Implementation of Vaccination Strategies on British Dairy Farms: Understanding Challenges and Perceptions

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"If you aren't in over your head, how do you know how tall you are?"

T. S. Eliot

For my Grandparents

Abstract

This PhD thesis aimed to identify the motivators and barriers of farmers and veterinary surgeons to the implementation of vaccination strategies on British dairy farms.

There is no universal cattle vaccination schedule in Britain, therefore vaccination decisions are made on a farm by farm basis, however there is a paucity of research investigating the decision-making behind dairy cattle vaccination. Twenty-four semi-structured interviews were carried out with dairy farmers and fourteen with veterinary surgeons. The transcripts were subject to thematic analysis which generated five key themes from each of the interview studies.

Farmers and vets perceive vaccines to be an effective and useful tool to control and prevent disease on British dairy farms and are motivated to vaccinate cattle if there is evidence of disease on-farm, or a perceived risk of disease entering a farm. Challenges to cattle vaccination chiefly arise from differences in how risk is perceived by vets and farmers, and farmers' potential lack of awareness of their herd's disease status. Enhancing the relationship between farmers and vets is therefore crucial to optimising vaccination decision-making. In order to optimise implementation of vaccination strategies further research including farmer vaccination compliance, vaccine efficacy, methods of communication and risk perception is needed. This will support creation of a practical vaccination strategy, and could provide a basis for national collaborative disease control strategy.

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Abbreviations

BCG: Bacillus Calmette-Guérin

BCoV: Bovine Coronavirus

BNP: Bovine Neonatal Pancytopenia (Bleeding Calf Syndrome)

BRD: Bovine Respiratory Disease

BRSV: Bovine Respiratory Syncitial Virus

bTB: bovine tuberculosis

BVA: British Veterinary Association

BVD: Bovine Viral Diarrhoea

CAQDAS: Computer-Assisted Qualitative Data Analysis Software

Defra: Department for Environment, Food and Rural Affairs

DOI: Duration of Immunity

FEI: Fédération Equestre Internationale

HOC: Heather M. O'Connor

HPV: Human Papilloma Virus

IBR: Infectious Bovine Rhinotrachetis

IFR: Imogen F. Richens

JK: Dr Jasmeet Kaler

MLB: Dr Marnie L. Brennan

MMR: Measles, Mumps and Rubella

NFU: National Farmers Union

NHS: National Health Service

NICE: National Institute for Health and Care Excellence

NW: Dr Nick Wright

OIE: World Organisation for Animal Health

PHW: Dr Pru Hobson-West

PI: Persistently Infected

PI3: Parainfluenza type 3 Virus

RCVS: Royal College of Veterinary Surgeons

RUMA: Responsible Use of Medicines in Agriculture

RVC: Royal Veterinary College

SPC: Summary of Product Characteristics

VMD: Veterinary Medicines Directorate

WHO: World Health Organisation

WSAVA: World Small Animal Veterinary Association

WW: Dr Wendela Wapenaar

A note on terminology

Throughout this thesis the more colloquial term ‘vet’ to is used to stand for veterinary surgeon. This was done to improve readability and to reflect the term most used by the interviewees in this study.

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1.1. Vaccination

1.1.1. History of vaccination

Smallpox appears to be the catalyst for the evolution of a practice known as variolation into the mass vaccination we know today. Variolation is thought to have been around for around 2000 years, originating from East Asia. Variolation was the technique of inducing mild cases of smallpox using material from smallpox lesion, thereby inducing immunity. The practice had been widespread in Britain for around 100 years prior to Edward Jenner's inoculation of James Phipps with cowpox in 1796. In 1840 the practice of variolation was made illegal and smallpox vaccination became free of charge for all, becoming compulsory in 1853 (Fine, 2014).

The success of mass vaccination has often been heralded as one of the greatest medical achievements of all time. Arguably with good cause; as a result of vaccination smallpox was declared eradicated worldwide in 1980 (WHO, 2015b), rinderpest was declared eradicated worldwide in 2011 (OIE, 2015) and in 2014 only three countries remained endemic with poliomyelitis (WHO, 2014).

Arguably as a result of this success, there have been vaccines developed for the control of a large number of viral, bacterial, fungal and parasitic pathogens across multiple species (WHO, 2015c, NOAH, 2015). Although this achievement should be celebrated, it also creates a dilemma for vaccination decision-makers. As a result of the number of vaccines available it could be claimed it is impractical to suggest that all vaccines available for a species should be administered to all individuals of that species. Vaccination decision-making could be described as having two components. Firstly, there is the question of choosing to vaccinate or not. Following this, a decision needs to be made regarding which vaccines should be administered, how they should be administered, and to whom.

Decision-making around vaccination can be supported through the use of vaccine schedules, protocols and guidelines. Vaccine schedules are lists of advised vaccines and encompass which vaccines should be administered and when, for example the human NHS vaccination schedule (NHS, 2014). The term protocol can be used to describe the directions for the administration of an individual vaccine, for example the dose, route and timing of administration. This information is present on the vaccines' Summary of Product Characteristics (SPC). Industry or professional body vaccination guidelines could potentially encompass both vaccine schedules and protocols in order to optimise vaccination (Day et al., 2010).

In Britain human vaccination policy is determined by a combination of committees and departments within the Department of Health and the National Institute for Health and Care Excellence (NICE). Policy is partially influenced by objectives established by the World Health Organisation (WHO) for the attainment of specific coverage levels and elimination of certain diseases. Further to these objectives, decisions are based on disease surveillance, economic analysis and mathematical modelling as well as taking into account safety and efficacy concerns (Salisbury et al., 2002). Many vaccines are available free of charge through the National Health Service (NHS) and can be grouped into three categories; the childhood vaccination schedule, vaccines for at-risk populations such as pregnant women or people with long term health conditions and travel vaccinations. There are also other vaccines such as yellow fever and rabies that are generally only available privately. Childhood vaccines and those for at-risk populations are considered to be core vaccines. The pathogens included in the core vaccination schedule may change over time, for example the recent inclusion of human papilloma virus (HPV) vaccine for 12-13 year old girls and the exclusion of the Bacillus Calmette-Guérin (BCG) vaccine for tuberculosis (Gordon et al., 2007, Markowitz et al., 2012). These schedules are determined by Public Health England. A patient or parent must still decide whether to vaccinate or not; no vaccine is compulsory. However, these vaccination schedules serve to act as guidance for health care professionals, patients and parents to inform the second part of vaccination decision-making; which vaccines should be administered and to whom.

In a veterinary context, in Britain, there is no NHS or NICE equivalent and the routine health care of animals is undertaken by veterinary surgeons in private veterinary practices which, although united in their goal to improve animal health and welfare, are not guided by a policy maker with regards to vaccination. As such there are no overarching policies where vaccines are recommended to be used, nor does there appear to be a universal goal for the use of vaccination. As with human health, no vaccine is compulsory and the animal owner must decide whether to vaccinate or not, however decisions must also be made as to which vaccines are administered to which individuals by vets and the owner of the animals. In companion animal medicine there is some guidance to aid vaccine schedule decision-making (Day et al., 2010) that could be equated to the overarching human vaccination schedule and this is discussed further in Section 1.1.2. For cattle vaccination schedules no such overarching guidance exists and therefore vaccination schedules between each farm are likely to be more variable.

Vaccination in veterinary and human contexts is discussed in greater detail below. These sections also include discussions around the literature investigating attitudes towards vaccination, vaccine schedules and the relationship between doctors and their patients and vets and their clients.

1.1.2. Vaccination in a veterinary context

<u>Biosecurity on cattle farms</u>

Cattle vaccines, although widely used (Cresswell et al., 2014), are not the only infectious disease control tool, nor are vaccines 100% effective (Hatton, 1990). The use of vaccines should therefore not remove the need for optimal biosecurity and management practices on farms.

The term biosecurity is often used synonymously with the concept of disease prevention and control throughout the literature. Despite discussion in the literature around stakeholders’ understanding of the term and the implications of this (Brennan and Christley, 2013, Pritchard et al., 2015), the term 'biosecurity' is used in this literature review interchangeably with disease prevention and control.

There are a number of biosecurity practices that are perceived to be useful by cattle farmers. These include isolating sick animals; maintaining a closed herd i.e. a herd in which no animals are brought or hired in from external sources; management of visitors and vehicles, and regular pest control (Brennan and Christley, 2013). However, even when a practice is perceived to be useful it is not always implemented. This apparent cognitive dissonance may be linked to a concept discussed by Brennan and Christley (2013) in their interview study of British cattle farmers' attitudes towards biosecurity; that a perceived lack of control over a situation or a perception something is not within a farmers' capabilities results in inaction.

Farmers' attitudes towards biosecurity

In contrast to the paucity of literature investigating attitudes towards cattle vaccination, there have been a number of studies investigating farmers' attitudes towards biosecurity, both in general and towards specific biosecurity related practices.

One method of describing farmers' perceptions towards biosecurity that has been used is to group farmers into defined 'types' of farmer according to their attitudes. An interview study by Kristensen and Jakobsen (2011) classified farmers into four groups, based on their perceptions of biosecurity;

Cooperatives, Confused, Defectors, and Introverts. Kristensen and Jakobsen (2011) suggested communication around biosecurity should be tailored differently to each of these groups of farmers.

A focus group study of farmers’ attitudes towards biosecurity identified both positive and negative perceptions toward the outcomes of implementing biosecurity (Gunn et al., 2008). The positive outcomes included improved profits, increased cattle health and welfare and professional pride. The negative factors included the financial and time costs of implementation, increased bureaucracy and a lack of faith in the efficacy of measures. Gunn et al. (2008) identified the association of disinfection and externally imposed behaviours as negative definitions of biosecurity. These associations are supported by Brennan and Christley (2013) in their study of cattle farmers’ perception of biosecurity. It was suggested that this was a result of the foot and mouth disease outbreak in 2001, causing farmers to associate the term biosecurity with disinfection, enforced measures and an emotional and stressful period in British farming history. In addition, the definition and understanding of biosecurity may be disease and context dependent (Brennan and Christley, 2013), for example farmers in certain areas of Britain may associate biosecurity with bovine tuberculosis (bTB) (Enticott and Vanclay, 2011).

Ultimately farmers’ attitudes towards biosecurity, as well as their behaviour are influenced by a number of complex and varied factors (Toma et al., 2013) and is likely to vary between farmers (Kristensen and Jakobsen, 2011).

The role of the vet in biosecurity on cattle farms

Vets are a key source of information for farmers on disease prevention and control and this is supported by the literature (Cresswell et al., 2014, Brennan and Christley, 2013, Gunn et al., 2008). Therefore this suggests that investigating vets' attitudes towards disease control is important in order to understand their advice to farmers and their role in disease prevention and control on cattle farms.

Gunn et al. (2008), in addition to focus groups with farmers, conducted a questionnaire study of vets investigating their perceptions of biosecurity constraints. Vets responding to the survey perceived that cattle and sheep farmers were not willing to, could not afford to, or were not interested in, implementing biosecurity measures. Vets did not see themselves as information sources on biosecurity to farmers, something that contradicted the farmers' responses. It was concerning that around a third of cattle vets felt that practising vets had no interest in and insufficient knowledge of biosecurity measures. Respondents to the questionnaire also raised concerns about the efficacy of biosecurity measures and a lack of public policy on biosecurity. Gunn et al. (2008) suggested that the lack of adoption of biosecurity measures is due to a lack of knowledge transfer to both farmers and vets. If the stakeholders involved were aware of the efficacy and economic benefit of these practices then farm-level biosecurity would improve.

However, recent work investigating cattle vets' awareness and understanding of biosecurity appeared to contradict these findings. A questionnaire-based study of cattle vets concluded that knowledge and awareness were not a limitation to vets offering advice on biosecurity; the limiting factor instead appeared to be a lack of time set aside to specifically discuss biosecurity with farmers (Pritchard et al., 2015). Interestingly, the vets in this study did feel that biosecurity measures were useful. This apparent contradiction could indicate that in the period of time between the studies knowledge transfer on biosecurity to vets has improved. Another explanation for this discrepancy could be that vets sampled in the study by Pritchard et al. (2015) did feel more informed than those in the study by Gunn et al. (2008) as the studies sampled two different populations. The vets in both studies did appear to agree however, that farmers' lack of knowledge and understanding was a reason that farmers did not undertake on-farm biosecurity measures. Interestingly, the vets surveyed by Pritchard et al. (2015) placed financial reasons for non-implementation lower than the vets in the Gunn et al. (2008) study. Both Pritchard et al. (2015) and Gunn et al. (2008) discuss the importance of effective communication between vets and farmers in relation to implementation of biosecurity practices. Gunn et al. (2008) discusses that although farmers highlighted vets as an important source of advice and information, vets did not see themselves as providers of this information and some vets did not feel their practices had the resources or expertise to be able to provide support to their clients. In addition, a concern about efficacy and practicality may contribute to a reluctance to discuss or advise biosecurity measures. Pritchard et al. (2015) suggests that miscommunication between vets and farmers and a general lack of time on the vets' part may result in a lack of implementation of biosecurity practices on-farm.

Twelve percent of cattle practitioners advised their clients on vaccination and worming as biosecurity measures (Pritchard et al., 2015). This appeared to be a low percentage given how widely cattle vaccines are used (Cresswell et al., 2014). This low percentage also appeared to contradict what vet students reported they had heard vets discuss with farmers whilst on Extra-Mural Study placements (Pritchard, 2010). Although only 38% of students had heard vets discussing biosecurity protocols in general with clients, the most commonly reported protocol that was heard to be discussed was vaccination and worming (80%). This maybe suggests that vets do not consider vaccination to be a biosecurity protocol, and the fact that it appears to be rarely discussed with clients, points to a need for further research into how vets perceive vaccination and why they do, or do not, advise its use to their clients.

Vaccination was cited as an important biosecurity measure by farmers in a focus group study by Gunn et al. (2008), but there was no discussion in the report as to why certain measures were perceived to be important. It may be that the apparent popularity of vaccines among cattle farmers (Cresswell et al., 2014) is that they are a tool that is perceived to be both useful and within a farmer's capabilities to implement and therefore they are implemented.

However, in the current literature, there appears to be limited evidence to support this hypothesis, when applied to vaccination.

The literature would suggest that biosecurity measures are implemented on British cattle farms, though uncertainties about their efficacy, perceptions of lack of interest and ineffective communication between vet and farmer may be constraints to their implementation. This suggests that further work is required to understand attitudes towards vaccination and its role on cattle farms, and to understand the role of the relationship between vets and farmers in the implementation of vaccination strategies on farms.

Veterinary vaccination

Vaccination in veterinary medicine is commonplace with vaccines licensed across multiple species (Table 1) (NOAH, 2015).

Table 1 Number of vaccines registered in the UK and number of pathogen species for which a vaccine is registered per species (NOAH, 2015)

Species	**Number of vaccines listed**	**Pathogen species encompassed by the available vaccines**
Poultry	52	15
Pigs	37	14
Cattle	36	17
Dogs	32	10
Chickens	27	13
Cats	24	7
Horses	18	7
Sheep	19	11
Turkeys	5	4
Fish	5	3
Pigeons	3	2
Goats	2	2
Ferrets	2	1
Rabbits	1	2

There have been vaccines used in veterinary medicine for many years and for many species vaccination has become part of the normal management of owning animals (McVey and Shi, 2010).

Cattle vaccination

For cattle, there are 36 vaccines for 17 bacterial, viral, fungal and parasitic species registered (Appendix 1).

Veterinary medications are assigned a legal category based on who is permitted to prescribe and supply them. For vaccines the most important are Prescription-only medicine- Veterinarian (POM-V) and Prescription-only medicine- Veterinarian, Pharmacist, Suitably Qualified Person (POM-VPS). These medicines can only be prescribed by a veterinary surgeon that has carried out a clinical assessment of the animal under their care (POM-V) or, by a vet, pharmacist or suitably qualified person who does not need to clinically assess the animal (POM-VPS).

With endemic diseases ongoing in Britain for which vaccines exist, vaccines are a key tool used by farmers and vets. Vaccines can also be used in the control of exotic cattle diseases, for example during recent bluetongue and Schmallenberg outbreaks. In the case of exotic disease outbreaks decision-making and policy for disease control is undertaken by the Department for Environment, Farming and Rural Affairs (Defra). During an exotic disease outbreak or national vaccination campaign farmers and vets are likely to be the people implementing the control strategies. This means that the advice given by and to them needs to be consistent and applicable. Variation in the advice given to farmers as well as the advice given to vets about control policies was of concern during a recent bluetongue outbreak (Cross et al., 2009). Following the foot and mouth disease outbreak in 2001 there was uncertainty in the media and general public as to vaccination decision-making (Breakwell, 2003). There is likely to be a level of uncertainty surrounding exotic disease and new vaccinations but how this uncertainty is managed and communicated is paramount (Fish et al., 2011). Uncertainty, or a lack of information, is something that appears to make vets uncomfortable (Cresswell et al., 2013). It is therefore important to understand drivers and concerns towards vaccination from farmers and vets so that in times of uncertainty they can be supported appropriately.

Cattle vaccination schedule decision-making

For cattle there are guidelines for the responsible use of vaccines from the Responsible Use of Medicines in Agriculture Alliance (RUMA, 2007), however these guidelines are not commonly used as a source of information by farmers (Cresswell et al., 2014).

As there is no universal 'British cattle vaccination schedule', decision-making around which vaccines to implement is currently performed on an individual farm by farm basis at the level of the farmer and their vet. There are articles that give guidance for how to decide which vaccines are most suitable for the farm in question. One article is aimed at farm animal veterinary surgeons and was published in a clinical journal (Paton, 2013). The second is a government report on decision-making behind vaccine implementation on organic cattle and sheep farms (VEERU, 2003). Both articles agree that not all vaccines can or should be given to all cattle; therefore decisions must be made about which vaccines are most appropriate for which farms. These decisions are based on the farm's current disease status and the risks of disease entering the farm. Paton (2013) also discusses the need to take into account the farmer's needs, drivers and risk perception. Practical outcomes of the report by VEERU (2003) were temporarily available (www.destvac.reading.ac.uk). One concern highlighted by VEERU (2003) in relation to a decision support tool developed as part of their report was a lack of national disease prevalence and incidence data. It was felt that this reduced the value of the tool as the apparent lack of data hinders the development of evidence-based decision-making.

Guidelines published in New Zealand for leptospirosis vaccination (Heuer et al., 2012) state that the decision to vaccinate for leptospirosis is the prerogative of the farmer, and their goals and objectives for the use of leptospirosis vaccination should still be established. However, although leptospirosis vaccination was not compulsory there was the potential for farmer litigation if any workers or family contracted the disease. The report advises the 'best practice' guidelines for leptospirosis vaccination in various situations; high and low risk and an outbreak situation.

When compared to companion animal and human vaccination the absence of an agreed upon vaccine schedule appears to be unusual. It is possible that the concepts applied to companion animal and human vaccination cannot be applied to the vaccination of production animals due to differences in the policies, stakeholders and attitudes towards vaccination in each of these populations. These differences will be further explored in the following sections on vaccination in each population.

Farmers’ attitudes towards cattle vaccination

When compared to the literature investigating attitudes towards human vaccination there is a distinct paucity of literature investigating attitudes towards veterinary vaccines.

A survey by Cresswell et al. (2014) found that cattle farmers’ main motivators to vaccinate their cattle were to reduce losses, following veterinary advice, and to control disease. Reasons for not vaccinating included no perceived problem, negative test results, cost and having a closed herd. There has been research investigating Dutch and German farmers’ motivators and barriers to vaccinating their stock for bluetongue (Elbers et al., 2010b, Gethmann et al., 2015). These were both questionnaire-based studies conducted to investigate the uptake of bluetongue vaccine, as well as farmer reported motivators and barriers to vaccination. These studies were conducted following a compulsory vaccination scheme in Germany and a subsidised vaccination campaign in the Netherlands. Motivators for farmers in these studies to vaccinate their stock included the prevention of losses, ability to export and a good experience with the vaccination campaign up to that point. Motivators not to vaccinate included a perception of reduced risk of disease and the cost of the vaccine. Although these studies provide insight into farmers’ vaccination decision-making they are grounded in an exotic disease situation and it is possible these decisions are different to those involved in implementing vaccines for more common endemic diseases in Britain. It is also possible that German and Dutch farmers have different motivators and barriers to vaccinating their stock than British dairy farmers, potentially due to variations in the relationships with government, disease risk and geographical and industry differences between countries.

In relation to endemic disease, there has been work investigating farmers' willingness to pay for a hypothetical bTB cattle vaccine. Bennett and Balcombe (2012) concluded that farmers had a substantial willingness to pay for such a vaccine. From this conclusion one could hypothesise that this indicates farmers would be motivated to use the vaccine, if such a vaccine was available, however the situation posed to the participants in the study was a hypothetical one as no such vaccine currently exists for use in Britain.

Due to the nature of the studies by Cresswell et al. (2014), Bennett and Balcombe (2012), Elbers et al. (2010b) and Gethmann et al. (2015), participants were unable to expand fully on their answers or the researchers to fully understand the reasoning behind the decisions. Further research can help to fully understand the decision-making, motivators and barriers of stakeholders behind cattle vaccination. This understanding can be used to support farmers and to optimise the implementation of vaccination strategies on farms.

In both companion animal medicine and human medicine many of the diseases commonly vaccinated for are rarely encountered. Polio has been eradicated from all but three countries globally (WHO, 2014) and since the introduction of the combined measles, mumps and rubella (MMR) vaccine in the late 1980’s outbreaks of measles are rare (Jick and Hagberg, 2010). Since the mass vaccination of dogs and cats there has been a dramatic decline in the diseases included in the dog and cat vaccination schedules in Britain (Day, 2011). Many of the diseases people and companion animals are vaccinated for can have devastating consequences. Thanks to the success of mass vaccination many people are now rarely exposed to these consequences. Lack of experience with the consequences of the diseases we vaccinate for has been identified as a possible barrier to vaccination of people. The risk or consequence of side-effects (e.g. autism) is perceived as greater than the risk or consequences of contracting the disease (e.g. death or encephalitis resulting from measles) (Yarwood et al., 2005, Burgess et al., 2006). In contrast many of the diseases that British farm animals are vaccinated for are endemic and widespread (NADIS, 2014) and so it is likely that many dairy farmers will have some experience of them, either on their own farm or on a colleague’s farm.

Adverse reactions to vaccination are not unheard of in cattle. These range from mild swelling at the injection site to more severe reactions such as anaphylaxis (NOAH, 2015). Severe adverse reactions attributable to vaccines have resulted in a vaccine available in Britain being withdrawn by the European Medicines Agency (Bastian et al., 2011). Despite this there is no evidence for anti-vaccination sentiment among British dairy farmers.

Vets' attitudes towards cattle vaccination

There is limited published research investigating veterinary surgeons' attitudes toward vaccination. Cresswell et al. (2013) used a discussion group to investigate the attitudes of a group of farm animal veterinary experts toward cattle vaccination. The study found that there was variation in vaccination advice between participants when presented with the same scenario. One of the major concerns of farm vets related to farmers compliance with storage and administration instructions of vaccines. The concern that farmers' compliance with vaccine storage and administration instructions is not optimal is supported by Meadows (2010), who identified poor compliance of farmers with relation to use of a vaccine for a common endemic disease in Britain.

Companion animal vaccination

Of all the veterinary vaccines the factors surrounding vaccination of companion animals such as dogs, cats, rabbits and horses in Britain could be most likened to the vaccination of people, especially children. The patient is generally presented as an individual by an owner and the aim is to protect the individual and vaccinate a sufficient number of individuals to confer population protection. There are vaccines perceived to be 'core' for dogs, cats and horses with other vaccines used only for at-risk populations for example, dogs that travel abroad, outdoor cats and horses that attend shows. For example, in equine vaccination all horses that compete in International

Equine Federation (FEI) competitions must be vaccinated for equine influenza (FEI, 2012).

Companion animal vaccination schedules

There are no compulsory vaccines for dogs or cats in Britain, except for rabies when travelling to other countries. The core vaccines are well established and most practices use the same protocols with some variation between different manufacturers- mostly with regards to the licensed timing of primary vaccination courses (NOAH, 2015). The core vaccines generally used are multivalent and are administered subcutaneously. In recent years there has been a move to reduce the number of vaccine components administered annually in both canine and feline protocols as the duration of immunity (DOI) has been shown, for some components, to last three years. There are international guidelines for the vaccination of dogs and cats. These cover the antigens, protocols and location of administration of vaccines (ABCD, 2012, Scherk et al., 2013, Day et al., 2010). Their development was prompted by concerns surrounding reports of severe vaccine related adverse reactions (Duval and Giger, 1996, Hendrick et al., 1992). It was found however, that the guidelines differed from each other, as well as from the vaccine’s datasheets (Dean et al., 2012). There are also concerns about the evidence base surrounding the creation of these guidelines, with limited information surrounding the methods used to develop them. This has resulted in confusion amongst the veterinary profession about the most appropriate vaccination protocols for cats and dogs in the UK and the schedules routinely used in feline vaccination in Britain are not consistent with these guidelines (Dean et al., 2012).

The schedules used in human vaccination in Britain are very prescriptive for which vaccines should be used and when. They are also readily available and accessible for both patients and practitioners. The guidelines for dog and cat vaccines are international and therefore need flexibility as not all pathogens are considered ‘core’ in all countries. They do, however, provide a reasonably rigid structure an owner or vet can adhere to. Although it has been found that awareness of the guidelines in Britain is likely to be low (Dean et al., 2012) most vaccine manufacturers use similar protocols and most dogs and cats are vaccinated for the same pathogens. The information on routinely used vaccines in Britain is easily accessible to veterinary surgeons through the SPC available for each vaccine.

No medicine is without risks and vaccines are no exception. Examples of potential adverse reactions listed on the SPCs of veterinary vaccines include mild swelling at the injection site, transient pyrexia and anaphylactic reactions. The incidence of these range from common- for mild swelling and pyrexia, to rare- for anaphylactic reactions (NOAH, 2015). Until recently there appeared to be little or no anti-vaccine culture amongst animal owners, however there has been debate about companion animal vaccination within the veterinary profession for years (Day, 2006). In the mid-1990’s there were concerns surrounding reports of vaccine related immune mediated haemolytic anaemia in dogs (Duval and Giger, 1996) and feline injection site sarcomas (FISS) in cats (Hendrick et al., 1992) . Concerns were raised about the aluminium-based adjuvants in some feline vaccines causing FISS. It is unknown if this potential link was a barrier to owners getting their dog or cat vaccinated but there certainly are vocal opponents of vaccination (Townsend, 2013).

The evidence for causality of these adverse events is poor and the incidence of FISS is very low (Dean et al., 2013). However, the resultant debate surrounding the potential over-vaccination of dogs and cats has been beneficial (Hendrick, 2011). The debate and production of the guidelines has prompted pharmaceutical companies to increase the DOI reported on certain SPCs for some vaccines (Dawson, 2007) and the development of vaccines without adjuvants (Merial, 2015).

<u>Attitudes towards companion animal vaccination</u>

There has been recent concern about anti-vaccination feelings extending to the pet owning population of the United States of America following the recent measles outbreak (Khamsi, 2015). There has been limited research investigating the attitudes of animal owners toward vaccination from which hypotheses could be drawn to explain the apparently increasing anti-vaccination movement.

To explore their attitudes toward vaccination Habacher et al. (2010) conducted a web-based questionnaire of cat owners. Important factors in cat owners' decision-making were found to be their perception of the severity of vaccine preventable diseases, experience of having unvaccinated cats with infectious disease and veterinary advice. A key factor described for owners being less likely to vaccinate their cat was the importance they placed on the stress to the cat of taking it to the vet and the importance placed on the cost of vaccination. Although Habacher et al. (2010) found little evidence of anti-vaccine sentiment in their online questionnaire of cat owners; other research has found that there are sources on the internet perpetuating anti-vaccine arguments (Townsend, 2013). Reasons found that pet owners do not vaccinate their animals include lack of trust in the veterinary surgeon, concern about adverse effects, use of alternative medicine and general issues with vaccines (Townsend, 2013). The lack of trust and importance of veterinary advice supports the importance of communication and the vet-client relationship.

1.1.3. The vet-client relationship

<u>Vet-farmer relationship</u>

The vet-farmer relationship has been investigated in an area of farming that is linked to disease control and prevention; the use of herd and flock planning. Kaler and Green (2013) used focus groups to explore sheep farmers' perceptions of their vets' role on their farm and Hall and Wapenaar (2012) used questionnaires to investigate differences in opinions of vets and dairy farmers to herd health management. In the study by Kaler and Green (2013) sheep farmers generally perceived their vet to be a 'fire-fighter', someone called in to help during a disease outbreak or emergency. Other than this, the main role in which vets were used as was an advisory service, with this advice being given free of charge. Some farmers accepted the vets' role in flock health planning, but vets were generally not perceived to have sufficient knowledge about sheep farming and this was a barrier to their use in this regard. Veterinary input was also perceived to be costly by the participants. The study concluded that there was an impasse in this potentially beneficial relationship; farmers perceived vets to be costly and lacking the required expertise however, it was apparent few farmers kept sufficient records and accounts to be able to understand how involving a vet in flock health management may benefit them. This study suggests that although there is potential for there to be a productive relationship between sheep farmers and vets, the barriers to this are currently too great to be overcome without a significant culture change from both parties.

Conversely, in a study investigating the differences between dairy farmers' and vets' perceptions of herd health management Hall and Wapenaar (2012) found that although there were differences in how farmers perceived the role of the vet on farm and what vets perceived their role was, the relationship was a positive one. The study highlighted differences between vets and farmers in their preferred way of how a vet should approach the farmer in terms of communication style. Another area of interest was a concern that although farmers valued discussions with their vet, only a small proportion of vets appeared to instigate discussions. The study by Hall and Wapenaar (2012), although potentially reflecting a more positive relationship between vet and farmer than Kaler and Green (2013), stresses the importance of effective communication between stakeholders when discussing herd health and production management.

Farmers identify vets as their preferred information source on vaccination (Cresswell et al., 2014) as well as other disease control topics (Brennan and Christley, 2013, Garforth et al., 2013). Applying the lessons learnt from human research, discussed later in this chapter, and from other areas of veterinary research it can be expected that the relationship and communication between farmers and vets is of crucial importance in vaccination decision-making. This may be especially important in the farm animal situation due to the apparent lack of guidance by other bodies aside from RUMA and the pharmaceutical industry on implementing cattle vaccination.

Vet-owner relationship

The relationship between a pet owner and their vet has inherent differences compared to that of a farmer and their vet, especially if the interaction around the time of vaccination is considered. A pet owner generally presents their cat or dog to the veterinary practice for a consultation where a vaccine is administered by the vet. It is likely that all cats and dogs presenting to that veterinary practice receive the same, or a similar, vaccine schedule. This consultation is traditionally an annual visit allowing a general health check, discussion of other preventative veterinary care and an opportunity to discuss any general concerns an owner may have (Robinson et al., 2015) and is probably more akin to the interaction between a patient or parent and their doctor.

Habacher et al. (2010) found that as the importance placed on the vet's advice increased, so did the likelihood of a cat's vaccinations being up to date. This highlights the importance of the vet-client relationship. Dawson (2007) discusses the importance of client choice in vaccination consultations in the light of the World Small Animal Veterinary Association (WSAVA) Guidelines. Although the farmer-vet relationship may be different from the companion animal owner-vet relationship, this research demonstrates that effective communication between a vet and their client is important and warrants further investigation in order to be able to support both parties in their decision-making.

1.1.4. Human vaccination

The goal of vaccination in human medicine is to protect the individual and in doing so protect sufficient individuals to create a population immunity. The ensuing reduced infection pressure partly protects individuals who cannot be vaccinated.

Attitudes to human vaccination

Much of the research investigating attitudes, beliefs and behaviours relating to human vaccination appears to be based around the concepts of risk and trust (Hobson-West, 2007). Risks of disease are weighed up against risks of side effects and trust in healthcare professionals and the government. Anti-vaccine advocates and other parents also affect the vaccine decision-making of parents and patients. These concepts, as well as the lessons learnt by researchers and practitioners can be applied to the veterinary industry (Yarwood, 2006). By appreciating the motivators and barriers to people choosing to vaccinate themselves and their children, we may start to understand motivators and barriers to vaccinating animals. Many of the studies discussed in this section are qualitative in nature.

The decision-maker in human vaccination will change depending on which of the three groups of vaccines are being considered. Firstly parents are making decisions about vaccinating their baby, toddler or child. Whereas the vaccination of older children and teenagers may include the child in the decision (Gowda et al., 2012). The vaccination of adults encompasses vaccines for travellers, at-risk groups and students. In these cases the decision belongs to the individual being vaccinated.

On the surface human vaccination seems simple from a patient's point of view. The pathogens and protocols used are predetermined by the government and committees; they are administered by a health care professional at a local doctors' surgery, school or pharmacy and are free of charge. There has, however been a wealth of research investigating the attitudes of a number of populations towards vaccination- most notably of parents in the aftermath of the combined measles, mumps and rubella (MMR) vaccine controversy (Brown et al., 2012, McMurray et al., 2004). This trigger for an increase in research in this field does not seem to have occurred in the veterinary vaccination field despite concerns surrounding adverse events associated with veterinary vaccines (Bastian et al., 2011, Hendrick et al., 1992).

The long history of the success of vaccination has been troubled with a long history of anti-vaccination, a movement which gained momentum following the introduction of compulsory smallpox vaccination and crossed Victorian social class boundaries (Bellaby, 2003). Much of the anti-vaccine sentiment of recent decades is often blamed on the now discredited link between the MMR vaccine and adverse effects such as autism and inflammatory bowel disease and seems to be directed at childhood vaccinations. The resultant decline in MMR vaccination has culminated in a resurgence of occasional measles outbreaks both in Britain and overseas (Public Health Wales, 2015; Zipprich et al., 2015). Despite this, the prevalence of vaccine preventable diseases have dropped dramatically since the advent of mass vaccination in Britain (Fine, 2014). Possibly linked to this decline are the concerns that have been raised about the number of vaccines children receive (Kennedy et al., 2011). There has also been concern about the components of vaccines. This suggests that not only is the decision to choose to vaccinate a child often emotional as well as practical, but there are also decisions to be made about each individual disease. For example, there has been opposition to the recently introduced HPV vaccine for girls. This opposition is not based on the addition to the schedule or the ingredients (although there are concerns about them within the generic anti-vaccine debate) but based on HPV being a sexually transmitted disease. There has been concern that vaccinating young teenagers for HPV may lead to increased sexual risk taking. There has been no evidence that this is the case (Mayhew et al., 2014) and advocates for the vaccine are heralding the advent of the first vaccine for a type of cancer. However, the concerns about HPV vaccination illustrate that decision-making surrounding vaccination, and certainly childhood vaccination, can be a complex process. Coupled with these issues is that mass vaccination campaigns could be perceived as a victim of their own success. Many of the core diseases have been consigned to the British history books; with polio eradicated from most of the world and the perception that measles, mumps and rubella are common childhood conditions is now something of the past. This means that most people have never experienced cases of these diseases and so perceive the risks to be low. If the risk of disease is low then any risks of the vaccine, and there is always a risk with any medication, become more important and more concerning to parents (Yarwood et al., 2005, Burgess et al., 2006). The anti-vaccine movement in human medicine has some public and vocal supporters and it is sometimes the case in situations such as this that they who shout loudest are believed (Leask and McIntyre, 2003). Public advocates of the anti-vaccine movement and the circulation of myths and misconceptions surrounding vaccination mean that effective communication between a patient or parent, and their health care professional is vital (McMurray et al., 2004).

Doctor-patient relationship

A trusting relationship between health care professionals and patients or parents is a prerequisite to effective communication and choosing to vaccinate. Benin et al. (2006), in a qualitative interview study of new mothers, identified trust in the doctor was a main promotor in accepting vaccination. Satisfaction with discussions around vaccination and a perception that their paediatrician was able to fully answer any questions helped to foster this trust. Those parents who chose not to vaccinate their children, despite apparently desiring a trusting relationship with a doctor, expressed feelings of alienation and a lack of trust in information from doctors, and had sought advice and guidance elsewhere. Health care professionals are seen as important sources of information on vaccination (Kennedy et al., 2011) and as Gellin et al. (2000) and Yarwood et al. (2005) argue, there are a number of opportunities for discussion around vaccination with different health care professionals over time. This highlights the importance of effective communication between health care professionals and parents, including the allowance of time to answer parents' questions and discuss any concerns they may have, in building a trusting relationship (Benin et al., 2006).

The paucity of literature investigating attitudes towards veterinary vaccinations, and cattle vaccines in particular means that one can only hypothesise that the concept of risk perception and the importance of a trusting relationship and effective communication between farmer and vet are important factors in veterinary vaccination decision-making and that vaccination decision-making itself is complex. Further research is needed to understand challenges to and perceptions of cattle vaccination and to untangle the decision-making behind it in order to optimise the use of this valuable disease control tool.

1.2. Study approach and methodology

1.2.1. Methods used to investigate attitudes towards veterinary vaccination and disease control

The methods used by researchers to investigate farmers', owners' and vets' attitudes towards disease control and vaccination often rely on quantitative, epidemiological methods such as the structured interviews used by Brennan and Christley (2013) or the questionnaires used by Gethmann et al. (2015), Elbers et al. (2010b), Cross et al. (2009), Pritchard et al. (2015), Cresswell et al. (2014), Habacher et al. (2010) and Gunn et al. (2008). Although questionnaires are useful for attitudinal research they are not able to collect the in-depth and rich data that qualitative methods such as interviews are able to elicit (Bryman, 2012b).

Qualitative studies have been undertaken in this field; for example although Gunn et al. (2008) used a questionnaire to collect vets attitudes towards biosecurity practices, focus groups were used to collect farmers' attitudes. Cresswell et al. (2013) utilised a discussion group to explore vets' vaccination advice and perceptions of farmer compliance with vaccine administration and storage instructions. The advantage of a focus group or discussion group as used by Cresswell et al. (2013) is that the rich data collected, in the absence of other research providing insight to the topic investigated, provides a starting point for future research.

As discussed in the section on human vaccination (page 24), qualitative research has been widely used to collect and understand attitudes, behaviours and beliefs surrounding human vaccination. These methods are not at the exclusion of the use of more quantitative questionnaires used to assess the frequency of opinions, as demonstrated by the long term survey tracking attitudes to childhood vaccinations by Yarwood et al. (2005). The use of surveys allowed the attitudes of a large, nationally representative sample of mothers to be collected over a period of 10 years. Something that potentially would have been difficult if the researchers had used a qualitative research approach.

The reliance on questionnaires in the veterinary sphere appears to be at odds with the more qualitative methods used by researchers in the human vaccination field. This could be due to the fact that qualitative research is fairly novel in veterinary research and researchers are more comfortable using more traditional methods such as questionnaires. It could also relate to the fact that, until recently, there has been no apparent need to investigate attitudes towards vaccination while there has been a need in human vaccination to better understand attitudes toward vaccination following the MMR controversy.

