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ABSTRACT

There is seen to be a need for better biosecurity – the control of disease spread on and off farm – in the dairy sector. Veterinarians play a key role in communicating and implementing biosecurity measures on farm, and little research has been carried out on how veterinarians see their own and farmers’ roles in improving biosecurity. In order to help address this gap, qualitative interviews were carried out with 28 veterinarians from Royal College of Veterinary Surgeon farm accredited practices in England. The results were analysed using a social ecology framework and frame analysis to explore not only what barriers vets identified, but also how vets saw the problem of inadequate biosecurity as being located.

Veterinarians’ frames of biosecurity were analysed at the individual, interpersonal and contextual scales, following the social ecology framework, which see the problem in different ways with different solutions. Farmers and veterinarians were both framed by veterinarians as individualised groups lacking consistency. This means that best practice is not spread and veterinarians are finding it difficult to work as a group to move towards a “predict and prevent” model of veterinary intervention. But diversity and individualism were also framed as positive and necessary among veterinarians to the extent that they can tailor advice to individual farmers.

Veterinarians saw their role in educating the farmer as not only being about giving advice to farmers, but trying to convince the farmer of their perspective and values on disease problems. Vets felt they were meeting with limited success because vets and farmers may be emphasising different framings of biosecurity. Vets emphasise the individual and interpersonal frames that disease problems are a problem on farm that can and should be controlled by individual farmers working with vets. According to vets, farmers may emphasise the contextual frame that biosecurity is largely outside of their control on dairy
farms because of logistical, economic and geographical factors, and so some level of disease on dairy farms is not entirely unexpected or controllable. There needs to be a step back within the vet-farmer relationship to realise that there may be different perspectives at play, and within the wider debate to explore the question of what a biosecure dairy sector would look like within a rapidly changing agricultural landscape.
Introduction

In an agricultural context the term “biosecurity” refers to practices that control the spread of disease both onto and within the farm (Dargatz et al., 2002). Instances of certain common livestock diseases have increased in recent years and it is widely claimed that better biosecurity practices are needed to improve animal welfare and enhance the financial viability of the dairy sector in the UK (Defra et al., 2004). The 2004 Animal Health and Welfare Strategy for Great Britain emphasised the responsibility of animal owners in managing animal health risks and stated that veterinarians (hereafter referred to as “vets”) are uniquely placed to promote animal health and welfare and should be at the forefront of delivering proactive disease prevention services (Defra et al., 2004), a point which is reiterated in a European context (European Commission, 2013). Yet research suggests that uptake of biosecurity measures on dairy farms is low with certain practices being very rarely carried out (Sayers et al., 2013; Brennan and Christley, 2012; Nöremark et al., 2010).

Research in the UK and Ireland suggests that despite low uptake of biosecurity practices, dairy farmers do see biosecurity as important (Heffernan et al., 2008; Sayers et al., 2013; Brennan and Christley, 2013). Vets have been identified as one of the most important (Gunn et al., 2008; Derks et al., 2012) and most reliable and credible sources of information for farmers on biosecurity (Garforth et al., 2013).

There has been little research done on vets’ views of biosecurity; their perceptions of their and farmers’ roles in biosecurity. Previous work on the vets’ role in biosecurity has mostly used quantitative surveys and identified lack of time; lack of knowledge; a belief that farmers are not willing or financially able to introduce biosecurity measures; vets thinking farmers already had a protocol in place; farmers not asking about biosecurity; vets not seeing themselves as the primary source of biosecurity information; and vets not being specifically
paid for advising on biosecurity measures, as barriers to increased veterinary involvement (Gunn et al., 2008; Sayers et al., 2014).

There have been more studies carried out within veterinary epidemiology on farmer’s attitudes towards biosecurity and barriers to improving biosecurity (Heffernan et al., 2008; Garforth et al., 2013; Alarcon et al., 2014). The majority of studies on biosecurity within veterinary epidemiology draw on socio-cognitive frameworks, of which there are numerous different types, Michie et al. (2011) state there are at least eighty three different theories. The most commonly used in veterinary epidemiology are the Health Belief Model (Valeeva et al., 2011) Theory of Reasoned Action (TRA) (Gunn et al., 2008; Garforth et al., 2013; Garforth, 2015) and Theory of Planned Behaviour (TPB) (Ellis-Iversen et al., 2010; Alarcon et al., 2014; Garforth, 2015). These theories focus on the individual, in this case the individual farmer, as the locus of behaviour change to bring about the desired outcome: improved biosecurity. Appendix 1 shows the frameworks used in a number of papers on biosecurity in veterinary epidemiology.

There are debates about the merits of socio-cognitive theories such as Theory of Planned Behaviour (Ogden, 2003; Ajzen, 2014; Sniehotta et al., 2014). Some claim these theories are methodologically flawed in terms of validity, utility and coherence (Sniehotta et al., 2014).

One criticism concerns the role of context and “external” forces in socio-cognitive theories. Within these frameworks, context and circumstances that the person acts within are relevant only to the extent that they influence their intention and the socio-cognitive constructs which make this up. The theory of planned behaviour for instance holds that an individual’s behaviour is influenced by their intention to act, which is determined by their attitudes; their subjective norms – the person’s perception of the social pressure to perform or not perform the behaviour; and perceived behaviour control – the perceived ease or difficulty of
performing the behaviour (Ajzen, 1991). Some claim that it has been shown these constructs cannot adequately account for the importance and influence of the person’s context, as contextual factors are not adequately translated into the constructs of attitude, subjective norms and perceived behaviour controls (Sniehotta et al., 2014).

Some also state that approaches which focus on individual behaviour alone as the locus of change are politically as well as methodologically problematic (Shove, 2010). Individual socio-cognitive approaches put the onus for action on individuals and ignore wider systematic and political change potentially involving greater buy-in and investment from government, industry and other sectors (Shove, 2010). These approaches frame the problem and the solution as existing with the individual and other factors are only relevant to the extent that they influence the individual.

One approach which goes beyond an individualistic account of behaviour is a social ecology approach to health promotion. Ecology is a discipline that studies the interaction between a biological organism and its environment (McLaren and Hawe, 2005). This perspective has been extended to the field of human health (Bronfenbrenner, 1996; Egger and Swinburn, 1997; Lake and Townshend, 2006; Panter-Brick et al., 2006) and to veterinary medicine (Ellis-Iversen et al., 2008; Sawford et al., 2013) in order to explore the role context plays in a determining individual’s and group’s health. An ecological perspective has also been used to explore differences in the results of policies to cull badgers to combat bovine tuberculosis (bTB) in the UK and Ireland (O’Connor et al., 2012). In the social ecology approach the individual is not viewed separately from their context, but rather behaviour is determined by, for instance, intrapersonal, interpersonal, institutional, community and public policy factors (Green et al., 1996). Such perspectives widen the scope for analysis as context and circumstances are not transformed into cognitive constructs that fit the model.
This paper will adapt a social ecology perspective to explore vets’ perceptions of barriers to better biosecurity in the dairy sector in terms of individual, interpersonal and contextual scales (Green et al., 1996). Individual framings of barriers see the problem — inadequate biosecurity — as having causes that originate within the individual and as requiring solutions that are targeted to individuals. Interpersonal barriers are seen as existing at the level of the relationship between people or groups of people and solutions as needing to be targeted to this level. The context will be divided into the physical environment, which consists of the geographical, architectural and technological context; and the social environment which includes socio-cultural, legal, political and economic factors (Stokols, 1992). Here barriers may be framed as outside one person’s, or a group of people’s control, but requires more systematic or structural change.

