' biosecurity behaviour. The two different approaches analysed reveal that the knowledge geographies of strategies of preventive animal health do appear to matter. On the one-hand, the geographically distant and broad forms of knowledge within the population approach can potentially have dangerous side-effects, exacerbating the use of existing practices that are contrary to policy objectives. By contrast, the more localised and situated forms of knowledge in the 'high-risk' strategy, as predicted by Lupton (1996) and Rose (1992), seem to help biosecurity adapt to different places. In the case of the ITA, the emotional bonds and knowledge compatibility between vet and farmer appear to have beneficial effects upon the uptake of biosecurity advice by enhancing levels of trust.

These findings reflect other research that highlights the breakdown in trust between farmers, the government and scientific institutions (Wynne, 1992 ; Heffernan et al., 2008 ; Enticott & Vanclay, 2011). The dominance of discourses about luck, chance and fatalism in relation to bTB and biosecurity speak further about the way farmers feel about the government and their apparent disengagement from agriculture. In response to the lack of trust, solutions that have been suggested include developing participative forms of governance and using trusted social networks to transmit information. In the case of bTB, however, these are unlikely to be enough. This is because it is not simply a matter of a loss of trust, but a loss of hope amongst farmers that the problem will be resolved (Enticott, 2008b). The dominance of discourses of luck and fatalism in these accounts instead highlights the extent to which farmers believe animal diseases like bTB are indiscriminate and there is little anyone can do about them by implementing biosecurity – whether or not they perceive themselves to be a "good farmer" (Heffernan et al., 2008). Although the data are limited to one before and after study, the suggestion is that high-risk strategies such as the ITA offer farmers hope: they provide a discursive opportunity to talk things through and in doing so receive a form of emotional care from their vet. But with that hope comes a different version of disease: one which must be changeable and adaptable to different social, natural and economic conditions.

Thus, when approaches to behaviour change seek to work with and adapt to local conditions, it also becomes apparent that biosecurity itself requires constant work and evolution for it to be translated to local situations. Without this reworking and accommodation of different experiences of disease, biosecurity interventions appear to be of little value. This means that biosecurity must always be seen as an outcome of social and ecological negotiations, and that there will always be limits to biosecurity. These are evident in the negotiations seen in the ITA between farmer and vet over what biosecurity interventions were practical and achievable which came to override the technical definitions of biosecurity within the scoring system. Thus, viewed as a form of choice architecture, the scoring system "worked" through its ability to raise questions and organise interactions, rather than establish fixed notions of biosecurity. This reveals the constructed nature to biosecurity: it is not reducible to a set of universal risk factors, as population strategies imply, but its processes and activities are situated and multiple, varying from place to place and borne out of practical experiences of living with disease. These negotiations over what should count as biosecurity could be interpreted as agricultural interests prevailing over those of animal health. However, in comparison to the results of the population strategy where notions of biosecurity are dismissed, the experience of the high-risk strategy suggests that flexibility an important element of biosecurity behavioural change initiatives.

Finally, in recognising the various versions of disease that are enacted by different approaches to biosecurity behaviour change, the paper provides some important lessons for policy makers concerned with biosecurity. Firstly, if constructing and fitting biosecurity to contexts is what is important to getting biosecurity to work, then it will also require particular geographies and forms of expertise. As Mather and Marshall (2011) suggest, living with disease is consistent with organising experts so that they become familiar with local variations and practices. However, these geographies of expertise are increasingly under pressure from neoliberal reforms to the veterinary profession (Enticott et al., 2011) leading to centralised concentrations of expertise rather than the localised version required by disease control that attempts to live with disease. But whilst the veterinary profession may play an important role in encouraging biosecurity, what perhaps is more important, are the relevant analytical skills to recognise that whilst biosecurity can be scientifically defined, it is ultimately socially and ecologically applied.

Secondly, thinking about the different versions of disease enacted by biosecurity interventions should also prompt broader thinking about the purpose and limits of disease control from the outset. One lesson for policy makers from this research is that reluctance to stray from bureaucratic biosecurity protocols may provide more harm than good. This may mean findings ways of living with disease by shifting the spatial scales at which they practise disease control. Policy makers should encourage a flexible approach to biosecurity that does not conform to pre-set guidelines and allows vets to use their judgement and flexible interpretations. Practically this means engaging with the indeterminate qualities of disease and its relationships with the social and ecological environments in which farmers are situated. Attempting to accommodate difference and 'live with disease' in these ways may be a risk for policy makers: not only does affect established notions of disease, but it could also challenge existing institutions associated with disease control, as well as – in some cases – the very need for disease control. But to do otherwise may not only lead to ineffective tools for preventive medicine but may also foster ongoing resentment between vets, farmers, governments and other actors responsible for animal health. In this way, living with disease may be essential in order to one day live without it.

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**Table 1: Risk factors used to calculate the bovine TB Biosecurity score.**

| |
|---|
| **Herd Size** |
| **Introduction of cattle** |
| • Most important source |
| • Parish testing interval of source |
| • Age of cattle being introduced |
| • Control measures on introduced cattle |
| **Mixing of herds** |
| • Grazing away from home farm premises with direct cattle contact |
| • Grazing away from home farm premises with indirect cattle contact |
| • Shared housing with cows from different herd(s) |
| • Showing cattle at fairs/shows with other cattle |
| • Young stock kept at a premise separate from the home farm |
| **Manure management** |
| • Manure used |
| • Source of manure |
| • Application |
| • Storage time |
| **Occasional contact** |
| • Number of contacts |
| • Type of boundary |
| **Local herds and land use** |
| • Land use of bordering fields |
| • Type of arable land use of bordering fields |
| • Average distance to neighbouring farm with livestock |
| • Parish test interval of your area |
| **Contact with other animals** |
| • Badger presence |
| • Badger access |
| **Shared or borrowed equipment** |
| • Vehicles for cattle transport (trailer, lorry, etc.) |
| • Vehicles for manure transport and application |
| • Manure that is spread though equipment of a contractor |
| • Other vehicles (tractor, combine, etc.) |
| • Equipment (crush, feed troughs, gates, hoof knives, clippers, etc.) |
| • Vehicles for cattle transport (trailer, lorry, etc.) |
| **Visitors and Protective clothing** |
| • visitors that have contact with your cattle |
| • Provision of protective clothing to farm visitors |

**Table 2: Descriptive Statistics From ITA Biosecurity Scores**

| | Round 1 | Round 2 | Actual Change | % Change |
|---|---|---|---|---|
| Number of Farms | 84 | 84 | | |
| Mean Biosecurity Score [a] | 528.39 | 467.55 | -60.85 | -10.69 |
| Median | 460 | 408 | -39.5 | -8.12 |
| Mode | 204[b] | 96[b] | 0 | |
| Standard Deviation | 348.73 | 325.82 | 147.43 | |
| Lowest biosecurity score | 82 | 71 | | |
| Highest biosecurity score | 1544 | 1407 | | |

Notes:
[a] Higher scores reflect poor levels of biosecurity
[b] Multiple modes exist. The smallest value is shown