Lessons learnt from the human medical field would suggest that if aiming to understand how and why people behave and make decisions it is imperative to understand their motivators, barriers and attitudes toward that behaviour or topic. It is also a requirement to investigate these using a method and philosophy that allows the collection of rich and detailed data allowing participants to frame their responses by what is important to them. Qualitative research appears to be the optimal way of doing this and a further discussion of how its use would be beneficial to furthering the field of research into attitudes towards cattle vaccination is presented in Section 1.2.2 below. However, given the apparent shortage of research investigating farmers' attitudes towards vaccination it would be prudent to extend the review of methods into research investigating farmers' attitudes to other related topics. This need for further information on attitudinal research prompted the instigation of a rapid review of the literature investigating farmers' attitudes towards cattle production. This review is presented in Chapter 2.

1.2.2. Qualitative research

Qualitative research is concerned with the meanings of the people being researched, and in understanding their view of the world (Britten et al., 1995). It is well suited for an in depth investigation of vets' and farmers' behaviour, perceptions and opinions as it allows participants to explain thoughts and opinions in their own words. Qualitative research is not as concerned with explaining or measuring data in terms of quantity or frequency as quantitative research.

In an editorial in a leading veterinary journal there has been a recent call for the increased use of qualitative methods in veterinary research (Christley and Perkins, 2010) similar to that in the medical world over 15 years previously (Black, 1994). Both medical and veterinary researchers discuss that qualitative research has been broadly overlooked by the mainly quantitative outlook of these research fields. Qualitative research can be complementary to quantitative research. This could be by identifying the variables important to the population being studied prior to a quantitative survey (Glanz et al., 2013, Elbers et al., 2010a), or by expanding on areas identified by a quantitative study (Duncan et al., 2012). Christley and Perkins (2010) advocated qualitative research as part of a mixed methods approach, and state that qualitative research is of interest to practicing clinicians as it “enables us to study what is important to our clients”. Black et al. (1994) proposed that “some situations are inevitably beyond the scope of quantitative methods but could be investigated more appropriately by qualitative ones”. An example of this is a study by Page-Jones and Abbey (2015) who used qualitative, narrative research to investigate the career identities of veterinary surgeons. The rich and detailed data in this study could not have been collected using a questionnaire, for example.

Both editorials discuss the qualitative research methods that should be used for data collection. However what they are lacking is highlighted by other qualitative researchers (Attride-Stirling, 2001, Millar, 1997)- a discussion of the epistemological and analytical decisions that must also be made. This is needed to emphasise that qualitative research encompasses more than a method of data collection, just like quantitative research encompasses more than surveys or laboratory techniques. Qualitative research includes the philosophical, epistemological and ontological basis of the research, the theories or frameworks that may underpin the research and the analysis that is applied to the collected data.

1.2.3. Sampling and sample sizes

In quantitative research the aim of sampling is often to provide a large, random sample of the study population to minimise bias and ensure the results are generalizable to the population. Although this probability sampling can be used in qualitative research the more commonly used technique is purposive sampling. Previous qualitative work studying farmers and vets have used a form of purposive sampling (Heffernan et al., 2008, Enticott and Vanclay, 2011, Moore et al., 2000), however there have been a number of different types of purposive sampling described (Bryman, 2012c). These subtypes of purposive sampling all aim to strategically sample with direct relevance to the research question. This may require ensuring there is maximum variation between participants in the area being studied (maximum variation sampling); sampling of typical individuals within certain subgroups (stratified purposive sampling) or ongoing sampling to refine the theories generated when using Grounded Theory (theoretical sampling).

The point at which data collection ceases in qualitative studies is determined by the concept of data saturation. Data saturation is the point at which no new information is being generated by continued sampling however it is a contested and debated topic. In richly researched areas it may be possible to predict the approximate number of focus groups or interviews that will be required to reach saturation- something sometimes required by funding and ethics committees, however there should be scope to extend or reduce this number dependent on when data saturation is reached. The concept of data saturation can be a flexible one depending on the aims and theoretical backing of the study and can be difficult to identify (Mason, 2010). In a review of PhD theses, Mason (2010) speculates that a 'just to be safe' approach to sampling may be a reason for the wide range of interview sample sizes and significant tendency towards samples of multiples of ten.

1.2.4. Interviews

Interviews are one of the most commonly used qualitative research methods of data collection. Semi-structured interviews involve the use of an interview guide- a set of broad open-ended questions that are used in all interviews, but can be tailored to follow the direction of each individual interview. An example of their use is Lastein et al. (2009), where vets were asked about their experiences, perceptions, practical observations and treatment of metritis. New follow up, probing or prompt questions can be asked to pursue points and perspectives that had not previously been considered or brought up by previous participants. The new questions can then be incorporated into a question guide for following interviews. The question guide therefore brings some structure and continuity across the interviews whilst remaining flexible enough to accommodate new perspectives and ideas that come to light during data collection. Open-ended questions allow the participant to fully express their thoughts and point of view and frame their answers according to what they feel is important. Semi-structured interviews have been successfully used in previous research with farmers (Garforth et al., 2013).

A challenge associated with interviews is that they are inevitably an artificial situation and the responses given must be analysed with the knowledge that they are possibly subject to recall, memory and researcher bias. It is also possible that the participant may present themselves in a particular way in response to their perception of what the interviewer expects. For example, Lastein et al. (2009) discuss the potential for influential interaction between interviewer and interviewee.

Interviews have been more commonly used than focus groups (Chapter 2, page 58) when investigating cattle farmers’ attitudes and opinions. They have also been used in qualitative research surrounding veterinary surgeons (Lastein et al., 2009, Mair and White, 2008).

1.2.5. Focus groups

Focus groups are a type of group interview used collect attitudes and to study interaction and communication between participants. When open questions are used they allow participants to explore the topic in their own words, creating their own priorities and expanding on what is important to them. This form of discussion can also help the researcher to understand social norms and cultural values of the groups or people being studied. Focus groups have been described as useful for studying under researched areas as they can collect a wide spread of in-depth data as a base to guide and develop further research (Elliott et al., 2011).

A rapid review of studies investigating methods used to measure cattle farmers' attitudes found few studies reporting focus group findings (Chapter 2, page 58). However, focus groups have been successfully used in agricultural research (Friedman et al., 2007, Gunn et al., 2008, Elliott et al., 2011, Morgan-Davies et al., 2006). Although in published studies the justification to use focus groups as a data collection method is not frequently reported, reasons for the use of focus groups have been: to inform the design of a questionnaire (Bennett and Balcombe, 2012), for exploratory research (Elliott et al., 2011), as a scoping exercise (Friedman et al., 2007) and to explore farmer attitudes (Gunn et al., 2008). Gunn et al. (2008) combined focus groups with a questionnaire to survey vets and a telephone survey for auxiliary industry representatives. Friedman et al (2007) decided to use focus groups only when sufficient farmers in the study area were prepared to attend the group meeting, otherwise interviews were used.

1.2.6. Thematic analysis

Thematic analysis is a widely used method to identify, analyse and report themes within qualitative data (Braun and Clarke, 2006). Brennan and

Christley (2013) used thematic analysis to organise farmers' definitions of biosecurity into different themes whereas the use of thematic analysis by Kaler and Green (2013) was directed toward the analysing the opinions of sheep farmers on the role of vets in flock health management.

Themes are described as patterned responses or meanings. These begin life as codes. Codes are sections of text highlighted as interesting and relevant which are then tagged with a label identifying what the selected text is about. They are the basic building blocks of thematic analysis. Text can be identified by multiple codes and can vary in length from one word to a whole paragraph depending on the level of theme being coded.

Codes are grouped into wider themes. By creating, collapsing, expanding and comparing themes across the dataset a final set of themes will be created within a coding framework. These themes must then be defined, named and the relationships between them analysed (Figure 1) (Braun and Clarke, 2006). The review process continues throughout the analysis with themes being refined and items being re-coded as the coding framework grows and evolves. Transcribing and reading the raw data as well as the writing process are all vital parts of thematic analysis as described by Braun and Clarke's (2006) as this helps to immerse the researcher in the data.

Phase	Description of the process
1. Familiarising yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking in the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells; generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Figure 1 The phases of thematic analysis from Braun and Clarke (2006)

Although the general premise of spotting patterns within data and then analysing them is often reported, the actual processes and steps used to produce and interpret them are less commonly described, or even agreed upon (Floersch et al., 2010, Moore et al., 2000, Kristensen and Jakobsen, 2011, Brennan and Christley, 2013). This may have contributed, in part, to some of the criticisms of qualitative research. How can results be valid and robust if every researcher is using a different method to produce them and report them? If the methods are not fully reported, or the data not analysed using consistent methods this limits repeating or comparing results of these studies with similar work. Although some subjectivity and differences between analysts will occur, given the nature of the method if standardised methods are used a better comparison and understanding of the research can be achieved. The same may occur if different philosophical perspectives are applied to the same initial data set.

The reporting of analytical methodology in qualitative research has been described as regrettably lacking by Attride-Stirling (2001), and Braun and Clarke (2006) produced their widely used paper in response to what they describe as “the absence of a paper which adequately outlines the theory, application, and evaluation of thematic analysis…”. The use of a citable source for researchers, such as the work described by Braun and Clarke (2006), gives other researchers a structure to accomplish comparable and robust outcomes in the emerging field of veterinary qualitative research.

1.2.7. Computer-Assisted Qualitative Data Analysis Software

The process of Thematic Analysis can be time-consuming and when done manually can produce a lot of mess. Software packages can help to collate and organise data and assist with the steps of thematic analysis. The packages are referred to as Computer-Assisted Qualitative Data Analysis Software (CAQDAS) and usually work as code-and-retrieve packages. Text can be tagged with a code and once coded, all text relating to that code can be retrieved. The researcher remains essential to interpret the codes and themes however CAQDAS can make the whole process quicker and more efficient (Bryman, 2012d).

There have been criticisms of CAQDAS including the temptation to quantify qualitative data (Hesse-Biber, 1995), the decontextualisation and fragmentation of data resulting in a loss of context of sections of interview data (Buston, 1997) and the loss of communication between participants in focus groups (Catterall and Maclaran, 1997). However as Bryman (2012, pp591-609) highlights- these sources are all pre-2000 and a lack of further criticism may indicate a shift towards acceptance of the use of CAQDAS.

1.2.8. Epistemology and ontology

As discussed previously, qualitative research is relatively novel in veterinary research and has been viewed critically in the past (Christley and Perkins, 2010). Epistemology and ontology are rarely discussed in the veterinary qualitative literature. Reasons for this may be that it is not a requirement of a commonly used qualitative research reporting guidelines to report the epistemological or ontological concepts behind the study (Tong et al., 2007). It could also be that editors and reviewers of veterinary journals may not appreciated or be accepting of such discussions and either request they are removed or reject manuscripts that discuss the concepts in detail. However, in order to understand the interpretation of qualitative research it is useful to understand the philosophies within which the research was conducted.

Epistemology is the theory of knowledge and the methods of studying it. Ontology is the study of the nature or existence of truth and reality. As discussed previously qualitative research is not just about the methods of data collection used, the epistemological decisions made are equally important. Decisions about the epistemological and ontological philosophies involved in a piece of research help define the project from the outset and direct the outcomes of the analysis (Millar, 1997). There are different epistemological and ontological standpoints that can be thought of as a sliding scale from one standpoint to another, depending on the researchers' philosophy on the understanding of the nature of truth and reality (ontology) and knowledge (epistemology). It is also possible to equate the various epistemological and ontological perspectives with each other. For example a realist ontological position could be equated to an objectivist epistemological position; and a relativist ontological position with a constructionist or subjectivist epistemological perspective (Moon and Blackman, 2014).

These two ends of the epistemological and ontological spectra tend to be portrayed as polar opposites. A constructionist researcher may take the view that "if we are really interested in the contents of people's heads, we should chose to be brain surgeons rather than social scientists" (Silverman, 1997, p15). This implies that responses in an interview setting are portraying a socially constructed reality between the researcher and participant. It is not possible to truly understand what goes on in people's heads, or to put it another way, how they understand and experience the world, by just asking them. The process of being interviewed creates one version of a constructed reality between the two or more people involved. A realist standpoint would be that people's lives and experiences can be understood by asking them questions and interpreting those descriptions and insights as true accounts of their experiences (Melia, 1997).

Melia (1997, pp 26-36) directs the epistemological question towards data collected from interviews. Are we listening to accounts of the interviewees' experiences, to be taken as truth? Or are they constructing, with the interviewer, a story about the experience "told as an exercise in self presentation"? If the first, we are working from an objectivist standpoint, if the second then the approach is more constructionist.

It could be argued that the decision to use interviews as a data collection method, and interpret them using thematic analysis is realist in itself. After all, interviews are not observations and so the researcher is assuming that the accounts given about actions taken, and knowledge claimed are true accounts.

The realist/objectivist approach feels the more appropriate for conducting the research presented in this dissertation. The philosophy of a single, independent reality from which truth can be discovered by applying scientific methods is ingrained into the method and thinking of natural scientists such as veterinary surgeons as it is akin to the traditionally (post) positivist philosophy of the scientific method (Moon and Blackman, 2014, Everitt, 2011).

In reality, it could be argued that most people are located at various points on a sliding scale somewhere between the two ends of the spectrum of realist and constructionist philosophies.

The outcomes of this research aim to be applicable and transparent to all stakeholders involved. This means that the research should be presented in a way that the reader feels is applicable to their situation. Given the aim and purpose of the research, it is believed that most, but likely not all, vets would subscribe to a realist philosophy resulting from their scientific background, as discussed on a more personal level by Everitt (2011, pp 72-75). The epistemological and ontological perspectives of a researcher and their research are important, however the opinion of Melia (1997, p30) seems to resonate most with qualitative interviewing in the veterinary field “if we are going to tell a story, we have to be less epistemologically squeamish and get on with it."

1.3. Knowledge gaps

The current literature on the use of dairy cattle vaccination appears to be scarce and this provides an opportunity to further this field. Literature investigating attitudes to cattle vaccines have been based around exotic diseases or hypothetical situations. There is some evidence for poor farmer compliance with storage and administration instructions but limited published information aiming to understand how and why farmers decide to vaccinate their cattle. There is currently no national strategy for cattle vaccination in Britain and limited provision of guidelines, when compared to human and companion animal vaccination. Vets have been identified as important and trusted sources of information for vaccination and other disease control advice and therefore it is important their opinions are investigated. In light of this, in order to support and optimise the decision-making of vets and farmers when implementing vaccination strategies on farms, research is required to understand how and why these decisions are made.

The wealth of qualitative research in the human vaccination field strongly places risk and trust as areas of importance to vaccination decision-makers, as well as highlighting the importance of effective communication between practitioner and patient when decisions are made around vaccination. It suggests vaccination decision-making is not as simple as choosing to vaccinate or not. Investigating, and understanding these areas can help to support and educate health professionals and patients in this important area of public health.

There is no published qualitative research investigating the motivators and barriers of farmers and vets to implementing vaccination strategies on British dairy farms. This PhD thesis aims to address this gap in the literature and provide the evidence required to further this field of research and optimise vaccination strategies on British dairy farms.

1.4. Aim and Layout of the Thesis

The aim of this thesis was to identify the motivators and barriers of farmers and veterinary surgeons to the implementation of vaccination strategies on British dairy farms. The outcomes will compliment additional studies involving expert opinion, including the attitudes and opinions of other stakeholders, on vaccination. The overall aim is to devise effective strategies to be used to optimize vaccination on farms, and to establish the means of translating outcomes of this project to farmers, vets, farm advisors and other herd health professionals.

The structure of the remainder of the thesis includes three research study chapters structured as standalone publications (Chapters 2-4) followed by Chapter 5 which combines the outcomes from Chapters 3 and 4, and a concluding Chapter 6.

The thesis progresses as follows;

Chapter 2: A rapid review of the literature investigating farmers' attitudes. This review was undertaken as part of my PhD training with a second PhD candidate, Heather M. O'Connor (HOC). The work and initial writing of the review was divided equally, however the initial development of the critical appraisal tool was undertaken mostly by HOC. The writing and submission of the manuscript was undertaken by myself. Other authors involved in the manuscript were Dr Wendela Wapenaar (WW), Dr Marnie L. Brennan (MLB), Dr Pru Hobson-West (PHW), Dr Nick Wright (NW) and Dr Jasmeet Kaler (JK).

The objective of the review was to identify and critically appraise the published literature investigating opinions, motivators and barriers of cattle farmers towards several aspects of cattle production. The review functions to fill the knowledge gap in the evaluation of methods used to collect and analyse farmers' attitudes as referred to previously in Chapter 1 (page 31).

Chapter 3: In order to understand how and why farmers choose to vaccinate their cattle, an interview study was conducted to investigate dairy farmers' motivators and barriers to implementing vaccination strategies on their farm.

Chapter 4: In order to understand how and why veterinary surgeons advise farmers to vaccinate their cattle, an interview study was conducted to investigate veterinary surgeons' attitudes towards dairy cattle vaccination.

Chapter 5: This chapter involves a discussion of the results from both interview studies. It compares and combines the results in order to further understand how and why decisions are made around dairy cattle vaccination as well as exploring the farmer-veterinary surgeon relationship. This Chapter provides a wider approach by combining the outcomes of Chapters 3 and 4. This will inform further studies in how to overcome the challenges to and perceptions of implementing vaccination strategies on dairy farms.

Chapter 6: The implications of the study findings to the dairy industry are discussed in Chapter 6 together with recommendations for further work. This chapter also contains a reflection on the methods used throughout the thesis, to enable other researchers to learn from the challenges faced. Concluding remarks summarising the thesis are found at the end of Chapter 6.

Chapter 2 Methods used to research farmers' attitudes toward cattle production: A rapid review

2.1. Abstract

Understanding farmers' attitudes and opinions on key topics is important as they are major stakeholders in areas of animal health and welfare, food security and policy. The purpose of this study was to use a rapid review methodology to identify and critically appraise the published literature investigating attitudes of farmers towards cattle production. A comprehensive search of CAB Abstracts (OVID) was carried out using a specific search strategy. Studies were examined for a variety of factors, including topic investigated, the type of data collection method and the type of analysis conducted. Fifty-seven studies were identified that represented a range of topics, methods and analyses. There appeared to be a discrepancy between the data collection method and the subsequent type of data analysis in some of the studies. There was also variation in the quality of the studies as categorised by a bespoke critical appraisal tool. The predominant use of quantitative methods to analyse data that was collected qualitatively highlights the potential for the loss of data depth and richness. This study demonstrates that the consistent reporting of methods and results using published guidelines is likely to significantly improve the quality of the published literature in this important area of research.

2.2. Introduction

When making decisions, individuals can be said to have motivators and barriers towards a particular course of action. These may vary between people and may vary for different decisions each individual makes (Pike, 2008). Theories used in psychological and social science to understand and predict behaviours include The Theory of Planned Behaviour (Ajzen, 1991) and The Health Belief Model (Abraham and Sheeran, 2005). These use attitudes and perceptions as determinants to an action and suggest that attitudes toward the behaviour preclude the intent to perform it. This would suggest that in order to understand why people make certain decisions or perform certain behaviours it is important to first investigate peoples' attitudes to that action or behaviour.

Understanding farmers' attitudes and opinions on key topics is important as they are the primary stakeholders in animal health and welfare, food security and policy. Studies by Ashby (1926) and Johnson (1960) are some of the earliest examples of considerations on the factors impinging on behaviour in farming, suggesting that this has been an area of interest to researchers for some time. There are a variety of methods that can be used to collect peoples' attitudes and opinions. These methods can broadly be categorised as qualitative, for example focus groups and semi-structured interviews, or quantitative, for example structured questionnaires. The use of mixed methods for data collection has also been described in the literature (Bryman, 2012e) which include examples of both qualitative (Vaarst et al., 2002) and quantitative (Benjamin et al., 2010) methods used to gather and analyse farmers' attitudes towards animal production. Methods of analysing attitudes and opinions can also be broadly classified as qualitative, for example thematic analysis (Braun and Clarke, 2006) or quantitative, for example the use of statistical tests to determine the frequency of an opinion, or compare opinions between groups of people (Bryman, 2012b). Methods that can be used to summarise existing knowledge and evaluate how other researchers have collected and analysed data in this field include systematic reviews or rapid reviews. Rapid reviews are a structured, objective method of evaluating existing research methods in a streamlined, yet systematic way (Ganann et al., 2010). They are, as their name suggests, designed to be quicker to undertake than a systematic review. Critical appraisal can then be used to help determine the quality of studies conducted in a given area.

The objectives of this piece of work were 1. To use a rapid review methodology to identify the published literature investigating opinions, motivators and barriers of cattle farmers towards a number of aspects of cattle production; 2. To identify the methods used in this literature and, 3. To critically appraise the identified literature.

2.3. Materials and methods

Where applicable the current study has been reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement as a guide (Moher et al., 2009).

A rapid review methodology (Ganann et al., 2010) was used to identify relevant studies and a critical appraisal component was included.

Literature search

CAB Abstracts (Ovid SP 1910-2012) was chosen as the primary search database for its coverage of agricultural research (Kawasaki, 2004, Grindlay et al., 2012). The decision to limit the search to a single database was taken in order to streamline the review process. The review was limited to cattle farming however other livestock terms were included in the search to ensure those studies that investigated cattle farmers in a wider farming population, for example studies including both cattle and sheep farmers were captured.

The search was performed in July 2012 using the following search strategy:

(exp farms/ OR exp farmers/ OR producer.mp. OR producers.mp.) AND (exp opinions/ OR exp attitudes/ OR exp perception/ OR exp motivation/ OR exp beliefs/) AND (exp cattle/ OR exp sheep/ OR exp pigs/ OR exp poultry/)

No exclusion terms were applied to the search strategy. Two researchers (HOC, IFR) independently performed identical searches which were compared to ensure agreement.

Inclusion criteria

Papers identified through the search strategy as relevant were subjected to the inclusion criteria listed in Table 2. Studies that did not meet all of the inclusion criteria were excluded. This was firstly performed at a title level, abstract level and finally a full text level. Studies that were not available electronically or from the University of Nottingham library were requested by inter-library loan from The British Library and studies not meeting the inclusion criteria were excluded at this point (Figure 2). Two authors (HOC, IFR) independently selected papers based on the inclusion criteria and compared their results to ensure agreement. When agreement could not be reached further advice was sought from other members of the research team (MLB, WW, PHW, NW) and a conclusion reached.

Table 2 Criteria for study inclusion in the rapid review of methods used to investigate farmers' attitudes towards cattle production

Inclusion criteria
Studies cattle farmers- including studies with cattle and other species and/or farming systems
Study measures/elicits farmer attitudes, motivators, barriers or opinions
Published as a research study in a research journal
Whole text available in English
Readily accessible electronically, or in paper format from the University of Nottingham library or by Inter-Library Loans through the British Library.

Data extraction and summarisation

Studies that met the inclusion criteria were assessed for the information listed in Table 3. In each area the classification was based on what the authors had explicitly stated in their study. If this was not made clear then the classification was based on the judgement of two researchers (HOC and IFR) derived from information provided within the studies. No further information or clarification was sought from study authors. The numbers of selected studies published each year were compared against the number of citable documents in the veterinary subject area published in the same year provided by SCImago (SCImago, 2015), although this information was only available from 1996. The categories of classification evolved during review and were finalised by two authors (HOC, IFR) once all manuscripts had been assessed. The main topic of interest (Table 3) was categorised using the following definitions:

- Disease: prevention and control- study investigates attitudes towards prevention and/or control of disease e.g. biosecurity practices
- Disease: treatment- study investigates attitudes towards medications or treatment of disease e.g. antibiotic usage
- Ethics and welfare- study investigates attitudes towards welfare of cattle or ethical decision making
- Management- study investigates attitudes towards management practices e.g. fertility management
- Adoption of new practices- study investigates attitudes towards adoption of new practices e.g. adoption of artificial insemination
- Other- study investigates attitudes of farmers but cannot be categorised in any of the previous categories

Two authors (HOC, IFR) undertook the classification of studies independently and then conferred to ensure agreement. Where agreement could not be reached further advice was sought from other members of the research team (MLB, WW, PHW, NW) and studies included or excluded as deemed appropriate.

Table 3 Information collected from studies included in the rapid review of methods investigating farmers' attitudes towards cattle production

Data	Categories
Main topic of interest	Disease: prevention and control; Disease: treatment; Ethics and welfare; Management; Adoption of new practices or Other
Year of publication	The year in which the study was published
Country	The country in which the research took place
Cattle type	Dairy, beef, veal, mixed cattle or unspecified
Data collection method	Questionnaire, interview, telephone survey, focus group or other. Multiple methods could be recorded for each paper
Type of analysis	Quantitative, qualitative or mixed

<u>Critical appraisal</u>

All studies were critically appraised using a bespoke tool developed for this review (Table 4).The aim and methodology of this study naturally resulted in the inclusion of a wide variety of study types. It was perceived that no single existing critical appraisal checklist was suitable for the range of study types that would likely be identified and the decision was made that all studies would be subject to the same critical appraisal tool.

Most of the initial development of the tool was undertaken by HOC and therefore a detailed description of the initial development is not reported in this thesis. In summary, the tool was developed using selected criteria from three existing critical appraisal checklists (Blaxter, 1996, Spencer et al., 2003, Crombie, 2010). The questions included in the critical appraisal tool were not used in all three published checklists but were instead those criteria which the authors identified as being key for their respective fields. This enabled the authors to systematically critically appraise studies with qualitative, quantitative or combined research methodology. Questions which were too specific for each discipline were excluded.

The checklist was completed for each study independently by two authors (HOC, IFR) and comments were made on the strengths and weaknesses observed in each study. Using the checklist and comments as a guide a subjective overall rating of 'high', 'medium' or 'low' quality was allocated to each paper by both authors. There were no specific conditions given for the classification of papers in relation to quality, instead the authors rated each paper independently after the paper had been assessed using the tool as a guide. Inter-rater agreement was assessed using an online tool (GraphPad, 2015) to calculate a weighted kappa coefficient to determine the reliability of the critical appraisal tool (Fleiss et al., 2003).

Table 4 Critical appraisal tool used in 'Methods used to research farmers' attitudes toward cattle production: A rapid review'

Question	Notes
Whole paper	
What is the general topic of the paper? [1]	
What is the population of interest?	
What is the study type? [2, 3]	
What are the data collection methods? [1, 2]	
What is the analytical method? [1, 3]	
Are the main findings of the research clear? [2, 3]	
Are the benefits of the study identified? [3]	
Are the limitations of the study identified? [1, 3]	
Is the paper easy to follow?	
Assessment of the overall quality of the paper?	
How useful is this paper to your interest? [2]	
Introduction	
Are the aims clear? [2, 3]	
Is there a theoretical basis indicated? [1, 3]	
Methods	
Are the methods clear? [1, 2, 3]	
Are the methods appropriate? [1, 2, 3]	
Are the methods justified? [1, 3]	
Data Collection	
Is the sampling frame / selection clear? [1, 3]	

Is the sampling frame / selection appropriate? [1, 3]	
Is the sample size justified? [2, 3]	
Analysis	
Is the analysis clear? [1, 2, 3]	
Is the analysis appropriate? [1, 2]	
Is the analysis justified? [1, 3]	
Results	
Are the results clear? [1, 2]	
Do the results appear to be correct? [1, 2]	
Discussion / Conclusion	
Is the interpretation clear? [1, 2, 3]	
Does the interpretation appear to be appropriate? [1, 2, 3]	
Is there any comparison to other research? [1, 2]	

References used for each point are [1]Blaxter (1996), [2]Crombie (2010) and [3]Spencer et al. (2003)

2.4. Results

A total of 528 records were retrieved following the initial search. Independent checks identified 471 studies that did not meet the inclusion criteria. This resulted in 57 studies remaining (Appendix 2), 44 of which were accessed electronically through the University of Nottingham and the remaining 13 were accessed via inter-library loan (Figure 2). There were no discrepancies between the two authors (IFR, HOC) in the independent searches nor in the resultant included studies.

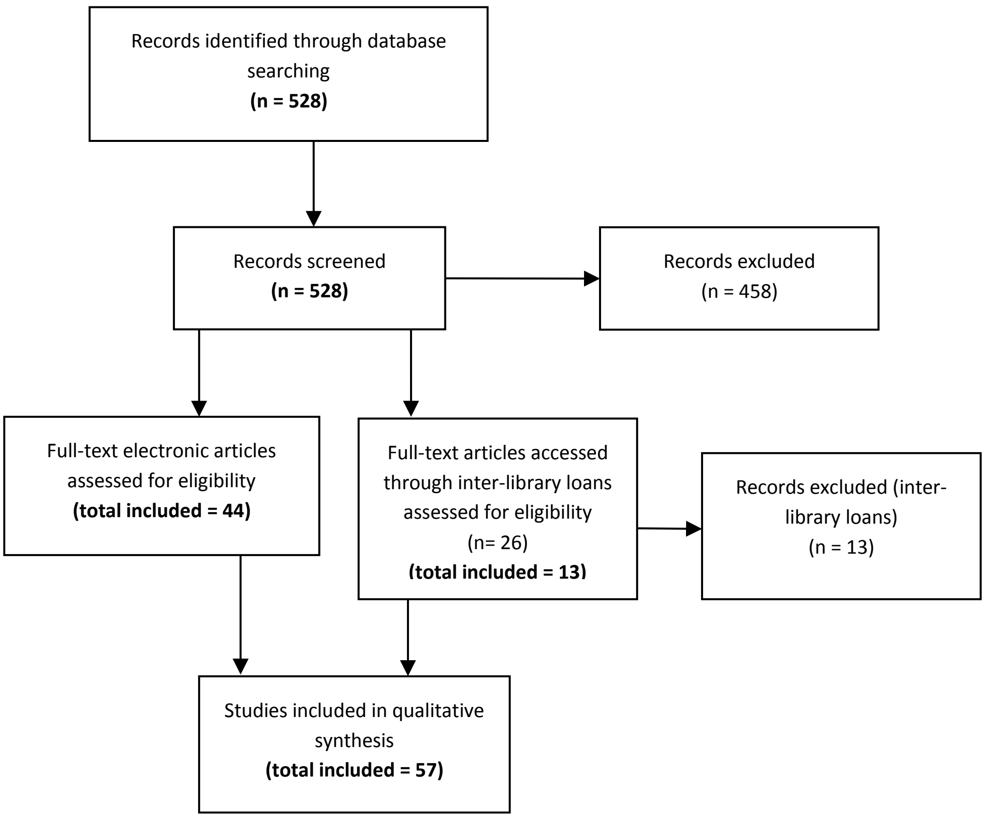


Figure 2 Flow diagram of the study search process in the rapid review investigating methods used to investigate farmers' attitudes towards cattle production, adapted from PRISMA (Moher et al., 2009)

The earliest study was published in 1989. From 2001 onwards the number of studies published annually increased with almost half (25/57; 44%) of the included studies being published between 2010 and 2012 (Figure 3). The increase in studies included in this review over time was similar to the increase in citable documents in the veterinary subject area over time (SCImago, 2015), although there appeared to be a spike in the number of papers eligible for inclusion in the rapid review that were published in 2010.

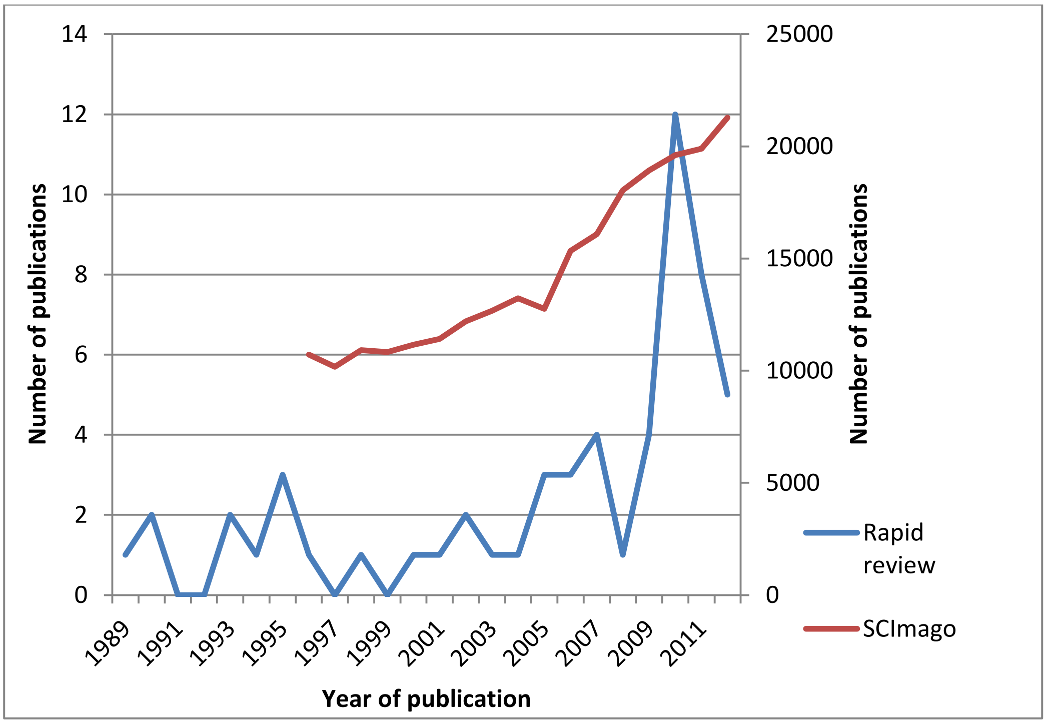


Figure 3 Number of studies by year of publication included in the rapid review, compared to the number of total published citable veterinary documents in the past two decades.

Exploration of the countries in which data collection took place highlighted that this type of research had been carried out in many parts of the world. The largest number of studies were conducted in Europe (20/57; 35%) followed by the USA and Canada (16/57; 28%), India (10/57; 18%), Australia and New Zealand (6/57; 10%), Africa (3/57; 5%) and the Middle East (1/57; 2%). One study did not specify where the research was conducted (1/57; 2%).

Studies covered various cattle production types. More than half focused on dairy production (31/57; 54%) with the next most prominent production type investigated being beef (11/57; 19%). One of the beef studies solely focussed on veal production. Two studies investigated both beef and dairy production and the remaining studies (13/57; 23%) identified their focus as being ‘cattle’.

When investigating the topic of focus of the research, most research focused on management practices, adoption of new practices and prevention and control of disease (Figure 4). Topics that were classified in the ‘Other’ category included one study each on constraints perceived by Indian dairy farmers, communication strategies, stockpersons’ personalities, and human-animal interactions.

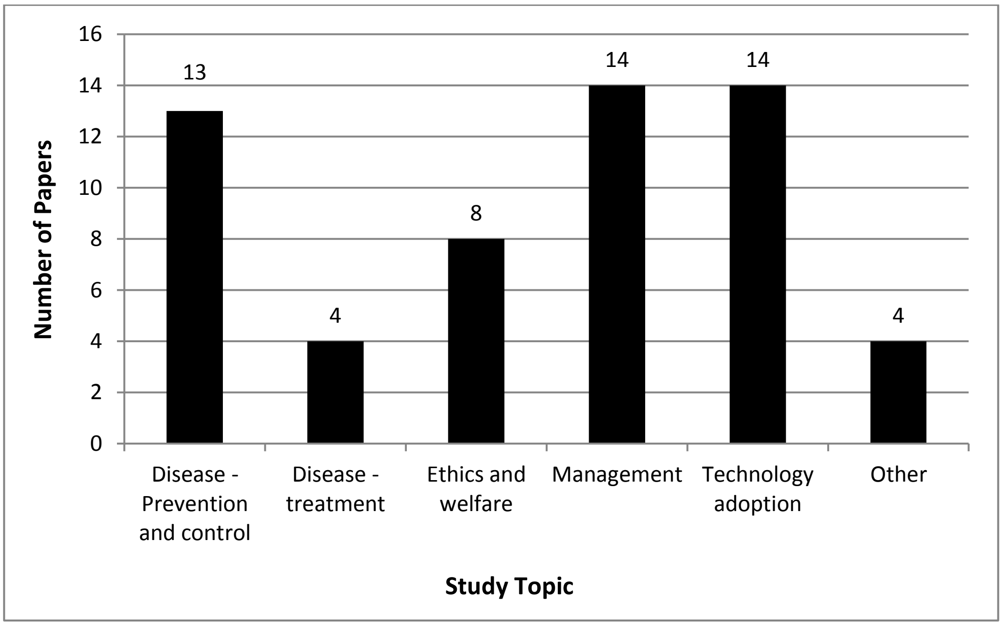


Figure 4 Number of studies included in the rapid review by topic of focus

A variety of data collection methods were described (Figure 5) with four studies (7%) using multiple methods. Questionnaires were the most common method used (35/57; 61%). Over a third of the papers (20/57; 35%) reported using interviews to collect data and group discussions were reported by three studies (5%). Almost one fifth (11/57; 19%) of the studies supplemented their data relating to participants responses with additional data. Examples included on-farm data such as information from farm documents, treatment records and observations of cattle. The use of databases as sources of information such as herd level data from national herd recording systems or historical health data from veterinary information systems was also reported.

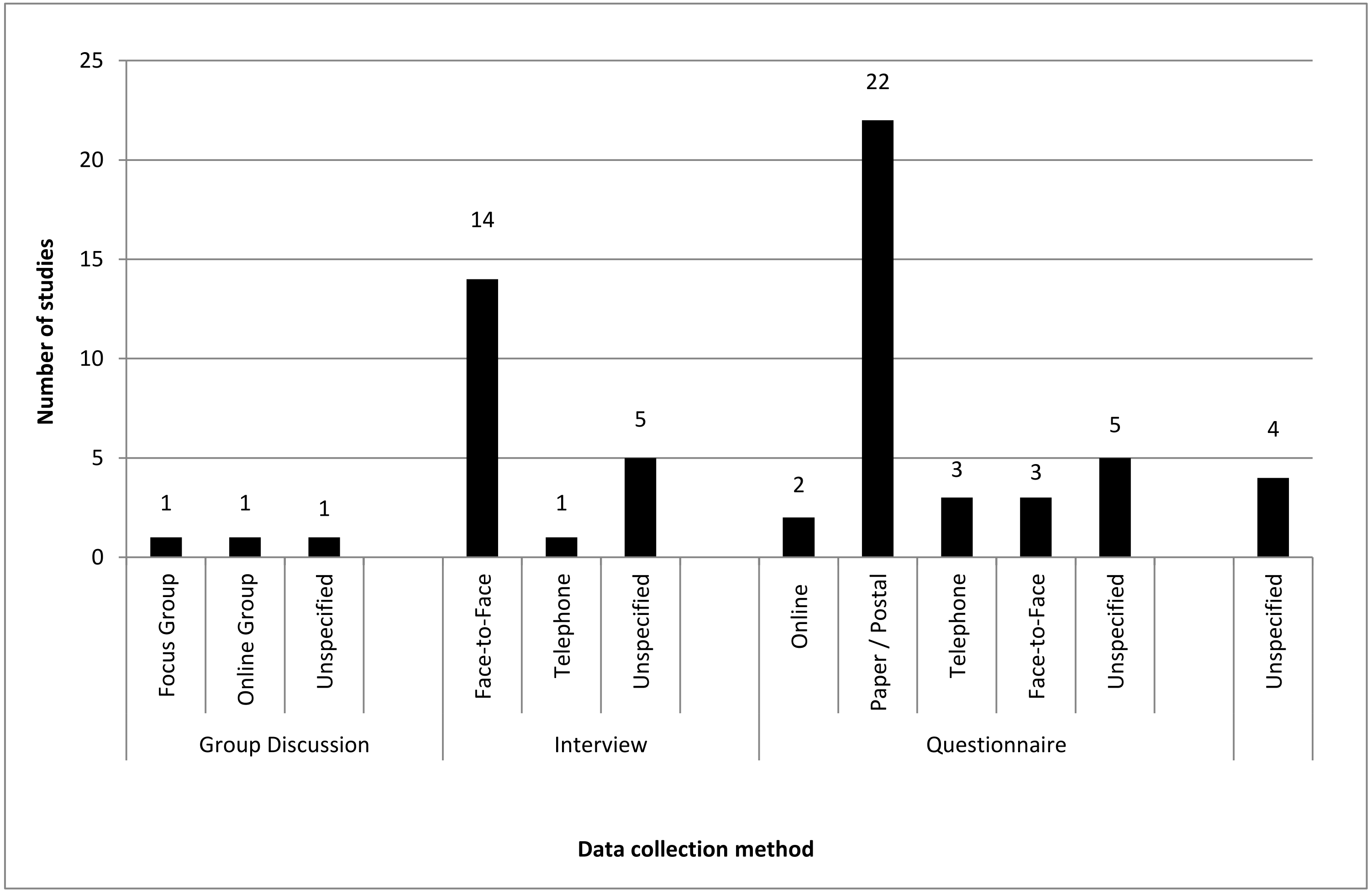


Figure 5 Number of studies included in the rapid review arranged by the methods described to collect the data.