The paper will use frame analysis to explore how the problem of poor biosecurity is framed as existing at individual, interpersonal and contextual scales. The term frame analysis has a long history in social science research, going back to one of the leading figures in sociology and anthropology; Goffman (1974). In research, a frame can be understood as a cognitive lens through which people order and represent ideas, or as a way in which people negotiate interaction (Dewulf et al., 2009). This paper uses the term frame in the former sense as an interpretive lens through which people see and represent reality, which draws our attention to particular aspects and leaves others out (Entman, 1993). According to Entman frames diagnose a problem, suggest causal explanations, make moral judgements and suggest remedies. Frame analysis is used within the social ecology perspective because the social ecology perspective allows a problem to be approached from different angles: at the individual, interpersonal and contextual scale. Scales can be defined as “the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon” (Gibson et al., 2000, p.218, as cited by van Lieshout et al., 2011, p.3). Frame analysis is particularly
useful in this analysis because it does not involve making judgements about how “true” or “accurate” those frames are, but rather it explores the different ways people view an issue simultaneously, which may be conflicting or complementary. This paper will explore the framing of biosecurity at the individual, interpersonal and contextual scale. Thus stating that biosecurity is framed by vets at an interpersonal or contextual scale means not only that the barriers to a problem are located at these scales but that the problem itself is being located at this scale. The idea being that one must first understand how people view a problem – where they see it as located, before it can be tackled.

Frame analysis has been used previously to explore the scale at which an issue is framed and the significance of this scale in wider debates (Kurtz, 2003; van Lieshout et al., 2012, 2011). Frame analysis has been used in an agricultural context on various topics including agricultural controversies in the UK media (Naylor et al., 2015; Nerlich, 2004; Nerlich et al., 2002), the framing of antimicrobial resistance in agriculture in the UK media (Morris et al., 2016); Bovine Spongiform Encephalopathy (BSE) in the Canadian (Davidson and Bogdan, 2010); and German media (Feindt and Kleinschmit, 2011). As well as exploring the framing of food security (Mooney and Hunt, 2009), planned mega farms in the Netherlands (van Lieshout et al., 2011) and a novel hen husbandry system in the Netherlands (Zwartkruis et al., 2011). Several of these studies use frame analysis to explore the framing of issues in the media, however frame analysis has not yet been used to explore how vets perceive biosecurity and the possibility of improving biosecurity.

The aim of this study was to use a social ecology perspective on health promotion to explore how vets frame biosecurity on dairy farms using data collected through qualitative interviews with a purposive sample of farm animal vets in England. The study aims to shed more light
on the discussion and, through the use of frame analysis, show where areas of
miscommunication or disagreement may exist that need to be addressed before “barriers” can
be overcome in any straightforward fashion.

Methods

Data Collection

Data was collected through 28 semi-structured interviews with practicing vets in the UK.

Purposive sampling was used to maximise the range of views accessed (Bryman, 2001).

Qualitative interviews are normally carried out with a smaller sample than quantitative data
and aim to provide in depth insights into the meanings and beliefs behind people’s actions
and decision making, rather than produce results that can be statistically generalised to a
particular population (Sawford et al., 2013). With qualitative research it is the
appropriateness of the sample for answering the research question rather than the size of the
sample that matters (O’Reilly and Parker, 2013). Vets were chosen through practices which
were Royal College of Veterinary Surgeons (RCVS) farm accredited. The RCVS describe
farm accreditation as: For Farm Animal practices, the standards reflect both the requirements
of a primary care practice which promotes the achievement of high standards of clinical care,
and also a proactive approach to management, through the use of health planning, client
training and communication (RCVS, 2012 p.1).

Vets from English counties with high density, with more than 120,000 cows and more than
400 holdings; medium density, with between 20,000 and 119,999 cows and between 100 and
399 holdings; and low density with less than 20,000 cows and up to 99 holdings of dairy
herds were chosen using data from DairyCo (2013). It was hypothesized that these vets may
have different levels of knowledge on biosecurity and be engaged in giving biosecurity
advice to farmers to a greater or lesser extent. Relevant veterinary practices were identified
using the RCVS online registration list (RCVS, 2015). The practices were contacted by telephone to ascertain if they met the study criteria. From this screening process 16 practices in low density, 20 in medium density and 37 in high density areas were then asked if any of their farm vets would be willing to take part in the study and an information sheet and consent form was provided to interviewees prior to interview. Of the 28 vets who agreed to take part, 21 respondents were male and 7 female; 11 were male directors or partners, 10 were male assistants, 2 were female directors or partners and 5 were female assistants. Interviews were conducted in person and over the phone with individual veterinarians by AR over a four month period in 2014 and lasted between 40 and 75 minutes. An interview guide of prepared questions was used and the interviews were semi-structured so the same questions were asked but different lines of enquiry were also pursued based on the respondents’ answers. The interviews were recorded and transcribed by a third party and the transcripts were checked against the recordings for accuracy by AR. Ethical approval for the study was obtained from the School of Veterinary Medicine and Science at the University of Nottingham. Data was encoded to ensure anonymity and data and recordings were kept in a locked filing cabinet.

The topics covered in the interviews that were used for the analysis were the characteristics veterinarians relationship with their clients, their definition of biosecurity, farmer’s views on biosecurity, the main barriers to implementing better biosecurity on dairy farms, the role they played in biosecurity, what needed to change to enable vets to better support and advise farmers on disease prevention and their views on the greatest risks facing dairy farmers and vets.

**Data Analysis**
The analysis followed two main steps: first the data was coded using the qualitative data analysis software Nvivo 10.0 (QSR, International) by three researchers independently (AR, OS and JK). Data was coded using thematic analysis (Coffey and Atkinson, 1996). Coding involves categorising the data according to particular themes with sub-themes within these (Bryman, 2001). The codes used in this paper are the barriers that vets identified to implementing better biosecurity, described in the results section below. When a respondent mentioned a particular barrier it was coded under the same theme. The software allows the researcher to group chunks of interview texts that are coded for the same themes together and read them consecutively. Validity in qualitative research is assessed based on the force and soundness of the arguments presented (Polkinghorne, 2007), as well as the thoroughness of record keeping and reporting of methods in the study, and the re-coding and comparison of findings between researchers (Mays and Pope, 1995). To this end the coding was checked between the 3 researchers for consistency.

At the second stage the themes were explored using frame analysis (Virkki et al., 2014), exploring how the vets viewed the particular themes. To clarify the terminology used in this study: themes are particular barriers, such as financial barriers or lack of time, and frames are the ways in which these themes are discussed, or the angle that is put on them, for instance as legitimate, illegitimate, within or outside the farmers’ control etc. Frames were identified by reading through the codes and focusing on how that particular theme is described. Notes were then made about the framing of the themes and codes were re-read to make sure that the frames identified were accurate and nothing was left out. The third stage of analysis was grouping these frames under the theoretical framework described in figure 1 which were used in the discussion section. Data saturation was reached during the analysis. This is the point at which no new information is emerging from the data (Guest et al., 2006) – where the same codes are emerging from the data and the codes are being described in similar ways.
Results

Inadequate biosecurity as an individual problem

We will first explore how biosecurity is framed by vets as an individual problem – either the individual farmer or vet’s responsibility. When biosecurity is framed at an individual scale, farmers and vets are seen as responsible and capable of bringing about change and are viewed as individual decision makers with their own idiosyncrasies and circumstances. Table 1 shows a summary of results.

Farmers’ barriers

Financial Barriers

Vets viewed financial barriers as being very important to farmers, and described different kinds of financial barriers that farmers faced. Sometimes financial barriers were framed by vets as being “legitimate” and beyond the farmers control, and sometimes they were framed as more malleable and also a question of farmer prioritisation – the individual framing of financial barriers.

Within the individual frame, farmers were framed as unwilling to spend money on biosecurity, which the vet framed as a false economy and an example of bad practice by the farmer.

Vet 16: […] it’s just like, “Yeah, that’s a good idea”, and there’s a bargain that’s too good to miss and so biosecurity goes straight out the window.

Here biosecurity is framed as something that will save the farmer money but the farmer does not see this.
Vet 16: There’s some of them are just quite difficult to convince that spending money is the best way to stop losing money but they don’t see money they’ve lost. They just see the bill that arrived.

Here, a financial barrier is framed as something the individual could potentially do something about – financial barriers are framed as actually being due to a lack of understanding of the benefits of biosecurity or not prioritising biosecurity.  

*Not taking the time*

Time was cited by the vets as one of the barriers to farmers implementing effective biosecurity, as biosecurity was seen as by and large time consuming and incurring extra work. Similarly to the framing of financial barriers above, sometimes this was framed as a genuine case of time poverty on the farmer’s part, and sometimes as a question of the farmer not prioritising biosecurity – the individual frame.

Vet 19: I think barriers are the amount of efforts it takes, the amount of time it takes, so if they take a trailer to market they do clean it when it comes back but whether they clean it with anything other than a power wash or if they actually use a disinfectant is another question.

Here biosecurity was framed as something the farmer would “cut corners” on. When asked how biosecurity could be improved vet 6 stated:

Vet 6: Spend less on drugs, more on time. With some farmers that is still something they just don’t want to do.

When it is framed in an individual way, lack of time is again as framed as a lack of understanding – of the benefits of thorough biosecurity, and a lack of farmer motivation, farmers don’t want to spend time on biosecurity.
Lack of education?

Some vets saw a lack of education as a barrier: farmers lack knowledge of the biosecurity risks they face and they lack knowledge about the measures they should implement, and it is the vet’s role to provide information and education.

Vet 34: It’s just an educational thing. We’re trying to do it now on all our farm talks. You know just trying to bring it up, mention it all the time, so highlighting it and they come in every day to get various drugs and things we’ve put a big banner saying “Watch your biosecurity” and explain it.

This was not the consistent message from the data however. Other vets framed the issue not as a lack of education – farmers did know enough about biosecurity, but that they weren’t putting that knowledge into practice.

Vet 25: I think their knowledge is probably a lot greater than the, than the actions taken on it. I think a lot of them, if you were to sit them down and […] asked them what would you do to make your farm more biosecure? They could reel off a list of things and they’ve just got lots of other things to do and they tend to slip down the priority list.

Vet 18 is ambivalent about the value of education:

Vet 18: Well maybe we could give them more information about it, maybe that’s true if they knew more of the detail about it but whether that would, I’m not sure even then some of them would take the time to do it […]

Here the problem is framed again in terms of time, or more specifically, taking the time to carry out biosecurity measures, rather than an education deficit.

Levels of education and receptiveness of farmers to additional information or education were framed by the vets as highly variable between farmers.
Vet 17: No I mean again it varies on farm level really, some of them are very knowledgeable others aren’t, so it’s hard to generalise when there is such a large variability on the bottom line really.

It was often framed as something of a mystery, why some farmers listened to biosecurity advice and others didn’t, vet 13 stated “I would love to know the pattern, the secret of it all really”.

While vets could not necessarily identify patterns as to why farmers didn’t act, they framed one of the strengths and a vital part of their role as giving individual advice to farmers.

Vet 19: I think that vets need to know the farm as an individual because that is vital because then you can give the correct balance and bespoke advice.

The relationship vets built up with farmers were seen to make them well placed to get to know how to pitch advice.

Vet 32: I can tailor that to knowing the person’s character, knowing how seriously they take things, knowing whether they need more evidence, whether they need more anecdotes, whether they are interested in the price of it, what the drivers are, the motivators are, and that’s the fun in developing a relationship with your clients [...].

Thus many vets were ambivalent about the value of farmer education, as a lack of information might not be the real problem and additional information might not be taken on board. The real issues were framed rather as a lack of time or motivation. Farmers’ levels of knowledge and receptiveness to advice were framed as very variable and something of a mystery, but within this vets framed themselves as well placed to work with farmers as individuals with different needs and values.

*Individual vet barriers*
Vets interviewed generally saw themselves as having an important role in promoting good
biosecurity on the dairy farms they worked with. All of the vets appeared to be invested in the
biosecurity of their dairy farms, often expressing strong emotions including frustration that
they could not bring about more change. They identified several barriers in their own role in
improving biosecurity.

Lack of knowledge and cohesion

In a few, though not many cases, vets were framed as lacking sufficient knowledge on
biosecurity.

Vet 6: I think people just don’t feel comfortable sometimes with a mastitis problem,
“well they’re the mastitis vet in the practice, ask them, I’m the fertility one”. Sometimes
there is a perception that, “that’s not my area that I like” [...].

Somewhat more common was the idea of there being a lack of cohesion and consistency
among vets on what best practice is.

Vet 16: I suppose we have to preach the message better and collectively. Without being
too self-critical, we probably aren’t brilliant at it as a practice compared to if you ask
four people the same question you’ll end up with five answers.