The method of analysis was treated independently from the method of data collection. Sometimes the method of analysis used had to be determined by discussions amongst the review authors because a quarter of studies were not explicit in the methods applied (15/57; 26%). However, sufficient detail was provided in the methods or results sections for the authors to apply classifications into qualitative, quantitative or mixed methods. Most studies (43/57; 75%) applied a quantitative only analysis with approximately one tenth of papers (6/57; 11%) applying solely a qualitative analysis. The remaining papers (8/57; 14%) applied mixed methods.

When considering study quality, high quality papers were deemed to be easy to follow with a logical structure of reporting. These papers had identifiable aims which were referred to throughout the study. Data collection methods and methods of analysis were clearly reported and the interpretation of results appeared both clear and appropriate, for example Vaarst et al. (2002) and Morgan-Davies et al. (2012). By contrast, low quality papers were generally found to be harder to follow. This was primarily due to a paucity of information reporting details of the study, such as limited or no information on the study population, data collection methods or methods of analysis, for example Halliday (1989) and Singh et al. (2009). Additionally the aims of low quality studies were not always easily identifiable.

Inter-rater agreement after critical appraisal was observed in over three quarters of the studies (44/57; 77%) with 19 high, 6 medium and 19 low quality studies being rated the same by both observers (Table 5). A weighted kappa of 0.71 indicated a substantial level of agreement (Sim and Wright, 2005).

Table 5 Comparison of observers' assessments of study quality in the rapid review, based upon the results of the critical appraisal

		Rater 1			
		High	Medium	Low	Total
Rater 2	High	19	0	3	22
	Medium	3	6	7	16
	Low	0	0	19	19
	Total	22	6	29	*57*

2.5. Discussion

Studies investigating cattle farmers' attitudes and opinions have been published in increasing numbers since 1989, although this increase appears to mirror the general increase in all publications (SCImago, 2015). It is interesting that there appeared to be an anomalous spike in publications in 2010. No obvious reasons could be found to account for this such as the publication of a special edition of a journal or a single research group publishing their work. The wide range of topics covered by the reviewed studies suggests that understanding farmer attitudes towards production is of interest across many areas of cattle farming.

Most researchers used a questionnaire for data collection (Figure 5). A similar number of studies used a method that allowed participants to respond to a researcher verbally, for example using a face-to-face interview. Appraisal of these interview type studies suggests that not all allowed for open or free-text responses. Many of the interviews appeared to follow a highly structured format that would suggest a 'questionnaire style' for delivery of questions. During the appraisal process it became clear that few studies asked farmers their opinions freely, with most collecting data on the spread of opinions assumed to be present by using the predefined answers set within a structured questionnaire. This may have affected the response of participants, as instead of formulating their own answer participants could have been steered by the available options, interpreted the answers differently or not provided the answer the participant wished to express (Bryman, 2012a). This could lead to prioritisation of interventions that are not in line with the needs of farmers and could result in poor uptake of suggested changes.

There was inconsistency in the terminology used to describe the methods that were employed in the reviewed studies; for example some authors stated that they conducted a questionnaire and that it was carried out face-to-face with a researcher. This same methodology used by another researcher was referred to as an interview. These different descriptions made comparison of study methods challenging, especially in cases where the authors were not explicit when describing their methods, as there appeared to be no single, consistent definition between studies of what constituted a questionnaire and what was an interview. In cases where the authors of this review had to categorise a study's methodology when there was inadequate information, best judgement was used based on the information provided. However given the lack of detail in some studies it is possible that other researchers may have classified the methods used differently. It is also possible that the differing background of the authors of this review may have influenced their categorisation of these 'unknown' methods. In an attempt to reduce any bias that may result, this review used one definition for each method category and the opinions of other members of the research team were sought in cases where the two main authors (HOC, IFR) disagreed. In this review questionnaires were classified as quantitative methods and interviews as qualitative methods. This means that it is possible that some of these studies may have been misclassified due to uncertainty surrounding their methods, and the proportion of qualitative and quantitative studies identified may therefore not be a true representation of the literature.

The method used to analyse data is determined by the nature of the data collected, the skills and experience of those carrying out the analysis, and what is required of the study. Although many studies did not state that they allowed for open or free-text responses it is possible some did use a method that could have potentially generated such data and therefore could have used a qualitative analysis. However it was found that nearly three quarters of the papers applied only a quantitative analysis. This suggests that researchers are acknowledging the value of qualitative data but are not consistent in following these principles through to the analysis. This could mean a loss of depth and detail that qualitative approaches can yield. It is possible that the broad classification of interviews as a qualitative data collection and questionnaires as a quantitative data collection method could also provide some explanation for the apparent discrepancy between method of data collection method and method of analysis. A structured interview could conceivably produce data more appropriate to quantitative analysis than qualitative and a questionnaire consisting solely of free text responses could produce data more appropriately analysed qualitatively. There was often not enough information in the methods sections of the studies to be able to determine these finer points.

The use of a single published critical appraisal tool was considered for the critical appraisal stage of this review. However these tend to focus on a single study design or are geared to either qualitative or quantitative research. The nature of the study aim and general nature of the research question resulted in the inclusion of a wide variety of study types and designs. It was therefore decided to integrate the concepts of multiple frameworks into a 'new' critical appraisal tool. This was done with the aim of preventing bias towards a specific discipline and to allow appropriate comparisons of studies that may be inter-disciplinary in nature. Agreement between researchers using the critical appraisal tool appeared adequate. It is understood that this is not validation of the tool; however it is a promising initial step. This indicates that the critical appraisal tool appears to be working well even when applied by two different authors (HOC, IFR). The different backgrounds of these authors may have resulted in a small number of studies (n=3) being classified as low quality by one author and high by the other. The application of a critical appraisal tool was beneficial in this review. The use of such tools by researchers and reviewers should be encouraged. However careful consideration should be given to the tool chosen to ensure that it is appropriate for the research being evaluated. The use of the critical appraisal tool allowed identification of some key areas that caused studies to be classified as either low or high quality. Many papers did not justify, or explain in sufficient detail, their methods. This may be due to publication restrictions but this lack of information resulted in difficulty evaluating the methods. A clear justification for the methods used aids reader interpretation of studies. A lack of information could also result in a barrier for researchers wishing to inform their studies based on previous work and to inform them of any common problems which may be faced.

The differences between studies judged to be at either end of the critical appraisal spectrum could be explained by the value placed by both researchers on 'lack of reporting'. It is possible that the studies that were scored as low quality were well-conducted pieces of research but this was difficult to assess due to a lack of information provided in the published articles. This could be due to a number of reasons, as discussed previously. It is also possible that these studies were, in fact, poor examples of science. If studies are not reported correctly then readers are less able to distinguish between well and poorly conducted research. Deficiencies in the reporting of study design and methodological information in veterinary research has been previously discussed along with the suggested use of reporting guidelines (Sargeant et al., 2009, Sargeant et al., 2010, O'Connor et al., 2010). There is also a lack of awareness of reporting guidelines amongst editors of veterinary journals (Grindlay et al., 2014) which may be a barrier to the use of the guidelines by authors. Enhancing the use of reporting guidelines and promoting the knowledge of different reporting guidelines for different study types (EQUATOR, 2015) may help to improve the quality of reporting in published research.

Although the search engine used (CAB Abstracts, Ovid) has been previously described as the most appropriate for the fields related to the scope of this review (Kawasaki, 2004; Grindlay et al., 2012), it is possible that limiting searching to a single database could have excluded published studies, particularly those published in non-veterinary related journals. The study could therefore be improved by repeating searches in additional databases.

Inclusion of only research articles published in recognised journals i.e. the exclusion of grey literature and books, does limit the scope of the literature sourced. The aim of this study was to be able to identify what studies have been published in a specific field and so limiting the search to this specific area may have prevented finding all relevant studies.

2.6. Conclusion

The inclusion of attitudes, motivators and barriers of farmers towards a number of aspects of cattle production research has increased over the past twenty years and covers a range of study topics and study types. However the quality of these studies, when assessed using a critical appraisal tool, varied widely, with the majority being of low or medium quality. This study demonstrates that the consistent reporting of methods and results using published guidelines is likely to significantly improve the quality of the published literature.

2.7. Relevance to the thesis

There appears to be a growing amount of literature investigating farmers' attitudes towards a variety of aspects of cattle production, however the review confirms the paucity of studies investigating attitudes to vaccination. None of the studies identified as investigating attitudes towards cattle vaccination used qualitative methods of data collection or analysis. There appears to be no pre-existing framework for investigating cattle farmers' attitudes. This suggests that for an under-researched area such as attitudes towards cattle vaccination, a method that can create a rich and detailed evidence base as a basis for future research would be the most appropriate. The results of this review show that the quality of reporting of research investigating farmers' attitudes towards cattle production is variable and this could be remedied by the use of reporting guidelines. These guidelines help to ensure enough detail is presented in published research for the study to be understood by other researchers. The Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines (Tong et al., 2007) will therefore be used for the reporting of the two studies that are presented in Chapters 3 and 4.

Chapter 3 Farmers’ Motivators and Barriers to Implementing Vaccination Strategies on British Dairy Farms

3.1. Abstract

Vaccine use in cattle is widespread but there are limited published guidelines for their use, contrary to the human and companion animal fields. Veterinary surgeons have been identified as important sources of advice on disease control and vaccination by farmers, as well as their preferred vaccine provider. The objective of this study was to explore dairy farmers' motivators and barriers to implementing vaccination strategies on their farms. Twenty-four semi-structured interviews were conducted with dairy farmers from across Britain. The data was analysed using thematic analysis. Five main themes were identified from the analysis. These themes suggest farmers are motivated to vaccinate their cattle, especially if there is evidence of disease present in their herd or if there is a risk of disease entering their herd. Vaccines are believed to be efficacious but there is concern about the number of vaccines used both in terms of the additional work this creates for the farmer and the added stress to cattle involved in the procedure. Farmers perceive that vets have an important role in facilitating all aspects of vaccination decision-making, as well as the more practical aspects of vaccine distribution. Vets are important advisors on the implementation of vaccines and participants perceived that other stakeholders had limited influence on their decision-making. To optimise the use of cattle vaccines this study indicates the importance of focussing further research on the role and attitudes of cattle vets towards vaccination.

3.2. Introduction

Vaccination is an important tool in the prevention and control of disease, both on and between farms. As described in Chapter 1 (page 10), in Britain there are approximately 36 vaccines registered for use in cattle, offering protection against a number of viral, bacterial, parasitic and fungal pathogens (NOAH, 2015). Although the exact coverage of these vaccines is unknown previous work has shown that 86% of cattle farmers use one or more vaccines on their farms (Sayers et al., 2013, Cresswell et al., 2014). Bovine viral diarrhoea (BVD), leptospirosis and infectious bovine rhinotracheitis (IBR) were the most commonly used vaccines identified in the survey of British farmers by Creswell et al. (2014). In Ireland the most commonly used vaccines were for leptospirosis, clostridal disease and BVD (Sayers et al., 2013).

Despite the apparently widespread use of vaccines there is limited evidence describing the decision-making behind the vaccination of cattle. It is important to investigate the factors behind decision-making in order to understand and therefore support, or perhaps change people’s decisions or behaviours. There has been some research investigating farmers’ attitudes toward vaccination. Elbers et al. (2010b) and Sok et al. (2014) discussed the motivators, barriers and willingness to vaccinate in the face of an exotic disease outbreak and Bennett et al. (2012) investigated English and Welsh farmers’ willingness to pay for a bTB vaccine. Although these studies give a useful and important insight into farmers’ attitudes toward vaccinating for specific pathogens, they focussed on exotic diseases or hypothetical situations. These studies may therefore be less applicable to the more common situation in Britain, where most vaccines are used against endemic diseases.

There are currently no compulsory vaccination schedules in place in Britain and therefore the decision to vaccinate lies with the farmer. If the farmer decides to vaccinate, they must decide which protocol to use, which pathogens to include, which vaccine to use, which animals to vaccinate and how often they will vaccinate. The costs of the vaccines are covered by the farmer and the vaccines are generally administered by the farmer or other farm staff. This decision-making process is often facilitated by a veterinary surgeon. There are no set, overarching vaccination schedules for farmers or vets to use. However there is a small amount of literature that can be used to aid their decision-making (Chapter 1, page 12).

This situation is in stark contrast to the situation with human vaccination in which the schedules are predetermined, core vaccines are available free of charge and are administered by health professionals. Although vaccination is actively encouraged by the government and health services and is perceived as the norm (Leask et al., 2006), ultimately the decision to vaccinate lies with the adult, teenager or parent and consent must be given- no human vaccines in Britain are compulsory. However, for the people involved in vaccine administration i.e. patients and medical professionals, there appears to be much more guidance as to the schedules used (NHS, 2014) when compared to cattle vaccination.

There is a wealth of research in the human medical field investigating the complex and varying motivators, barriers and attitudes towards vaccination ranging from altruism (Leask et al., 2006); trust in medical professionals (Benin et al., 2006, Glanz et al., 2013); fear of adverse effects; 'free-riding' i.e. relying on the fact that others are vaccinated and so you do not need to be; and trust in anti-vaccine advocates over medical professionals (Benin et al., 2006). Such research findings can have an influence on human vaccination policy and recommendations (NICE, 2009).

Research investigating decision making in the field of animal disease prevention and control often assumes that farmers are entirely rational economic decision makers (Sok et al., 2014). There is no universal approach toward animal disease prevention and control and although economics can be a factor, it is not always the only barrier to disease control. Other barriers to implementing disease control measures that have been described include the belief of a lack of efficacy, a belief that it is not the farmers' responsibility and a lack of practicality (Kristensen and Jakobsen, 2011, Ellis-Iversen et al., 2010). Vaccination is an important and widely used tool in disease prevention and control on cattle farms. Nevertheless, due to the paucity of vaccination specific attitudinal research it is unknown whether the motivators and barriers to implementing general disease prevention and control measures can be extrapolated to the, potentially more specific, motivators and barriers towards implementing vaccination strategies.

A key area in the use of vaccination as a disease control tool is maintenance of the cold-chain and correct administration. If vaccines are not administered or stored correctly their efficacy is likely to decrease (Meadows, 2010) which may cause the farmer to lose confidence in the vaccine and stop using it. Cresswell et al. (2014) as well as Meadows (2010) found evidence of poor compliance to cold chain storage and administration recommendations. Meadows (2010) found that 34% of farmers surveyed never referred to the product datasheet, 21% gave BVD vaccine at either the incorrect dose or by an incorrect route and 48% gave the second dose of the primary course at the wrong time. Creswell et al. (2014) found that 52% of surveyed farmers had used an incorrect time interval between vaccinations in the primary course and 27% apparently using the incorrect route of administration.

Dairy practitioners' main concerns with regards to cattle vaccination also included issues of compliance with correct storage and datasheet instructions (Cresswell et al., 2013). The majority of vaccines in Britain require a veterinary prescription and 93% of cattle farmers purchased their vaccines through their veterinary practice (Cresswell et al., 2014). The opportunities for knowledge transfer and discussion provided through the use of Herd Health Plans, routine fertility visits and the act of handing over the vaccines place vets in a position to give advice on correct vaccine use and stress the importance of compliance. However, with farmer compliance highlighted by vets as a concern and evidence to suggest that farmer compliance with administration and storage instructions is not optimal, this area deserves further exploration.

The apparent importance of the vet as an information source and the importance of the relationship between farmers and their vet when it comes to disease control suggests further investigation into this relationship would be prudent (Brennan and Christley, 2013, Cresswell et al., 2014, Garforth et al., 2013).

Vaccines are not the sole solution in disease control and other measures are recommended (Paton, 2013) which can reduce pathogen challenge to a level where the vaccine can work most effectively. Often a combination of methods is used to allow eradication of a disease from a farm or prevent the disease entering the herd in the first place. There is concern amongst some vets that farmers see vaccination as the easy, or only necessary option which may compromise other aspects of disease control (Cresswell et al., 2013). The vet is in a position to give advice on the most suitable disease control program for their clients as they have knowledge of the animal health aspects on each farm, as well as the local disease epidemiology and are perceived as important sources of information and advice (Gunn et al., 2008).

Vets' perception of their role and communication style on farm are at odds with what farmers report their preferences to be (Hall and Wapenaar, 2012). These inconsistencies as well as differences in 'veterinarian perceived' and 'farmer reported' barriers to vaccination (Cresswell et al., 2013) could result in miscommunication or a lack of discussion surrounding vaccination strategies. The findings from these studies give further evidence for the need to investigate the relationship between farmers and vets in a way that allows participants to expand on their answers and frame their responses by what is important to them.

If researchers, vets, policy makers and other stakeholders are to understand why farmers make the decision to vaccinate their cattle or not then it is important to understand their motivators, barriers and attitudes towards vaccination in the first place (Pike, 2008). With an improved understanding of these attitudes more tailored advice can be provided, taking into account the motivators and barriers important to the farmer. In addition in the case of an exotic disease outbreak where vaccination is required, we may be able to design the most appropriate strategy for maximal vaccine coverage. The need for inclusion of social research in vaccination studies is further stressed by Chambers et al. (2014) in their discussion on cattle tuberculosis vaccination, stating that understanding the drivers for acceptance of vaccination by vets and farmers is crucial to a successful vaccination policy.

In both human (Hobson-West, 2005) and companion animal medicine (Dawson, 2007) vaccination could be perceived as somewhat prescriptive in that, all people and companion animals are vaccinated against the same pathogens using the same schedules. This is not the case in cattle vaccination. It is therefore important to understand how and why dairy farmers choose to use the vaccines that they do. This study aims to use semi-structured interviews and thematic analysis to explore dairy farmers' motivators and barriers to implementing vaccination strategies on their farms.

3.3. Methods

As discussed in Chapter 2 (page 67) the reporting of studies investigating the attitudes of cattle farmers is of variable quality and the use of reporting guidelines was recommended. This study is therefore reported following the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines (Tong et al., 2007).

3.3.1. Pilot study

The results of the rapid review presented in Chapter 2 suggest that the most commonly used methods for collecting farmers' attitudes have been questionnaires and interviews. As discussed in Chapter 1 (pp 30-37), qualitative methods were considered more appropriate for this research. Extrapolating the results of the rapid review would suggest that interviews are the method of choice; only three of the 57 included studies utilised discussion groups, and one of these was an online group (Figure 5). However, as discussed previously (Chapter 2, pp 66-68) the authors had difficulty categorising the methods used in the studies included in the rapid review, due to a lack of reporting clarity. This may have resulted in some studies being misclassified, resulting in a misrepresentation of the actual methods used in these studies. There was also limited justification as to why researchers had chosen a certain method. This information that would have been highly valuable in informing research such as that presented in this thesis. Therefore, due to the experiences of the research team and the knowledge that focus groups can produce rich data due to the interaction between participants that cannot be achieved in face-to-face interviews, it was still felt that focus groups would be the optimal data collection method for this study. Focus groups were therefore originally chosen over the use of interviews.

A pilot focus group was held in the Midlands region with conventional (non-organic) farmers. In February 2013 participants were recruited as described for the interview study that followed this pilot focus group.

The response rate was low, with 96 non-respondents out of 155 participants contacted. This response rate was thought to be partly due to the contact numbers being landlines. Farmers are often out on the farm, away from their landline so calls were often unanswered or answered by other members of the family. Of the respondents two farmers agreed to participate, 50 farmers declined to participate and seven farmers were interested but unable to confirm their attendance at the time of invitation.

Of the number of farmers (50/59 respondents) who declined to participate the predominant reasons were that they were too busy (40%) or had retired from dairy farming (36%). Some farmers indicated that they were retiring soon (8%) or were not interested (6%). The remaining reasons for non-participation were that it was too far to travel; the person contacted was not a farmer or 'other' (10%).

A focus group was organised in April 2013. Four participants confirmed they would be attending and nine were interested in attending but were not able to say for certain if they were able to until the day before. Four cancellations were received in the 24 hours running up to the group and out of the remaining two confirmed and seven probable attendees no one arrived at the location on the day. The main reason given for being unable to attend at the last minute was increased workload.

Considering the poor focus group response semi-structured interviews were decided to be used as an alternative method of data collection.

It was expected that response rates would improve due to the fact that interviews could take place at a location and time convenient for the participant. An option of conducting a telephone interview was suggested for those farmers if preferred to a face-to-face interview.

Those farmers that initially agreed to attend the focus group were contacted to invite them to participate in the interviews.

3.3.2. Recruitment

Farmers were recruited using maximum variation sampling from a database held by the dairy levy board (AHDB Dairy) containing information on all levy payers. All farmers present in the database were eligible for inclusion in the study. Information extracted from the database included the postal contact details and farm information including herd size and whether they were an organic or conventional farm. Extraction of information from all levy paying dairy farmers from the database was performed (Microsoft Excel, 2010) to allow transfer and manipulation of the information from the database to a secure server.

For this study it was hypothesised that farmers in different regions of Britain, who have different herd sizes and those that farm conventionally or organically, would have different attitudes towards vaccinating their cattle.

To allow for maximum variation sampling all farms were categorised by region, herd size and production type (organic or conventional). The English regions were based on the Defra government office regions (Defra, 2010). The six regions were defined as South West, South East, Midlands, North (England), Scotland and Wales. The herd sizes were defined as small (0-49 cows), medium (50-149 cows), large (≥150) and unknown (entries with no herd size recorded).

Farmers from each regional, herd size and production type group were contacted between April and August 2013 (Appendix 3). Those farmers who were in one of two online telephone directories (yell.com and thephonebook.bt.com) were contacted by phone, those who were not received an invitation by post (Appendix 4). If the phone was engaged, or the farmer was not available then the next person on the randomised list was contacted. Further information was sent by post or email when requested. On initial contact with farmers they were given a short introduction to the project and asked if they would be interested in participating. Farmers were given the option to be entered into a draw to win £100 of gift vouchers. Farmers who agreed to be interviewed were sent further information confirming the time, date and location of the interview along with contact and study information by post or email (Appendix 5). Recruitment continued until interview analysis indicated data saturation was reached (Bryman, 2012c).

3.3.3. Data collection

Semi-structured interviews were conducted either face-to-face at the participant's farm, at another preferred place or over the telephone between May and August 2013.

All interviews were conducted by one researcher (IFR). The interviewer did not introduce herself as a vet, nor disclose the main funding body of the study. However, the interviewer was open about her background if this information was requested by the participant.

Written consent (Appendix 6) was obtained prior to face-to-face interviews and verbal consent was recorded prior to telephone interviews. The interviews were audio recorded using a digital voice recorder (Olympus VN-711PC) with telephone pick-up (Olympus TP-8 Telephone Pick Up Microphone) where required.

A question guide (Appendix 7) was used to ensure that the required topics were covered. Questions were mostly open-ended and covered topics including the farmer's background and farm description, the use of vaccines on their farm, information sources, who is involved in decision-making, the farmers' attitudes to vaccination and if there is anything that they would like to change about dairy cattle vaccination. Questions were developed through discussion with farm animal veterinarians, and based on the research team's experience the dairy industry or experience with qualitative research techniques. The question guide was trialled with two people with experience in the dairy industry. Amendments were made as required to improve the clarity and aid the flow of the questions. The guide was flexible and the questions were not read verbatim; if relevant topics came up in the interviews not covered by the questions then these were followed and added to the list of questions so that they could be brought up in future interviews.

In some cases other people besides the participant were present during the interview. These non-participants were made aware of the presence of the voice recorder. If they became part of the interview and their contribution was felt to be useful to the research a second consent form was completed. Following each interview reflective field notes were written. These included the participant's body language and behaviour towards the interviewer, if any non-participants/multiple participants were present, any disturbances that created noise that may obscure the recording, reasons for the recorder being switched off and any relevant themes or notes from the content of the interview. The field notes were used to inform the transcriber of any disturbance in the recording to provide context to the interview during analysis. No repeat interviews were carried out and the transcripts were not sent to the participants for checking.

3.3.4. Data analysis

The audio recordings were transcribed verbatim by external transcribers. Transcripts were checked against the recordings for accuracy and to remove identifying features. The anonymised transcripts were imported into qualitative data analysis software (NVivo 10, QSR International) for thematic analysis (Braun and Clarke, 2006).

All interview transcripts were subjected to an initial coding. Each transcript was individually assessed and the content coded; i.e. sections of text were tagged with a code representing the main element of what the piece of text referred to. The entire data set was coded using inductive themes i.e. the themes were derived from the data and not determined a priori.

The codes from all transcripts were then assessed and any duplicates merged and any codes that were superfluous were deleted. The codes were then grouped into sub-themes, which contained codes relating to similar topics. The sub-themes were then grouped into wider, major themes. Codes, and sub-themes, could be housed under multiple sub-themes or major themes. This method of coding resulted in a hierarchical or tree-like framework. After organisation and assessment of these codes into a framework the data was subjected to a second coding using these codes and themes.

To assess the robustness and thoroughness of the coding framework analysis a sample (15/24) of the transcripts were coded independently by a second researcher (Barbour, 2001). After the initial coding was completed the researchers met and discussed their coding frameworks. Any discrepancies between the two frameworks were resolved through discussion and an agreed framework was established after which a second coding was performed.

Whilst interviews are a common method of data collection in qualitative research, there are competing schools of thought about how to analyse the data that is generated. For example, some argue that interviewees are giving a particular account (Dingwall, 1997) of their reality and, for example, provide socially acceptable answers. Others adopt a more realist interpretation, arguing that interview data can in fact be read as evidence of what participants think or believe about a particular issue. Further discussion of this debate can be found in Chapter 1 (page 40); suffice to note that this study bears most similarity with the latter approach.

The study received ethical approval from the School of Veterinary Medicine and Science Ethics Committee, The University of Nottingham.

3.4. Results

In total 250 farmers were invited to participate. Twenty-nine farmers agreed to be interviewed. Twenty-four interviews were carried out (Table 5). On two occasions a second participant was present who made a significant contribution to the interview. A consent form was completed for these additional participants and their contribution was included in the thematic analysis. Quotes from these interviews are labelled with the letter ‘a’ or ‘b’ to distinguish between participants. The mean interview length was 27 minutes (range 10-59 minutes). Thirteen interviews were conducted on farm, ten of the interviews were conducted over the telephone and one interview was conducted at the farmers’ other place of work.

The farmers were interested to be interviewed and seemed relaxed throughout the interviews, especially those farmers who participated in face-to-face interviews. Some farmers who participated in telephone interviews seemed to be more rushed or reluctant to expand on their answers. It is possible this was related to neither interviewer nor interviewee being able to read each other's body language, or that some of these participants requested a telephone interview because they were busy or reluctant to be interviewed in the first place. Some of the discussion was grounded in humour. However, when discussing personal experience of disease outbreaks there was, in some interviews an undercurrent of tension which could be due to fear of disease. Sixteen farmers were currently using one or more vaccines at the time of the interviews and three farmers had never vaccinated their cattle (Table 6).

Table 6 Farm information and vaccination history of the 24 farmers interviewed to investigate motivators and barriers to the implementation of dairy cattle vaccination strategies

Farmer ID	Region	Herd Size	Herd type	Currently vaccinates?	Diseases	Vaccinated in past?	Diseases
1	Midlands	Large	Conventional	Yes	IBR, leptospirosis, BVD, lungworm, clostridial pathogens, pneumonia	Yes	BTV
2	Midlands	Large	Conventional	Yes	Leptospirosis, BDV, IBR	Yes	BTV, *Salmonella*
3	Midlands	Medium	Organic	Yes	BVD, *Salmonella*, lungworm	Yes	BTV
4*	North	Small	Conventional	No	N/A	Yes	BVD, leptospirosis
5*	North	Small	Conventional	Yes	lungworm	Yes	BTV
6*	North	Medium	Conventional	Yes	BVD, leptospirosis, IBR	Yes	BTV
7*	North	Medium	Conventional	Yes	Leptospirosis, IBR, lungworm	No	N/A
8	North	Large	Organic	Yes	BVD, leptospirosis, IBR, lungworm	Yes	BTV, pneumonia
9	Scotland	Medium	Conventional	Yes	BVD	No	N/A
10	Scotland	Medium	Conventional	No	N/A	Yes	*Salmonella*, BTV
11	Scotland	Medium	Conventional	Yes	BVD, leptospirosis	Yes	BTV, neonatal diarrhoea

12*	Scotland	Medium	Organic	Yes	BVD	Yes	IBR, BTV
13	South East	Small	Conventional	No	N/A	Yes	BTV
14	South East	Medium	Conventional	No	N/A	Yes	BVD, IBR, BTV
15*	South East	Large	Conventional	No	N/A	Yes	BTV, leptospirosis
16*	Wales	Medium	Conventional	Yes	leptospirosis	No	N/A
17	Wales	Large	Conventional	Yes	*Salmonella*, lungworm	Yes	Leptospirosis, BTV
18*	Wales	Medium	Organic	No	N/A	No	N/A
19*	South West	Small	Conventional	No	N/A	No	N/A
20	South West	Medium	Conventional	Yes	BVD, leptospirosis	Yes	BTV
21*	South West	Medium	Conventional	Yes	Neonatal diarrhoea	No	N/A
22	South West	Large	Conventional	Yes	BVD	Yes	Leptospirosis, BTV
23	South West	Large	Conventional	Yes	Leptospirosis, BVD, IBR	Yes	Lungworm, ringworm, BTV
24	South West	Small	Organic	No	N/A	No	N/A

* indicates a telephone interview was conducted

Thematic analysis yielded five main themes from which motivators and barriers to vaccination could be identified:

1. Farmer knowledge and expertise
2. Disease control
3. The veterinary surgeon
4. Technology
5. Wider stakeholders

The entire data set was coded and all of the codes were attributed to minor themes, which were included in these five major themes. Codes were not analysed further if they did not relate to the research question of this particular study, though they provided context to the answers given by the farmers. A key example of this is the discussions many farmers had about bTB control.

The five main themes are expanded on, with quotes to illustrate the key elements within each theme, below.

3.4.1. Farmer knowledge and expertise

This major theme encompassed subthemes relating to the farmers themselves. These included their strong sense of responsibility for disease control on their farm and for the care of their cows; their awareness of their farm's disease status or disease risks to their farm and how the farmers classified their farms with regards to herd size, environment and 'way of farming', and how this influenced their vaccination decision-making.

<u>Responsibility</u>

Overwhelmingly the farmers interviewed agreed that the responsibility for disease control and vaccination on their farms was theirs. Although the vet was perceived to be involved in decision making on some occasions it was still felt to be the farmers' responsibility to contact the vet for advice, and how to proceed considering the veterinary advice.

> *It should lie with the owner. It should be the one that says "Yes." And, he's responsible. It's like me, they're my cows so I'm responsible for them and the decision is mine. I mean the vets might recommend [vaccination] but at the end of the day I can turn around and say "No. I don't want to do it." (Farmer 6)*

However in cases of notifiable disease outbreaks, for example foot and mouth disease and bovine tuberculosis the responsibility of the government was acknowledged, especially when it came to organising disease control schemes.

> *Well 95% [responsibility] with the farmer, but presumably things like foot and mouth and possibly TB. Well definitely TB. There has to be state veterinary input as well because getting all farmers to do the right thing at the right time is pretty damn difficult. (Farmer 3)*

Awareness

A farmers' awareness of their farm's disease status and risk of disease entry to the herd was cited as a prerequisite to consider the use of vaccines. If a farmer was not aware of a disease being a problem, or having the potential to become a problem, then there was no need to vaccinate.

> *A lot of farmers don't bother and don't realise what- Knowledge of what's going on in your herd makes you aware of what you should be doing or that vaccinating is the right thing to do. (Farmer 1)*

> *Well, when we've done tests in the past there hasn't been any signs of any problems. If it's not broken, you don't fix it, do you? (Farmer 9)*

Perceptions of the risk of disease outbreaks and the ability to have some control over disease were major contributors to vaccination decision making.

> *You're going from one milking to the next and I think you've got that safety in knowing that you've vaccinated and you've actually done something… (Farmer 8)*

A minor theme identified within that of 'Farmer knowledge and expertise' was the perception of vaccination as an insurance policy, to control costs and give peace of mind.

> *And BVD, I almost treat it as an insurance policy just in case. It can do so much damage. We've seen that. For the cost of that vaccine. I'd quite happily to continue doing that. (Farmer 12)*

Similar considerations of assessing risk came into play when discussing when to stop vaccination.

> *We stopped buying in, you know, there's not a lot of contact between cattle and neighbouring cattle. So we sort of, you know, it was one of those things that we did for a few years and then thought the risks were lower, closed herd and no need to [vaccinate for leptospirosis]. (Farmer 22)*

<u>The farm</u>

The way a farmer described or categorised their farm was a factor in vaccination decision-making. Different types of farm, as well as the environment in which the farm was placed, were perceived to be at greater or lesser risk of disease outbreaks.

The environment surrounding the farm, for example watercourses, neighbouring cattle and areas such as standing water or woodland that may encourage flies or midges were considered risk factors.

> *I think I became more aware of lepto[spirosis]. It was more in the press and vets became- Well it was more talked about. And also because we're at risk as well. So that becomes an issue. The watercourse we do realise is a high risk. (Farmer 1)*

Farmers with smaller herd sizes or that perceived their farming system to be low intensity felt they did not require the use of vaccines as their cows were not pushed to produce high yields, or put in situations such as a high indoor stocking density. These factors were perceived to put their cows and calves under stress, which was described as a risk factor for decreasing immunity.

Because we're organic and we we're a low input farm, we don't push the cows and I believe that the cows build up their immunities to these things. (Farmer 18)

It was mentioned by farmers that if they ever had to increase their herd size that vaccination would be something they would have to consider as they perceived they could not farm the way they do now with more cows.

I suppose people can't do what I do, because the size I am. You can't farm the way I farm on a bigger unit. Just would not work. (Farmer 24)

Vaccination was also described as a method of protecting their income, and therefore the farm as a business.

As farmers we want to have healthy stock. If you've got healthy stock, you've got good milk supply. You sell better stock… We've got a moral obligation haven't we as part of our business as well. To make money, you've got to have healthy animals… (Farmer 8)

The farmers placed the responsibility for disease control on their farm firmly with themselves, except for exotic disease outbreaks and in the case of bTB. It was noted by farmers and indicated by their discussion around reactive vaccination that awareness of the disease status of the farm, perceived or known, was a prerequisite for deciding to vaccinate their cattle. It seemed that the way farmers described their farm also had some influence on their decision-making.

3.4.2. Disease control

This theme places vaccination as one tool in the armoury to fight disease. Due to the nature of the study vaccination was the main focus of the interviews; however farmers did discuss other disease control tools. When discussing how and why vaccination as a disease control tool was used farmers tended to justify their use of vaccines as either a way of preventing a disease coming onto their farm or controlling a disease already on their farm. This section starts with how farmers described their use of vaccination in terms of disease control and continues onto other disease control tools and how their use affected vaccination decision making. There then follows subthemes on the role of luck in disease control and the effect that disease had on the cattle and the eventual effect this had on the farm as a business.

Vaccination as a disease control tool

Farmers felt vaccination was an important tool to control disease. Farmers used vaccines because they felt they needed to- either because of a disease outbreak or risk of disease coming onto the farm.

> *If you actively had BVD, IBR or lepto[spirosis] in your herd and it was really pulling you down, then you would have to. In any decent sense of business you would have to vaccinate because you just can't go on without it can you. (Farmer 14)*

Conversely farmers did not vaccinate if they felt they did not need to- they did not feel they were at risk of, or had a problem with that particular disease.

Well [vaccination is] obviously an important tool isn't it. It's your perceived risk isn't it is whether you use it or not. (Farmer 22)

Analysis revealed vaccines were used in three different ways; to prevent disease coming onto farms; to control disease once it was on a farm; and as a treatment for disease- to be used during an outbreak. Once the disease was perceived to be no longer a problem the vaccine was no longer required.

The use of vaccination to prevent disease coming onto a farm was either due to a perceived risk of disease or due to a feeling of obligation.

There's quite high levels in our area. So just a precautionary measure. We never suffer from, as far as I know, from BVD abortion, but there's always a possibility it could occur. So just mainly the precautionary measure. (Farmer 6)

A perception of an obligation to vaccinate was more commonly discussed in terms of bluetongue vaccination.

Yeah. We did. The first year it was a big scare about [bluetongue]. Everyone ran around vaccinated. Again a right pain. Expenditure. We never had a problem. We vaccinated on scaremongering really. It really was. We vaccinated on fear or a concern, you know, reading publications about, 'Oh god. This has happened. That's happened.' (Farmer 14)

Vaccination for leptospirosis and salmonellosis was described as a way of protecting staff from the zoonotic potential of the diseases as well as disease control amongst cattle.

But lepto[spirosis] more for staff really. Because it can transmit to humans. (Farmer 5)

In many cases vaccination was implemented reactively in an attempt to control a disease outbreak on farm.

We had an outbreak of IBR. We had a couple of late abortions and a little bit of milk-drop. We tested and it was IBR. So we vaccinated straightway and we've done ever since. So that was that. (Farmer 1)

A minority of farmers described using vaccination as a treatment, or as a cure. This appeared to be a reactive way of thinking about vaccination but was less long-term. Vaccines were used to resolve the problem and then stopped once the disease was perceived to no longer be a problem.

That is going to be my standpoint from now on. That if I have a problem, I will cure it. After that, you know, we'll stop for a bit and we will see and monitor. (Farmer 14)

Once farmers had started vaccinating some described considering the point at which they may stop vaccination. Some farmers took a decision to stop against the advice of their vet; some participants did not consult their vet at all, while others discussed the options with their vet. However it appeared that many farmers in this study would not risk stopping vaccinating.