This lack of cohesion was seen as leading to variations in practice which was seen as leading
to confusion for the farmer. Variation in veterinary advice and their perception of what is
important and effective also emerged during the interviews. For example, vet 41 stated he did
not recommend farmers always vaccinate for diseases not on the farm because it was not
good practice to “over vaccinate” cattle, whereas vet 44 stated that naïve herds should always
vaccinate for certain diseases. One vet framed this lack of cohesion in the veterinary
profession as difficult to address.
Vet 6: Farm animal vetting is a little bit individual, or maverick; you’re on your own in the car, they’re your clients – “don’t talk to my clients; these are my clients!” You could argue that there hasn’t been a culture of togetherness. It can be a bit like herding cats.

This lack of knowledge was also framed at times as the vet not seeking out new evidence but rather basing advice on anecdotal evidence of what has worked previously.

Vet 17: I think probably as vets we’re probably quite, I think farm vets in general are probably quite bad about keeping up with new research and new advice and you kind of get oh well this has worked for the last five years it’s going to work this time and you get stuck in your rut […].

This lack of cohesion and individual nature was at times framed as part of the job.

Vet 13: If you ask five individuals you may get five slightly different answers, I mean there would be some things obviously you would get the same answer but yes their take on things would be slightly different, but yes that’s just the nature of the profession really and our role here.

Here vet 13 frames differences of opinion as not necessarily being a problem, but a part of the vets’ role. We will return to this idea in the discussion.

Here vets’ role in biosecurity is framed as something they as individuals need to improve on, and vets’ collective individualism, as it were, is seen at times as something holding the profession back: vets are framed as individualistic and not trying to act as a cohesive group, which impairs their ability to improve biosecurity.

Not taking the time
Similar to the framing of farmers above, also framed the problem as them not taking the time to implement biosecurity measures.

Vet 25: And I think also vets, and I must say that I’m guilty of it, probably don’t set the best example of biosecurity when I go from farm to farm. You’re often in a hurry or a rush. You don’t disinfect everything properly with, “oh those overalls aren’t too bad, I’ll keep wearing those”.

There to be variation in the types and extent of biosecurity practices the vets undertook themselves on the farm, suggesting this is an individual framing. Other vets stressed the vital importance of their own biosecurity measures when entering a farm, to stop the spread of disease and because of the message it communicated to farmers:

Vet 37: I think never never taking the short cut not to wash your wellies thoroughly, is a key thing. So if farmers see vets not really taking the disinfection seriously then that doesn’t send a very good message.

**Inadequate biosecurity as an interpersonal problem**

This section will outline the frame of poor biosecurity as a problem located in the interpersonal relationship between the vet and farmer\(^1\). Certain aspects of this relationship and the interpersonal problem are seen to be within the farmer’s or the vet’s control.

**Differing values and perspectives**

The role of the vet in educating the farmer about biosecurity was framed in the interviews as not only about the vet giving the farmer additional *information*, but in terms of the vet imparting their *perspective* and *values* about biosecurity to the farmer. Some vets framed

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\(^1\) There are also other interpersonal barriers that emerged in the interviews, such as vets’ views on how relationships between farmers are, between farmers and government officials, and between farmers and industry bodies seen to aid or hinder biosecurity practices. But this is beyond the scope of this paper, which focuses primarily on the role of vets in on-farm biosecurity.
farmers and vets as having different values and priorities around biosecurity. Vets framed farmers as having a higher tolerance for the presence of disease on their farm than the vet had. Vet 44 speaks in the farmers’ voice to explain the idea that disease issues in and of themselves were not always seen as a problem:

Vet 44: “[…] yes my BVD bulk milk is higher okay, but actually my cows are really well, they’re milking better than they’ve ever done and yes I have losses there but, which I don’t see, I can’t perceive them *per se* […] but actually in general my farm is working quite well. So therefore it isn’t broke do I fix it?” We will try and educate them as they should be doing because they can be better again.

The farmer is framed as having a different way of assessing disease problems to the vet and the vet tries to educate the farmer to come around to his way of seeing things. The phrase “if it isn’t broke don’t fix it” was used by vets on several occasions to express the farmers point of view. Whereas for the vet, disease problems indicate that something *is* broken and needs fixing.

The vet also tried to educate the farmer by trying to change their perspective on how controllable disease problems were. When asked who farmers tend to blame for a disease outbreak many vets stated that there was no “blame culture” in farming and farmers often attributed it to luck and the vagaries of farming.

Vet 19: They could take more control. They could take more steps about it, so if it happens they just tend to blame bad luck and “that’s farming for you”, sort of, attitude.

Whereas vet 19 sees disease problems as controllable and would prefer if the farmer came around to this way of seeing it in order to take control of the situation.

*Role of the vet on the farm*
Vets also stated that many farmers did not fully understand the benefits of regular contact with the vet. Vets viewed regular contact with the client and the development of a functioning, trusting relationship as essential for improving biosecurity.

Vet 25: I think it’s not understanding the input and benefits that having a regular visit and a good relationship with your vet brings about.

For some the lack of contact was connected to the “test and treat” model where farmers only called the vet out when there was a problem, to cure individual sick animals.

Vet 12: Unfortunately I think the huge majority of our farmers are still in, sort of test and treat mode and therefore you know they are most likely to engage with what they should do to prevent BVD when they’ve got BVD.

It was also stated the vets themselves also struggled to make the move from a “test and treat” view of their role to a “predict and prevent” role. It was stated that vets did not take a holistic preventative approach to disease prevention, and it was framed as an area vets needed to improve on.

Vet 12: We’re also a profession, I think that’s got to look at itself and say “I think a lot of the failings in what you want to discuss today of biosecurity, have got to be pointed hard at vets really.”[…] whether it’s looking at something like BVD and just saying “oh well just vaccinate and forget about it”, you know.

This theme about the changing nature of the veterinary profession and how vets are managing this is covered in more detail in a recent paper using the same data (Ruston et al., 2016).

**Communication barriers**
One of the most common barriers identified by vets related to communication issues on biosecurity: they or other vets were described as not trying hard enough to communicate about biosecurity issues or not communicating effectively.

The issue of not communicating well enough came in several forms: the vet wasn’t explaining things well enough, wasn’t giving compelling enough reasons, wasn’t targeting his arguments to the farmer or wasn’t engaging in joint decision making with the farmer.

Vet 7: [...] so if you work on the premise that you know if somebody does something wrong generally it’s because you haven’t explained yourself well enough rather than the fact that that’s a stupid farmer, you know I don’t see many stupid farmers but I do find plenty of farmers where people haven’t taken the time to explain well enough to them that perhaps a better way might be beneficial.

The idea that “farmers don’t like being told what to do” came across clearly. The idea that joint decisions between farmer and vet were the best kinds of decisions was frequently expressed in the data.

Vet 20: You have to see them [farmers] as a partner because if you don’t, you’re not going to take them along with you.

This issue was also often traced back to the farmer’s response and was framed as farmers not picking up on their messages about biosecurity and so vets would become frustrated and would stop trying to communicate. The phrase “banging my head against a brick wall” was used on several occasions.

Vet 17: Probably more because I just can’t cope with doing it again, sometimes I mean if you’ve told them a lot of times and they’ve kind of dismissed you then sometimes you do go I’m not going to bother because they’ll just get annoyed about me doing it again, but a lot of it is I just can’t face the discussion again [...].
Here vet 17 implies that the vet-farmer relationship will suffer if he brings it up again because the farmer will get annoyed. The main impediment to effective communication on biosecurity is framed as being the farmer, and the vet is unable to overcome the farmers’ disinterest and loses heart.

Thus interpersonal barriers within the vet-farmer relationship of differing values and perspectives on biosecurity, the relationship not being used as it could be to prevent rather than just treat disease problems, and a lack of effective communication between farmers and vets were framed alternatively as a problem the vet or the farmer was responsible for.

**Inadequate biosecurity as a contextual problem**

When biosecurity was framed as a contextual problem, it is seen as an issue that resides within the larger environment vets and farmers operate in and largely outside of the control of individual vets and farmers to change. We will explore this frame in terms of social environment and physical environment.

**Social environment**

**Financial barriers**

As well as being framed an individual barrier, described above, financial barriers were also framed as residing in the wider environment farmers operated within. The investment costs of biosecurity measures, such as improving housing to reduce animal overcrowding, were seen by some vets as prohibitive.

Vet 20: So, yes, money’s not the only thing, it’s an important thing. But it probably comes into the “You should do this, you should split these cattle off.” “We don’t have the buildings.” “Why don’t you have the buildings?” “We don’t have the money”. “You should get on and vaccinate all these... however often.” “We don’t have the time. We don’t have the manpower”, all comes back to money I suppose.
Thus while the individual framing of financial barriers framed the real problem as being the farmer not understanding the importance of spending money on biosecurity, or not being motivated to, here the financial barriers are framed in some sense as more “legitimate” and outside the farmer’s control. Vets also stated that farmers forego expenditure on veterinary services when they are under financial pressure, which vets framed as a significant challenge to their effective involvement with the farmer. Vets stated that the downward pressure on milk prices and loss of farmer income reduced the farmers’ ability to invest in biosecurity.

Vet 20: […] when I first graduated I saw a lot of improvements in cattle welfare and investment and then with downward pressure on prices over the years it certainly hasn’t advanced, there’s a lot more pressure on cows and livestock these days, simply because of the pressure on prices […].

At other times financial barriers were framed as something closer to a market failure where farmers are not adequately compensated for measures which benefit the public good as well as their own.

Vet 44: […] if someone achieves BVD accreditation why can’t they get, where’s the added value to them? So they’ve spent all that money done that work, some will say the added value to them is that their animals are healthier but they take them to market and they get the same price as the bloke who’s selling a BVD animal next door […].

Thus the contextual framing of financial barriers located the financial barrier to improving biosecurity as largely outside of the farmer’s control: farmers did not have the resources for biosecurity measures because of current economic conditions in the milk industry, and there was a market failure in the dairy industry which did not create financial incentives to improve biosecurity.

Lack of time
Lack of time was also framed as something outside of the farmer’s control. One vet linked lack of time to difficult financial pressures on the farmer:

Vet 44: Are they going to isolate a milking cow till they’ve got it vaccinated? You know that’s four weeks apart plus a week let’s say, that’s five weeks of isolation feeding that cow separately it’s just the work involved and I think, I mean obviously dairy prices, milk prices well they come down three pence but you know they’re being quite good but historically they’ve been bad for quite a while so what’s gone off farms? Labour, it’s the first thing they can ditch. You know so they do more themselves, they work longer hours, they haven’t got the labour or manpower to go round and so all these so they’re going to buy cows that need milking they’re going to put them in the milking herd […].

Time was also framed as an issue impeding the effectiveness of the vets’ role in biosecurity. In contrast to the individual and interpersonal framing, here the issue of a lack of time was generally framed as something outside of an individual vet’s control. It was rather a feature of their job that they had other more immediate tasks to attend to than discussing disease prevention and biosecurity and undertaking this role effectively. Vet 6 stated that vets often did not have the time to engage with farmers on disease prevention work as the “bread and butter” work of treatment and testing got in the way. Vet 32 stated he did not have time to document the actions taken on farms as this would severely limit his ability to get clinical work done. Vet 13 stated that vets often did not have time to explain disease control issues fully to the farmer. When the issue is framed in this way it is rather seen as something that needs to be tackled in the veterinary profession as a whole if vets are to become more effective in improving biosecurity, a subject which is dealt with at greater length in Ruston et al. (2016).

*Lack of biosecurity culture*
Though vets framed farmers at times as idiosyncratic individuals, the vets interviewed also almost unanimously viewed dairy farmers as a whole as being poor at implementing biosecurity measures. The most common answer to the question of what proportion of the farmers they dealt with maintained good biosecurity was 5-10%. At times this overall poor biosecurity was framed in terms of a lack of biosecurity culture: eight of the vets compared the dairy sector unfavourably with the pig sector, which was seen as having a culture of very tight biosecurity practices, which vet 4 called “a whole different world”.

Vet 42: In terms of, there’s probably only one guy I can think of who will insist that you dip your boots before you go onto his farm. […] Whereas we have some pig clients and it’s just, the mind-set is incredibly different.

Here the problem is framed as that of the farmer’s mind-set, or a collective mind-set or attitude which does not prioritise biosecurity in the dairy sector.

**Physical environment**

**Logistical barriers**

At other times, this overall, sectoral biosecurity issue was framed not in terms of a different mindset, but as due to practical, logistical barriers. Practical barriers included the physical layout of the farm which was not always seen as conducive to biosecurity practices, as vet 50 states in relation to isolating new animals:

Vet 50: The main issue I see with dairy clients is that they are buying in animals to join the dairy herd and it is not always possible for them to quarantine the animals and also test before they arrive on the farm so that can be an issue, and they have not necessarily got a place where they can house them separately and milk them separately.
Here the problem is framed as being outside the farmer’s control, and is related to the issue above that farmers also often do not have the money to invest in buildings that are more conducive to good biosecurity.

The fact that dairy cows graze means that they have exposure to wildlife and to other cattle, which is seen as difficult for the farmer to control. One vet compared the dairy sector to the pig sector, and highlights how the outdoor nature of the dairy production means it is inherently more difficult to make biosecure.

Vet 49: How do you biosecure a river or a stream? If that was the case or wild birds, which as a freak example could have picked up some contaminated material and dropped it on the farm so that is very hard to control again.

Thus a dairy industry wide barrier was framed as a question of biosecurity culture and/or logistical issues.