I think it is more of a security thing. We're becoming a bit more that way, and again as the herds have got bigger, I think we're too frightened to stop. (Farmer 8)

Reasons to stop vaccinating included cost, inconvenience, perceived reduction in efficacy or lack of efficacy and a feeling they no longer needed to vaccinate.

> *Being a farmer, probably cost I think. We didn't seem to have any problems, so we stopped[vaccinating for leptospirosis] I think. (Farmer 17)*

Despite many of the farmers vaccinating for bluetongue when the vaccine first came out none were vaccinating for bluetongue at the time of the interviews. The main reasons for this were that the risk of infection was perceived to be reduced or that vets and the press had stopped talking about it.

> *I mean when the second season of blue tongue, it just seemed to go away didn't it and we didn't bother with the second season. It seemed to be of lower risk. It never got as bad as potentially it could then. So by the second season we never vaccinated again. (Farmer 22)*

<u>Other disease control tools</u>

It was highlighted by a number of farmers that there were other disease control options that could be used aside from vaccination, with one farmer describing the use of vaccines showing that they had failed in their management.

> *I mean if you feel that you haven't done a good job in preventing [the disease] in the first place, but you know, it didn't happen and you've got [the disease]. So you need to do something about it. (Farmer 3)*

Being a closed herd was an important disease control tool discussed. Farmers attributed disease breakdowns, and therefore a need to vaccinate, to buying in cattle or due to contact of their livestock with neighbouring animals.

> *We used to have a closed herd. Everything was sort of zero on readings. Obviously very naïve which was the worrying thing, but my strategy bit me on the arse basically because I thought well if I buy in from fully vaccinated herds, I should be okay, but we managed to buy a BVD PI from a so-say fully vaccinated herd, which was not good. (Farmer 22)*

Being a 'flying herd' or buying in replacement cattle was perceived to be a high risk strategy.

> *From my experience buying in cattle's a bit of a disaster. (Farmer 12)*

Those farmers who were not surrounded by other cattle farms felt less at risk of disease from outside their farm.

> *If we had sort of lots of neighbours with cattle looking over gates and getting out all the time, we would obviously be a higher risk than where we are almost with dairy cows with no other cattle around, you know, arable sort of next door with the River Severn on the other side. (Farmer 22)*

What farmers perceived to be a closed herd varied and the concept of closed seemed to be a sliding scale. Some farmers described their herds as closed but discussed buying in bulls or other cattle, which would place them at risk of buying in disease.

Some farmers had previously run a closed herd but had had to buy in cattle at some point. An example of this was as a result of a bTB breakdown. Another consequence of being under bTB movement restrictions was a perceived unavoidable increase in stocking density resulting in disease outbreaks which led to a need to vaccinate.

When buying in cows there were varying criteria for what farmers were willing to purchase. This sometimes led to a discussion surrounding trust in other farmers and whether there should be mandatory declarations of disease status, with both sides of the argument given as to who should take the responsibility when trading cattle.

> *It relies on me, doesn't it. If I'm buying in cows I make sure those cows are vaccinated or come from a healthy herd or whatever. (Farmer 19)*

> *I personally think people should declare. At the end of the day, why should buyer beware? Dairy cows a lot of money nowadays… If for some reason we had to buy in, I would want to know what diseases those animals had. (Farmer 20a)*

Another way of controlling disease that was discussed by the farmers related to the way they farmed in terms of intensity. The less stressed or pushed they felt their cows were, the higher the cows' immunity was perceived to be, meaning vaccination was not required.

> *Well in my system, because they're not pushed, they're not susceptible to diseases like your modern sort of conventional common dairy cow because they're pushed so hard, they don't have any immunity. So you have to*

vaccinate and they're not long enough in the herd some of them are they to sort of build up their immunity. It's like I've got cows out there that are fifteen-sixteen years old. I mean they're going to have full immunity. (Farmer 18)

When discussing eradication, national BVD eradication was perceived to be achievable and that if BVD was eradicated vaccination may no longer be necessary. If eradication was to be achieved then the requirement for collective action and the involvement of the government was considered vital.

An awareness of the level of disease in the herd was cited as a reason to vaccinate or not. How farmers monitored their herd for disease ranged from regular disease testing, such as bulk milk testing, observing overt clinical signs and being a good stockman. The concept of "if it isn't broke, you don't fix it" was mentioned by the farmers suggesting that farmers were reluctant to change and possibly upset the status quo. This term was used both when discussing why they had not started vaccinating as well as why they had not stopped vaccinating.

Well if you were tested and you were low-risk of anything, then obviously you might give it a miss. That might be the wrong thing to do. I don't know, but if it isn't broke, you don't fix it do you. (Farmer 21)

<u>Luck</u>

There was a perceived degree of luck involved in contracting a disease which influenced the farmers' future planning. The term 'touch wood' was used by many farmers implying that some aspects of diseases transmission are out of their control. This perception of luck may be a motivator for vaccination; at least through the use of vaccination they are able to do something to protect their stock and perhaps reduce the influence of luck.

> *Obviously, with being a closed herd, touch wood again, you would like to think it limits the risk of introducing any unwanted diseases into the herd, basically. (Farmer 9)*

<u>The effect of disease</u>

Themes relating to the effect of disease were split into the effect on the cows and the effect that the disease had on the farm as a business.

The effect disease had on cattle was generally discussed in terms of the clinical signs exhibited. Vaccines were used to prevent or control disease in their cattle and so reduce or prevent clinical signs.

> *What the reasons are [for vaccinating]. Well, what I've just been through really. Stop abortions, help the conception rates. Basically to keep a clean herd. You know, you don't want to be losing animals for a few pounds worth cost of a drug really. (Farmer 5)*

The clinical signs of disease had an impact on production, which in turn impacted the farm business. The use of vaccination was to prevent or control the effects of disease on the cattle, which meant the production and therefore the farm business was protected as the following quote discussing the reasons for vaccinating cattle demonstrates:

Stop them getting these diseases and by stopping them getting the diseases it improves the performance of your herd fertility wise, milk yield, and performance. (Farmer 17)

3.4.3. The veterinary surgeon

The analysis showed that farmers consider the vet as the most important outside influence on vaccination decision-making. This theme concentrates on two aspects; the 'use' of the vet, and the multiple roles the vet has in the implementation of vaccination strategies on-farm.

<u>Use of the vet</u>

Analysis of the discussion around the general role of the veterinary surgeon, revealed two themes. The first was the role of the vet as a 'fire-fighter' i.e. for emergency work that the farmer was unable to deal with themselves, and as pharmacies. The second was the use of the vet as a preventative and herd health practitioner; with the vet being on farm regularly for routine fertility work as well as for emergencies.

[We use them] for just fertility about once a month, treating fertility in cows, making sure everything's fit for cycling when they come in season. Scanning, getting them in, making sure they're in calf, they're supposed to be in calf, and then just routine, calvings, things like that. Castrations. And any fire brigade tactics that are needed. Any disasters. (Farmer 10)

The identification of a vet as a 'fire-fighter' seemed to be linked to a sense of pride that the farmer rarely had to rely on a vet.

I think thirty years I've only ever had the vet to calve one cow. (Farmer 18)

Reasons given for not using the vet on a regular basis were cost, the farmers' experience and the perception that low veterinary bills and decreased vet contact were positive indicators of health.

It does pay because for example 2012 my vet bill was £1,200 for the whole twelve months. About a hundred pound a month isn't it. And it's only because we did some de-horning it was bumped up and some TB testing. It wasn't really for disease control or anything like that. It was more veterinary work on the farm. I was talking to my neighbour and his was £12,000. (Farmer 18)

This was in contrast to the farmers who used their vet more regularly. Although lower veterinary bills were still seen as a positive indicator of herd health, the cost was perceived to be a necessary requirement to keep their herd healthy.

At the beginning of each year we obviously set up a budget and if I have to increase the budget for vet and med, then you know, obviously we have the discussion obviously why, but I don't have a very high vet bill anyway… So in reality there's got to be a benefit for that vet bill to go up and I know other farmers have got huge vet bills but we do a lot of our own work as well, you know, retained cleansings and that sort of thing. If we think there's a problem, yeah the vet's there. (Farmer 8)

These more regular visits were important for communication between the vet and farmer as well as for fertility monitoring.

Usually we have a general chitchat for half an hour [after the routine visit]. Just basically how the fertility visit's gone, what concerns have we got at that time, is there anything we should be doing? He's pretty open, the lad. If he sees there's something not right he'll say, you know "Retained cleansings" and things like that. No, quite a good relationship. Seems to work quite well. (Farmer 9)

Regardless of the roles of the vet on the farm, farmers would ask their vet for advice and information on vaccination but those who had their vet on farm regularly had more opportunities to discuss problems and protocols and to ask questions. Vets were identified as an important information source on vaccination and local disease epidemiology.

Well quite a lot of fairly high level [of IBR] in a few farms in our area the vets were telling me. So we thought we'd better use it. (Farmer 6)

Vets were also utilised as a trusted information source to get their opinion on, or get further information from, articles and advertisements in the press. In addition vets were used as a way of contacting drug companies.

I mean we do a little bit of research on products and things on the internet, but it's better to hear it from someone you trust I think. So yeah we'd go through [the vet]. (Farmer 2)

<u>The roles of the vet in vaccination</u>

The analysis identified five themes which relate to how the role of the vets is perceived by the farmer. Not all themes were evident in all interviews, which in itself emphasises the need for an individualised veterinary approach. The multiple roles of the vet in vaccination highlights that farmer decision-making in the implementation of vaccination strategies is a process and not a one off event.

Identification of 'a problem'

The first role the farmers expected of the vet was to explain and help identify the problem that may require the implementation of a vaccination protocol. In some cases the farmer identified the problem and called the vet in as a 'fire-fighter' to confirm and treat the problem. In other cases more surveillance type methods linked to the vet such as regular disease testing or routine fertility monitoring had indicated a problem. Finding problems on their farm was something that affected farmers emotionally- the realisation that their fertility was not up to scratch caused a normally upbeat event to be something of a concern.

> *Well, we've always had pretty good fertility, didn't we. But then, we have a monthly fertility visit… and you get a feel that, it's usually quite a cheery time, isn't it. You know, four weeks in calf, five weeks in calf, six weeks in calf, but then there was just a little dip [in fertility]. (Farmer 9)*

Both the identification of a problem through veterinary fire-fighting and through disease surveillance were brought up by farmers as motivators for discussing implementing vaccination strategies with their vet.

Diagnosing the problem

Once a problem was identified, by either the vet or the farmer, the vet’s role moved into diagnosing the cause of the problem. The diagnosis was usually achieved with a method of disease testing using samples collected from an individual sick animal or through routine herd surveillance.

> *I mean I’d say the vet makes you act on it. I mean you see the problems. You tell the vet. That vet does a test. There’s a problem. We have to act on it. Then I think then that judgement of where you start and stop, and financially start and stop, actively falls down to the farmer because at the end of the day you know your cows. You know what your bottom line is and you know how you need to get on and how you’ve got to run your business. (Farmer 14)*

The evidence from the diagnostic testing presented by the vet was a trigger for discussion about vaccination. This evidence was a motivator for farmers to vaccinate their cattle.

Advising to vaccinate

Once a diagnosis had been made the vet’s role was to advise the farmer to vaccinate or not. Generally the participants claimed to follow their vet’s advice and maintained that they would continue to do so in the future. In most cases where veterinary advice to vaccinate was provided, this advice was followed.

> *I think it's got to be a common sense thing really. If the vet really advises you to do it, they're telling you for a reason. (Farmer 4)*

However, vaccination appeared at times to be a short term strategy as vaccination was sometimes discontinued. Some farmers did not follow their vet's advice to vaccinate, or had stopped vaccinating against their vet's advice. Reasons were the cost and hassle of the vaccines or a perceived lack of efficacy.

> *And even though the vet did advise against [stopping vaccinating], I'd missed the date to redo the boosters so I decided well let's see how it goes knowing full well that it could relapse and if it does, then I say, 'Well I stand here with egg on my face. I've made a mistake', but we haven't had a problem. (Farmer 14)*

> *…the vet said "Oh it's lepto[spirosis]. You've got to vaccinate cows with lepto[spirosis]." Got the vaccine and it didn't make the slightest bit of difference. (Farmer 15)*

Perceptions of a lack of efficacy appeared to be based on the farmers' view of the problem and were infrequently supported by further evidence such as diagnostic testing.

<u>Providing the vaccine</u>

If the farmer decided to vaccinate, the role of the vet became that of the provider of the vaccine(s). Most of the participants who vaccinated their cattle purchased their vaccines from their vet, despite the fact they could have obtained a prescription and purchased the vaccine elsewhere. Some farmers did purchase, or mentioned considering purchasing their vaccines from agricultural merchants due to reduced cost and increased convenience but argued that they would still go to their vet for advice.

The BVD I have to [get from the veterinary practice] because it's still under licence to the vets. The lepto[spirosis] we bought outside because it was cheaper. (Farmer 20a)

There was a slight feeling of unease amongst a few farmers that vets had too much control over the price of vaccines and they considered that some vets (but not their own) would like farmers to continue vaccinating purely for financial reasons.

The vets have got a bit of a monopoly over the price of vaccines haven't they. You can only get it off them. So it seems quite expensive sometimes. (Farmer 17)

However, cost did not appear to be a major barrier to vaccination. Many of the farmers were reluctant to stop vaccinating once they had started and felt that the vaccines were worth the cost.

Well the IBR one is definitely [worth the cost] for us. The BVD and lepto[spirosis], a lot of it's peace of mind if you're buying in cows. It can lead to a sort of big loss if you suddenly get an outbreak. (Farmer 23b)

<u>Advice on implementation</u>

Once the vaccine had been supplied to the farmer this was occasionally the point at which the vet's role ended. However, other farmers used their vet as a source of further advice on implementation of vaccines on their farm.

Examples of advice sought included which animals to vaccinate, the use of concurrent vaccines on the same day and whether or not to stop vaccinating. It was also noted that different vets within the same practice and from different practices sometimes gave different advice.

> *The vet actually did say that he didn't think [bluetongue vaccination] was, I don't know how he worded it now... Appropriate really. He didn't think it was a necessary expense to go to. (Farmer 4)*

> *Well just our veterinary practice didn't they. They sort of pushed [bluetongue vaccination] a bit. (Farmer 23b)*

Participants tended to distinguish 'my vet' from other vets.

> *So I spoke with four different vets from the same practice [about Schmallenberg vaccination] and I've had four different answers. One says do it. That was the oldest of the vets. 'Do everything', he says. The next one says they need to understand it a bit more themselves, the position I was in. The second one says, 'Well just do the cows that aren't in calf yet'. And I'm thinking, 'Well hang on. I'm getting mixed information'. Then my own actual vet, [name of vet], he actually said to me, 'Well let's start at the bottom and just guarantee that we protect the heifers', which is fair enough. So that's where we're going. (Farmer 8)*

When asked about where responsibility for disease control and vaccination lay, the overwhelming response was that it lay with the farmer. However, participants did still place some responsibility on the vet's shoulders.

There's a fair responsibility lies on the farmers' shoulders. Obviously, if he has a problem then if he reckons his problem's getting out of hand he needs to be prepared to go to the vet. And I'd say about fifty-fifty between, or maybe sixty-forty because the farmer has to make the initial call to the vet if he thinks the problem he has is getting out of hand. And mostly I am responsible for the vet, to advise him properly in what we do with the vaccines. (Farmer 10)

What defined a good vet, or a good farmer-vet relationship varied between participants and how they used their vet.

We're pretty well free of disease with our system, you know, we hardly require a vet. We just mainly use them for drugs. We have a good relationship with them. (Farmer 6)

Other participants described good vets as practitioners who were practical, experienced, opinionated, knowledgeable and had the right attitude towards them and their business.

Don't see the senior partner quite so often [laughs]. I like having him because he's a farmer's son and seriously practical, whereas some of the younger ones perhaps haven't quite forgotten what they learnt in vet school [laughs]. (Farmer 3)

The relationship between the farmer and their vet was considered important when discussing vaccination strategies, with the vet facilitating decision-making in multiple ways. All participants felt their relationship with their vet was good; however, the description of the relationships varied between participants. Likely due to this good relationship, most participants would ask their vet for advice regardless of how frequently they were using their vet's skills on their farm.

3.4.4. Technology

Subthemes that related to vaccines themselves were grouped together under the theme' The Technology'. These included the efficacy and cost of the vaccines and the perceived stress to the cows and related adverse effects of vaccination.

<u>Efficacy</u>

Farmers decided whether or not vaccines worked by whether or not the problem went away, or if no problem developed.

> *Well all I can do is sort of say on our experience and before we vaccinated we had a problem and after we vaccinated, after they'd had their sort of two shots, we didn't have a problem and from that point we've come through and we've got them in calf and we haven't had an issue since and that's all I can really say. It worked. It done the job. (Farmer 14)*

Some farmers mentioned that they were aware that vaccines were not 100% effective and that there were situations that may reduce the efficacy of the vaccine.

> *But the vet does say that none of the vaccines are ever a hundred percent effective. I think if you introduced, say if you bought in a PI, and it was running the way you want it to vaccinate, there might be some who'd still get it. But it should help to make it less likely. (Farmer 11)*

Some farmers felt certain vaccines were not effective when others were.

> *With bluetongue we were doing it for two or three years. I think we just cleared them up of bluetongue. Lepto[spirosis] I couldn't really see the difference so I don't use it. (Farmer 15)*

Farmers who did not have much experience with different vaccines either extrapolated from human vaccination or from the single vaccine they did use that other vaccines should also be effective.

> *Well the rotavec works. So no reason why the others shouldn't work is there. (Farmer 21)*

<u>Pin-cushion cows</u>

Famers were concerned about how often they had to handle and inject their animals, especially when bTB testing was factored in. The term 'pincushion' was used as a way to illustrate how often farmers had to inject their cattle. The following quote is from a discussion surrounding why a farmer decided to stop vaccinating their cattle, the second quote describing the effects of the number of injections on the cows.

> *[The veterinary surgeons] just said it was totally my decision. They said some people do it and don't have any comebacks, and some people, once they've started vaccinating just keep vaccinating for it. But I don't like to treat my cows as pincushions. (Farmer 10)*

You can see the little lumps on them can't you. I mean prod, prod, prod isn't it. Then they come along with TB and prod them again with that. I mean they get- It's any wonder they want to go in the crush. (Farmer 1)

Adverse effects post-vaccination that had been noted were generally attributed to the stress of handling and being injected not to the vaccine itself.

Sometimes you get cows aborting. Because we're like autumn calving. They'll be heavily in calf when you're vaccinating. So we sometimes get a couple of cows slipping calf and you wonder if it's from the stress of vaccinating, handling them. (Farmer 17)

Some adverse effects were attributed to the vaccine itself- one farmer mentioned experience of bleeding calf syndrome due to BVD vaccination, though they were still vaccinating for BVD.

Ideas for reducing the stress of vaccination on their cattle included 'all-in-one' vaccines akin to clostridial vaccines for sheep or needle free methods of administration such as oral or pour-on vaccines.

I think if they invented vaccines that you could just pour on them to minimise the stress to the cattle it would help the job a lot. (Farmer 10)

While these ideas for reducing the stress of vaccination were discussed the methods of stress reduction that the farmers currently used were having good handling systems, vaccinating on the same day as other management tasks and using multiple vaccines on the same day.

Getting all the cattle in and jabbing them. It's not too bad if your handling facilities are alright. We usually just do it after milking. So it's not too bad. (Farmer 17)

We tend to cheat a little bit because we tend to do it in the TB test… So actually on the first test we tend to BVD, lepto and run PDs, coordinate the lot in one day… It's a lot less stress on the animals. Well animals are going to be stressed anyway… (Farmer 20a)

There was discussion over which vaccines could be given concurrently and it was understood that not all vaccines were licensed to be given at the same time.

I mean I rang the vets up and said, you know, he says we're not supposed to [give them at the same time but] he said, 'Well there's no reason you shouldn't. It's just not proven and you'll probably cause more stress getting them in three times than you would doing them all together.' (Farmer 1)

Well you can only do- You can't do all three at once. We've got to do I think its IBR separately. I think it's something like that. I think you've got to do one separately. (Farmer 23b)

Despite concerns about the stress and post-vaccination adverse effects only one farmer in this study gave the stress to the cows as a reason to stop vaccination. It seemed the benefits of the vaccine outweighed the concerns about any adverse effects caused by the stress.

It was also noted that vaccinating dairy cattle was likely to be easier and less stressful compared to vaccinating beef cattle due to perceived differences in handling.

Cost

Although cost was discussed, and some farmers gave it as a reason that other farmers may not vaccinate their cows, in general those who vaccinated felt it was worth the cost.

> *I wouldn't do it if I didn't think it was worth it really. Again it's peace of mind isn't it a little bit. A little bit is obviously your cows, well most of it's your cows really, but you do need peace of mind because the job's hard enough as it is… (Farmer 8)*

There was a slight suspicion that vets may prefer the farmers to continue to vaccinate for purely financial reasons. However most of the farmers who were interviewed stated they purchased their POM-V vaccines from their veterinary practice.

> *I mean to be honest, at the end of the day if it was down to my vet and all the people that think of it in a right nature, I would be vaccinating even now against the protection of it, but they ain't the one that's forking out five or six hundred pound a year on a struggling farm to do it… So yeah it does feel a bit of a money-making tool sometimes especially when they say, 'Well you're going to have to do this for years now just to-' Yeah. (Farmer 14)*

Some farmers did purchase their POM-VPS vaccines from agricultural merchants, though not all. The reasons for this were cost and convenience.

The farmers mostly believed vaccines to be effective and the evidence of this was the reduction or lack of clinical signs of the disease. There were concerns about the stress to cows in relation to the number of injections and amount of handling that was required, especially when bTB testing was factored in. The cost of vaccines was a concern but generally vaccines were perceived to be worthwhile.

3.4.5. Wider stakeholders

Although the veterinary surgeon was perceived to be the most important influence after the farmers themselves, other stakeholders were also identified. Other than their vet outside influences were felt to have minimal influence over how individual farmers vaccinated their cattle, but were perceived to have an influence over the industry as a whole. Other stakeholders identified were the government, pharmaceutical companies, milk buyers, organic certification companies and consumers. Sources of information other than the farmers' own vet included the farming press, other farmers and the internet. The perceived purpose and influence of these stakeholders are presented below.

<u>The government</u>

The government was perceived to have a level of influence over vaccination but this was mainly secondary to their influence over disease control in general. How welcome this influence was, and the role that the government were perceived to have, depended on the disease situation discussed and varied widely. The government was generally synonymous with Defra when mentioned by farmers.

We don’t enjoy spending money on vaccines. That if Defra had better controls or controlled things better, we may not need to use them. (Farmer 20a)

Obviously you’ve got sort of some diseases which are taken out of our hands unfortunately, but yeah the buck stops at the farm door doesn’t it. If governments want to run it, well so be it. I think probably best left to the farmer. (Farmer 22)

Scottish farmers discussed the government’s influence in terms of the current BVD eradication scheme.

I think everybody should vaccinate in Scotland and try and get BVD eradicated. I think it would be worthwhile. Because that's why they're needing the government to push it, because in an area you can have ten farms all vaccinating, and if one person's sitting in the middle of those ten farms not bothering then they're just going to re-infect everybody else… (Farmer 11)

<u>The pharmaceutical industry</u>

Vaccine manufacturers were identified as sources of information however the information was taken with a level of scepticism and was not felt to directly influence farmers’ decision-making. There was also a concern for some that companies may be exerting a negative influence through advertising either by scaremongering or making claims some farmers felt were beyond what the vaccine was capable of.

But sometimes I feel the big companies are worse. Their advertising is more like scaremongering. (Farmer 10)

Vaccine manufacturers were also perceived to be the ones in control of any changes that could be made to vaccines or vaccination.

The trouble is with vaccinating, we do them all together. We're just waiting for the drug companies to have that magic all-in-one vaccine. (Farmer 1)

The relationship between the pharmaceutical companies and vets was acknowledged- with both sides being able to exert influence on the other.

Well presumably the companies that make them [laughs] seriously influence the vet. Having been in the surgery one day when some rep turns up in a top of the range Audi [laughs]. (Farmer 3)

So I think vets can be a little bit side-tracked themselves into what deals they can get with different drugs companies as well. But obviously [vets] is a very big practice and would have some pulling power on any company anyway. (Farmer 8)

<u>The milk buyer</u>

Generally milk buyers were perceived to have no interest in disease control or vaccination as long as the milk that was supplied was free of antibiotic residues.

As long as everything sort of seems to go okay, they're [the milk buyer] not sort of forcing farm issues at all really. As long we supply them with sort of *antibiotic free milk that's not gone off, they seem to be- They let you get on with it. (Farmer 22)*

One farmer identified their milk buyer as a good information source on disease control and another farmer identified his milk buyer as attracting proactive farmers.

My milk goes on a [milk buyer] milk contract, and in our contract we have to monitor for all sorts of diseases… And then we have to have a protocol in place to act on really. So that's why… But yeah, IBR's just creeping up a little bit, so we thought we'd better just jump on that really. (Farmer 6)

<u>Organic certification bodies</u>

Organic certification bodies were not perceived to be a barrier to vaccination- vaccination was permitted as long as it could be shown it was required, which organic farmers did not see as an issue.

If you have a farm problem then you do something about it, but you don't go vaccinating everything that you could possibly vaccinate if there's no- The organic standards are on the whole very sensible. (Farmer 3)

<u>Consumers</u>

Supermarkets were not perceived to have an influence over how they farmed, and no influence over if and how they vaccinated, but there was potential for them to have an influence on dairy farming in general by putting up more hoops for the farmers to jump through.

Marks & Spencer's now, they're tweaking milk now. They want the fat and protein's got to be reduced. So that means the farmer's got to work that much harder. Is he going to be paid any more to work harder? I doubt it. (Farmer 20a)

The general public was not perceived as thinking about whether cows were vaccinated, or even where their milk came from.

I have teachers [come on my farm] who didn't even know cows had to give birth before they had milk. Vaccinations and things like that are the least of their worries, but that's talking about somebody who doesn't come from a farming background. (Farmer 8)

The recent 'horsemeat scandal' was discussed generally as a positive thing for the farming community- encouraging the public to think about where their meat and milk comes from and what they are prepared to pay for it.

The only thing they worry about is what the price is mainly nowadays I think. It did scare them a little bit when we had this horsemeat put in this and that didn't it. (Farmer 24)

<u>Sources of information</u>

Other farmers, the farming press and the internet were all mentioned as sources of information on vaccination and therefore being able to have some influence through advertisements and endorsements of vaccines. Vets were used to check the accuracy of these sources.

Influences outside of the farmer's vet were perceived by the farmers to be minimal on their vaccination decision-making. However, it was noted that any of the outside influences such as Defra and retailers had the potential to exert their influence over the dairy industry in general.

3.5. Discussion

Vaccination was perceived to be an important and efficacious tool in disease prevention and control. Although other methods of disease control were discussed, often these were perceived to be infeasible. This corresponds with veterinary surgeons' concerns that vaccination may be seen as the easy option (Cresswell et al., 2013). However, if the farmer perceived other options as impractical, ineffective or not within their control then they were less likely to use them (Brennan and Christley, 2013) and so vaccination may be perceived to be their only option. For example, vaccination was mentioned as being required as a disease control tool when the maintenance of a closed herd following a bTB breakdown was perceived to be impossible.

Reaction and prevention

The major motivator for farmers in this study to start vaccinating was either a perceived need to prevent a disease coming on to their farm affecting their cattle or in reaction to disease being found on the farm. These two uses of vaccination were based on the perceived risk of the disease entering the herd and the disease status of the herd. When farmers decided to vaccinate reactively there would first have been a problem. Sometimes this problem was investigated further using diagnostic tests. The diagnosis of disease may occur following routine surveillance, for example after diagnosing a reduction in reproductive performance at a routine fertility visit or increased antibody titres in a bulk milk sample. Investigations could be prompted at a herd level but also at the individual cow level, for example a cow with clinical signs. The vet was generally involved in the decision making process to reactively vaccinate. The decision to vaccinate preventatively i.e. the farmer believed that the disease was not present on their farm and therefore vaccination would prevent that disease affecting their cattle if it did enter the herd, was based on the farmers' perception of the risk of the disease entering. How the farmer described their farm appeared to be linked to how at risk they felt they were of disease outbreaks. Risk perception is taken into consideration when deciding on vaccination protocols (Paton, 2013); however what the data from this study suggests should also be taken into account, is the level of importance each farmer places on these risks. For example, a farmer who bought in cattle but felt that attending cattle shows was a high risk for bringing disease onto his farm and so did not attend them. This distinction feels counterintuitive but different situations may have a different perceived risk for different people.

<u>The farmer-vet relationship</u>

Advice from a vet was a major motivator to vaccinate. Vets were involved at multiple points throughout the vaccination decision-making process and helped to facilitate awareness of the farmers' need to vaccinate. In general if the vet advised vaccination in response to a diagnosed problem the participants were motivated to vaccinate. However, once a vaccination protocol was in place other forces beside the vet had more influence. Examples of these forces included the perceived efficacy of the vaccine or the stress to the cows of multiple injections. This would suggest that in order to maintain the vaccination status of dairy herds vets would be advised to go beyond just advising their clients to vaccinate. Ongoing support and advice may be required- especially if the perceived risk to the herd is reduced. Vets were a highly valued source of advice to the participants and were where the majority of farmers purchased their vaccines. Using the vet to check information obtained from other sources, such as articles in the farming press, was also found to be a theme when pig and sheep farmers were interviewed in a study investigating attitudes to disease risk management by Garforth et al. (2013). This suggests that trust in veterinary advice is not limited to the dairy farmers in this study, but that vets are important in advising farmers on disease prevention and control across the farming sectors.

Vets could be involved throughout the process- most crucially in diagnosing a problem that could be vaccinated for and then advising vaccination. The fact that farmers tended to distinguish ‘my vet’ from other vets suggested that assigning an individual vet to every farm client would be proactive step to strengthen the relationship between farmer and vet. This is similar to what has been shown in human medicine; people tend to distinguish ‘my doctor’ from other doctors and the health service in general (Casiday et al., 2006). Promoting this farmer-vet relationship would enable farmers to have a single point of contact and the vet is able to tailor their advice to the farm. Part of the vet's role in promoting awareness of a need to vaccinate, and one reason that farmers place importance on their vet's advice, was their perceived knowledge of local disease epidemiology. This was taken into consideration when farmers assessed the risk of disease outbreaks on their farm, and therefore a need to vaccinate. Further research is required to investigate if and how vets understand and communicate local disease epidemiology. One important drawback of this is the limited presence of prevalence data and a trend towards a reduction in government support for veterinary surveillance. With farmers appearing to rely on their vets for information regarding disease risks and prevalence, vets would be better placed if more information in this area was available.

Though not all farmers will want, or be able to afford, routine fertility visits an annual herd health plan is a requirement of farm assurance schemes and so could provide a useful tool to engage farmers in discussion about their current vaccination protocol. The two roles of the vet on farm tended to lead to different members of the practice coming on the farm: 'my vet' was the person used for routine fertility work, herd health and advice, whereas in an emergency it was whoever was available. This is the nature of farm animal veterinary services but suggests that a good relationship between the farmer and a single vet will improve knowledge transfer and communication. This farmer- vet relationship confirms and possibly explains why, in previous work farmers identified vets as their most important source of information for vaccination (Cresswell et al., 2014) and biosecurity (Gunn et al., 2008, Brennan and Christley, 2013).

Although the participants in this study identified themselves as being responsible for disease control and vaccination on their farm there was some responsibility placed on their vet's shoulders. This suggests the importance placed on the vet in the farming team and is a positive step in the direction of integrated and improved farmer-vet relationships. This relationship can, in turn, help combat the challenge of coordinating the conflicting demands of maintaining animal health and welfare whilst delivering food security in an environmentally sustainable way (Statham and Green, 2015).

An area that deserves discussion is the perception among some participants that having low vet bills was a good herd health indicator. The truth in this assumption would depend on what the money is being spent on; if on medications and emergency work then a low vet bill may be an indicator of good herd health. However if money is spent on preventive herd health monitoring, routine fertility testing and vaccinations then this may suggest a proactive approach to herd health which would improve overall profitability of the farming business. Traditionally the veterinary profession do not perceive themselves as service providers to businesses and a business model for charging for services is not well established. When this is coupled with the farming community's perception that veterinary services are too expensive and their charging is not transparent a cultural barrier is formed (Lowe, 2009). The Lowe report also highlighted that although vets identified disease prevention and health planning as an area they could add value for their clients, when farmers were asked what value was added by their vets they could not identify any area where this was the case (Lowe, 2009). The perception that vets are expensive is not confined to the dairy industry. As discussed in Chapter 1 Kaler and Green (2013) found that British sheep farmers thought vets were costly and their main role on-farm was as a fire-fighter. Although still perceived to be an expense, with some dairy farmers perceiving their vet's role to be a fire-fighter, the vet-farmer relationship in this study was found to be more positive than that described by Kaler and Green (2013).

Following on from the theme of veterinary costs was the vet's role in the sale of vaccines to farmers. Vaccines were purchased from vets because it was perceived they had to be, and from agricultural merchants because it was cheaper and more convenient. In the traditional farm animal veterinary business model medicine sales are a major contributor to income (Statham and Green, 2015). The slight feeling of unease from a minority of the participants surrounding vaccine pricing echoes the concern highlighted by Lowe (2009) that pricing of veterinary medicines was not transparent. This was, however, a minority opinion among the participants. Some veterinary vaccines have been de-regulated from the legal classification of POM-V to POM-VPS. There has been concern among the veterinary profession about the re-classification of these vaccines (BVA, 2007) however the classifications have remained at POM-VPS.

The current study seems to suggest farmers' perceptions of veterinary charges have not changed dramatically since the Lowe report. Vets are still perceived to be expensive and in a number of cases were only used as a dispenser of medications and occasional emergency services. Veterinary advice was perceived to be trustworthy and was sought throughout the vaccination decision-making and implementation process. Although the farmers were not explicitly asked if their vets charged for this advice the perception throughout the interviews was that the advice was given free of charge over the phone or whilst on the farm for other reasons. This finding echoes Kaler and Green (2013) in their study of sheep farmers' attitudes towards the role of the vet. A change in culture appears to be required in both the dairy farming industry and veterinary profession. The perception that increased veterinary contact and veterinary bills are a proxy for poor herd health needs to be shifted to the integration of vets into the farm team with a shift of spending on veterinary advice and preventative care instead of medicines. Although emergency veterinary work will always be required it has been shown that management and preventative medicine changes can reduce the incidence of diseases such as left displaced abomasums (Mueller, 2011), milk fevers (Husband, 2005) and the effects of infectious disease (Newcomer et al., 2015) occurring on farm. For the veterinary profession a culture change is needed in the business and charging models of farm animal practice to situate this development of a more preventative approach. A move away from medicine sales towards a more advisory and preventative herd health role is required (Statham and Green, 2015). This shift is slowly happening in both the farming industry and veterinary profession but there is still some distance to be covered.

Wider stakeholders

Other than their vet the outside influences which may manipulate a farmers' vaccination decision were perceived to be few. Advertising in the farming press and discussion with other farmers were described as ways farmers may become aware that vaccines were available however in general advertising was viewed with scepticism. Participants' vets were used to verify and expand on the information. This again emphasises the trust placed in vets' advice and opinion and echoes similar findings from other farming sectors (Garforth et al., 2013).

The reasonably high uptake of bluetongue vaccination by the participants (15/24) in the first year (Table 5), and the perception by the participants that they had to vaccinate, indicates that a voluntary national vaccination campaign for an exotic disease can be successful. Cultivating the perception of a need to vaccinate for a novel and exotic disease is effective whilst there is a perception of susceptibility. This susceptibility is fuelled by experience of clinical cases and a perception of risk. Once the risk has decreased however, keeping vaccination levels up for following years is difficult, especially in cases such as bluetongue where the disease is seasonable. Research in other countries also found that in the year following either compulsory (Germany) or subsidised (the Netherlands) bluetongue vaccination campaigns farmers willingness to vaccinate as well as actual vaccination rates dropped (Elbers et al., 2010b, Gethmann et al., 2015). The reasons for this appeared to be perception of reduced risk of disease and concerns about cost. The results from the participants in the current study appear to echo these attitudes.

<u>An 'ideal world'</u>

Farmers discussed things that may motivate them to use more vaccines, or that may convince other farmers to vaccinate. These factors could be thought of as hypothetical motivators as they involved ideas that are do not currently exist such as multivalent vaccines that included all the diseases they were concerned about, needle free vaccination techniques such as in-feed vaccines and national eradication programmes. National eradication efforts outside Scotland were an important concern for Scottish farmers as if BVD were to be eradicated in Scotland, the disease would still be endemic in England and there is currently free movement of cattle across the border. It is therefore possible that although eradication of a disease would be a barrier to vaccination, the high-risk position Scotland may be in is in fact a motivator to continue to vaccinate for BVD.

It was also perceived by participants that lowering the cost of vaccines may motivate other farmers who are not currently vaccinating their cattle to vaccinate, though for the participants cost was not determined to be a major barrier to vaccination. A multivalent clostridial vaccine was mentioned by many farmers as something that was essentially the norm in the management of sheep farming. This could be because this is a well-established vaccine and that clostridial disease is a common cause of mortality in lambs. Due to the seasonal nature of sheep farming in Britain this means that mortality due to clostridial disease tends to result in multiple deaths in a short space of time and so an effective vaccine could be perceived to have a greater impact. It could be speculated that although multivalent clostridial disease vaccines are available for cattle that these diseases are not as high on dairy farmers' priority list.

In a recent survey a higher percentage of beef farmers used a clostridial vaccine when compared to dairy farmers (Cresswell et al., 2014) so it would expected that beef farmers would support the dairy farming participants' request for a multivalent vaccine. Another possibility is that there are fewer licensed vaccines covering fewer pathogens for sheep when compared to cattle and so the use of one vaccine in particular is more likely to be commonplace. There are multivalent vaccines available in America that do offer protection against BVD, IBR and leptospirosis and if these were to become available in Britain it would appear it would be in high demand.

Maintaining vaccination protocols

Once farmers had started vaccinating the next decision-making process was whether to continue vaccinating or not. Stopping vaccinating was perceived as a high-risk step, and therefore depended on the farmers' level of risk aversion. This is different to human medicine. In cattle most vaccines are advised to be repeated at least annually for continuing protection (NOAH, 2015) however in human medicine only the seasonal influenza vaccine requires an annual booster.

Core vaccines in people are given free by the NHS making cost a negligible reason for parents to stop vaccinating their child. Farmers weighed up the annual cost with the stress to both cows and farmers of having to vaccinate their animals, especially if the efficacy or need for the vaccine was perceived to have decreased.

Although arguably the baby, childhood and teenage vaccination schedules contain more pathogens and could be perceived as more complicated than many vaccination schedules used on British dairy farms, this may not be the case. Firstly although at a patient level only one person or cow is being vaccinated the number of individuals involved under the person responsible i.e. the parent or farmer is very different. In herds that have an all year round calving pattern it is possible that many cows will require vaccinating with the same vaccines at different times- for example not all vaccines are licensed for use in pregnant animals and therefore must be given after calving, in an all year calving herd this is different for each cow. This means managing cattle vaccination schedules can become complicated and time consuming.

It would appear on the surface that compliance with vaccination protocols is easier in human medicine. To complete their vaccinations people mostly do not need annual vaccination to maintain protection and people rely on the NHS to remind them and provide guidance. This is in contrast to farmers who have to continue to vaccinate their cattle annually to maintain adequate levels of protection whilst fitting in multiple vaccines that cannot be given on the same day and are potentially receiving differing information from multiple sources. The use of vaccination reminders is common in human and companion animal medicine however they seem to be rarely used in farm animal practice.

Adverse vaccine events and 'pincushion cows'

As has been discussed in Chapter 1, the decision-making behind human vaccination is often not that simple. There are emotional connotations and perceptions of risk and trust involved. An undercurrent of uncertainty has blossomed into a powerful anti-vaccination movement (Fine, 2014). In contrast to the literature on human vaccination there was no strong anti-vaccination feeling toward cattle vaccination in this study and most of the adverse effects that were noticed post-vaccination were attributed to the stress of handling or being injected. Only one farmer perceived this stress to be a significant enough barrier to cause them to stop using vaccines. Other farmers used other strategies to help reduce the stress and handling or felt that the adverse effects it did cause were not concerning enough to stop them vaccinating. This was an area where the pharmaceutical companies were perceived to have an influence. If they were able to produce a multivalent vaccine, a vaccine that does not require a two dose primary course or does not need annual boosters, or needle free methods of vaccinating, farmers perceived the uptake of vaccines would increase. This concern about ‘pincushion cows’ has implications for any new vaccines that may come on to the market, there may become a point where farmers are not only not able to physically fit them all into their management but also will not tolerate injecting and handling their cows any more.

Barriers to vaccination

Although cost, hassle and stress to the cows were not, in themselves, major barriers to vaccination they were contributing factors to the decision making process and when combined with other factors such as a perceived lack of efficacy, or a reduction in risk of disease coming on to the farm may just be the factor that tipped farmers over the edge into not, or stopping vaccinating.

The major barrier to farmers vaccinating their cattle was that they perceived they did not need to vaccinate as they did not have the problems that you can vaccinate for on the farm or that they were not at risk of the disease coming onto the farm. This would suggest in order to motivate a farmer to vaccinate then strong evidence that there is a pathogen present that they can vaccinate for, or one at great risk of entering their herd, is important. One farmer, who no longer vaccinated their cattle, described using vaccines in terms of a cure, or treatment, for disease, rather than for prevention or control. They did then go on to discuss them in terms of protection, and prevention of the disease spreading to his unaffected cows. This may suggest that although farmers are aware of how vaccines could and should be used, the way in which they perceive they implement them is different. It would be useful therefore when discussing vaccination with farmers to understand what they are hoping to achieve with the vaccine. It is also important to find out if there are other things that may be causing or contributing to the problem as if a vaccine is implemented and is not perceived to be efficacious then this would be a barrier to continuing to vaccinate. The effects of disease were generally discussed in terms of clinical signs, therefore if the clinical signs persist a vaccine may be perceived as ineffective.

Disease status

The terms “touch wood” and “if it isn’t broke, you don’t fix it” were mentioned a number of times. These seem to encompass two areas- a feeling that there is perhaps an element of luck, or possibly some elements beyond the farmer’s control involved in disease control and a reluctance to change a strategy that appears to be effective. The element of luck and lack of control may be a motivator for vaccinating as at least the farmers perceive they are able to do something. This would also fit with the theme of vaccination used as an insurance policy. Farmers’ reluctance to change either from a point of vaccinating or a point of not vaccinating are two separate challenges. It is possible farmers may be vaccinating that do not need to but are risk averse and so do not want to stop vaccinating just in case something happens as a result of it. Conversely, other farmers may not vaccinate and be reluctant to change because they are happy with where they are. These farmers may not be aware that vaccination can help improve health and production in their herds. This is where awareness of their herd’s disease status and how that is affecting their herd's performance would be a powerful tool to motivate these farmers to vaccinate.

Limitations

It was not the aim of the study to be representative so caution must be used when applying the findings to the British dairy industry as a whole. Despite this the use of maximum variation sampling, a form of purposive sampling such as that used by Coyne et al. (2014), meant that that a diversity of farmers and farming types were included in this study, covering the range of farms in the British dairy industry. The use of the interviews and thematic analysis has allowed the collection and analysis of wide ranging and in depth data surrounding the topic of motivators and barriers British dairy farmers have towards cattle vaccination, an area that has been previously neglected in the literature. Data saturation was achieved and the use of maximum variation sampling allowed the inclusion of farmers who had different opinions due to their different situations. This study has also highlighted points that were unexpected such as the farmers' concern about the stress on their animals of the whole process of vaccination and their apparent reluctance to stop vaccinating once they had started.

There are a number of areas that warrant further discussion and are best compared and contrasted with the outcomes from Chapter 4. The points are summarised here and are further discussed in Chapter 5.

This research helps us to understand what drives dairy farmers in Britain to implement, or not implement vaccination strategies on their farms. This information can help those stakeholders involved in cattle vaccination to support and guide farmers in those decisions. The farmers in this study were generally predisposed to want to vaccinate their cows however there needed to be a perceived need to vaccinate; either an immediate requirement due to a perceived current problem or a perceived risk of disease entering their farm. There were no barriers identified from this analysis similar to the more extreme barriers to human vaccination that could be placed under the umbrella of 'anti-vaccination'. There was some concern about the stress of the process of vaccination to their cattle and some farmers identified adverse effects causing them to stop that particular vaccine. However, these in themselves did not stop the farmers using other vaccines. Lack of awareness of a problem, either due to a genuine low risk or lack of disease, or that the farmer does not perceive there to be a problem when there is one, is a barrier to the farmer vaccinating their cattle. This work highlights the influence that vets have on the vaccination decision-making as well as the more practical aspects of vaccine distribution and advice on implementation.

3.6. Conclusion

The major motivator for the farmers in this study to vaccinate their cattle was that they felt they needed to. This need was either in reaction to a problem found on the farm or because they felt at risk of the disease coming onto their farm and a key facilitator of these decisions was the veterinary surgeon.

The major barrier to farmers vaccinating their cows was there was not a perceived need to vaccinate. Either the farmer did not feel at risk of disease coming onto their farm or they were not aware of a problem on their farm that required vaccination. This would suggest that in order to encourage dairy farmers to vaccinate or to change their vaccination behaviour their veterinary surgeon would be a key player and that evidence of a problem or risk of disease would be an important factor in influencing their decision-making.

Chapter 4 Veterinary Surgeons’ Motivators and Barriers to Implementing Vaccination Strategies on British Dairy Farms

4.1. Abstract

Vaccine use in the cattle industry appears to be widespread but there is limited published guidance or set protocols for their use. Veterinary surgeons have been identified as important sources of advice on disease control and vaccination by farmers, as well as being their preferred vaccine provider. The veterinary profession also has a role in promoting food security and public health, part of which is the responsible use of vaccines and other disease control tools. It is therefore important to understand how and why vets make decisions about the vaccination of dairy cattle.

The objective of this study was to explore farm animal veterinary surgeons' motivators and barriers to the implementation of vaccination strategies on British dairy farms. Semi-structured interviews were conducted with fifteen British vets. The data was analysed using thematic analysis. Five main themes were identified from the analysis. These themes suggested that vets have a positive attitude towards the use of vaccination and have few barriers to advising its implementation. Vets appear to group farmers into three 'types' of farmer and these groups influence the vet-farmer relationship and communication. The requirement for evidence of disease or increased risk of disease however, seemed to be overruled in many cases by a risk averse attitude. In order to optimise vaccination strategies on British dairy farms this study would suggests vets are in need of further information such as prevalence data and how poor compliance affects efficacy to be able to confidently advise farmers about vaccination. A need for methods to increase

farmers' awareness of their herd's disease status and solutions to provide more time and resources to enable vets to discuss disease prevention and control with clients was also highlighted by this study.

4.2. Introduction

The role of the veterinary surgeon in farm animal vaccination is different to that of vets and health professionals in companion animal, equine and human health. In these situations the health care professional administers the vaccine. The vaccination schedules are generally pre-defined and are often the same for all recipients. It is also the case in companion animal and human medicine that reminders to attend vaccination appointments are commonly sent out and vaccination is perceived as the norm (Leask et al., 2006, Day, 2011). In contrast to this, in the farm animal industry in Britain farmers generally administer the vaccines themselves. They must also make additional decisions encompassing logistics, cost and which vaccines to implement. There are no agreed upon 'core' vaccines for cattle in Britain in the sense that there are for humans and companion animals, and there are no universally agreed upon vaccination schedules.

There is information in the veterinary literature on designing vaccination strategies for cattle farms (Paton, 2013) however, as discussed in Chapter 1 it is not known if vets are using this information, or if they find it useful. The decision-making behind dairy cattle vaccination, and arguably the relationship between the vet and farmer is different than that of owners and companion animal vets, and people and their doctor. It must also be taken into account that farming is a business. The unique characteristics of each farm would suggest universal protocols such as those used in human and companion animal medicine may not be suitable. The goals, perception of risk, and actual risks vary from farmer to farmer and farm to farm.

As found in Chapter 3, vets are perceived by farmers to be involved throughout the vaccination decision-making process and are perceived to be trusted advisors on vaccination, as well as the main vaccine supplier. In general if a vet advises a farmer to vaccinate, the farmer is likely to vaccinate (Chapter 3, page 120). However if the vet is not aware that there is a problem that requires vaccinating for then they are not able to facilitate the process of implementation.

The attitudes of vets towards dairy cattle vaccination, and their perception of how the discussion about vaccination with the farmer is initiated are therefore vital. It would seem sensible to assume that an effective and trusting relationship between a farmer and their vet would make it easier for farmers to navigate the long list of vaccine choices available. The majority of the diseases these vaccines protect against are endemic to Britain and are therefore are potentially all a risk to a herd. But, as suggested by Paton (2013), it would be difficult, costly and not necessary for every farmer to vaccinate for every disease. Given the fact farmers identify their vet as their primary source of advice on vaccination and local disease epidemiology as well as other disease control topics (Brennan and Christley, 2013, Gunn et al., 2008) it would suggest that vets are in an excellent position to advise farmers on vaccination. Vaccines are not the only area in which vets may be involved in on-farm decision-making. For example, previous research has shown that farmers identify vets as important referents for biosecurity (Gunn et al., 2008, Brennan and Christley, 2013). Understanding how vets make and communicate decisions, and their role in farmer decision-making, will be of importance to other areas of dairy farming and veterinary practice.

As discussed in Chapter 3, the role of vets on dairy farms can be different for each farm and it is possible that this has an impact on how farmers and their vet communicate. A reason for farmers not to vaccinate identified by Cresswell et al. (2014) is that they were not aware of a problem that needs vaccinating for. It has been shown that there are variations at what level disease, such as lameness, is noticed, or acted upon by farmers (Leach et al., 2010). This means it is possible some vets will not be aware of problems on some farms as the farmer may not call them for advice if they do not perceive to have a problem. If the vet is on farm more regularly, for example for routine fertility visits there are more opportunities for discussions with their client, and identify problems on farm. Another point of contact between the vet and farmer is the use of herd health plans. Previous work has shown that farmers feel that their herd health plan is an inactive document with little or no relevance to their farm (Bell et al., 2006). More promisingly Blease et al. (2013) found that although the dairy farmers felt the herd health plan to be an inactive document, farmers who had routine fertility visits were more likely to be positive about herd health plans. There are other stakeholders that farmers can use in advisory roles such as lay pregnancy scanners or herd health consultancy companies and these must be considered as sources of advice that may agree with or contradict the advice of the farm’s vet and will therefore influence the farmers’ decision-making regarding animal health issues.

As well as a source of advice and information and being a facilitator for identification of a problem on-farm, vets are also distributors of vaccines. The majority of vaccines in Britain are classified under the legal category POM-V (NOAH, 2014). Some vaccines can be supplied without a veterinary prescription (POM-VPS). To dispense these vaccines there is no requirement for the animals to be clinically assessed. The vaccines that are licensed for cattle and which legal category they fall under are listed in Appendix 1.

In 2007 the British Veterinary Association (BVA) contested the reclassification of vaccines offering protection against leptospirosis, clostridial disease and neonatal diarrhoea from POM-V to POM-VPS. Their objections were related to the complex and often multifactorial nature of disease, the zoonotic potential of leptospirosis and the need for intimate knowledge of the farm’s facilities, biosecurity practices and current disease status when advising on vaccination strategies. These factors are important and the vet is best placed to advise on them (BVA, 2007). The legal categories were not altered following the BVA’s contest however this highlights that the veterinary profession has concerns about the potential inappropriate use of vaccines and the advice farmers may be receiving from sources outside the veterinary profession.

Given that vets are perceived by farmers to have an important role in the decision-making around vaccinating cattle, and that vets are the providers of vaccines, it is important to understand their motivators, barriers and attitudes towards vaccination (Pike, 2008). With an improved understanding of vets' attitudes more tailored information and advice could be provided by stakeholders advising the veterinary profession. This is relevant when new vaccines are introduced, during an exotic disease outbreak where vaccination is required, or when a national eradication strategy involving vaccination would be implemented. Vets are likely to be the people implementing the strategies with farmers, as demonstrated during the bluetongue vaccination campaign in 2008. It is important in these situations that the advice disseminated to the farmers is consistent which, in turn requires the information that is disseminated to vets to be applicable, understandable and consistent. Cross et al. (2009) found that not only was there variation between farmers and vets but also variation between vets in their preferences for different control strategies for bluetongue. The study by Cross et al. (2009) also highlighted the variation in the advice and proposals between organisations such as Defra, the BVA and the Sheep Veterinary Society that could be used as information sources by vets. It could be hypothesised that this variation may account for a recurrent theme from the interviews with farmers conducted by Cross et al. (2009) of insufficient information reaching them. If vets were uncertain about the information they were receiving they may not have felt confident in relaying this information to farmers. The suboptimal communication of, among others, vaccination advice between 'central control' and other stakeholders in the field, was highlighted by experts discussing the implementation of vaccination during a British foot and mouth disease outbreak (Breakwell, 2003). In this study the National Farmers Union (NFU) called for consistent advice to farmers and the BVA was concerned about a lack of coherence between the people making policy decisions and those vets who had knowledge of what was happening in the field. For policymakers and professional organisations to be able to effectively support vets on vaccination it is important to understand the drivers behind the advice that veterinary surgeons give on vaccination. Answering these questions requires a social research methodology, the need for which in vaccination studies is further stressed by Chambers et al. (2014) who stated that understanding the drivers for acceptance of bTB vaccination by vets and farmers is crucial to a successful vaccination policy.

Another important area of the livestock veterinary profession's role is that of food security and public health (Statham and Green, 2015). Biosecurity, including the use of vaccination, is a key part of this. Through maintaining the health and welfare of dairy cattle the profession helps to optimise milk production and limit the spread of diseases important to public health. Maintaining food security and protecting public health is not without its challenges and therefore understanding the veterinary professions' attitudes to vaccines as a tool to protect the health and welfare of animals and the public is of importance.

The demographics of veterinary surgeons can affect their attitudes, for example towards pain and analgesia (Thomsen et al., 2010) and can also affect their involvement with proactive disease control (Higgins et al., 2013). In these studies it was found that the age of the veterinary surgeon had an influence on their attitude towards analgesic use in cattle and that the veterinary surgeon's position in the practice, their level of continuing professional development (CPD) and if they had a postgraduate certificate influenced their involvement in proactive disease control on dairy farms. This would suggest that when sampling a population to gain a wide range of opinions it would be prudent to ensure that a variety of vets be sampled to encourage a wide range of responses.

This study used aimed to explore farm animal veterinary surgeons' motivators and barriers to implementing vaccination strategies on British dairy farms.

4.3. Methods

As discussed in Chapter 2 (page 67) the reporting of studies investigating the attitudes of cattle farmers is of variable quality and the use of reporting guidelines was recommended. This study is therefore reported following the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines (Tong et al., 2007).

4.3.1. Selection

Recruitment of participants was undertaken by purposive sampling (Bryman, 2012c) of mixed and large animal veterinary surgeons from a database of practices held by the School of Veterinary Medicine and Science at the University of Nottingham. The database contained contact details and practice type information of the majority of veterinary practices (n= 4526) in the UK.

Practices employing veterinary surgeons treating dairy cattle were purposively sampled. To be eligible for inclusion in the study veterinary practices had to be listed as either a 'mixed' or 'large animal' practice or stated they treated 'cattle'. Practices were excluded if they were not located in Great Britain. Each practice was allocated one of six regions based on their address for logistical reasons. The regions were defined as described in Chapter 3.

An internet search was used to confirm practice eligibility. If this could not be confirmed the practice was left in the database and their eligibility checked at first contact.

4.3.2. Recruitment

Recruitment and interviews of veterinary surgeons took place between January and April 2014 (Appendix 8). A farm or mixed animal veterinary surgeon from each practice was invited to participate in the study. If no eligible veterinary surgeons were available then a better time to call back or an email address was requested to send further information (Appendix 9).

Veterinary surgeons who agreed to be interviewed were sent further information by post or email (Appendix 10). Aside from lunch no incentives were offered to the participants.

4.3.3. Data collection

Semi-structured interviews were conducted either face-to-face at the participant's veterinary practice or by telephone. All interviews were conducted by a single researcher (IFR). The information of the interviewer's background information was not offered to the participants unless requested.

Written consent (Appendix 11) was obtained prior to face-to-face interviews and verbal consent prior to telephone interviews. The interviews were audio recorded using a digital voice recorder (Olympus VN-711PC) with telephone pick-up (Olympus TP-8 Telephone Pick Up Microphone) where required.

A question guide (Appendix 12) was used and topics included the participant's background and practice description, the role of vaccines in disease control, information sources, their perception of farmers' attitudes towards vaccination, vaccine distribution and vaccine efficacy. Questions were developed through discussion with farm animal veterinary surgeons, researchers and using the research team's experience. The questions were trialled with a farm animal vet and amendments were made to improve the flow of questions. During some interviews other people were present. These non-participants were always made aware of the presence of the voice recorder and if they made a contribution that was recorded this was not included in the analysis.

Following each interview reflective field notes were written. These included the participant's body language and behaviour towards the interviewer, if any non-participants/multiple participants were present, any disturbances that created noise that may obscure the recording, reasons for the recorder being switched off and any major themes or notes from the content of the interview. These notes were used to give context to the interviews during analysis.

Whilst interviews are a common method of data collection in qualitative research, there are competing schools of thought about how to analyse the data that is generated. For example, some argue that interviewees are giving a particular account (Dingwall, 1997) of their reality and, for example, provide socially acceptable answers. Others adopt a more realist interpretation, arguing that interview data can in fact be read as evidence of what participants think or believe about a particular issue. Space precludes further discussion of this debate; suffice to note that this paper bears most similarity with the latter approach.

No repeat interviews were carried out and the transcripts were not sent to the participants for checking.

4.3.4. Data analysis

The audio recordings were transcribed verbatim by external transcribers. The transcripts were then checked against the recordings to check accuracy and to remove any identifying features. The anonymised transcripts were imported into qualitative data analysis software (NVivo 10, QSR International) for thematic analysis (Braun and Clarke, 2006).

Coding was complete and inductive. All data were systematically subjected to an initial coding. The codes from this initial coding were then reassessed and any duplicates merged and any codes that were superfluous were removed. The codes were then grouped into themes. Codes could be allocated to multiple themes. After these codes were organised and assessed, the data was then subjected to a second coding using these codes and themes.

To assess the robustness and thoroughness of the coding framework a sample of the transcripts (8/14) were coded independently by a second researcher. After coding was completed the researchers met and discussed and compared their coding frameworks. Both coding frameworks were very similar and the same major themes were identified therefore only minor changes were made to the final coding framework used for the second coding.

The study received ethical approval from the School of Veterinary Medicine and Science Ethics Committee, The University of Nottingham.

4.4. Results

In total 14 interviews were carried out with 15 participants who covered a range of years since qualification and university of qualification (Table 7). The median interview length was 51 minutes (range 32-77 minutes).

Table 7 Demographic information of the 15 veterinary surgeons interviewed to investigate motivators and barriers to implementing dairy cattle vacation strategies

Vet ID	Region	Years Qualified	Species treated[1]	Practice type[2]	Partner or Associate[3]	Gender
1	South West	0-5	LA	LA	assistant	Female
2	South West	5-10	LA	Mixed	assistant	Female
3	South West	5-10	LA	Mixed	assistant	Female
4	South West	>10	LA	Mixed	partner	Male
5	Midlands	5-10	LA	Mixed	assistant	Male
6	Midlands	5-10	Mixed	Mixed	assistant	Male
7	Midlands	>10	LA	Mixed	partner	Male
8	South East	0-5	Mixed	Mixed	assistant	Male
9*	South East	5-10	LA	Mixed	partner	Male
10	North	5-10	Mixed	Mixed	assistant	Female
11^	Wales	0-5	Mixed	Mixed	assistant	Female
12^	Wales	0-5	Mixed	Mixed	assistant	Female
13	Wales	>10	Mixed	Mixed	partner	Male
14	Scotland	>10	Mixed	Mixed	partner	Male
15	Scotland	>10	LA	Mixed	assistant	Male

* indicates telephone interview performed

^Participants interviewed simultaneously

[1]The species the participant worked with: (Large animal (LA): production species and the occasional equine client. Mixed: working with companion, production and equine

[2]The type of practice the participant worked for taking into account the practice as a whole, not the department the participant worked in

[3]The role the participant took in the practice: these were mostly as identified by the participant or obtained from the practice or RCVS websites.

All participants were keen to talk and seemed relaxed throughout the interviews. In one case two veterinary surgeons from the same practice were interviewed at the same time (Table 6). In this case both interviewees were recently graduated and being interviewed together improved their contribution. Their answers seemed to prompt each other into further responses and they appeared more at ease than perhaps they would have been if interviewed individually. The data collected was richer for having interviewed them simultaneously.

The entire data set was coded and all of the codes were attributed to minor themes, which were included in five main themes. Some codes were represented in more than one minor theme and some minor themes were represented in more than one major theme. Some codes, although attached to a theme, were not analysed in great detail or discussed at length in this thesis. These codes however, provided context to the answers given by the vets. Some examples of this are the discussions some vets had about the use of antibiotics, veterinary education and the future of the veterinary profession.

The main themes that were identified from the data were:

1. Rationale for vaccination
2. The veterinary surgeon-farmer relationship
3. Perceptions of farmers' rationale for vaccination
4. Technology
5. Outside influences

4.4.1. Rationale for vaccination

The veterinary surgeons interviewed in this study had broadly similar attitudes towards dairy cattle vaccination. There seemed to be minimal variation in the steps involved in decision-making between the vets when discussing dairy cattle vaccination in general.

The participants were positive about the use of vaccines but were also keen to stress that vaccines were only part of the solution when it came to disease control on dairy farms. Despite this vaccines were perceived to be one of the easiest disease control tools both for the farmer to implement and for the veterinary surgeon to prescribe. This perception of vaccination being the easy way out for farmers and possibly for other vets to advise vaccination came with a sense of frustration at times.

> *With vaccine, I know that's not – it's not the whole picture, but it is a big part of that and they like to be able to do something proactive and it's a lot easier for them to give them a jab of vaccine than have to change their whole farm management or build a new shed or something like that. (Vet 3)*

When discussing how vaccines were used the participants described the potential uses of vaccination in two different ways- for control of disease already present in a herd and for prevention of disease entering the herd.

> *I suppose you're using [the vaccine] for two different reasons. One for complete prevention, and one to treat in the face of infection to start with, I suppose, depending on the vaccine. (Vet 9)*

The use of vaccines for control of disease was described by participants as vaccines being advised in reaction to a diagnosis of disease on a particular farm. The use of disease testing was commonly described as a way of assisting in the decision-making as to whether to vaccinate or not. The use of disease testing was described in situations that varied from being called out to a cow with clinical signs to routine bulk milk tests. Following the diagnosis of a vaccine preventable disease, in many cases vaccination was advised. The need for a diagnosis suggests that vets require evidence to help support their decisions.

> *Well [I would advise vaccination] if we've diagnosed a problem, whatever infectious disease on the farm at that time and there's a vaccine available. (Vet 7)*

> *I think our clients appreciate that because I think there maybe is a tendency to say, 'Oh you should vaccinate against everything', maybe for some vets, but no. We have to have evidence before we would advise vaccination. I mean there are some things which are an absolute no-brainer. So I would always sort of Heptavac whatever… (Vet 13)*

Reaction to an outbreak or diagnosis of a disease seemed to be the main reason why the use of vaccination was advised by a vet- a problem had been diagnosed and therefore vaccination was required to control that disease in the herd.

When asked specifically what the role of vaccination was in disease control however, many of the interviewees discussed the use of vaccines in the prevention of disease. Vaccination was seen as an insurance policy for farmers- it was perceived to be better to protect your herd and spend a certain amount of money because the cost of an outbreak will cost much more.

> *[The role of vaccination is] preventing disease on the farm in the first place really and I think it's about trying to explain to your clients the actual potential cost of a disease outbreak. (Vet 13)*

Vets advised the use of vaccination for prevention of disease based on risk. The participants appeared to be risk averse when it came to vaccination strategies- especially when it came to naïve herds. There was a sense of fear and worry when discussing the reason to vaccinate. The concern related to the fact that if they advised a farmer that they did not, or no longer, needed to vaccinate and then there would be a disease outbreak that it would be their fault. Two participants independently and spontaneously discussed a case where a farmer had sued their vet because of an outbreak of disease in their herd and felt they had not been advised to vaccinate.

> *At the same time, we don't want to have undue risk. The famous case is the farmer that tried to sue the vet for three million because he hadn't advised IBR vaccine. Thankfully he was able to go back through his records and say, 'Well actually I did', and it was settled out of court, but that could have went the other way. What if he'd never kept that record? What if he'd lost? What position would that put vets in then? 'Oh gosh. He was sued for three million. I just better vaccinate for everything.' (Vet 15)*

Vaccination was perceived to be an insurance policy by the participants- a phrase used to describe the farmers' use of the vaccines as paying a sum of money to protect their herd from future losses and something that is unlikely to cause harm.

> *Well, it cost you over £300 a year to vaccinate and if you were to buy anything in or if something got out it can be relatively catastrophic. It's a £300 insurance policy; it's not doing the cows any harm, why not? (Vet 5)*

If the tables were turned and the farmer came to the veterinary surgeon and asked if they could stop vaccinating then the veterinary surgeons perceived they would have an honest discussion with the farmer about the risks but the advice would likely be against stopping. The potential negative outcomes of not vaccinating appeared to weigh heavily in the practitioners' decision-making. Despite this the vets would leave the final decision up to the farmer.

> *I'm not sure we would advise him to stop. Again, you can say, well the perceived risk is reduced and we haven't seen any infectious disease, and we can carry on bulk milk testing and/or blood sampling on a regular basis so we can see if there's any danger in it, or so we can stop vaccinating and wait and see or vaccinate heifers. (Vet 7)*

The way vet described their decision-making around whether to advise implementation of a vaccine was almost as if they were stuck in a 'catch-22' situation. If there was a problem diagnosed on the farm and there was a vaccine for it, then vaccination should be advised; if there was not a problem on the farm, especially if the farm was naïve to the disease then there were few veterinary surgeons who would risk advising not to vaccinate. Some participants did discuss that strict surveillance and a closed herd were advised for some of their naïve herds however this strategy was acknowledged to come with some risk.

> *And either way you can't argue against it, 'cause if they're all negative it's a risk, and if they're positive they need to vaccinate. (Vet 14)*

The most commonly discussed disease throughout the interviews was BVD. Together with IBR and leptospirosis these were considered the three main diseases that farmers vaccinate for and were perceived by some vets to be the 'routine' vaccines. When asked in general about vaccines these were the ones brought up by participants spontaneously and were often discussed in combination.

> *So, for sort of, routine vaccinations, so BVD, lepto[spirosis] and IBR, to be honest, the farmers are mostly supposed to be vaccinating and all we do is occasionally remind them. (Vet 2)*

BVD was a current topic of debate, especially in Scotland with a BVD eradication scheme underway, encouraging the discussion about whether eradication would be possible in England. There has been ample discussion about BVD within the veterinary profession (Brownlie and Booth, 2014). The veterinary surgeons in this study gave the impression that eradication, or at least control of BVD was a feasible goal.

The prevalence of leptospirosis in parts of Britain was thought, by some participants to be low however the zoonotic risk of the disease was a major motivator for vets to advise their clients to vaccinate.

> *Lepto[spirosis] I tend to advise all my dairy farms to do it on a public health side so it's up to them. I think it's a very difficult area for us not to advise them just because it's zoonotic and they're taking a risk, and that's a good enough reason to vaccinate really probably. (Vet 4)*

Each disease and accompanying vaccine was considered differently; in the case of leptospirosis clinical disease was not a requirement for vaccination to be advised and the implementation of pneumonia and neonatal diarrhoea vaccines tended to be used in a reactionary situation- becoming preventative in following years. The use of these vaccines in particular was sometimes perceived as a sticking plaster over suboptimal housing or management situations which either could not or would not be changed. It was perceived that if these other issues could be resolved then vaccination against pneumonia or neonatal diarrhoea may not be needed.

> *That's what they're looking for when they've got a pneumonia problem is for you to say "Oh yeah, go ahead and vaccinate and it'll solve it all", whereas probably they'd be better off doing other things. (Vet 3)*

The term 'cost-benefit', as used by the participants in this study, could be described as weighing up the outlay of the cost of the vaccines with the financial, production or health benefits of using those vaccines. The theme of 'cost-benefit' was present throughout the interviews as both a reason for and a reason against advising farmers to vaccinate. It was perceived that a barrier to farmers vaccinating was that they did not understand the potential cost-benefit of implementing vaccination. Although the initial cost of the vaccine was sometimes perceived to be large, vets mostly perceived the benefits of vaccination to outweigh this. One justification of a positive cost-benefit 'analysis' was if the cost of a case of the disease or the losses in production was greater than the cost of the vaccine and therefore by preventing these losses vaccines actually saved the farmer money in the long term. Communicating this message to farmers was perceived to be difficult. However, vets were confident that if they could get farmers to understand the cost-benefit of vaccinating then they would be more likely to vaccinate, indicating the level of importance given to this concept by vets.

> *Obviously, they see the bill for the vaccine, they don't see the money that they haven't lost because they don't have BVD raging in the herd. (Vet 2)*

The theme of 'cost-benefit' was also a contributing factor to some vets not advising farmers to vaccinate. In particular the vaccines that were not felt to be cost-effective were the Schmallenberg and mastitis vaccines as they were both felt to be expensive and either the risk of disease or the efficacy of the vaccine was not felt to be high enough. If it was perceived that the cost of the vaccine outweighed the risk of a disease outbreak or the efficacy of the vaccine then they were less likely to advise it. Though the feeling was that if the farmer was keen to use the vaccine regardless then they would not stop them.

> *…the mastitis vaccine which we haven't mentioned but that they're trying to develop, which potentially could make a massive difference for a lot of farms. But I think there's still quite a bit of work to make them 100% effective for the price they're asking. So it's got to be a cost benefit, the thing on all the farms the whole time you've got to make a decision on. (Vet 9)*

The income derived from vaccines sales was not perceived to be a major motivator. Participants who had no financial interest in their practice aired a suspicion that practice partners may be financially motivated to advise farmers to vaccinate but also commented that this influence was not perceived to be significant in their decision-making.

> *I have no doubt the partners have a financial thought in it, absolutely no doubt at all. There is very definitely an argument that once you become a partner there is, unconsciously or not, a part of you that is selling drugs. Not unnecessarily but there is no way it can't cloud your judgement. (Vet 5)*

Some vets cited drug sales as a hypothetical motivator for large, possibly corporate, specialised farm practices that were perceived to have little interest in client relationships and more interest in profits.

Few barriers were identified in the analysis to the implementation of vaccines on dairy farms. If vets did not perceive a need for vaccination to be advised or implemented then vaccination was not necessarily advised. However, if a farmer remained keen to vaccinate regardless of the perceived lack of need then they would not stop them. A major barrier to vaccination uptake by farmers was perceived to be the farmer themselves- vets were keen to vaccinate but if the farmer was not aware of a problem then they were unlikely to be motivated to vaccinate.

> *[If you could] force the farmers to keep better records as well as it's impossible to talk to them about what you perceive to be a problem, if they don't perceive it to be a problem, if they don't keep records of the number of calves with pneumonia or whatever, and compare it to other farms. Because if they don't know it's a problem, they're not going to want to do anything about it. (Vet 11)*

There were practical barriers to the implementation of vaccines on-farm such as supply problems and the potential for vaccines to interfere with disease testing. The potential for vaccines to interfere with disease testing was linked to discussions around if the vets would ever advise against vaccinating on a farm.

The interviewees felt well informed on vaccination and were aware of resources they could access. The vaccine's SPC and colleagues were the first ports of call but for information on updated protocols and new vaccines veterinary surgeons mostly relied on representatives from the pharmaceutical industry. Although there was an air of pragmatism about the information they were given this was still a beneficial relationship for advice- especially regarding off license use of vaccination.

> *The drug companies are always visiting us to talk to us about them and usually keep us up to date with new developments and things. When we do phone them for queries and things, they're always available, so generally pretty good*

and, as I say, we've got so many leaflets and booklets and internet and all sorts of stuff to go for reference now, that we're pretty well informed. (Vet 9)

When asked about how and if their knowledge had changed since graduating from university participants felt their knowledge and confidence in discussing vaccination had improved with experience over time. The inclusion of vaccination in dairy cattle in the undergraduate curriculum was perceived to be limited.

I think I wasn't that confident to begin with when you're vaccinating. Like you learn fuck all about vaccination don't you at uni? …And they tell you all about these diseases and what type of virus they are and what their incubation period is and then you come out to the big wide world and there's all these drug companies that are trying to sell you things and you don't really know whether you should be using them or not. (Vet 1)

The confidence to discuss vaccines with farmers seemed to be linked to how informed the vet felt.

But certainly I don't feel confident enough pressing too hard [for farmers to vaccinate], because if I start getting questioned too much I can't answer, then the whole argument falls apart, even though I can say why it is beneficial. (Vet 8)

Vets' attitudes toward implementing vaccination strategies on dairy farms were generally positive and seemed to vary little between practitioners when discussing vaccination in general. When making decisions about advising farmers to vaccinate the interviewees took into account the results of disease testing, the risks of the disease coming onto the farm and the cost-benefit to the farmer. However, overriding all these factors was an undercurrent of a 'better to be safe than sorry' attitude resulting in a reluctance to advise a farmer that they did not, or no longer needed to vaccinate.

4.4.2. Vet - farmer relationship

The relationship and communication between the veterinary surgeon and their farm clients was an important theme when discussing advice and implementation of vaccines. This relationship defined how conversations around vaccination started and defined the role vets perceived they had on farm.

Initiating the vaccination discussion

When asked about who usually brought up the topic of vaccination many of the vets claimed it was themselves. Often vaccination was discussed in response to the diagnosis of a problem on farm.

> *It's probably usually the vets bringing it up. And I suppose with the dairies the scenario tends to be you either see an animal that you think is suspicious of a disease that there is a vaccine available for, or you have a calf that is doing poorly and you diagnose it with BVD, or you have an outbreak of abortion that you diagnose as Lepto[spirosis]. (Vet 2)*

The route to the diagnosis varied but there was a consensus that in order to convince clients to vaccinate there needed to be evidence of a problem.

However once a problem had been diagnosed it was perceived that most farmers were interested in vaccination advice.

> *I think on the whole most of them – you know if we actually test them and they've got a result there saying that, "You've got an issue with this" and if they've got the clinical picture that fits it as well on the farm, then they would be quite receptive to suggesting vaccine. (Vet 3)*

The routes of diagnosis or 'triggers' which led to vaccination being brought up included the vet noticing a reduction in fertility at a routine fertility visit, routine disease surveillance such as quarterly bulk milk testing, being called out to a cow or group of cows with clinical signs prompting further investigation, testing as part of regional disease control schemes and testing as a result of pharmaceutical company funded disease testing. These 'triggers' to the diagnosis of a problem depended on the vet being on the farm and noticing something of concern or undertaking testing for a scheme or the farmer calling the vet out to a problem they had noticed. Either way it appeared that effective and trusting communication is required between vet and farmer prior to the decision to vaccinate is even made.

> *So all the herd health planning, all the sort of meetings and everything you can have, it's worth nothing if the famer doesn't actually believe that what you're talking about is correct… It's getting on farm and being seen to be able to do the job and work with them, and it's also about being honest about the information you give out. (Vet 15)*

Other triggers for vets to discuss vaccination with their farmers included: farmers meetings, conducting Herd Health Plans and as part of discussing a regional disease control scheme, such as the Scottish BVD eradication scheme.

Farmers were perceived to rarely initiate a discussion about vaccination although they were often the primary cause, by notifying the vet about a problem on their farm. Sometimes however, farmers did initiate the discussion and this was perceived to be the result of a number of influences. Outbreaks of disease such as pneumonia or exotic diseases seemed to prompt a direct request for vaccines as opposed to the more frequent situation where farmers called the veterinary surgeon out to investigate. Other farmers discussing the vaccines or neighbours having an outbreak could also prompt the discussion, as could information in the farming press and attendance at practice meetings where vaccination was discussed.

> *Sometimes farmers will come to us – they're getting for example pneumonia problems in their calves and they'll have heard of a friend or somebody – and they'll want to know if there's a vaccine that they can use. (Vet 3)*

<u>How the veterinary practice influences the vet-farmer relationship</u>

The type of veterinary practice that the participants worked in appeared to have an influence on the relationship vets had with their farmers. It was perceived that certain types of farmers were attracted to certain types of veterinary practices. Some of the participants perceived that their farmers used their practice because of the 'hands off' nature of the practice. These were the farmers that were perceived to be 'stuck in their ways' and the more proactive farmers were more likely to use a more proactive, specialist farm animal practice.

> *… most of the farmers who aren't with [a named practice] and are with us because, generally, they want to be left alone and [the named practice] are very much into their preventative and always been on the farm, and I think their pricing, rather than paying for a visit and what have you, they're so much per month, and it's involving all these things. And a lot of the farmers we have are old-fashioned and traditional and the last thing they want is someone interfering. (Vet 8)*

The relationship they had with their clients seemed to relate to the amount of time that they could allocate to being on farm. Time for discussion and getting on farm was perceived to be a positive factor in encouraging farmers to vaccinate however this was not always possible in some practices.

> *It's just it's difficult being in a mixed practice when you've got to consult in the morning, do ops, consult in the afternoon, and here especially our main like financial input is from the small animals. So it's really difficult to find time all together or even individually to sit down and actually try and push the farm side, but yeah there are ways of pushing it more definitely, but it's just having the time isn't it? (Vet 11)*

Vets in these practices sometimes felt they were fighting an uphill battle with their farmers and sometimes with their colleagues with regards to a more preventative medicine way of working. This is a potential barrier to an effective vet-farmer relationship.