Discussion

To the authors’ knowledge this is the first paper that provides an in-depth analysis of vets’ views on biosecurity on dairy farms. The use of a social ecology perspective on health promotion explored through frame analysis in this paper allows for an exposition of how inadequate biosecurity is framed as a different kind of problem requiring different kinds of solutions at the individual, interpersonal and contextual scale. In this section we will draw out the implications of these frames and compare our results to previous literature.

Individual Barriers
When inadequate biosecurity is framed at an individual scale, farmers and vets are seen as individual decision makers with their own idiosyncrasies and circumstances. This individual frame characterises the problem of inadequate biosecurity as, to a certain extent, within the individual vet or farmer’s control to change. The individual barriers within this frame were farmer’s financial barriers; vet and farmer lack of time; a potential lack of knowledge among some farmers; and lack of knowledge and cohesion among vets. Farmer’s lack of time, money and knowledge were framed as fundamentally due to a lack of motivation.

As highlighted in the introduction, previous studies have found lack of time (Sayers et al., 2013; Hall & Wapenaar, 2012) and money (Palmer et al., 2009; Lowe, 2009; Ellis-Iversen et al., 2010; Derks et al., 2012; Sayers et al., 2013; Alarcon et al., 2014) as barriers to farmers implementing biosecurity measures. It is difficult to directly compare the findings of these studies to our analysis as they do not use the same framework of different scales of barriers. Ellis-Iversen et al. (2010) state that farmers did not see a financial benefit from investing in biosecurity – similar to the individual frame identified in our study, and did not have the profit margin to invest – similar to the contextual frame used in our study. Vets also highlighted these issues in previous studies (Gunn et al., 2008; Sayers et al., 2013; Pritchard et al., 2015). Gunn et al. (2008) found vets thought clients were not willing to invest in biosecurity – the individual frame used in this study, and could not afford to invest in biosecurity – the contextual frame.

There has been uncertainty in the literature about lack of knowledge among farmers as an important determinant of implementation of biosecurity on farms, reflecting the uncertainty expressed by vets in this study. Some studies have suggested that lack of knowledge about biosecurity was an important reason why farmers did not implement biosecurity measures.
(Pritchard et al., 2015; Sayers et al., 2013; Toma et al., 2013). However other work in the UK (Hall and Wapenaar, 2012) and the Netherlands (Jansen et al., 2010) suggest that farmers thought they had, or did have, knowledge to implement disease control.

Previous research has also reported vets not giving consistent advice and having heterogeneity in clinical beliefs on effectiveness of strategies for disease control (Higgins et al., 2014). Though it was not the most commonly cited reason in the interviews for heterogeneity in veterinary advice, it has been pointed out that this might be partly explained by a lack of evidence on the effectiveness of different veterinary interventions on farm (Higgins et al., 2014). A study by Anderson (2010) found variation in the biosecurity practices taken by vets on farms, and overall low levels of uptake of biosecurity measures.

Thus, interestingly, while farmers are often framed as having idiosyncrasies and being reluctant to change, vets were also seen this way, as vet 6 described the difficulties of getting vets to change their practice and the advice they gave.

When vets framed barriers in individual terms they often voiced a certain amount of confusion and pessimism about biosecurity. Farmers were framed as a collection of disparate individuals and it was difficult to identify patterns across their behaviour. However, within this frame there were still seen to be ways to improve biosecurity measures on farms. Change could be brought about gradually over time through positive contact with the vet, as vets are well placed to get to know individual farmers, a point which has been reiterated in the literature (Atkinson, 2010; Higgins et al., 2013). Vets’ diversity and individualism is also seen by vets as part of their role as identified by vet 13. This has previously been pointed out by (Higgins et al., 2013) in treatment of footrot and by Enticott (2012) in relation to how bTB testing protocols are applied by vets on the ground and demonstrates how the situated nature of veterinary work means that any protocols or guidelines must allow a large leeway for
veterinary interpretation and application. In this respect, a certain amount of variation in veterinary practice is seen as normal and healthy given the very individual and relational nature of farmer-vet interactions.

Framing barriers in individual terms puts the onus on the individual to make change (Shove, 2010). In political terms, this resonates with how animal disease is framed in some policy literature; the 2004 Animal Health and Welfare Strategy (AHWS) states “The primary responsibility for the health and welfare of animals rest with their owners” (Defra, 2004 et al., p.12). The AHWS set out a plan for less government involvement in on-farm disease prevention and a greater emphasis on the role of individual farmers and vets, and the industry to bring about change. Enticott (2014) uses the term “biosecurity citizenship” to refer to this perspective (p.133). The individual framing also accords with neoliberal government policy in recent years in around agriculture – of less government support for agriculture, vets having a smaller public sector role and spending cuts on animal health services (England Advisory Group on Responsibility and Cost Sharing, 2010; Enticott et al., 2011; Woods, 2011; Enticott, 2014). With the exception of bTB, which is seen by some as a special case because it is a zoonosis and its historical significance (Carslake et al., 2011), the government in England, where this study was carried out, is not pursuing any ambitious farm animal disease eradication programs, in comparison to state sponsored programs in Scotland, Wales and Northern Ireland (Boden et al., 2015). However, the other framings below suggest that vets do not see biosecurity only as an individual problem, and other approaches are also needed to effectively improve biosecurity.

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2 Collective action on biosecurity is however being promoted by industry bodies in the UK. In England the industry body the Cattle Health and Welfare Group (CHAWG) is leading mass biosecurity campaigns, with Defra as a contributor (CHAWG, 2016), including the extension of a BVD eradication scheme from Wales and Scotland to England (AHDB Dairy, 2015).
Interpersonal Barriers

Barriers framed as existing at the interpersonal scale consisted of issues within the farmer-vet relationship. In this study vets highlighted differing values and perspectives between vets and farmers on biosecurity; communication problems around biosecurity; and a problem in moving from a “test and treat” to a “predict and prevent” model of veterinary involvement. Surveys of vets’ opinions have restated the view that the vet will give up trying to communicate with farmers about biosecurity because of a belief that farmers are not interested in biosecurity (Gunn et al., 2008; Sayers et al., 2014). The point made by vets that they would benefit from more training communication and persuasion is also recommended in the literature, particularly in relation to joint decision making with farmers (Mee, 2007; Lowe, 2009; Jansen et al., 2010). The reasons why the vet would not see the farmer as often as he or she would like was often seen as due to certain farmers being wedded to the “test and treat” model of veterinary intervention and not appreciating the need to move to the ”predict and prevent” model, a point which is reiterated in the literature (Lowe, 2009; Hall & Wapenaar, 2012; Orpin & Sibley, 2014). Similar the views expressed by vets in the interviews, it has been pointed out that some vets may also be operating within the “test and treat” model and there have been calls for reform of the veterinary profession (Lowe, 2009; Kaler and Green, 2013; Woods, 2013), which is described in greater length in (Ruston et al., 2016).