I think well here anyway, it's only really as like the new grads are coming in that I feel like we're pushing [vaccination] more, whereas the older vets here are more just treat the individual sick cow rather than think about herd health as much. (Vet 11)

Without prompting some of the participants described their practice as proactive and although these vets did describe some of their clients as unlikely to change and unengaged they were also the participants that used the term proactive to describe their farmers.

I'd like to think our dairies are pretty good proactive dairies. They get, they don't get, because they're not allowed to be complacent or whatever, but I think that's the type of farm practice we are in terms of the proactive progressive side on the beef and sheep goes to sort of, you know, transfers over to the dairy side I think. (Vet 10)

A perception that the veterinary practice was proactive appeared to correlate with vaccination being a regular topic of discussion. These practices actively encouraged their farmers to vaccinate.

We do. We do. We push. And it may be that- Do our clients raise vaccination? No because we're down their throats about it… We're quite proactive but then we don't push vaccines unless we see a perceived need for it. (Vet 13)

Some of the interviewees spontaneously discussed the fact that many of their farmers were already vaccinating for BVD, IBR and leptospirosis and that it was almost practice policy to advise these three vaccines.

> *So for, sort of, routine herd vaccinations, so BVD, IBR and Lepto[spirosis], to be honest, the farmers are mostly supposed to be vaccinating and all we do is occasionally remind them. (Vet 2)*

Communicating vaccine advice

There were different methods of communicating vaccination information to farmers. These ranged from discussions on farm either whilst on a visit or during the completion of a herd health plan to newsletters and farmer meetings. Herd health plans were generally perceived to be useful to aid the discussion of many management and preventative health topics, including vaccination. However, vets also perceived that farmers did not want to pay for the time it took to properly complete the document. Herd health plans were perceived by some vets to be a bulky and impractical tool for farmers to use.

> *And I tell farmers honestly what [I think is more useful than a health plan] to do is get a wall chart, write on the wall chart what you do, when you do it, and keep it up there, and then you just know what you did in the next year, and that'll be your reminder for what you do this year. (Vet 14)*

The use of a reminder system for vaccinations was as something participants would like to use. Due to the complexities of cattle vaccination protocols however, it was not something that they had achieved as yet.

Providing information and educating farmers via newsletters and meetings were useful methods to transfer best practice vaccination guidelines. Ensuring veterinary surgeons lead by example, such as being seen to offer fresh needles and maintaining the cold chain was also seen as a way to inform the client about compliance with administration and storage instructions.

> *I always say as it goes out the door, I say, "Are you taking it straight home and using it straight away? If not, do you want a chilly bag?" Or it's just – I think just saying things like that just reminds them that, "Oh shit, yeah it does need to go in the fridge and I can't keep it in the truck until tomorrow" and I always say if I'm selling vaccine, "Do you need new needles? Do you know what size needles you need? Oh just remember it goes into the muscle". You know it's just saying things like that as it goes out the door which helps and just puts it in there. But we've got a responsibility to do that anyway. We should be telling them as we prescribe it how we use it. (Vet 1)*

Information about administration was mostly communicated by the use of labels on the vaccines when they are distributed to the farmer however there was scepticism as to whether farmers paid attention to the labels. When prompted some participants felt they could do more to advise their clients on administration and storage and felt that once the vaccines had left their practice then it was out of their control. However, the general opinion was that it was the responsibility of the vet to improve farmer awareness of administration and storage instructions. If the farmer was new to vaccination or starting a new protocol then they would discuss how to use the vaccines. As many clients had developed a yearly routine, administration technique and compliance was not something that was discussed that often.

> *[Vaccination] probably hasn't come up [in farmer meetings] for a while, but then that's probably because we feel that it's been covered and that the*

farmers should know about it and get on with it. I wonder whether actually, not necessarily related to vaccination but in general, we need to go back and do a more basic range of talks, because there are some interesting holes in knowledge that come up. So yeah, I think we feel it's been covered and we want to talk about more interesting things. It might well be a useful topic for farmers to hear about again. (Vet 2)

<u>The role of the vet on dairy farms</u>

The role the veterinary surgeon felt they had on farms also affected their relationship with farmers. Vets indicated that being present on farm and having regular contact with the farmer improved their relationship and communication.

It's getting on farm and being seen to be able to do the job and work with them, and it's also about being honest about the information you give out. (Vet 15)

Yeah, I think the [farmers] that are [on routine fertility visits], they are better, because they know your face. (Vet 8)

If the farmer only called their vet for 'fire-fighting', or was not perceived to be able to afford regular routine fertility visits then communication was perceived to be more difficult. In those situations vets perceived their clients had no interest in or time for communication beyond the task in hand.

[Discussion about vaccination] doesn't really happen. I mean because I'm not TB testing yet, that's our main sort of way of getting onto the farms. So you know, when you're going out to see sort of sick cows and stuff, you are just

treating. You don't particularly have too much time for chatting about other things. (Vet 12)

How the 'type' of famer affects the vet-farmer relationship

Analysis suggests vets tend to group farmers based on their perception of their clients. The factors that went into these groupings were common across participants and included how engaged or proactive they perceived the farmer to be, their herd size, their age, how they perceived the farmer felt about cost and their attitude to change. How vaccination was discussed, or even if vaccination was discussed with each of these groups varied depending on how the veterinary surgeon perceived the farmer. The participants appeared to place their clients in one of three categories. Firstly there was the farmer who was perceived to be proactive, engaged and in some cases one step ahead of the vets. These farmers were often farmers who were already vaccinating with routine vaccines.

> *There'll probably be about twenty years age gap difference between the young guy being a lot more proactive than the older guy. Being very old-fashioned, traditional. So yeah. Very much two ends of the spectrum with that and you really have to push to get him to do anything with one guy whereas the other guy, you know, if you said to him, 'We maybe ought to do this', he'll go, 'Oh yeah. That's fine. Yeah let's do that.' (Vet 10)*

The second group was where the majority of farmers were perceived to be. These farmers were perceived to be receptive to advice and change however, generally required a level of prompting from the vet to motivate them to vaccinate their cattle and required ongoing reminders and encouragement. Vets felt they needed some evidence or leverage to convince these farmers to change however once they had taken on board the advice they would not need further encouragement.

> *Yeah, it is so much based on like the character of the farmer isn't it? (Both laugh) Because you know the farmers that are going to tell you it's a waste of time and I always mention it, but I'll know which farmers I can talk round (laughs) and persuade. (Vet 1)*

The third group of farmers had almost been given up on by participants. These farmers were perceived to be reluctant to change and disengaged with the vet.

> *There are bound to be farms either that aren't just that interested in [disease control and testing] and are doing perfectly well or aren't interested and aren't going to be there in a few years' time anyway. (Vet 4)*

How discussions around vaccination with farmers were initiated and the role vets' perceived they had on their clients' farms confirmed that participants had different relationships with their clients. The relationship depended on how the participants categorised the farmer and that this in turn affected communication around vaccination and therefore had an effect on the implementation of vaccination strategies on-farm.

4.4.3. Perceptions of the farmers' rationale for vaccination

Vets assumed farmers' perceptions of vaccination were positive; farmers would not use them if they did not think they were efficacious or cost effective.

> *Some of them definitely see it as a good thing, well worthwhile, otherwise they wouldn't do it and carry on doing it year on year on year and they wouldn't pay as much for it. (Vet 5)*

Despite this, veterinary surgeons also felt farmers perceived vaccines to be costly and an additional inconvenience in an already busy business.

The participants' perception of farmers' motivators to vaccinate could be grouped into three subthemes. These perceptions may influence how vets frame their vaccination discussions with farmers as well as how they 'grouped' farmers, which in turn may affect their relationship and communication with their clients.

<u>Reaction to a problem</u>

Farmers were generally perceived to use vaccines in a reactionary way and that they needed to be given evidence in order to convince them to vaccinate. Previous experience of the disease, cattle with clinical signs or diagnosis of a disease that can be vaccinated for were described as motivators for farmers to vaccinate their cattle.

> *They use [vaccination] in terms of usually it can be they've had a bad outbreak of something and then it's a reaction as opposed to, because the cost is still*

> *perceived as an issue and I know you can show them as many cost benefit analyses as you like and they still will sort of go, 'Oh god. It's £2.50 a cow!' And if you think, 'Well if it saves one calf? Yeah.' The only thing that makes it quite frankly is if they have a hammering. They have a hammering and then they'll go, 'Oh my god. We'll vaccinate.' (Vet 13)*

Prevention of disease

In some cases the participants described farmers using vaccines preventatively.

> *Or there might be some people who want to use the vaccine because they're frightened of it coming in, but that tends to be rarer. (Vet 15)*

Examples used to illustrate the point included a farmer who decided to vaccinate for BVD after his neighbour's herd had an outbreak, the perception that farmers use vaccines just to be safe, or that if they vaccinate they would not need to use any other disease control tools.

> *I've literally just spoke to a farmer who- very good stockman, really good client, but will not vaccinate [preventatively] against BVD. We have a big breakdown on one of his mates and he knows about it and he's on the phone to him this morning. He said, 'Look. I've been thinking about it. I think I should vaccinate.' And you think, "Hallelujah. Five years [name], but there we are. Never mind." (Vet 13)*

One vet described the reason a perceived cost averse farmer would use vaccines preventatively was that although the vaccines were expensive they were cheaper than veterinary costs if a problem did occur.

Outside influences

Vets perceived farmers' vaccination decision-making to be influenced by other farmers. This could either be through recommendation of the vaccine or a disease outbreak on a neighbouring farm.

> *[Farm 1] were BVD free and have been BVD free since time began. But then they get a neighbour and the herd gets bigger, and they get a wee bit edgy, so they just started vaccinating as a preventative thing. (Vet 14)*

Two vets described using benchmarking of anonymised disease testing results, which allowed farmers to compare themselves against other farmers, to be an effective way of encouraging farmers to consider vaccination.

> *…we benchmarked all our farms on bulk milk results, so we just did a graph saying "Here are all our bulk milk results for Lepto[spirosis], BVD, IBR, and you're this farm", and the farms that had high antibody with circulating virus and stuff would say "Oh god, we're not very good compared to [other farms]" but if you went to that farm and said "Your antibody is very high" they weren't interested, but if you went to their farm and said "You're very high and these guys are really low" they said "Well, we ought to do something about it", and as a result on that quite a lot of people started vaccinating. (Vet 4)*

Other influences which were perceived to have an impact on farmers' decision-making included the farming press, the pharmaceutical industry and agricultural merchants. Vets mentioned that the Scottish BVD eradication scheme had had a positive influence on Scottish farmers vaccinating for BVD.

And normally they'll come in and they'll have read some article by Intervet or Farmer's Weekly or whatever it is, or Dairy Farming. It's amazing how the Dairy Farmer magazine comes in, Dairy Vet, or whatever it is, and I'll read it. And then the next day the farmer's on the phone wanting to ask about exactly the same thing that's in there. (Vet 14)

Farmers' barriers to vaccination

When discussing why certain farmers did not use vaccines on their farm a commonly discussed barrier was the one-off financial and labour costs of the vaccine when compared to awareness of the ongoing costs of the disease. This brings into play the fact that farmers were perceived to need to be aware of the problem before they would act on it. For example, if they had always had suboptimal fertility or a high number of scouring calves every year then the farmer may perceive this to be normal and have no impetus to control disease.

Expensive would probably be top of the list. Expensive both in financial outlay, but also the time to do it… So, expense would be one thing. The thing is if they don't perceive a problem then they're not going to spend the money to stop that problem. (Vet 6)

Sometimes participants thought that farmers did not vaccinate because they did not need to. If the herd had no evidence of the disease on the farm and was a closed herd with a small risk of disease, perhaps not vaccinating was most appropriate in these few cases.

For example, we've got a couple of herds that are literally naïve to everything and it does worry me slightly that they're not vaccinated, but they are low risk in that they haven't bought anything onto the farm for 20 years and things. But there's certainly a risk there that they could have something go through them and they're pretty naïve to it. (Vet 9)

A potential barrier to vaccination was vets perceiving that if BVD was eradicated farmers would no longer be inclined to vaccinate. In Scotland this was felt to be a high risk strategy as there was potential for BVD to be brought in from England and introduced to a naïve herd or country.

I suppose my worry is that if we go to the next stage of BVD eradication and people think, 'Oh we can drop our guard now', and then just stop vaccinating. Worst case scenario, Scotland becomes naïve. England's still got it and then it comes back up and it kicks off again. (Vet 15)

The participants perceived that farmers were generally motivated to vaccinate their cattle, given evidence of a need to do so. This could be in reaction to a confirmed disease outbreak on their farm or on a neighbouring farm. Other farmers were perceived to have a level of influence over farmers' vaccination behaviour and some vets exploited this through the use of benchmarking as a method of starting discussions about disease control and vaccination.

4.4.4. Technology

Factors integral to the vaccines themselves had influences on vets' attitudes towards vaccination, for example the protocols, efficacy and potential off license use.

Although participants felt that their knowledge about vaccination was generally good, especially for the vaccines that they used regularly, the exception to this appeared to be the bovine respiratory disease complex vaccines. The protocols were felt to be complicated, although this did not appear to prevent participants from advising farmers to implement vaccination.

> *I'm a little uneasy with calf pneumonia because there's so many different ways of doing it, you start off intra-nasal, go intra-muscular, it's very easy to get confused and I think if people do it without the right advice, or at least the right protocol, it can be a waste of money. (Vet 5)*

Farmer compliance with administration and storage instructions was perceived to be poor.

> *Famous quote from one of the farmers with IBR vaccine was, "in the muscle is under the skin", that's my favourite quote! (Vet 14)*

Compliance was an area of concern for vets with regards to effective vaccination. When asked about the impact of poor administration, vets thought that it probably would affect efficacy of vaccines.

I think there's probably a lot of work gone into those drug companies to get them brought onto the market and there's a reason why they need to be stored at a certain temperature and not kept in the front of the car or given at certain booster times or under the skin compared to in the muscle. (Vet 9)

Moreover, if there was a breakdown of the disease the vaccine was for, they could go back to the pharmaceutical company to discuss a vaccine failure. However, accurate compliance would be a prerequisite in these cases. There was uncertainty surrounding which aspects of (such as cold chain storage, route and frequency of administration and dose) and to what extent poor compliance would have a detrimental effect.

Will a drug company ever admit that actually if you just give it 1 ml it'll be fine [laughs]. I would love to know. If you find out those answers you tell me. (Vet 10)

It was understood by vets that many of the claims and instructions on the SPC were there because that was what was used for registration purposes and so no further claims could be made by the company about the vaccine's efficacy when used outside the indicated instructions. Vets would source advice from the pharmaceutical companies regarding off-license use and would use this knowledge to advise as to the best course of action for their client.

But in cases [of off license use of vaccines on the same day] we would often check with the pharmaceutical company, with our rep, and say, "This fellow's proposing to do that. What are your thoughts on that? Have you any advice?" (Vet 7)

When asked as to what advice they gave when farmers wanted to give multiple vaccines on the same day, or if a farmer had administered the vaccine incorrectly the response tended to be similar. However the reasoning behind and the specific advice given did vary between participants which would go along with the lack of evidence in this area for the use of vaccines off license.

And this is probably a scapegoat but when farmers ask me, I always start off by saying, "It's not licensed, there is no data to show whether it's going to affect them or not". Personally I know a lot of people that do it haven't had any issues, so that's all you can go on isn't it? (Vet 1)

Sometimes a lack of trust in the capability of their client would deter vets from instigating vaccination protocols.

Yes, [my advice may differ between farms] because farm to farm there's all sorts of different risk factors, and closed or open herds or whether you think they're actually capable of sticking to a vaccination plan, because a lot of them need boosters or with the initial courses a double vaccination and things. (Vet 9)

Vaccines were considered to be generally efficacious. The use of vaccines in the face of overwhelming disease challenge was felt to be an area where farmers may not understand the limitations of vaccines. In some diseases eradication was not perceived to be possible using vaccination alone. On the other hand, some vets expressed surprise at how efficacious they perceived some vaccines to be given the perceived lack of compliance by farmers.

I think farmers are pretty crap at doing everything right. So actually probably it's amazing how many vaccines do manage to work despite all the stuff we throw at it. When we say no vaccine's a hundred per cent, bless, it never would because it's never been done right. (Vet 10)

Although vets were aware of the limits of vaccine efficacy, there was uncertainty how to communicate vaccine efficacy to their clients.

Because if you say it's not 100% effective and it will only work 80% of the time, then you're going to lose a proportion of people that would buy it. You don't go out there and overtly lie and say, "Give them this and you will never have this disease in your herd every again." (Vet 5)

I'd always say, "You can't rely on them 100%; they don't stop you getting it, they just help protect the cows a bit better and help them deal with it better", so yeah we do do our best to make people aware of that. (Vet 3)

The efficacy of vaccines and farmer compliance with administration and storage instructions were linked throughout vets' discussions about vaccination. Vets expressed both surprise at how effective vaccines appeared to be despite perceived poor compliance, and concern about the effect of a reduction in efficacy due to poor compliance.

4.4.5. Outside influences

There were some perceived pressures on the veterinary surgeons' vaccination decision-making other than the farmer.

Pharmaceutical companies were claimed to be a major source of information on vaccines. The relationship with the pharmaceutical sales representative was seen as positive but some vets described a level of scepticism when appraising the information presented to them.

> *I won't sit there and just take in all the information and say, "Yeah that's great, we'll use your vaccine", like I do want to know the specifics of it all. (Vet 1)*

Pharmaceutical companies were also important in funding disease diagnosis on farm and sponsoring farmer meetings.

> *Come August September is always a drive for pneumonia vaccinations because it's coming up to the pneumonia season and so we all get nice pens and new mugs and sometimes we get jackets as well, and we get persuaded to go and do all sorts of bits and pieces on farm and try and push more pneumonia vaccines. Invariably there's pneumonia meetings and it goes in the newsletter and all this sort of stuff, and it's always in the letter. And it's always buried within a more holistic, visual intonation work, and you group things, your colostrum and all that sort of stuff, but more often than not those meetings are sponsored by a drugs company that is either looking for revenue from vaccinations or antibiotics, or both. And that's just the way the world works. (Vet 5)*

The participants felt that they had lost some of their vaccine sales to agricultural merchants. They were unsure how many of their farmers were using vaccines that could be acquired without prescription from a vet. Not knowing what was happening on some of their farms was a situation that appeared to make them uncomfortable, especially as they were not sure what advice had been given to the farmers by the agricultural merchants.

> *Well it makes it a bit more complicated with us sometimes if there is a breakdown because obviously you don't automatically go, 'Oh you should be vaccinating for that', and if the farmers then turn around and say, 'Well I am', you know, you've got no record of that or no sort of way of working round. So I think it would be more useful if it was coming through us and then it might be that they'd be more likely to come to us for advice about it rather than just going to the ag merchants and just buying a vaccine and, you know, going on that, that that would be a miracle cure. (Vet 12)*

Although it was claimed that veterinary medicine sales were not a motivator to encourage farmers to vaccinate there was a concern about being able to compete with agricultural merchants on price. The quality of the advice being given to farmers by non-veterinary sources was a concern. Because of the local knowledge and their relationship with their clients participants felt they would be best placed to give advice.

> *I'd prefer it not [being allowed to be sold by trade] because you just don't know what people are using and are they getting their advice. I think the big difference between a vet practice and the trade is farmer education. Someone will come in and, 'I want a bottle of X'. I'll go, 'Well why do you need this bottle of X? What are you using this for?' They'll go, 'Well I'm using it for such and such'. I'll say, 'Well you really shouldn't be using it. You should be using a bottle of Y. It's more cost-beneficial and you shouldn't be using bottle X at this time of year or for that particular thing for this reason.' (Vet 10)*

National and other disease control plans seemed to focus the vets' efforts and support the vets' advice to vaccinate. They were perceived as encouragement for farmers to consider vaccination and disease control.

> *…we've been quite involved in the "Healthy Livestock Initiative" which has been a really, really good scheme for disease prevention and just getting people to take stock of what their disease status is and think about whether they need to be doing something about it or not. (Vet 3)*

Although the use of vaccines in other countries was not a frequent consideration of the participants they did use successful eradication programmes in other countries as examples of the potential there was for eradication in Britain.

> *The BVD. I think there's too many defeatist attitudes and like I say we are getting left behind the rest of Europe and it's shameful in a way. It needs sorting, but it's going to have to be government legislation and good on Scotland for cracking on. I mean good on them. I know Ireland are going down the tissue-tag testing route but yeah, whichever way. (Vet 10)*

The government's influence was not perceived to be directly related to the participants' decision-making process for cattle vaccination however government input was acknowledged to be important for a national control scheme.

In summary, outside influences on cattle vaccination were perceived by participants to have both beneficial and detrimental effects. The beneficial effects were for example the pharmaceutical sales representatives as information sources- supporting the vet's advisory role on farm. A detrimental influence was concern over advice given to farmers by some non-veterinary sources.

4.5. Discussion

As far as the author is aware this is the first study that has investigated veterinary surgeons' attitudes towards dairy cattle vaccination.

The discussion will expand on concepts from the main themes that are of importance when considering practical, policy and further research implications. These implications will be discussed in greater detail in Chapter 6.

<u>Veterinary decision-making and advice</u>

Throughout the study vets had a positive attitude towards cattle vaccinations, however they were keen to stress that vaccines were only part of the solution when it came to disease control. The perception that vaccines are efficacious and perceived to be easy disease control tools for farmers has facilitated vets to recommend their use. In addition, the fact that participants tended to err on the side of caution when advising vaccination may explain why vaccines are so widely advised by veterinary surgeons.

The decision-making regarding vaccination appeared to be similar across the participants. This appears contradictory to findings by Cresswell et al. (2013) where practical individual vaccination advice from vets, when presented with the same scenario, showed considerable variability. Creswell et al. (2013)

hypothesised this variability was the result of a lack of evidence-based information. Decision-making was instead based on experience, training and other sources which will differ between vets. As the participants in the current study were not given a specific scenario to advise on it may be that on the broad aspects vets agree on the implementation of vaccination, however participants advise may also have differed is presented with a specific scenario as in the study by Cresswell et al. (2013). Nonetheless, participants appeared to be united in a motivation to advise vaccine implementation where there is evidence vaccination is required. The steps taken throughout the decision-making process appeared to be similar between vets. However, the level of evidence required to motivate a vet to advise vaccination may vary depending on their risk perception; the farmer's risk perception; the disease status of the herd; the type of herd, and the vet and farmer's previous experiences.

The underlying decision-making process itself being similar i.e. assessing the disease status and biosecurity risks of a herd to inform the requirement for vaccination, the differences seem to be in the resulting advice, due to variation in risk perception. The variability in advice from farm to farm may reflect the diverse population of dairy farms present in Britain, with different farmer attitudes to risk and disease control and differing prevalences of within and between herd vaccine preventable diseases. Variation in clinical veterinary opinions for disease interventions has been found previously, highlighting concerns surrounding the profession's ability to provide a united approach to disease control (Higgins et al., 2014). It could be hypothesised that without a united aim for disease control there cannot be a united approach. Factors which motivate vets to advise certain vaccines are therefore important to understand how decision-making occurs. In many cases, given the endemic nature of many of the diseases commonly vaccinated for, there is arguably a permanent risk of the disease being present on farm or entering the herd and this risk was to taken into account by the participants in their advice to vaccinate.

The vaccines perceived by the participants that could be described as ‘core’ were those for BVD, IBR and leptospirosis. BVD and IBR are perceived by vets to always be a risk to herds that do not have the disease. The risk related to leptospirosis was perceived differently as, although the prevalence of the disease was either unknown or considered to be low, the zoonotic potential of the disease took priority in decision-making. Vaccination for diseases such as pneumonia and neonatal diarrhoea tended to be more reactionary and these were regarded more as management related diseases integral to the farm itself. If the farm did not already have pneumonia or neonatal diarrhoea then they probably did not need to vaccinate preventatively, as the risk of disease was perceived to be low. In these cases vaccination was used as a last resort when management changes were unable to be implemented, or had failed and could be considered ‘non-core’ vaccines. This would suggest that vets make decisions regarding vaccination partly based on the disease they are faced with as well as the perceived risk. These distinctions are a reflection of the current way cattle vaccine decision-making occurs, i.e. on a farm by farm basis. However, the distinction between perceived ‘core’ vaccines and ‘non-core’ vaccines is one made in human and companion animal vaccination schedules (NHS, 2014, Day et al., 2010). If a universal cattle vaccination schedule were to be introduced then the distinction between diseases made by vets may help to inform the creation of the schedule.

<u>Risk aversion</u>

The risk averse stance that participants took towards vaccination seemed to be related to the participants’ concern over the consequences of not advising vaccination. For herds that were disease free, vaccines appeared to be advised as an additional layer of protection. The ‘default’ setting to advise vaccination may follow a heuristic approach-making a quick decision based on mental shortcuts or rules of thumb (André et al., 2002). Heuristics have been described as part of a pragmatic decision-making process in doctors “when in doubt the best way is to avoid problems and preserve parent’s confidence” (Borrell-Carrió et al., 2014). This risk averse approach may result in the over-prescription of vaccines on dairy farms. There is evidence of a similar risk averse approach to the use of perioperative antibiotics in companion animal surgery where 80% veterinary surgeons surveyed agreed that ‘If I am not sure if antibiotic prophylaxis is needed, I tend to give it’ (Knights et al., 2012). The inappropriate and over-use of antibiotics can have devastating effects on human and animal health. There is currently appears to be no evidence of resistance to the cattle vaccines used routinely in Britain, or that the over-use of vaccination in cattle is detrimental to the health of cattle or to people consuming food animal derived produce. Unlike in humans, many of the cattle diseases we vaccinate for in are endemic in Britain. Therefore the risks of disease could be said to outweigh the risks of potential adverse effects of vaccination. However, the over-prescribing of vaccines adds to farm expenditure in an already challenging agricultural financial climate.

As discussed in Chapter 3 (page 130), there appeared to be no anti-vaccine sentiment among participants, despite vaccine related adverse events having affected the industry in recent years. No adverse event could be said to be acceptable, however it would appear most seem to be mild in cattle. Vets are advised to report adverse events relating to veterinary medicines to the Veterinary Medicines Directorate (VMD, 2015), however it is likely to be an under-representation of the true incidence (Paton, 2013). Farmers may tend to attribute adverse effects to the stress of vaccination, not to the vaccine itself (Chapter 3, page 131). Conversely, parents and pet owners seem to be more inclined to attribute adverse effects to the vaccine (Chapter 1 page 26).

Any potential arguments against over-vaccination could therefore relate to the farmer. In the current situation of no national, overarching aim for the use of vaccines, and the acceptance by the veterinary profession that it is impractical and costly for farmers to vaccinate for everything (Paton, 2013), then over-vaccination may have undesirable practical and financial effects on farmers. The implementation of a vaccine on farm due to the risk averse attitude of a vet and farmer would seem practical and as long as the farmer can incorporate the vaccination protocol into their management and finances.

A need for more information

There appeared to be a need for evidence of disease prior to advising vaccine implementation. The need for evidence prior to advising vaccination found in this study correlates with findings by Cresswell et al. (2013), however the risk averse attitude to advising vaccination was not something described in Creswell's study. This would suggest that vets are stuck between two mind-sets; on one hand, the need to justify their advice with the use of evidence of disease whilst ensuring a cost-effective strategy. On the other hand, vets are worried about the consequences of not advising, or advising against, the use of a vaccine and therefore advise its use regardless. This contradiction is possibly partly a conflict between wanting to do what is best for their client and fear of the consequences if the advice does not lead to better production and animal welfare. This may be propagated by the lack of policy or a cohesive industry aim for the use of vaccination. Without the support of a universal pre-determined vaccination schedule, a possible solution to overcoming this apparent conflict in veterinary decision-making is clear communication between vet and farmer. Describing the reasoning and evidence behind their advice and including the farmer and their goals in those decisions may help reduce anxiety surrounding the consequences of not recommending a farmer to vaccinate. Farmer personalities differ widely and different approaches may be needed for different communication efforts. It is possible some farmers will prefer to be given explicit instructions and will follow their vet's advice regardless of the reasoning and evidence behind them.

In order for a vaccine, or any veterinary medicine, to be authorised it must be shown to be safe and effective. Efficacy of vaccines is generally demonstrated by the comparison of pre and post-vaccination antibody titres. Although this demonstrates an immune response it does not show efficacy in terms of clinically relevant outcomes such as reduction in morbidity and mortality. Studies investigating clinically relevant outcomes in cattle medicine, for example Bradley et al. (2015), are rare and tend to be undertaken once the vaccine has been licensed. There is limited evidence for the field efficacy of vaccines in the published literature (Uzal, 2012, Theurer et al., 2014, Snedeker et al., 2012). However, as discussed by Crawshaw and Caldow (2015), field efficacy studies of cattle vaccines are difficult to conduct, which may explain their rarity in the published literature. Despite this paucity of efficacy evidence participants perceived vaccines to be efficacious because of a perceived reduction in incidence of clinical disease, sometimes supported with diagnostic evidence. Therefore, it could be argued that the perception that vaccines work in the field negates the need for further studies on efficacy. The results of this study suggest that currently vets perceive that vaccines are efficacious. Contrary to this, Cresswell et al. (2013) reported a concern amongst farm animal vets about the lack of information available on the field efficacy of vaccines and a need for further information to be able to best inform their clients. It could be hypothesised that the vets involved in the discussion group in the study by Cresswell et al. (2013) were brainstorming an ideal situation. Although these vets were expressing legitimate concerns about the levels of evidence for vaccine field efficacy, the vets involved in the current study were discussing vaccination efficacy and advice in terms of a more pragmatic approach i.e. one in which a decision must be made despite a suboptimal evidence-base. This approach appeared to use the vets' own experience and the perception that although they had limitations vaccines were still a useful and efficacious disease control tool. In order to optimise vaccination decision-making, information such as local disease prevalence data, the efficacy of using vaccines contrary to the SPC instructions, and information relating to cost effectiveness would support the decision-making of vets. The development of human vaccination schedules take into account objectives established by the World Health Organisation (WHO), disease surveillance information, economic analysis and mathematical modelling as well as safety and efficacy concerns (Salisbury et al., 2002). They are then funded through general taxation and provided free of charge through the NHS. There is no equivalent of the infrastructure behind the development of human vaccination schedules in veterinary medicine and animal health. This makes addressing these issues both expensive and difficult.

The role of the vet on the farm

The role that the participants perceived they had on farm was an important factor in their relationship with their farmers, which in turn was a factor of how the veterinary surgeon ‘grouped’ and therefore communicated with their clients. Being called out to a problem identified by the farmer often the first step towards discussing vaccine use, however this required the farmer to firstly notice a problem, and then contact their veterinary surgeon.

Some of the veterinary surgeons did seem to think certain types of practice tended to attract certain types of farmer. This would agree with a marketing framework, and the information given by the RCVS on choosing a veterinary practice (RCVS, 2015). However, with the number of farm and mixed animal practices decreasing there is the likelihood that some farmers may have no choice in their veterinary practice, which may impact the chance of a good vet-farmer relationship.

What constitutes a ‘good vet’ and a good relationship appeared to vary between farmers (Chapter 3, page 108) and it could be hypothesised that this is reflected in how vets ‘grouped’ their clients. When investigating the opinions of farmers and vets towards herd health management Hall and Wapenaar (2012) highlighted that there were differences between individual farmers’ preferences in how their vet approached their relationship. The vets in that study appeared to favour one approach in particular- that of ‘a friend of the farmer style’. These variations in expectations of the vet both between farmers and between vets and farmers highlight one of the challenges to the veterinary profession. As discussed in Chapter 1 effective communication and the relationship between the vet and farmer is likely to be crucial to optimising vaccination strategies on British dairy farms. With the changing nature of the dairy industry resulting in a variation in farm types; ranging from small, family farms to large, more business orientated units, an ability to tailor advice and services to each farm is an important skill for a vet to have.

Interestingly, when small animal vets and clients were asked their perceptions on what attributes make ‘a good vet’, communication skills were not ranked as highly by clients as they were by vets (Mellanby et al., 2011). This difference was subtle, but still of interest given the emphasis placed on communication in the veterinary curricula (Latham and Morris, 2007), RCVS ‘Day one skills’ document (RCVS, 2011) and in this thesis. The survey also compared small animal vets with other disciplines (including large animal, equine, mixed and exotics vets). Although the study population of vets in other disciplines was small, a difference found between the two groups when asked to list their top three attributes of ‘a good vet’, was that a larger proportion of non-small animal vets identified ‘good practical skills’ as an attribute than small animal vets. This would appear to fit with what some farmers in the current study felt made ‘a good vet’ (Chapter 3, p114). Mellanby et al. (2011) surveyed vets and clients from one geographical area, and clients from a population visiting small animal practices, therefore it is possible that these results cannot be extrapolated across Britain, or to a farming population. The authors also discuss that ideally more qualitative methods would be used to expand and test these findings, however this is an important step in a currently under-represented area of research (Mellanby et al., 2011).

There is a current trend in declining numbers of dairy farms but not cattle. This suggests that the remaining herds are larger. The dairy industry is experiencing significant fluctuations in milk prices and efficient production is essential to remain viable as a business. The need for efficiency and increasing herd sizes has prompted a move from the veterinary profession from the more traditional 'fire-fighting' role on farms to discussing cost effectiveness and optimising production whilst maintaining animal welfare at a population level. This has resulted in a discussion around different business models of practice in order to serve the changing industry (Statham and Green, 2015). However, the dairy industry is still in flux with not all farms being large and geared towards a business like philosophy. This is reflected in the variation in veterinary practices in Britain. Although there appears to be a move towards specialisation and corporatisation in farm animal practice, small independent practices are still a part of the veterinary profession and these practices may be more likely to provide services to smaller, less business orientated farms. Learning about how farmers choose their vet and what they perceive to be a good vet would facilitate vets to further improve the vet-farmer relationship. If veterinary practices are able to understand why their clients chose their practice, and understand the farmers' goals, the practice may be better able to tailor their services. Whether the groups of farmers identified in the analysis are a true reflection of the dairy farming population is unknown but this study provides an insight into how vets perceive their clients and, when contrasted with the farmer perspective of their impression of their vet, may help target and improve communication strategies with an aim to improve implementation of disease control tools, including vaccination.

Different groups of farmers require different methods of communication. For example, Jansen et al. (2010b) found that information on udder health needed to be given in different ways to different types of farmers for effective communication and depended on the goal of the message. It is likely that this is the case for other aspects of disease control, such as vaccination. Jansen et al. (2010b) found that although both methods of communication, through central, i.e. the use of argument-based educational tools and peripheral i.e. the use of cues to subconsciously encourage behaviour change, routes were effective, they reached different types of farmer and were each more useful at achieving different aims. When applied to the area of cattle vaccination Jansen's findings would suggest that the use of argument-based educational tools would be effective for aiming at the general improvement of infectious disease control and prevention on-farm. These tools would be best aimed at those farmers already motivated to work on disease control. The use of implicit persuasion using cues of authority and social proof may be more effective for single behaviour changes such as compliance with cold-chain storage and be able to influence those farmers who are more reluctant to change. In order to optimise dairy cattle vaccination it would seem that both approaches to communication are required, as implementing vaccine protocols and the compliance with storage and administration instructions are both perceived as important by vets. Interestingly, the data suggests that participants were already using both of these communication methods when discussing vaccination with their clients therefore it may be of interest to further explore if these methods are effective and whether those veterinary practices that utilise these methods have clients with improved compliance.

Cost effectiveness

Cost effectiveness was a recurring theme throughout the data. Vets used the term 'cost-benefit' to describe the concept of weighing up the financial cost of the vaccine with the benefits resulting from implementation. For most vaccines veterinary surgeons felt that they needed to be able to justify the cost-benefit of vaccine use to convince farmers to vaccinate. Generally the cost-benefit of a vaccine was based on the cost of a case of the disease or the ongoing losses that may occur versus the cost of the vaccine. This suggests that more data on how much farmers can save, or gain by controlling or eradicating these diseases would provide vets with evidence to advise farmers. However, how cost effectiveness decisions were made was unclear. When discussing cost-benefit the participants tended to use production and financial benefits to compare to the cost of the vaccine for farmers and no other potential benefits such as increased welfare. Cost and financial implications were given more importance as themes in the veterinary surgeon interviews than was found with farmers (Chapter 3, page 128). If vets perceive that cost is an important factor to farmers then they are more likely to frame their discussions with farmers in that way. Hall and Wapenaar (2012) suggest that both vets and farmers were interested to 'improve economics on farm' when considering the advantages of herd health and preventative medicine. Hall and Wapenaar (2012) also highlight the challenge to vets in demonstrating the cost-effectiveness of herd health schemes.

Wider influences

The outside influences such as privately organised disease control schemes, government and pharmaceutical companies are useful to vets as they support the importance of vaccination in the control of disease, and these external factors are helpful discussion points about vaccination with farmers. The perception of the participants appeared to be that these outside influences did not change their decision-making but that they provided a platform from which to discuss vaccination and disease control with clients. It was felt by vets that some of these outside influences could be a source of the further information, such as efficacy data, data surrounding off license use and disease prevalence data. The use of pharmaceutical sales representatives as an information source was not uncommon; and it would appear pharmaceutical companies are an important source of accessible information on medications for the veterinary profession in Britain. It should be considered, however, that although the relationship between vets and these sources of information appears to be useful, the evidence provided by the pharmaceutical industry may be biased. Therefore an ability and opportunity to critically appraise the information received is an important skill for vets.

Some vets were concerned about non-veterinary sources for vaccine purchases. It could be argued that the loss of money from the sale of these vaccines could be a factor influencing this concern, however the main concern vets reported was the quality of the advice that farmers may recieve when purchasing their vaccines from places other than their veterinary practices. It may also highlight that veterinary surgeons are uncomfortable with the loss of knowledge, or perhaps control, of what is happening on their clients' farms. If vets do not know the history and usual practices of the farm they may feel they are less prepared and equipped to advise the farmers. This problem could be resolved through effective and regular communication between vet and farmer and other stakeholders. One method of this could be the annual herd health review, another being ensuring that a thorough history is taken during an investigation of potential disease outbreaks in order to establish the vaccination history of the herd.

Farmer compliance

There was uncertainty about whether poor compliance with administration instructions did affect the vaccines' efficacy. Previous work suggests that farmers' compliance with administration and storage instructions is not optimal (Meadows, 2010, Cresswell et al., 2014), and concerns about farmer compliance were raised by vets in a discussion group study by Cresswell et al. (2013). There was an understanding from the interviewees that more could be done by the profession to improve compliance but there was also a perception that the inclusion of such topics in newsletters and farmers meetings would not be of interest to farmers. This may be a representation of the participants' own feelings towards the topic of vaccination and compliance or an assumption that of previous experience clients know who to correctly carry out vaccinations. This assumption is potentially a dangerous one as even if farmers are administering and storing vaccines correctly, SPCs can change and veterinary practices can change the pharmaceutical company from which they obtain the vaccines. This may result in administration instructions changing without farmers realising. This suggests it would be worthwhile regularly reinforcing the importance of compliance, even for farmers who have been vaccinating for years. The need for further information was also present throughout this theme. Interestingly, despite believing that poor compliance would affect efficacy, vets also reported advising the concurrent administration of vaccines not licensed to be used together. This apparent contradiction would suggest that vets do make a distinction between aspects of administration and storage and their resultant effects; however what evidence these decisions are based on is unclear. Further evidence is required to be able to further examine the effects of poor compliance, and which aspects are the most important with respect to efficacy and safety.

Vaccination knowledge

When exploring where practitioners felt their knowledge about vaccination originated from, many cited experience in practice and that education surrounding cattle vaccination at university was sparse and limited. One interviewee pointed out that *"…it's not really a new grad[uate] job is it?" (Vet 2)*. However, vaccination protocols may be asked about when new graduates are on farms, following disease testing or during an exotic disease outbreak.. It therefore follows that decision-making around vaccination and disease control in general on cattle farms should be emphasised in the undergraduate veterinary curriculum. Cresswell et al. (2013) showed that there was a difference in vaccination advice given by vets in practice and by final year students. This difference could be attributed to a lack of knowledge of cattle vaccination and the absence of clinical experience to help to determine the advice and information relevant to a particular farm. It appears that vaccination in companion animal practice is perceived to be easier, possibly due to the more prescribed nature of the vaccination schedules. This would suggest that cattle vaccination in the undergraduate curriculum needs to include how to assess a farm's disease status and biosecurity risks- finding the evidence to advise vaccination and practically and effectively communicating the recommended protocol. The concepts of cattle vaccination are taught in the veterinary curriculum however, as the curriculum in Britain is geared towards producing an omnicompetent vet, the ability to effectively deliver the required knowledge of each species is challenging. The curriculum is already perceived to contain too much information and the advances in science and technology over the past decades have led to more information which has to be covered every year (May, 2008). Veterinary education is constantly evolving, and studies such as this may help to shape curricula in the future. When linked to the knowledge that vets in practice appear to receive much of their information about vaccines from pharmaceutical sales representatives it is possible that some of the knowledge gained may be subject to bias, something that could be avoided if the information was taught effectively at university.

Summary

It was not the aim of the study to be representative of all vets in Britain, therefore caution must be used when applying the findings to the British veterinary profession as a whole. Despite this, the use of purposive sampling such as used by Coyne et al. (2014) meant that that a diversity of vets and practice types were included in this study. The use of interviews and thematic analysis has allowed the collection and analysis of wide ranging and in depth data surrounding the motivators and barriers cattle vets have to implementing vaccination strategies.

Interestingly, the data saturation point was reached after fewer interviews compared to dairy farmers (Chapter 3, page 83). This could indicate a more homogeneous population with regards to their opinions towards cattle vaccination compared to dairy farmers. It could be hypothesised that all vets are trained in a similar way whereas farmers vary more in their backgrounds. Or, it could mean that dairy farmers were less comprehensive in their answers than veterinary surgeons and so more interviews were required to reach saturation. It is the authors impression that the apparent homogeneity of the vets and the fact that the answers given by the veterinary participants were more comprehensive than those given by a number of the farmers contributed to fewer interviews being needed to reach data saturation.

This study has highlighted some points that were unexpected such as vets' apparently risk averse prescribing of vaccines. There are a number of areas that warrant further discussion through comparing and combining with the outcomes from the farmer study in Chapter 3. These points are summarised here and discussed further in Chapter 5.

This research helps us to understand what drives vets in Britain to advise the implementation, or not advise implementation of vaccination strategies on their clients' farms. This information can help those stakeholders involved in cattle vaccination to optimise vaccination strategies. Vets generally have a positive attitude towards vaccination and are motivated to advise vaccination given evidence of disease on a farm, or ideally preventatively. Despite this there seems to be an undercurrent of risk aversion in the profession using a 'default' setting of advising to vaccinate as a precautionary measure. The vet-farmer relationship was important and seemed to be influenced by how vets grouped their clients. This may have implications for methods of communication. Decision-making around vaccination advice is reportedly based on the cost-effectiveness of vaccine implementation, the pathogen involved and evidence of an outbreak or risk of disease on or entering the farm. What evidence these factors were based on was unclear. Vets perceived their own knowledge on vaccines to be good and this knowledge was mainly gained after graduation through experience, colleagues and pharmaceutical companies.

Whilst there is no universal cattle vaccination schedule, in order to optimise vaccination decision-making it is important to understand what the farmer aims to achieve by the use of vaccination and their perception of risk. This means a trusting relationship and effective communication between vet and farmer is crucial.

Currently most vaccines in Britain are being used on an individual farm basis for either control of outbreaks on farms, to eradicate disease(s) from a farm or to prevent of disease affecting a farm. If industry guidelines for the use of vaccination were to be developed it would be crucial to be clear what these guidelines aim to achieve.

4.6. Conclusion

The participants were pragmatic in their vaccination advice to farmers, framing their discussion in terms of risk and evidence of disease as well as cost and inconvenience to the farmer. The requirement for evidence of disease or increased risk of disease however seemed to be overruled in many cases by a risk averse attitude and vaccination was, often advised as a precautionary measure. In order to optimise vaccination strategies on British dairy farms this study would suggests vets are in need of further information such as prevalence data and the effect of poor compliance to be able to confidently advise farmers about vaccination. A need for methods to increase farmers' awareness of their herd's disease status and solutions to provide more time and resources to enable vets to discuss disease prevention and control with clients was also highlighted by this study.

Chapter 5 Combined discussion of farmer and veterinary surgeon interviews

In this chapter the main findings from the farmer and veterinary surgeon interviews will be combined and discussed in light of each other. In combining the results from these key stakeholders a more holistic view can be taken of the choices and challenges faced in implementing vaccination strategies on British dairy farms.

5.1. Vet-farmer relationship

Cattle vaccination schedule decision-making in Britain is currently undertaken on an individual farm basis by farmers and their vet (Chapter 1, page 5).

Due to the variation in epidemiology for each vaccine preventable disease, and the local differences in each region and farm, a universal schedule for vaccine preventable diseases would appear difficult to consolidate with the understanding and beliefs of farmers and veterinary surgeons. Nor would a universal vaccination schedule encompassing all available vaccines be feasible with the current administration and financial practicalities of implementing vaccines on farm. The lack of a current national or regional aim for a comprehensive strategy may also complicate the realisation of such a schedule.

The opposite of such all-encompassing vaccination schedules could be termed ‘individualised medicine’, something that has been discussed previously in terms of companion animal medicine (Day, 2006). Individualised medicine, i.e. a departure away from prescriptive guidelines and protocols, requires an effective relationship between farmer and vet (Paton, 2013).

Interestingly all of the farmers in this study reported that they were happy with the relationship they had with their vet; however what that relationship entailed varied between farmers. The relationship between farmer and vet is clearly an important one, reinforced by the use of the terms ‘my vet’ and ‘my farmers’ by participants in both interview studies, something that has also been noted in the human vaccination field (Casiday et al., 2006). As discussed in Chapter 3 this would suggest that in many cases the assignation of individual vets to farms is a good way to build this relationship into a profitable team.

In dairy herds that have routine fertility visits there is often one vet responsible for an individual farm. Assigning vets to those farms that have infrequent or no fertility visits may encourage a better vet-farmer relationship, which is a step towards achieving change. This concept has been alluded to in previous veterinary literature (Lowe, 2009). As discussed in Chapter 4, vets appear to group farmers into ‘types’ of farmer, and adjust their expectations, communication and relationship accordingly. Following analysis of the farmer interviews it could be argued that these types of farmer were evident in this study. However, further research investigating if these types of farmer are a true representation of the dairy farming population and how best to communicate vaccine advice to each type of farmer would be useful, especially if vaccination guidelines were to be introduced.

When investigating farmers’ and veterinary surgeons’ attitudes towards herd health management, of which vaccination is only a part, Hall and Wapenaar

(2012) found that although farmers valued discussions with their vet, only a quarter of the vets surveyed initiated a discussion about herd health and preventative medicine, with only 15% of farmers perceiving that the vet initiated these discussions . In contrast, in the current study vets perceived that they were the major initiator of discussion around vaccination. Due to the reactive nature of farmers' decision making, although vets may initiate the topic of vaccination in discussion, they were first made aware of a problem that required the implementation of a vaccination strategy by the farmer. Therefore, before a veterinary initiated discussion on vaccination can occur, the farmer must first contact their vet and so it would appear that vaccination discussions require a trigger and do not occur spontaneously. It has been suggested that a close relationship and effective communication between a farmer and their vet helps increase awareness of the disease status of a farm (Hall and Wapenaar, 2012). This suggests that there is an opportunity for a more proactive approach by vets to discussing vaccination. A more proactive approach to vet-farmer communication can also be applied to disease testing, herd health and biosecurity as a whole; paving the way for a more holistic veterinary approach.

A more proactive, business orientated, preventative health advisor role may also improve vets' confidence and ability to charge for their advisory services, something the profession has traditionally been struggling with. This has been partly been due to the perception of vets that farmers are not willing to pay for advice (Lowe, 2009). If vets are able to charge for their time undertaking advisory, consultancy or herd health planning roles this may help to overcome the barrier of a lack of time identified by some vets to discussing and advising on disease control in general. If the time taken to create herd health plans and develop vaccination or disease testing schedules became as profitable as the more traditional roles of the veterinary surgeon then this type of advisory work will likely be prioritised by vets. The need for farm animal practices and veterinary surgeons to evolve with the changing farming industry, with all of its challenges, has been emphasised by the profession (Statham and Green, 2015).

Influence from a farmer's peers was a more important theme in the vet interviews than the farmer interviews. Two of the vet participants in this study claimed that benchmarking was a successful method of increasing farmer awareness. This allowed farmers to see their farms' position in comparison to their peers and stimulate discussion about how to improve. Farmers tended to describe other farmers as an occasional information source but not necessarily as a driver to choose to vaccinate their cattle. A perceived lack of influence from peers on the implementation of disease control measures from other farmers was also found by Garforth et al. (2013). The study investigated the attitudes of pig and sheep farmers towards disease risk management and found that other farmers barely figured in their analysis of the interview transcripts. This appears to suggest it is a perception that crosses types of farming and perhaps supports the notion that every farm is different. What one farmer does on their farm cannot necessarily be applicable to another therefore the potential influence of what other farmers do on their farm is reduced.

Caution is required in interpreting the importance, or otherwise, of others. It could simply be that farmers are not swayed by their peers. However, it could also be that farmers do not perceive their peers to be influential when in fact this could play a role. Alternatively, farmers interviewed could have felt that playing down the role of their peers was the socially acceptable answer in the interview situation. Or it could be that veterinary surgeons, as has been shown in other studies (Hall and Wapenaar, 2012), perceive that their relationship with their clients is different to how clients perceive their relationship with their vet and so place themselves lower down in the list of people who may influence a farmer's decisions. However the influence of a farmer's peers is perceived, they are still an influence and benchmarking is a way of contextualising the situation on an individual farm. The use of benchmarking may also help to break the 'acceptable level' barrier where what one farmer perceives is a normal level of disease is unacceptable to another farmer or a vet.

A trusting relationship and effective communication between a farmer and their vet is vital to understand what the farmer wishes to achieve by the use of vaccination. This study would suggest that individualised medicine, with the individual referring to a farm and not an individual cow, is how vaccine decisions are generally made in dairy cattle vaccination in Britain. Unless a national vaccination scheme is implemented and is supported by all stakeholders it would appear that the individualised approach is how vaccination strategies are best received. Therefore having an understanding of how vets and farmers perceive their relationship is crucial to optimising vaccination in dairy cattle.

Further conclusions about future policy implications will be discussed in Chapter 6.

5.2. The ‘need’ to vaccinate

Both farmers and vets were motivated to vaccinate provided there was evidence of a need to do so. This ‘need’ could be broken down into either evidence of disease present in a herd or evidence of a risk of disease entering a herd.

5.2.1. Evidence of disease

Both farmers and vets were motivated to vaccinate if a vaccine preventable disease was present on the farm. What constituted evidence of disease in a herd from a farmers’ point of view appeared to be clinical signs of disease, usually followed by veterinary confirmation that a particular disease was present. Confirmation of disease was often undertaken by laboratory testing, but not always. For vets, evidence of disease on a farm was also a combination of clinical signs with or without laboratory testing. Despite apparently agreeing on what constitutes evidence of disease, the level at which the clinical manifestation of disease was detected may differ between farmers and vets. For example, the vet may identify clinical signs that the farmer had not previously recognised, such as a drop in fertility found at a routine fertility visit or a group of coughing calves identified whilst the vet was on farm for another reason. Additionally a farmer could assume the incidence of clinical signs, such as neonatal diarrhoea, to be normal and therefore not contact their vet. In comparison, another farmer, or vet may find that level of diarrhoea to be unacceptable. This variation in how disease is interpreted has been previously highlighted by qualitative researchers investigating the process of treating lame cows. Horseman et al. (2014) found there were a range of terms used to describe a lame cow, and the perceptions of the farmer were associated with these definitions. The way a farmer described the mobility of a lame cow had implications for the subsequent treatment of the cow and might not be the same term and resultant treatment decision used by a vet, or another farmer. This was suggested to have implications for differences in estimates of lameness prevalence.

If a farmer does not perceive there to be a problem they are unlikely to act upon it. In this case, if their relationship with their vet is such that they only contact their vet as a 'fire-fighter', then their vet may not be aware of the problem and consequently an intervention, such as vaccination, will not be advised. Therefore, as discussed in Chapters 3 and 4, effective communication and regular on-farm contact between farmer and vet are crucial to facilitate early identification of a problem and effective implementation of a vaccination strategy.

Lack of awareness of a problem is not a barrier unique to farm animal vets, nor the veterinary profession as a whole. In companion animal medicine, despite the drive to move away from the traditional yearly booster consultation, an 'annual health check' visit is still encouraged as a method to facilitate early identification and reassessment of any problems (Day et al., 2010). These visits can allow the owner to discuss any concerns they have with the vet, as well as allowing the vet to perform a full health check. This clinical examination can facilitate detection of problems that might not have been picked up by the owner, for example poor dental health or arthritis. In human medicine the NHS and some condition-specific charities use advertising campaigns to encourage people to visit their doctor at the first sign of anything unusual, such as a persistent cough or haematuria, in order to enable prompt diagnosis and treatment of potentially life threatening conditions (NHS, 2015). The use of disease screening of at risk populations, for example screening for breast cancer, also serves to identify problems as early as possible, even before the patient is aware there is a problem. Although disease screening is perceived by some to be controversial (Gigerenzer, 2014), it can be seen as a useful method of detecting certain diseases.

When these examples are considered in terms of dairy farming, the Herd Health Plan could be compared to the companion animal 'annual health check consultation'. It is an opportunity for the farmer to raise any concerns and for the farmer and vet to evaluate the status of the herd. However, as this relates to a group of animals and not an individual, it is impractical to suggest the vet performs a full clinical examination of every cow in the herd. There are other methods of assessing the health and welfare of the herd including lameness scoring, assessment of body condition scores and screening antibody tests. Those farms that have regular visits by a vet may be more likely to have any problems detected early. These visits provide an opportunity for regular communication between vet and farmer and an opportunity for the vet to assess the health of the cattle they are presented with. In effect the routine fertility visit could be considered to be a screening test for a number of issues, not least diseases that may affect fertility. It could, therefore, be argued that farms who have regular visits from their vet will have more effective vaccination schedules in place than those who do not. Further research assessing individual farm vaccination schedules and disease incidence is required to test this hypothesis and this would necessitate the use of a more quantitative and representative approach.

5.2.2. Risk perception

The risk of a disease outbreak was a major motivator for both farmers and veterinary surgeons to vaccinate dairy cattle. A key finding from this research however, is the apparent discrepancy in risk perception between vets and farmers, and that this risk varied by disease and farm. This difference is mentioned by Garforth et al. (2013) who suggest that pig and sheep farmers' perception of biosecurity measures aimed at reducing the 'silent spread' of disease as unnecessary highlights a difference in how vets and farmers perceive disease risk.

Advising vaccination appeared to be a default setting for vets. Conversely farmers generally required the identification of a problem before they were motivated to vaccinate. Vets were motivated to advise vaccination as a precautionary measure. This apparently risk averse prescribing of vaccination by vets is discussed in Chapter 4 and will be expanded upon below.

Risk aversion

This study suggests that vets are more risk averse than farmers with relation to vaccination. As discussed in Chapter 1, in human vaccination and, to an extent in companion animal vaccination the vaccination schedules that are implemented by health care professionals have been predefined by policy makers. These schedules effectively remove a level of uncertainty from health care professionals' and vets' decision-making around the vaccination of the individual presented to them. Cattle vets, in comparison are required to make this decision on a farm by farm basis and this work demonstrates that in situations of uncertainty, i.e. deciding which vaccines a farmer should implement, or if a vaccine is required, vets are inclined to opt for the perceived low risk strategy of advising vaccination as a precautionary measure.

Whether the risk vets were more concerned about was the risk of a resultant disease outbreak or the risk of litigation due to not advising vaccination was unclear. Although a different line of questioning may have helped to unravel this uncertainty further it is also possible that vets themselves are unsure of, and unable to unpick the threads of this fear. A fear of litigation has been suggested to be a contributor to poor mental health within the veterinary profession (Bartram and Baldwin, 2008) and so may, for some vets, be a true driver for the apparent risk aversion demonstrated by this analysis. This would suggest that greater support is required for vets making vaccination decisions, especially for new and recent graduates.

Risk aversion for the farmer appeared to be less of a concern, this may be because farmers do not experience the additional layer of responsibility; if a wrong decision is made and disease occurs, it affects them and they will have to deal with the consequences but it will not affect others. This is different for the vet. In addition, for vets the advice is given by them but the actual carrying out of the work is outside their direct control, something that could add to feelings of uncertainty.

It could be hypothesised that a tendency of vets to advise vaccination as a precautionary measure could reflect a lack of confidence in the efficacy of other disease control tools, or a belief that farmers will not, or cannot implement them. This is supported by the findings of Gunn et al. (2008) who reported that approximately 30% cattle vets surveyed did not believe biosecurity was beneficial to their clients, over 90% vets perceived their clients were not willing to invest in biosecurity and over 70% believed their clients did not have the time to implement biosecurity measures. The perception of vets that farmers use vaccines as a ‘sticking plaster’ over poor management or disease control would support this hypothesis, however further work would be required to understand vets’ and farmers’ attitudes towards disease prevention and control measures outside of vaccination.

The relationship between vet and farmer is a two way process where vets may feel responsible for their clients, as well as for the animals in their care. An example of this is discussed by Bartram and Baldwin (2010). In a review of literature investigating influences on vets’ increased suicide risk Bartram and Baldwin (2010) highlight the emotional support vets provided to farmers during the 2001 foot and mouth disease outbreak as a potential cause of emotional distress. This suggests the consequences of a disease breakdown on a farm will affect vets in many different ways, be that economically, emotionally or on animal welfare grounds. It is possible that fear of litigation, a perception of responsibility and the effects of a disease breakdown all have a role to play in the apparent risk averse attitude to vaccination advice, and the importance of each may vary between vets and the farms they work on. It is important to consider that vets, because of the wider implications of their advice with regards to animal and farmer welfare, have an element of emotional input in their vaccination decision-making, even if it may not be a conscious one. The identification of risk aversion as a motivator for vets to advise vaccination suggests that further work could investigate the relevant strength of these factors (such as fear of litigation versus fear of disease). This would help to understand the underlying thought processes of risk aversion and could potentially be applicable to other areas of veterinary prescribing.

Risk aversion and hence precautionary prescribing has been illustrated in the prescribing of antibiotics in companion animal medicine (Knights et al., 2012). The potentially far-reaching effects of irresponsible antibiotic prescribing are well documented (WHO, 2015a), however there appears to be no evidence for the development of resistance to veterinary vaccines. When considered in the light of results suggesting there is no overt anti-vaccination sentiment among either dairy farmers or vets, and any adverse events from vaccination are considered mild and relating to the stress of handling (Chapter 3) this would suggest that adverse effects resulting from the over-prescribing of vaccines on dairy farms are likely to be financial, relating to time constraints of the farmer or relating to the stress to the cows from handling.

<u>Balancing the risk of disease with the risk of adverse events</u>

All vaccine preventable diseases except bluetongue and Schmallenberg virus were endemic to Britain at the time of the interviews. It is likely that the effects of these endemic diseases are experienced by farmers, either personally or through colleagues, and by veterinary surgeons on a regular basis and the risk of disease entering a herd is tangible in many cases. This is in contrast to what has been reported in the human literature and is hinted at in the companion animal literature. In human medicine the diseases vaccinated for are rarely experienced due to the success of mass vaccination programmes. In companion animal medicine many of the diseases are less commonly experienced as a result of vaccination, with some diseases such as canine distemper now being rare. A lack of exposure to the effects of vaccine preventable diseases results in the perceived risks of the disease being low, which in some cases results in the risks of adverse effects being perceived as high (Yarwood et al., 2005, Day, 2011). This shifting of risk priorities could be linked to the finding in this study that if disease risk was perceived to be low, then factors such as the cost, inconvenience and stress to the cows of using a vaccine may become a more important barrier to vaccination.

It is important to stress that this study did not find an overt anti-vaccine feeling, as described in the human literature (see Chapter 1) and a fear of adverse effects was not identified. Interestingly, adverse reactions attributable to vaccines are not unheard of in cattle vaccination. For example, in the Netherlands no mandatory vaccination policies have been rolled out since the early 1990's, due to a concern surrounding vaccination uptake following the contamination of IBR vaccine with BVD virus during a mandatory vaccination campaign in the 1990s (Elbers et al., 2010b). In 2010 an association between a BVD vaccine and bovine neonatal pancytopenia (BNP) resulted in a vaccine being withdrawn by the European Medicines Agency (Bastian et al., 2011). No studies have fully explored the effect that these events have had on farmer and vet attitudes towards vaccination in Britain. Surprisingly, cases of BNP being associated with a particular vaccine were not found to be a barrier to vaccination in this study.

There was, among some of the farmers, a concern about the number of injections their cattle were receiving; the 'pin cushion cow' effect. This appeared to be more in relation to the physical act of handling and injecting the cattle and less to do with the number of pathogens involved. A concern regarding the stress of vaccinating stock appears to be a concern across farming sectors and has also been reported in previous research. Garforth et al. (2013) noted that some sheep farmers involved in the study investigating attitudes to disease risk management, took the stress to their sheep of vaccinating into account when making decisions about implementing vaccines.

Farmers' solutions for overcoming the number of injections their cattle receive included the development of multivalent vaccines including more of the 'core' pathogens and needle free methods of administration. In the absence of these technologies for cattle vaccination it is important to take into account farmers' concerns regarding the stress vaccination has on their stock. This is especially of concern when advising the addition of a vaccine to a farms' vaccination schedule and may be an area where vets' tendency to advise vaccination as a precautionary measure opposes the farmers' concerns and may result in vaccination advice not being followed. A way of overcoming this potential barrier could involve reassessing the current vaccination schedule on a regular basis, for example during the herd health plan annual review. If concerns are raised about handling or multiple injections then the removal of a vaccine from the schedule for which the disease risk is low could be discussed. Farmers and vets are reluctant to stop vaccinating and it is therefore possible there are ‘redundant’ vaccines being used, or it may be possible to improve a vaccine schedule to allow concurrent administration with the new vaccine. These opportunities can be explored when good communication and regular contact between the farmer and the vet occurs.

5.2.3. A need for more information

The control of endemic cattle diseases in Britain are governed locally through farmers and private vets, apart from the Scottish BVD eradication scheme and the national bTB control scheme. This study indicated that vets would feel better able to advise farmers of the risks of disease breakdowns and therefore their need to vaccinate if there were regional prevalence data available. For example, vets were unsure about the prevalence of leptospirosis and mainly advised vaccination on a public health basis, despite being sceptical of the need to vaccinate due to a perceived low disease prevalence. If there were prevalence data available then vets may be more confident in advising farmers that vaccination was not needed on their farm. There is commercially derived data available suggesting that 58% of non-vaccinating dairy herds have been exposed to *Leptospira* (Veterinary Times, 2015). This would suggest that leptospirosis is still prevalent however the method of data collection was not reported and therefore the interpretation of reported figures deserves caution. It is hypothesised that an aspect of vets’ risk averse advice regarding vaccination stems from uncertainty around the local prevalence of disease. As discussed by Cresswell et al. (2013), vets are uncomfortable providing advice whilst perceiving they do not have adequate information. Not knowing if a disease is prevalent in the local area may cause vets to relapse to the heuristic of advising vaccination as a precautionary measure.

One must consider the possibility that investing in the provision of more information would not necessarily result in a change in vets' vaccination advice to farmers. Due to the many variables involved in the risk assessment of disease on a farm, a risk assessment with 100% certainty with regards to the decision is unlikely to be achieved. The results of this study do suggest however, that providing vets with more data would improve their confidence to discuss vaccination strategies with their clients. Vets appeared to need more information on certain aspects of vaccination but whether they would change their practice in light of that information cannot be confidently concluded from this study.

In terms of the need for more information for farmers, the results of this study suggest that merely making farmers *aware* of the risks of disease and therefore the need to vaccinate is unlikely to fully motivate them to vaccinate. Farmers need to *feel* at risk of the disease and this perception can depend on a number of factors. This links to the concept of the deficit model which has previously been critically applied to the topic of human vaccination (Hobson-West, 2003). This model assumes that the reason the general public are sceptical, or even hostile, towards science and technology is due to a lack of knowledge and understanding of the issues being discussed. Therefore education of the public will change opinion and possibly behaviour. When applied to dairy cattle vaccination the deficit model would assume that the reason farmers do not vaccinate their cattle is because they do not understand how vaccinations work, or why they are important. Therefore in order to optimise vaccination the deficit model would suggest giving farmers more information about vaccination and the disease to be vaccinated for to motivate them to vaccinate. This echoes what is discussed by Gunn et al. (2008) who suggest that the reason farmers, as well as other stakeholders, do not adopt biosecurity measures is because they are not aware of the efficacy and economic benefit of doing so.

However, opponents of the deficit model argue that a dialogue between participants is required and that factors other than knowledge, such as trust in the institution providing information, or previous experience, may be more applicable (Hobson-West, 2003). Indeed farmers in the present study did not appear to be requesting more information about vaccination. In fact, the main ‘piece of information’ that farmers appeared to require was their vet advising them to vaccinate. When considering the deficit model in terms of compliance with administration and storage instructions, further research would first be required to understand the motivators and barriers to compliance. Arguably, farmers already have access to information regarding administration and storage, so if compliance is suboptimal (Cresswell et al., 2014, Meadows, 2010) it would appear that the deficit model has been challenged and perhaps it is not the amount of information, but how that information is transferred that matters.

5.2.4. Cost effectiveness of vaccination

The cost effectiveness of vaccination was a theme present predominately throughout the veterinary surgeon interviews as a component of their decision-making behind whether to advise vaccination implementation. This was sometimes discussed using the term 'cost-benefit'. The term cost-benefit is widely used in other fields. For example, in the discipline of economics cost-benefit analysis is a key tool for analysing problems relating to, for example, policy decisions such as whether a new hospital should be built. There are however, issues with defining what a cost is and what a benefit is, the relative importance of these and to whom these should relate (Layard and Glaister, 1994). In this study vets used the term 'cost-benefit' to summarise the concept that if the financial cost of the vaccine was less than the economic consequences of the disease then a positive cost-benefit was a motivator to vaccinate. Their interpretation of cost-benefit, excluding non-monetary benefits, is synonymous to cost effectiveness. It was interesting to note the limited evidence vets appeared to use to substantiate their cost-benefit belief, although this does not mean their assumption is factually incorrect.

Some farmers did discuss cost effectiveness, in that they perceived vaccines to be worth the financial cost because a case of the disease or an outbreak of the disease would be worse, but it was a less prominent theme and generally was the result of prompting questions, whereas vets tended to discuss the concept spontaneously. However, financial cost did not appear to be a barrier to farmers if there was a perceived need to vaccinate.

While vets appeared to perceive the value of financial benefit information as a motivator for their clients, the results of this study indicate that solely providing the more information on the economic advantage of vaccination may not, in itself, motivate a farmer to vaccinate. It is therefore worthwhile to consider other factors, in addition to cost effectiveness, to aid a farmer in their decision-making. Other potential benefits resulting from vaccination could include the improvement in animal health in welfare and a sense of pride in having a healthy herd. As mentioned in Chapter 3, and shown in other research (Kristensen and Enevoldsen, 2008), farmers each put their own value on the motivators and barriers identified in this study. Although common factors are observed it remains crucial to consider the farmers' individual situation when aiming to influence their decision-making.

Finally, one could argue that the question of cost effectiveness is one area where a comparison with the human vaccination field is less helpful. In the NHS context, recommended vaccinations are usually free at the point of use. They are of course funded out of general taxation, so whilst the individual patient may not be weighing up the financial cost, the NHS as a whole *is*. One could therefore argue that the government is the primary economic decision-maker for human vaccination and not doctors or patients, whereas in cattle vaccination the farmer, with input from their vet, is. However, further research could fruitfully look at the economic models and other factors used by human vaccination decision makers (Chapter 1, page 3) to see whether lessons could be learnt for the field of dairy cow vaccination.

5.3. Compliance and efficacy

5.3.1. Perceptions of compliance and the consequences for vaccine efficacy

In this study both farmers and veterinary surgeons aimed to achieve the control or prevention of disease on farms. The 'success' of a vaccine equated to a reduction or avoidance of clinical signs, and maintenance or an increase in production levels. The way farmers and vets understand disease, and therefore the effect vaccination has on its manifestation on farm is a point of interest. It has implications when discussing efficacy of vaccines and compliance with administration and storage instructions. Understanding perceptions of disease and efficacy could also be helpful for discussing implementation of other biosecurity practices as well as additional management changes on-farm.

Discussion around the topic of compliance with vets followed on from questions on the distribution of vaccines. This often resulted in prompting questions around the area of compliance. However, compliance was not a theme that came up often in the farmer interviews and farmers were not prompted on the topic. Despite this, suggestions related to vaccines compliance such as concurrent administration of vaccines outside SPC instructions and a desire for multivalent vaccines, were discussed, often framed in terms of attempts to reduce stress to the cows. The apparent discrepancy between the importance of farmer compliance in the eyes of vets and farmers warrants further investigation.

In human medicine the term compliance can mean several things. It can mean following advice to actually take the medication that is recommended, or it can also mean taking a medicine in the manner in which it is recommended (Mitchell and Selmes, 2007). In this study compliance was not a barrier to the *implementation* of vaccination but it is a barrier to *effective* vaccination. Farmers were motivated to vaccinate if advised to do so by their vet, however farmers' compliance with storage and administration instructions was a concern to the vets in this study. Maintenance of the cold chain was of particular concern to the vets, as well as uncertainty regarding the effect of incorrect administration on the efficacy of vaccines. This was coupled with an element of contradiction; vets perceived poor compliance affects efficacy, but at the same time agreeing that off license concurrent administration of vaccines was a fairly low risk strategy. This indicates that the aspect where compliance is failing is of importance to how vets give advice about vaccination.

The theme of compliance was entwined with the theme of efficacy in the vet interviews. Vets were impressed at how effective some vaccines were despite a presumed lack of compliance from farmers. How efficacy was understood by both vets and farmers seemed to be based on resolution of the problem if vaccinating reactively, or an apparent lack of disease if vaccinating preventatively. Measuring on-farm efficacy using presence or absence of clinical signs could pose a problem as the causes of symptoms such as reduced fertility are often multi-factorial (Hudson, 2011). In these cases although a vaccine may be effective in controlling the pathogen(s) it is aimed at, the clinical signs may persist and the vaccine believed to be ineffective. The use of clinical signs as a proxy for efficacy could also pose problems for sub-clinical diseases. This method of determining efficacy appears subjective. However if the motivator to use the vaccine in the first place was to decrease or prevent the clinical effects of disease then it could be argued that it is appropriate. If, however, the vaccine was being used in a disease eradication programme then on-farm efficacy of the vaccine would ideally be determined through the use of diagnostic testing. Careful communication between vet and farmer is required to ensure the situation is interpreted and managed appropriately and vaccination is not just implemented to 'fix' a presumed cause of a problem. Another area to consider is the cessation of a vaccination strategy. Stopping vaccination was something both vets and farmers appeared reluctant to do but was, on occasion, done without the input of the vet because the vaccine was perceived to be ineffective by the farmer. This further stresses the importance of regular communication between farmer and vet about the reasons for and goals of implementing a vaccine on a farm, and the multifactorial nature of endemic diseases on their farm.

Both farmers and vets felt that vaccines in general were effective, though they had their limitations. However it would appear vets and farmers would find it useful to know what practical aspects of vaccination affect the efficacy of the vaccine. This would allow vets to focus their compliance advice efforts as it may be that poor compliance with for example, administration instructions would continue to result in effective vaccination. Attempts have been made to assess vaccine efficacy but a cause and effect relationship has been difficult to confirm in a field study investigating disease outbreaks in vaccinated herds (Crawshaw and Caldow, 2015).There was a perception among vets that pharmaceutical companies had information regarding the use of vaccines outside of SPC instructions, but that this was unofficial and unpublicised. Pharmaceutical companies were reported by vets to be a useful source of information regarding use of vaccines contrary to the SPC instructions. It is possible that this use of pharmaceutical companies suggests an aspect of passing the responsibility to another party and although there was no clear evidence for this in these interviews it may be linked to fear of litigation, whilst wanting to do the best for their clients by making vaccination as manageable as possible.

5.3.2. Improving compliance

As already highlighted, there is a difference between vaccination compliance with instructions and effective administration. In human and small animal medicine factors of administration and storage are the health care professional’s responsibility. In cattle vaccination, as farmers generally administer the vaccines these factors become their responsibility. Interestingly, vets in this study did appear to recognise their own responsibility to improve farmer awareness of the importance of correct storage and administration. Compliance was felt to be a topic that farmers should already be aware of and vets generally did not follow up on farmers carrying out vaccinations. There was no shortage of opportunities to discuss compliance or methods used to improve compliance described by vets. However, the topic was perceived to be of no interest to farmers and this may result in vets being less likely to discuss compliance with their clients. Vaccination was sometimes discussed as part of disease specific farmer meetings but administration and storage were rarely part of this. Not all farmers attend farmer meetings or farm skills courses, so it is important to reinforce compliance messages at the time vaccines are dispensed. Different methods of communication are effective for farmers when trying to effect change (Jansen et al., 2010a) and the use of multiple communication strategies such as discussion groups, reinforcing the message at the time of dispensing and other methods, for example the use of newsletters, are more likely to reach the greatest number of farmers.

Despite a level of concern from vets, there were positive efforts made to make it easier for farmers to maintain good practice through the provision of cool bags and needles. However, vets felt they could do more to improve compliance. It could be hypothesised that vets felt poor farmer compliance was partially their responsibility but were not confident their efforts were effective, and therefore continued to feel compliance was poor. This could indicate that veterinary surgeons are unsure which methods of communication are most effective for improving compliance. Compliance with responsible medicine use is a topic often discussed in the farming and veterinary press, predominantly focussing on the use of antibiotics (De Briyne et al., 2014, Mateus et al., 2014). Although responsible use of vaccines is important, currently there is no evidence that poor compliance has as far reaching effects as in the case of antibiotics (WHO, 2015a). Nevertheless, if vaccines are not used effectively then control and eradication of disease is more challenging and animal welfare may suffer due to suboptimal disease control.

The actual prevalence of farmers not complying with SPC instructions is largely unknown. The poor compliance as perceived by vets is supported by few small studies (Meadows, 2010, Cresswell et al., 2014). In addition, the areas where lack of compliance occurs may not affect vaccine efficacy. If the animal mounts an adequate immune response to a vaccine mistakenly administered intramuscularly instead of via subcutaneous injection, one may consider inadequate compliance, but this may not have affected the animals' protection against disease.

If vets are assuming that farmers know what they are doing and farmers only check with their vet if they are unsure then there is the possibility of errors in administration and storage that are going unnoticed. In addition, if vets perceive that farmers think topic is uninteresting they are unlikely to discuss compliance regularly with farmers. This is a potentially dangerous situation unique to the farm animal industry, as in human and companion animal vaccination health care professionals generally administer the vaccines, giving vets a valid reason to have concern about compliance through loss of control over what happens to the vaccines once they leave the practice.

There are methods that could be used to help improve compliance; some of which were mentioned by the veterinary surgeons in the study and others that have been used in other areas. Reminder systems in human medicine have been found to improve vaccination rates (Jacobson Vann and Szilagyi, 2005) and reminder systems are already part of companion animal veterinary care (Gerrard, 2012). The potential use of reminders was discussed by the veterinary surgeons, but was perceived to be difficult to implement given the complex nature of cattle vaccination protocols.

Other tools used to improve compliance in other areas of veterinary medicine include on-farm posters for best practices in avoiding medicine residues in milk (BCVA, 2014) and online videos and ‘how to guides’ for cat owners administering medication (ICC, 2013). It is a requirement of the RVCS Professional Conduct Department that certain information, including dosage and administration instructions, are present on the label, despite there being no legal requirement to do so if the product is in its original packaging and not being prescribed under ‘the cascade’. However, many vets in this study were sceptical of the number of farmers who actually read the information provided with the vaccines. The benefits of clear labelling have been highlighted previously by Cresswell et al. (2013).

Understanding compliance with vaccine instructions by examining the perspectives of farmers and vets may also be helpful in understanding compliance with other pharmaceuticals or management changes, or help inform how veterinary advice surrounding medicine administration should be given and applied. Given current concerns around responsible use of antimicrobials (Scannell and Bruce, 2015), this information is important and potentially useful in improving communication around veterinary pharmaceutical use.

5.4. Areas for further discussion

An added area of interest for discussion is what was not discussed or expanded upon during the interviews.

The analysis of the farmer interviews revealed little evidence of farmers working together to implement vaccination protocols or biosecurity measures. Other farmers were mentioned as information source, but not as collaborators. In fact the participants felt that a united approach to disease control in Britain would require government input. Results from an interview study by Heffernan et al. (2008), investigating drivers to biosecurity collective action, suggested that this may not be an unusual finding. Heffernan et al. (2008) suggests that constraints to collaboration were linked to a lack of trust within the farming community, although perceptions of the government were also negative. The omission of collaborative effort in the analysis in this study does not necessarily mean that dairy farmers do not collaborate to implement biosecurity measures, but it could be extrapolated that perhaps the participants did not feel it was an important factor and so did not discuss it.

Throughout the farmer and vet interviews ran the assumption that vaccines were required and ‘a way of life’. This may have been a reaction to the fact the interview topic was vaccination, and therefore an assumption was made by the participants that the use of vaccines was important. Although there were discussions around not using individual vaccines on individual farms, the use of vaccination as a tool to control disease on a general level was not questioned, except in times of future disease eradication. There are other disease prevention and control tools that can be used, and some countries have eradicated endemic diseases without the use of vaccines. The widely accepted use of vaccines may be a reaction to a belief in a lack of efficacy of other measures. Or perhaps a perception that the eradication of endemic disease is too far in the future to consider not using them. In either case the decision not to use vaccines would be perceived as risky. This assumption may also stem from the widespread use of vaccines in human and companion animal medicine. It appears for the moment at least, whilst there is a risk of infectious disease there is a perceived need for vaccines.