An important finding from this study which adds to our understanding of communication issues between farmer and vet was that the vets’ role in educating and giving advice to farmers was not only seen to be about communicating information but about the vet trying to convince the farmer of their perspective and values around disease control. This issue will be
dealt with in more detail after the section on context, as understanding the contextual frame is relevant to understanding this difference in framing.

When barriers are framed as existing at the level of the interpersonal barriers, the relationship between vets and farmers is seen as not operating as well as it could to improve biosecurity. Within this, different aspects of this relationship are seen as within the control of different parties: the farmer has control over how often they see the vet, but the vet has a certain amount of control over if and how they communicate about biosecurity.

Contextual Barriers

Social Environment

Barriers to implementing biosecurity measures were also framed by vets as operating at the scale of the social context, including the economical, socio-cultural, legal and political environments vets and farmers worked within (Stokols, 1992).

The framing of “no biosecurity culture” in the dairy sector, with farmer seen as having little interest in biosecurity and little social pressure from other farmers to make change, resonates with the findings of Heffernan et al. (2008) who found there to be little group cohesion or appetite for collective action in the cattle and sheep farmers in the UK. Similarly, the idea of there being no “blame culture” around biosecurity accords with the findings of Enticott (2016) that farmers in New Zealand view luck as an important determining factor of their bTB status.

Financial barriers were also framed by vets as a collective as well as an individual issue facing dairy farmers. The public goods nature of biosecurity has been highlighted in the past, with calls for this to be recognised and compensated by industry and government (England Advisory Group on Responsibility and Cost Sharing, 2010), as vets in this study called for
more financial incentives for selling cows with high disease status. The economic conditions
dairy farmers operated within, especially low milk prices has previously been reiterated in
interviews with farmers as a barrier to better biosecurity in relation to zoonotic control
programs (Ellis-Iversen et al., 2010).

Here, in contrast to the individual frame, farmers and vets are framed as a group, with
common patterns identified across biosecurity barriers. At the moment there was a feeling
among vets that group norms in the dairy sector are not conducive to good biosecurity and the
economic conditions facing the dairy industry are more difficult for dairy farmers as a group
to influence.

**Physical Environment**

While the biosecurity culture in the dairy sector was often compared unfavourably with that
in the pig sector, cattle farmers have emphasized the constraints imposed on them by the
physical context they work within: the farm geography, technology and infrastructure
(Enticott and Vanclay, 2011). An appreciation of the contextual features of biosecurity which
are to some extent beyond individual farmers’ and vets’ control is important for coming to
terms with biosecurity (Enticott, 2008). Enticott (2008) stated that because of the open nature
of dairy farms and uncertainty about the effectiveness of measures, many farmers maintained
that disease risks could not be influenced on their farm, but a more systematic approach,
badger culling in the case of bTB, was needed. Vets in this study did emphasise the physical
contextual barriers to better biosecurity, and the only thing vets appeared to agree on was the
heterogeneity of the physical environment on farms and the need for farm-specific
approaches, which vets were well suited to adapt their advice to. However, if vets emphasise
the context scale frame too much this may downplay their role and potential to intervene in
biosecurity, and they stress that there is always a certain amount that can be done in each context.

Using the social ecology perspective, one can compare the point that the physical context of the farm makes biosecurity very difficult for some farmers, to the point made in relation to obesity that some environments are more or less conducive to promoting good health – so-called “obesogenic” environments can make it difficult for people to maintain a healthy weight (Lake and Townshend, 2006). This raises two points – about the limits of the individual and interpersonal frames to improve biosecurity on current farms, and for the need to have a discussion in the wider debate about what an ideal dairy sector would look like in the context of biosecurity – what is a “biosecurogenic” dairy farm? The dairy sector is currently mostly characterised by open, fluid farm systems, but is compared unfavourably with the superior biosecurity in the more closed, self-contained pig sector. These comparisons with the pig sector surely require more thought, given the substantial and important differences between the two sectors. And a discussion may need to focus on good biosecurity within a multiplicity of dairy farm types, different imaginings of “biosecurogenic” environments.

**Conflicting frames**

According to the vets in this study, and in other literature, vets and farmers may take a different view of how effective biosecurity can be within the physical constraints on the farm. The vets in this study stated that farmers do not always take responsibility for biosecurity and there is no “blame culture” in the dairy farming sector over disease. Here farmers can be seen to be framing biosecurity barriers as existing at a contextual scale – biosecurity is an issue related to the open nature of dairy systems which the farmer inherently has little control over.
Because biosecurity was not seen by farmers as entirely controllable, vets often stated that farmers had a higher tolerance for disease status on their farm than the vet would prefer: they may be aware that they have a disease issue on their farm but they may still resist treating it as the vet advocates. According to the vet some farmers may see some level of disease problems as a normal part of dairy farming. The vet sees the farmer as operating with their own meaning of “good enough, not broke” biosecurity.

Within the interpersonal vet-farmer relationship the vet tries to convince the farmer that a disease problem means that something is broken and needs fixing and that it is possible to fix it. They try to reframe the issue to the individual or interpersonal scale. This is also the frame that is promoted by government and others (Defra et al., 2004): biosecurity is poor but the farmer and vet acting together can have an impact on biosecurity. According to vets, the farmer is resisting both of these messages. The farmer may not have the power to convince the government or vets of their framing of the issue: that biosecurity is adequate for their current purposes or in any case difficult to influence given their current situation, but they do have the power not to pay for the vet’s disease prevention services or take the vet’s advice, and to ignore the messages from government. Thus vets express frustration that their message about better biosecurity is not being listened to and they do not see the farmer enough.

This analysis focused on the role of vets, and their perception of farmers’ role, and did not touch on the role of industry and government in biosecurity, which present further ways of considering biosecurity. These could be important given the public goods nature of biosecurity benefits (Sibley, 2010). Another limitation of the study is that qualitative methods do not provide information on the prevalence of views among a particular group but rather aim to explore the meanings around a topic in depth. In addition frame analysis does not tell
us whether vets’ views on biosecurity are correct or incorrect, but rather it gives us
information about the different ways in which vets view the situation.

Conclusion

We can take three important points from this discussion. Firstly, biosecurity barriers, often
the same barriers, were framed by vets in different ways that define the problem differently
and offer different solutions. Biosecurity can be tackled at the scale of farmers’ individual
barriers, vets’ individual barriers; the interpersonal relationship between farmers and vets;
and at the scale of the social and physical context they operate within. Vets’ influence was
mostly seen to be at the individual and interpersonal level, they had little perceived control
over the context they and farmers operated within. But even at the individual/interpersonal
levels vets felt they were struggling to make the impact they would like to.

Secondly, vets framed themselves and farmers at times as idiosyncratic groups of individuals
that lacked cohesion. For farmers this was seen to be because their attitudes could be very
different and they all had a different physical context on their farm. Vets expressed
exasperation about the diversity of views and situations, but also framed themselves as well
placed to work with individual farmers and build up a relationship over time. Heterogeneity
among vets was viewed as good or necessary to the extent that vets face different
circumstances and will need to tailor advice to each farmer, but in a negative light to the
extent that it inhibited the spreading of best practice and painted the veterinary profession as
lacking consistency.

And thirdly, vets’ role in education and advice giving was seen to be not only about
information but communicating their perspective and values on biosecurity to farmers. In
order to increase their relevance to on-farm biosecurity, vets may be operating with the
individual and interpersonal frames of biosecurity: disease control is possible and worthwhile
through a good interpersonal relationship between farmer and vet, and the farmer taking individual responsibility for biosecurity measures. The farmer, according to the vets in this and other studies, may be emphasizing the *contextual* frame of biosecurity that sees barriers as operating at the sectoral, geographical and logistical level. They downplay the individual frame and their control on biosecurity. Both frames are legitimate in some sense, but it means that vets and farmers may be talking past each other through using these different frames. Thus the analysis suggests a need to step back in the wider debate and within the vet-farmer interaction and ask “barriers to what?” – how could shared goals and understanding around what “good biosecurity” means be created? Many suggest that joint decision making between farmer and vet is needed, and that an important and often missing step on biosecurity is the process of vets listening to farmers and the setting of mutual goals (Atkinson, 2010). Within the wider debate we could ask what “good biosecurity” should look like in a future dairy sector? More research and discussion is needed on these questions if barriers are to be tackled.
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Figure 1 Framework for analysis and interpretation of data

Thematic analysis of qualitative data on biosecurity

Exploration of themes using frame analysis

Grouping of frames into scale frames based on the social ecology framework

Individual frames  Interpersonal frames  Contextual frames
Table 1. Vet respondents’ framing of farmer and vet barriers to implementing better biosecurity in the dairy sector.

<table>
<thead>
<tr>
<th>Scale frame:</th>
<th>Individual barriers</th>
<th>Interpersonal barriers</th>
<th>Contextual barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial</strong>: farmer not prioritising biosecurity – making false economies.</td>
<td>Differing values and perspectives: farmer does not problematize disease on the farm. Farmer does not take control of it. Vet sees disease problems as more “problematic” than farmer. Wants farmer to take control of them.</td>
<td>Time: farmers do not have enough time to implement biosecurity measures. Vets do not have enough time to adequately deal with biosecurity.</td>
<td>Logistical: Farmers do not have adequate facilities and infrastructure for biosecurity. Logistical: Dairy farms are open systems – hard to regulate flows of disease.</td>
</tr>
<tr>
<td><strong>Time</strong>: farmer not prioritising biosecurity – not taking the time. Vet not prioritising biosecurity – not taking the time.</td>
<td>Role of the vet on the farm: Farmer does not make adequate use of vet’s services. Vet wants to see farmer more regularly. Farmer wedded to “test and treat” model of veterinary intervention rather than “predict and prevent” model. Vet wedded to “test and treat” model of veterinary intervention rather than “predict and prevent” model.</td>
<td>Financial: farmer does not have the money to invest/spend on biosecurity – linked to milk prices Market failure – not enough market reward for good biosecurity.</td>
<td></td>
</tr>
<tr>
<td><strong>Farmer knowledge</strong>: some farmers do not have enough knowledge on biosecurity. Some farmers do have enough knowledge but are not motivated to implement it.</td>
<td>Communication</td>
<td>Lack of biosecurity culture: collective mentality among farmers does not recognise the value of biosecurity</td>
<td></td>
</tr>
<tr>
<td><strong>Vet knowledge and cohesion:</strong> Some vets are not well enough informed on biosecurity. Vets are also not working together adequately to share knowledge.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 1. Summary of frameworks used in veterinary epidemiology studies of biosecurity.

<table>
<thead>
<tr>
<th>Authors and year</th>
<th>Title</th>
<th>Theoretical framework</th>
<th>What was studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garforth et al. 2006</td>
<td>Farmers' attitudes towards techniques for improving oestrus detection in dairy herds in South West England</td>
<td>Theory of Reasoned Action</td>
<td>Attitudes (outcome belief and outcome evaluation); and subjective norms (subjective belief and motivation to comply).</td>
</tr>
<tr>
<td>Heffernan et al. 2008</td>
<td>An exploration of the drivers to biosecurity collective action among a sample of UK cattle and sheep farmers</td>
<td>A socio-psychological approach. Attitudes are made up of cognitive and affective factors. Attitudes and contextual factors drive behaviour</td>
<td>Attitudes toward individual vs. group behaviour; attitudes towards existing biosecurity regulations; and perceptions of threats/emotive factors.</td>
</tr>
<tr>
<td>Gunn et al. 2008</td>
<td>Measuring and comparing constraints to improved biosecurity amongst GB farmers, veterinarians and the auxiliary industries</td>
<td>Framework based on Theory of Reasoned Action</td>
<td>Attitudes (outcome perception and importance of outcome); and subjective norms (referents and importance of referents).</td>
</tr>
<tr>
<td>Ellis-Iversen et al.</td>
<td>Perceptions, circumstances and</td>
<td>Social ecology model using Theory of</td>
<td>TPB – Attitudes; normative beliefs; and beliefs in self</td>
</tr>
<tr>
<td>Authors (Year)</td>
<td>Description</td>
<td>Framework/Model</td>
<td>Motivators and Factors</td>
</tr>
<tr>
<td>---------------</td>
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</tr>
<tr>
<td>Alarcon et al. (2013)</td>
<td>Pig farmers’ perceptions, attitudes, influences and management of information in the decision-making process for disease control</td>
<td>Theory of planned behaviour</td>
<td>TPB – Attitudes (outcome belief and outcome evaluation); subjective norms (subjective belief and motivation to comply); and perceived behavioural control (control belief/self efficacy and power of control).</td>
</tr>
<tr>
<td>Garforth et al. (2013)</td>
<td>Farmers’ attitudes to disease risk management in England: A comparative analysis of sheep and pig farmers</td>
<td>Developed own framework from TPB and TRA and literature on animal health</td>
<td>Exposure to sources of information; attitude to animal disease risk; previous experience; knowledge/awareness of practices; attitude to practices; social influences; inertia/habit; perceived farm constraints; and perceived ability to implement practice.</td>
</tr>
<tr>
<td>Valveeva et al. (2011)</td>
<td>Perceived risk and strategy efficacy as motivators of risk management strategy adoption to prevent animal diseases in pig farming</td>
<td>Framework based on health belief model (HBM)</td>
<td>HBM – Perceived susceptibility to disease occurrence; perceived benefits of action; and perceived severity of disease impact. Additional factors – cues to action (past experience with animal disease); internal risk exposure; risk attitude; and self-protection behaviour.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planned Behaviour and extrinsic factors</td>
<td>efficacy; and extrinsic circumstances – community and industry; culture and society; and knowledge, skills and ability.</td>
</tr>
</tbody>
</table>