5.5. Summary

Veterinary advice and farmers’ motivators to vaccinate dairy cattle in Britain are based on perceived risk and evidence of disease. The current study supports the findings of the more quantitative studies by Cresswell et al. (2014) and Elbers et al. (2010b). The factors of risk and need are disease specific due of the different epidemiology of the vaccine preventable diseases. A national scheme to control or eradicate a disease, providing a consistent message about how to implement vaccination, could be a successful way of implementing an optimal vaccination and disease control strategy. The results of this study suggest that if a national eradication or control scheme were to be introduced, there would be support from dairy farmers and the veterinary profession. The conditions of this support would appear to be that the disease was felt to be of sufficiently high risk, there was consistent and coherent information, collaborative effort from all stakeholders and the probable requirement for government involvement.

There is an apparent divergence in the risk perception and relative importance placed on preventative and reactive vaccination between vets and farmers. It has been hypothesised that this may be a barrier to the optimal implementation of vaccination strategies.

Both parties agree that if there is a problem on the farm then vaccination is a reasonable solution in many cases. It is the perception of risk of disease entering the farm and the use of vaccines preventatively where there appear to be differences between farmers and vets. However, if the aim of implementing vaccination on a particular farm is not eradication of a disease locally or nationally then it could be argued that the reasoning behind the decision to vaccinate is less important; assuming the welfare of the animals is not in jeopardy. The variability could be a result of differences in the goals of vaccination for different individuals. This emphasises that there needs to be transparent communication between vets and farmers as well as across the veterinary profession and cattle industry as to the aim of implementing a vaccination strategy.

Clear communication between farmers and vets could potentially be aided through the use of guidelines. The guidelines need not be a rigid universal vaccine schedule, but could be used as a tool to aid decision-making. Additional disease prevalence data would enable farmers and vets to make better informed decisions and lead to vaccines being used in a more evidence-based way. Further research would be required to understand if there is a wider knowledge of the guidelines discussed in Chapter 1 (page 12) and if so, why they are not utilised. Understanding motivators and barriers to the use of guidelines could inform the creation of more guidelines or conversely, suggest that guidelines are not the ideal way to optimise vaccination on British dairy farms.

In the current situation, with an aim to optimise vaccination strategies on dairy farms, this discussion has proposed the need for individualised medicine. The discussion between farmers and vets of the goals of implementing a vaccine on the farm is imperative. Farmers' risk perception of disease appears to be local and farm specific but they trust their vet's advice as to if implementation is required. Vets perceive they require more information on a number of aspects, such as local disease prevalence data and vaccine efficacy, in order to best advise their clients. This information may give more confidence to vets when advising that a vaccine is not needed on a farm or changing how a vaccine is implemented on-farm in order to improve compliance without affecting efficacy.

There is no evidence for the over or under use of dairy cattle vaccines in Britain and there is no overarching, collaborative goal for their use. This also supports the need for individualised medicine and the importance of the vet-farmer relationship. The results from this study provide further understanding of the motivators and barriers to vaccination, which help us understand the decision-making behind dairy cattle vaccination. Findings from this study may also have wider applications; for example compliance with administration instructions for other veterinary pharmaceuticals or improving vet-farmer communication surrounding other areas of disease prevention and control.

Chapter 6 Integration of study findings and suggestions for further research

6.1. Implications for the dairy industry and veterinary profession

The essence of the type of research undertaken in this study is to understand the attitudes of a population towards a topic, often in order to make recommendations about how best to change their behaviour. For example, research could be designed to better understand people's attitudes towards smoking, in order to design interventions designed to motivate and support people stopping smoking. Indeed, there is a wealth of literature on human public health interventions such as smoking, sexual health and health screening and as such the results from these studies can be synthesised in order to combine the evidence (Hannes et al., 2013). This allows researchers to look at the topic as a whole and gain a greater understanding of the outcomes. For example, Carroll et al. (2013) synthesised the qualitative evidence of views on workplace smoking reduction or cessation interventions. However, in these cases there is a fixed strategy and aim such as the development of tools to support people who are stopping smoking. Qualitative evidence synthesis requires an evidence-base large enough to perform the synthesis, and would require an overarching aim for the research outcome.

Although the aim of this research is to understand the challenges and perceptions of implementing vaccination strategies, it must be understood that there is no overarching industry strategy and goal for the use of vaccination in dairy farming in Britain. Nor do we have evidence that levels of vaccination uptake are poor. It is therefore not the aim of this research to understand the motivators and barriers of farmers and veterinary surgeons towards implementing vaccination strategies in order to design interventions to *increase* dairy cattle vaccination. Rather, it is the aim to understand these factors in order to *optimise* dairy cattle vaccination strategies, be that increasing or decreasing the number of vaccines used on an individual farm, and provide suggestions of how to support farmers and vets in doing so.

This study is part of a wider research programme with the wider aim to combine current research, farmer and veterinary surgeon attitudes, and expert opinion to develop best practice guidelines for biosecurity and vaccination on British dairy farms. This PhD study, by itself, cannot fulfil this aim, but contributes a part of it and can nevertheless suggest how to best move forward based on these partial findings.

There are four main areas where further research would be beneficial: the farmer-vet relationship; the evidence and risk related decision-making behind vaccination; the issue of compliance, and the use of vaccination guidelines.

6.1.1. Farmer-vet relationship

The relationship between farmer and vet is crucial in vaccine decision-making on farms. In short, the implementation of vaccination strategies is not a single event, but a process and vets are involved throughout this process. A difference in how risk is perceived by vets and farmers may be a barrier to vaccination with vets apparently being more risk averse than farmers. This barrier could, in part, be overcome by effective communication between vets and farmers in order to assess which vaccines are required, and which are not or no longer required, on each farm.

For farmers, maintaining contact with their vet and the use of regular disease surveillance can help to keep all parties informed of the herd's disease status. This can allow monitoring for a potential need to vaccinate or assess the progress of an implemented vaccination strategy. For vets it is crucial to cultivate relationships with clients and effective communication is vital. Assigning a vet to each farm for preventative herd health care would appear to be a method of maintaining contact that would be beneficial to both vet and farmer. For vets to be able to achieve an effective increase in vet-farmer contact the allowance of more time for herd health planning, interpretation of test results and discussions with farmers will be required. Extra time is often difficult to find, especially in a profession traditionally finding it challenging to charge for such services, coupled with the perception from farmers that veterinary time and medications are expensive. There have been calls to change the veterinary business model and involving clients in how and why farm animal practice is changing may help smooth the transition. The involvement of farm animal clients may help to inform practice and shape services that benefit both vets and their clients. For example, the use of a yearly contract that includes all preventative herd health care and visits.

Methods of maintaining contact with farmers who do not have regular fertility visits could include monthly phone calls, ensuring annual herd health visits take place and are a useful exercise for all involved, or quarterly herd health visits to assess and discuss any concerns the farmer or vet may have.

Inclusion of methods to improve farmer engagement and implementation of farm animal vaccination strategies in the veterinary undergraduate curriculum and CPD courses would appear to be something that may improve vets' confidence in advising farmers on vaccination.

Further research to help understand and improve the vet-farmer relationship would be of benefit, not only for vaccination, but also in other areas of disease prevention and control. The results of this study suggest that avenues of research that would be beneficial include; investigating if the 'types' of farmer that vets appear to group their clients into are representative of the dairy community and how this affects communication styles and the vet-farmer relationship. In relation to education, research investigating if and how British veterinary undergraduate courses tackle the issue of cattle vaccination strategies with an aim to optimise this teaching would be important. There has been some qualitative research that has successfully investigated ethics teaching in veterinary schools (Magalhães-Sant'Ana, 2014). It is possible this methodology could be extended to other areas of the curriculum.

6.1.2. The 'need' to vaccinate

Farmers and vets were both motivated to vaccinate when there was a perceived need to do so. This need was based on either evidence of a vaccine preventable disease being present on farm or a perceived risk of disease entering the herd.

Evidence of disease presence was based on the presence of clinical signs or through disease testing. An area that deserves further investigation is the point at which a farmer identifies a problem in their herd. It is expected that what is perceived to be a normal incidence of disease by one farmer is not an acceptable level to another. There are similar challenges for subclinical diseases such as BVD. Investigation of what motivates a farmer to investigate a problem and to call their veterinary surgeon would appear to be a fruitful field of research to optimise disease prevention and control. One method of overcoming a lack of awareness of a herd's disease status could be the use of cattle health schemes such as those covered by the Cattle Health Certification Standards (CHeCS, 2015). However, not all farmers use these schemes and so knowing the motivators and barriers to farmers participating in such schemes and vets to advising their use would be useful to further understand how and why uptake of organised schemes occurs.

An apparent discrepancy in how vets and farmers perceive risk of disease may be a barrier to vaccination for farmers and a motivator to vaccination for vets. The apparent risk averse attitude of vets tends to result in vaccination being advised as a precautionary measure. It is hypothesised that local disease prevalence data may give vets more confidence in either having the evidence to support their supposition of risk of disease incursion on a farm, or in not advising vaccination because the prevalence is low. The provision of easily accessible regional and national prevalence data would require collaboration between a number of stakeholders. Farmers, private vets, laboratories, pathologists, epidemiologists and the Animal and Plant Health Agency would all have important roles to play in the research and dissemination of outcomes in order to achieve such an aim.

Further investigation of how farmers and vets perceive disease risk, and how the apparent differences between them influences their disease control choices would improve our understanding in this field. It will also help to unravel the reasons behind the apparent risk averse nature of vets when advising vaccination to farmers. This research could be extended to investigate if this risk aversion extends into other areas of veterinary medicine. The outcomes of such research could provide support vets in their decision-making.

6.1.3. Compliance

If there was clear evidence that some aspects of 'going off license' did not affect the efficacy then farmers and vets could work together to develop a strategy that was tailored to the needs and constraints of each farm. This is potentially a role for the pharmaceutical industry. The pharmaceutical industry is in a good position to either have access to this information already, or to conduct the required research. In order to answer this question future research should aim to understand how poor compliance affects the on-farm efficacy of vaccines. It is understood that this type of research is not without its complications (Crawshaw and Caldow, 2015), however the outcomes could help to optimise the way cattle vaccines are implemented and administered. The relationship vets have with pharmaceutical companies could be exploited to work with the companies to encourage the dissemination of evidence of efficacy and use of vaccines outside of the current SPC.

Currently, whilst there is no evidence for how poor compliance affects the efficacy of vaccination, it would appear sensible to advise against using vaccines contrary to the SPC. If compliance appears to be an issue then working with the farmer to reassess their protocol is advised. Pharmaceutical companies have developed options for the concurrent administration of some vaccines and therefore if a new vaccine is to be introduced to the vaccination schedule on a farm changing vaccine manufacturer may minimise the inconvenience to the farmer, and the stress to the cattle through handling and injecting them on multiple occasions. If it is possible to discontinue the use of a vaccine this may improve compliance with the administration of other vaccines. If the aim is to reduce the number of vaccines being used on a farm then evidence of the efficacy of other disease control tools may indicate that these may be more effective, easier to implement or cheaper. Further research investigating the evidence for and efficacy of other disease control tools would then indirectly contribute to the optimisation of vaccination implementation. This could be achieved through the use of cohort studies or case series to compare the outcomes from farms that do and do not implement certain disease control measures. This type of research is not without its challenges, however the information obtained would add to the evidence-base of disease prevention and control.

Support for both farmers and vets to encourage effective administration is required. There is evidence that compliance is not optimal therefore future research should aim to investigate what drives famers to use vaccines correctly or not. It would also be sensible to investigate vets' motivators and barriers to communicating compliance messages to farmers. There are already guidelines for the responsible use of vaccines in cattle (RUMA, 2007), future research should include investigation of why these are not being followed. These research questions may best be answered through the use of qualitative research methods. However, in order to truly assess compliance on-farm it could be useful to compare the results from previous quantitative studies investigating compliance (Meadows, 2010, Cresswell et al., 2014) with an observational study of farmers vaccinating their cattle. This type of research may help to bridge the gap between what farmers describe they do and what they are seen to do.

Discussion and collaboration between vets, farmers and the pharmaceutical industry may help to fill this apparent void of information, or direct further research in order to answer the questions most pertinent to the stakeholders involved.

6.1.4. Vaccination guidelines

As discussed in Chapter 1 there are is no universal vaccination schedule for cattle in Britain. The reasons for this have been alluded to throughout this thesis but suffice to say that currently vaccination decision-making is undertaken on a farm by farm basis by each individual farmer and their vet. The decision to vaccinate is based, among other things, on evidence of a herd's disease status and a perception of the risk of disease entering a farm. It is not the place of this study to suggest that a universal cattle vaccination schedule could, or should be implemented. However, the wider aim of the research programme is to develop 'best practice' guidelines for the use of vaccination and this implies it is perceived these guidelines would optimise the implementation of cattle vaccination in Britain.

In order for guidelines to be developed there needs to be a transparent goal for their use. If the guidelines are to be used to reduce prevalence of disease one needs to be transparent on whether the aim is to reduce the prevalence of specific diseases or disease prevalence in general.

If the guidelines are to reduce the prevalence of specific diseases through the use of vaccination, as used in human vaccination, the logical progression is then to decide which pathogens should be included in the guideline. Despite the number of pathogens included in the human vaccination schedule in Britain this still does not encompass all vaccine preventable diseases, similarly it appears impractical to include all available cattle vaccines in a proposed guideline.

Before making firm conclusions about which diseases to prioritise it would be sensible collect more evidence such as prevalence data, and further information on the cost-effectiveness of vaccination and on-farm vaccine efficacy. It would also be prudent to undertake further qualitative research to determine which diseases are important to the various stakeholders in the dairy industry, and whether these guidelines are likely to receive support from all industry stakeholders.

This study suggests that a universal vaccination schedule as used in human health and, to an extent in companion animal health may not be practical or well accepted by farmers or veterinary surgeons. The reasons for this include; that not all farms are perceived to be at risk from all vaccine preventable disease; the required number of injections would cause unacceptable stress to the cows; and the fact that farmers must cover the costs of the vaccine. However, if the industry were to include vaccines that were felt to be 'core' for the dairy industry, vets appeared to perceive BVD, IBR and leptospirosis to be the minimum required vaccines.

Returning to the question of what the aim of the guidelines is to be; if the aim is to reduce disease prevalence in general, then guidelines for effective vaccine use and guidelines advising how to decide which vaccines to implement on which farm should be considered.

There are guidelines in place for the 'correct' use of vaccines in the practical sense from RUMA (2007); however previous work has shown that cattle farmers do not follow these guidelines (Meadows, 2010, Cresswell et al., 2014). Data would suggest that poor compliance may partially be in order to reduce the stress to cattle. This study would also suggest that vets are making efforts to discuss compliance with their clients but feel they should be doing more. The perception is that it is not a topic farmers are interested in and that vets are unsure of the best ways of communicating the information. These are barriers to the discussion of compliance with farmers. Further work is required to understand the motivators and barriers of farmers to comply with administration and storage instructions, and of vets to promote or discuss this issue with their clients.

If the guidelines are to be based on assessing the need for each vaccine on each individual farm then both farmers and veterinary surgeons seem to agree that risk of disease entering the herd is an important factor and there are, as discussed in Chapter 1, guidelines to assist decision-making (Paton, 2013, VEERU, 2003). None of the vets or farmers mentioned these articles as sources of information when discussion vaccination decision-making, however the decision-making steps the vets appeared to take were similar to those described by Paton (2013). One factor contributing to the risk of disease entering a herd is the prevalence of disease in the local area. In this study this was generally a qualitative definition based on veterinary knowledge and word of mouth from within the farming community. VEERU (2003) called for more quantitative prevalence data in order to improve their decision-making tool; however whether this information would truly change the decisions of vets and farmers is not known. The data from this study suggests that prevalence data may reduce the number of vaccines advised by vets but may not affect the decisions of farmers as they tended to base their risk of disease more on the characteristics of their farm and were reliant on their vet for local epidemiological information.

The vet and farmer are not the only stakeholders in the team making animal health decisions. There can be other advisors on farm who have roles which can be contradictory or complimentary. For example some farmers use herd health consultants, ultrasound scanners and nutritionists in addition to the vet. In addition farmers are approached by pharmaceutical companies and agricultural merchants. In turn, vets work with pharmaceutical companies, regional and national government and other organisations to share information, plan protocols and implement schemes. It is imperative that messages concerning disease control are consistent and that all relevant parties are involved and aware of the aim and can contribute to the decision-making process. A collaborative effort is most likely to be a powerful tool in effecting change on dairy farms. An example of this has been the development of the DairyCo Healthy Feet Programme. This has involved industry, researchers, foot trimmers and vets in practice and aims to help dairy farmers reduce the number of lame cows on their farms by identifying and applying the right management techniques (DairyCo, 2015).

Although farmers and vets are likely to be the stakeholders implementing the guidelines, there are other important groups who are involved and have an important part to play in further research. These stakeholders need to be involved and their collective expertise taken into consideration. Suggested stakeholders include: pharmaceutical companies, AHDB Dairy, the NFU, the BVA, immunologists, RUMA, milk buyers, Defra and the Animal and Plant Health Agency. The collation of the valuable data these stakeholders could produce, when combined with the farmer and vet data from this study could be powerful in directing the future of dairy cattle vaccination strategies in Britain. The aim should be to *optimise* the use of vaccination on dairy farms. This nuance must then be communicated effectively by those discussing vaccination policies at a national level.

6.1.5. Know, think and do

An alternative way of presenting the practical implications of the findings of this research is to consider what each of the major stakeholders should know as a result of the research, what they need to think about the results, and what they need to do with the information. The major stakeholders in this study are dairy farmers, their vets and the funding body of this research AHDB Dairy and the main points are presented in Table 8.

Table 8 Table of the practical implications of the results of this research

	Know	Think	Do
Dairy farmers	Their herd's disease status is important in order to make informed vaccination decisions	What is their goal in using a particular vaccine?	Ensure regular contact and discussion with their vet surrounding vaccination Ensure compliance with administration and storage instructions
Vets	Farmers are motivated to vaccinate if shown a need- cost is a minor issue Farmers trust their vet and see their vet as their primary advisor and source of information on vaccination	What are the farmer's goals and what is important to them? How can more time and resources be provided to enable vets to discuss disease prevention and control with clients?	Increase farmers' disease status awareness Be proactive in initiating vaccine discussions Use different communication methods to reach different farmers Be proactive in identifying compliance issues
AHDB Dairy	The vet is a trusted and important source of information and advice to farmers Farmers are individuals and vary in terms of disease control priorities and use Farmers and vets are motivated to vaccinate dairy cattle given a need- cost is a minor issue	What is AHDB Dairy's role in the optimisation of vaccine use in the dairy industry? Vaccination is not the only method of disease prevention and control, how can it be used alongside other measures? Are guidelines useful and practical?	Co-ordination with the veterinary profession and other stakeholders to provide consistent, clear and applicable advice to farmers, from all sources of information Find out, through the use of research, farmers' and vets' attitudes to the use of other biosecurity measures Find out, through the use of research, why farmers and vets are or are not using existing vaccination guidelines

6.2. Reflections on the study

6.2.1. Study limitations

As far as the author is aware this is the first study to qualitatively collect and analyse the attitudes of dairy farmers and vets towards cattle vaccination. It should be considered how this study fits into the wider field of research and how it may relate to other sectors of farming as well as other countries.

The use of qualitative methods has allowed a unique insight into how and why vaccination decisions are made but the results and conclusions should be interpreted with a level of caution. Further reflection on the methods used in this study and how that relates to interpretation is discussed later in this chapter but here it is important to note that due to the methods used the results of this study cannot be said to represent the attitudes of all dairy farmers and vets. Nor could the results be assumed to be applicable to other farming sectors or countries. Nevertheless, this study provides an important starting point in this under-researched area and the results can be used as springboard for research into other sectors, countries and for further research to strengthen the evidence-base in the dairy sector. Another point to recognise is that vaccination is only one part of disease prevention and control. Although widely used it is not always the most appropriate or only tool and should be considered as part of a holistic disease prevention and control plan. Although dairy farmers and vets are important stakeholders in the dairy industry they are not the only parties involved in maintaining the health and welfare of dairy cattle and securing the future of the dairy industry. This study only interviewed dairy farmers and any effort to control or eradicate cattle disease in Britain would also have to involve stakeholders from the beef industry.

This study does not provide the solution to optimising dairy cattle vaccination but is part of a wider project. Nevertheless, the results of this study have some immediate applications, as discussed earlier in this chapter. Focussing on vaccination may not be the solution to improving and optimising disease prevention and control for reasons discussed throughout this thesis, however when used effectively their use can eradicate disease, reduce antibiotic usage, and improve animal health, welfare and productivity.

6.2.2. Recruitment

Farmers

The database used to recruit farmers was supplied by the industry levy board. This database included the postal contact and farm information of all levy paying dairy farmers in Britain, which should include all commercial dairy units. During the recruitment phase of the farmer study it became apparent that some of the entries were not dairy farms and that a proportion of the farms were no longer in business. This, in part, may have contributed to the low response rate to postal invitations.

The use of maximum variation sampling in the farmer study ensured a wide range of farmers was recruited. Although not aiming to be representative of the general dairy farming population in Britain, the farmers involved in this study varied in location and herd size and included both conventional and organic herds. These factors were deemed important to collect wide ranging attitudes and opinions whilst still achieving data saturation. The categories used for the sampling were chosen as other studies have demonstrated likely differences in attitudes between these different groups (Bock et al., 1995, Ellis-Iversen et al., 2010, Flaten et al., 2005). Farmers in different areas of Great Britain are exposed to differing levels of disease risk and external restrictions or disease schemes. The density of cattle in different regions of the country may also have an influence on the local disease epidemiology, and perhaps the farmers' awareness of disease. Bovine tuberculosis (bTB) has strong regional densities (AHVLA, 2013) and the Scottish Government BVDV eradication scheme (Government, 2011) was underway by the time this study began. It has been shown that experience of a disease outbreak or control scheme can influence farmers' perceptions of disease control (Nerlich and Wright, 2006, Enticott et al., 2012, Elbers et al., 2010b) therefore farmers in areas where they are exposed to diseases may possibly have different attitudes to those farmers in less cattle dense and lower disease risk areas.

<u>Vets</u>

The database used to recruit vets was supplied by the University of Nottingham and contained veterinary practice level information. This information allowed the veterinary practices to be divided into regions for logistical reasons and for those vets that worked with cattle to be purposively sampled. Although the original sampling was at a practice level, the information regarding what species an individual vet treats was not available in an easily accessible format. Purposive sampling of veterinary practices, and the vets that work there, was performed so that only vets that worked with cattle were included in the study.

Maximum variation sampling was not used to sample the vets as firstly the sampling took place at a practice level and other than dividing the database by region the only criteria relevant to the aim of the study were that the veterinary practice had cattle farmers among their clients. At the veterinary surgeon level there is limited published evidence to suggest that there would be differences between 'types' of vets, which there was hypothesised to be for farmers. Purposive sampling was therefore felt to be an appropriate choice for sampling vets. Recruitment of vets from the purposively sampled practices was continued until ten interviews had been conducted. The variety of veterinary surgeons was deemed satisfactory and so recruitment continued using this method until saturation was reached.

Due to the nature of the selection and recruitment methods used in both interview studies there was the potential for self-selection of participants. The participants may have been particularly interested in the topic of vaccination, thereby skewing the results and not representing the attitudes of vets and farmers for whom vaccination is not a particular topic of interest.

The aim of this study however, was neither to be representative of the dairy industry and veterinary professions nor to produce results that could be generalised across the dairy industry. The aim was to collect and analyse a wide range of opinions to suggest explanations for how and why decisions around dairy cattle vaccination are made. It is possible however, that some attitudes such as anti-vaccination were not included in this study due to self-selection. Therefore the results of this study should be interpreted with a level of caution. This would be the same for other studies using similar qualitative methods.

6.2.3. Interviews and focus groups

Following the experience of the pilot farmer focus group it could be concluded that focus groups with farmers that are not already part of pre-defined groups or meetings were not a fruitful data collection method. The reasons for this have been discussed in Chapter 3.

Interviews appeared to be a suitable data collection method for the farmers and vets in this study. There was a good farmer response rate and apparent enthusiasm for the project when it was introduced as an interview study. It is possible this related to the convenience of an individual interview. There can be no comparison made between focus group and interview data as no focus groups were undertaken however, most farmers were engaged throughout the interviews. It is also possible that farmers felt more comfortable in an environment familiar to them, with one interviewer and no other participants. Although the data collected from focus groups is likely to have been different to that collected from the interviews the differences were unlikely to affect the outcomes of the study.

Through the use of qualitative research philosophies and methods this study has been able to collect rich and in-depth data in order to understand British dairy farmers' and vets' attitudes towards vaccination. The use of semi-structured interviews gave flexibility to both the participants, allowing them to participate at a time and location convenient to them, and to the researcher through the use of a flexible question guide. When comparing interviews conducted by telephone with those conducted face-to-face it would appear that they were of a slightly shorter duration. From an interviewer's perspective the telephone interviews were slightly more challenging to conduct due to the lack of visual cues from the participant's body language. This resulted in more concise questioning and answering from both parties with an increase in interviewer and interviewee talking over each other than during the face-to-face interviews. Despite the reduction in interview length the quality of the data from the telephone interviews did not appear to be less than that from the face-to-face interviews. The use of telephone interviews possibly resulted in some farmers who would not have participated in face-to-face interviews being included. Looking forward from this study it would appear that the inclusion of telephone interviews can widen the participation of interviewees and their use in combination with face-to-face interviews may enrich the data collected in further interview studies with dairy farmers. The experiences from this study imply that if interaction between participants is not essential to a study's aim, then interviews are perhaps the preferable data collection method.

The use of incentives in farmer and vet interviews is rarely discussed in the literature. Some studies explicitly mention that farmers were not financially incentivised (Ellis-Iversen et al., 2010) whereas others do not mention incentives at all (Heffernan et al., 2008). Studies have found variable responses to incentivising interviews of various types in other areas of research (Coogan and Rosenburg, 2004, Lynn, 2001, Hansen, 2006). In a study involving focus groups of sheep farmers (Kaler and Green, 2013) the participants were offered £20 to cover their travel expenses, however it was unknown if this affected response rates during recruitment. Although there is little or no evidence that an incentive, financial or otherwise, would improve response rates it was felt that some gesture of gratitude should be given to the farmers and vets for contributing their expertise and time. As there was no group of farmers or vets invited to interview where no incentive was offered a comparison cannot be made so it cannot be inferred that the incentive encouraged or discouraged participation. It is the impression of the author that although farmers were pleased with the incentive offered its use did not increase positive responses to the invitation to interview. The provision of lunch potentially motivated vets to be more likely to accept the invitation possibly caused vets to be less likely to cancel the interview.

Semi-structured interviews could be criticised, from a more quantitative philosophy for their flexible nature. Not all participants are subject to the same question guide as in a structured interview. The data becomes richer through the participants leading the direction of the interview by what is important to them, and via the flexibility to include topics brought up in one interview, in following interviews with other participants.

Having had the results of the study, this would have dictated different questions to be asked during the interviews. Having had the knowledge of the vets' 'better safe than sorry' approach to vaccination advice in advance would have given opportunity to further probe the participants' fear and worries surrounding their motivations for this.

It must be taken into consideration that there may have been some aspect of social desirability bias in this study. It was not within the scope of this study to be able to confirm any claims made by the vets and farmers during the interviews. It would be helpful to investigate the similarities or differences between verbal claims and actual performance on farm, as this would help to justify data collection methods such as interviews and questionnaires, where similar challenges apply.

Another factor to consider is that as the study progressed, so did confidence and experience of the interviewer. This occurred through the practice and increased familiarity with the order and meaning of the questions so that if a topic was covered during the interview prior to a question being asked it was easier to retain this information and continue the interview without the need to check the guide and stall the conversation. Piloting the interviews more thoroughly prior to starting the interviews may have resulted in a more consistent interview quality.

6.2.4. Robustness of the analysis

The use of thematic analysis is appropriate for this exploratory study. The method's flexibility allows its application to a multitude of topics and data collection methods, as well as different epistemological and ontological philosophies. As has been discussed in Chapter 1, critics claim that qualitative research is subjective (Christley and Perkins, 2010).

As this research is being conducted in, and presented to, the traditionally quantitative farming and veterinary communities, efforts were made to ensure that the validity and robustness of the methods was sufficient. This was achieved through the application of double coding to a subset of the data and following a well-used and published thematic analysis methodology (Braun and Clarke, 2006). The use of a second researcher to code a subset of the interview transcripts in both studies demonstrated that the coding framework was similar when the analysis was performed by two independent researchers. However, it must be taken into account that even if the coding frameworks from two different researchers were similar, the background of the researcher and the epistemological and ontological framework within which the analysis takes place will affect the interpretation of the results, which may lead to a different emphasis on some of the results.

The use of double coding has increased confidence in the robustness of this study and double coding would appear sensible to apply to future studies using thematic analysis, especially when aiming to publish in traditionally more quantitative research areas such as veterinary medicine.

6.2.5. Epistemological and ontological decisions

The decision to adopt a more realist philosophy (see Chapter 1, page 42) was felt to be the most appropriate framework to apply for the traditionally quantitative fields of veterinary medicine and agriculture. This choice of analysis will have impacted on the conclusion reached. The responses of the participants were taken as 'truth' and were assumed to be a reflection of their true perceptions. Despite this they were analysed with the knowledge that an interview is a constructed environment and it is possible the participants were presenting a particular version of themselves in reaction to the perceived background of the interviewer. This is where imagining the epistemological and ontological positions on a sliding scale becomes useful; the position of this study was not at either end of the spectrum but leaning towards the realist position. This assumes that what was said in the interviews was a true representation of the participants' thoughts and that knowledge can be both intrinsic and socially constructed.

6.2.6. Background of the researcher

It is important to acknowledge the background of the researcher. Whilst the authors' veterinary qualification was not disclosed unless requested, it is possible that the prompting questions used may have resulted in the interviewees making assumptions about the interviewer's knowledge and opinions about vaccination and the dairy industry. This may have resulted in participants not fully explaining the scientific rationale behind their vaccination decision-making. On reflection, the topic of vaccination in cattle appears not to be a controversial one to vets and farmers and at no point did the interviewer feel that participants were holding back information because of the interviewer being present. Therefore it is possible, but unlikely that the influence of the interviewer would cause the participants to significantly alter the way they presented their attitudes to vaccination policy.

6.3. Conclusion

Farmers and vets perceive vaccines to be an effective and useful tool to control and prevent disease on British dairy farms. Both stakeholders are motivated to vaccinate cattle if there is evidence of disease on-farm, or a perceived risk of disease entering a farm. Challenges to cattle vaccination arise from differences in how risk is perceived and farmers' potential lack of awareness of their herd's disease status. Understanding and enhancing the relationship between farmers and vets is a crucial step for optimisation of decision-making around vaccination. The results of this study indicate there are four main areas where further research would be beneficial: the farmer-vet relationship; the evidence and risk related decision-making behind vaccination; the issue of compliance, and the use of vaccination guidelines.

Bibliography

ABCD. 2012. *The European Advisory Board on Cat Diseases: Guidelines* [Online]. Available: http://www.abcd-vets.org/Pages/guidelines.aspx [Accessed 20/04/2015].

ABRAHAM, C. & SHEERAN, P. 2005. The Health Belief Model. *In:* CONNER, M., NORMAN, P. (ed.) *Predicting Health Behaviour.* 2 ed. England: Open University Press. pp. 28-80.

AHVLA 2013. *Bovine tuberculosis: Infection status in cattle in GB. Annual surveillance report for the period January to December 2013.* [pdf] London: Animal Health and Veterinary Laboratories Agency. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/413806/tb-pub-surveport-gb13.pdf [Accessed 28/07/2015]

AJZEN, I. 1991. The theory of planned behaviour. *Organizational Behaviour and Human Decision Processes,* 50**,** 179-211.

KENNEDY, A., BASKET, M. & SHEEDY, K. 2011. Vaccine Attitudes, Concerns, and Information Sources Reported by Parents of Young Children: Results From the 2009 HealthStyles Survey. *Pediatrics,* 127, S92-S99.

ANDRÉ, M., BORGQUIST, L., FOLDEVI, M. & MÖLSTAD, S. 2002. Asking for 'rules of thumb': a way to discover tacit knowledge in general practice. *Family Practice,* 19**,** 617-622.

ASHBY, A. W. 1926. Human motives in farming. *Welsh Journal of Agriculture,* 2**,** 1-25.

ATTRIDE-STIRLING, J. 2001. Thematic networks: an analytic tool for qualitative research. *Qualitative Research,* 1**,** 385-405.

BARBOUR, R. S. 2001. Checklists for improving rigour in qualitative research: a case of the tail wagging the dog? *British Medical Journal,* 322**,** 1115-1117.

BARTRAM, D. J. & BALDWIN, D. S. 2008. Veterinary surgeons and suicide: influences, opportunities and research directions. *Veterinary Record,* 162**,** 36-40.

BARTRAM, D. J. & BALDWIN, D. S. 2010. Veterinary surgeons and suicide: a structured review of possible influences on increased risk. *Veterinary Record,* 166**,** 388-397.

BASTIAN, M., HOLSTEG, M., HANKE-ROBINSON, H., DUCHOW, K. & CUSSLER, K. 2011. Bovine Neonatal Pancytopenia: Is this alloimmune syndrome caused by vaccine-induced alloreactive antibodies? *Vaccine,* 29**,** 5267-5275.

BCVA 2014. *Best practices to prevent medicine residues in milk.* [pdf]. Available: http://www.bcva.eu/system/files/resources/BCVA%202014%20Milk%20Residue%20Poster_FINAL.pdf. [Accessed 27/05/2015]

BELL, N. J., MAIN, D. C. J., WHAY, H. R., KNOWLES, T. G., BELL, M. J. & WEBSTER, A. J. F. 2006. Herd health planning: farmers' perceptions in relation to lameness and mastitis. *Veterinary Record,* 159**,** 699-705.

BELLABY, P. 2003. Communication and miscommunication of risk: understanding UK parents' attitudes to combined MMR vaccination. *British Medical Journal,* 327**,** 725-728.

BENIN, A. L., WISLER-SCHER, D. J., COLSON, E., SHAPIRO, E. D. & HOLMBOE, E. S. 2006. Qualitative Analysis of Mothers' Decision-Making About Vaccines for Infants: The Importance of Trust. *Pediatrics,* 117**,** 1532-1541.

BENJAMIN, L. A., FOSGATE, G. T., WARD, M. P., ROUSSEL, A. J., FEAGIN, R. A. & SCHWARTZ, A. L. 2010. Attitudes towards biosecurity practices relevant to Johne's disease control on beef cattle farms. *Preventive Veterinary Medicine,* 94**,** 222-230.

BENNETT, R. & BALCOMBE, K. 2012. Farmers' willingness to pay for a tuberculosis cattle vaccine. *Journal of Agricultural Economics,* 63**,** 408-424.

BLACK, N. 1994. Why we need qualitative research. *Journal of Epidemiology and Community Health,* 48**,** 425-426.
BLAXTER, M. 1996. Criteria for the evaluation of qualitative research papers. *Medical Sociology News,* 22.
BLEASE, S. C., BEHNKE, M. C., BRIZUELA, C. M. & SINCLAIR, L. A. 2013. Herd health plans for farm assurance: dairy farmers' opinions. In: British Society of Animal Science, *Innovation from animal science- a necessity not an option.* Nottingham, UK, April 2013. UK: Cambridge University Press. p.12.
BOCK, R. E., BLIGHT, G. W., KINGSTON, T. G. & VOS, A. J. D. 1995. A survey of cattle producers in the Boophilus microplus endemic area of Queensland to determine attitudes to the control of and vaccination against tick fever. *Australian Veterinary Journal,* 72**,** 88-92.
BORRELL-CARRIÓ, F., ESTANY, A., PLATT, F. W. & MORALESHIDALGO, V. 2014. Doctors as a knowledge and intelligence building group: pragmatic principles underlying decision-making processes. *Journal of Epidemiology and Community Health*. 0, 1-3.
BRADLEY, A. J., BREEN, J. E., PAYNE, B., WHITE, V. & GREEN, M. J. 2015. An investigation of the efficacy of a polyvalent mastitis vaccine using different vaccination regimens under field conditions in the United Kingdom. *Journal of Dairy Science,* 98**,** 1706-1720.
BRAUN, V. & CLARKE, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3**,** 77-101.
BREAKWELL, G. M. 2003. *Public perceptions concerning animal vaccination: A case study of foot and mouth 2001.* London: Defra.
BRENNAN, M. L. & CHRISTLEY, R. M. 2013. Cattle producers' perceptions of biosecurity. *BMC Veterinary Research,* 9 [Online]. Available: http://www.biomedcentral.com/1746-6148/9/71 [Accessed: 28/05/2015]
BRITTEN, N., JONES, R., MURPHY, E. & STACY, R. 1995. Qualitative research methods in general practice and primary care. *Family Practice,* 12**,** 104-114.
BROWN, K. F., LONG, S. J., RAMSAY, M., HUDSON, M. J., GREEN, J., VINCENT, C. A., KROLL, J. S., FRASER, G. & SEVDALIS, N. 2012. U.K. parents' decision-making about measles-mumps-rubella (MMR) vaccine 10 years after the MMR-autism controversy: a qualitative analysis. *Vaccine,* 30**,** 1855-1864.
BROWNLIE, J. & BOOTH, R. 2014. Bovine viral diarrhoea: update on disease and its control. *Veterinary Times,* 44.
BRYMAN, A. 2012a. Asking questions. *Social Research Methods.* 4 ed. United States: Oxford University Press. pp. 245-267.
BRYMAN, A. 2012b. The nature of qualitative research. *Social Research Methods.* 4 ed. United States: Oxford University Press. pp.379-413.
BRYMAN, A. 2012c. Sampling in qualitative research. *Social Research Methods.* 4 ed. United States: Oxford University Press. pp. 415-429.
BRYMAN, A. 2012d. Computer-assisted qualitative data analysis: using NVivo. *Social Research Methods.* 4 ed. United States: Oxford University Press. pp. 590-609.
BRYMAN, A. 2012e. Mixed methods research: combining quantitative and qualitative reseacrh. *Social Research Methods.* 4 ed. United States: Oxford University Press. pp. 627-651.
BURGESS, D. C., BURGESS, M. A. & LEASK, J. 2006. The MMR vaccination and autism controversy in United Kingdom 1998-2005: inevitable community outrage or a failure of risk communication? *Vaccine,* 24**,** 3921-3928.

BUSTON, K. 1997. NUD*IST in Action: Its Use and its Usefulness in a Study of Chronic Illness in Young People. *Sociological Research Online* [Online], 2. Available: http://www.socresonline.org.uk/2/3/6.html [Accessed: 27/05/2015]

BVA 2007. *Distribution category review- Cattle vaccines, pig vaccinaes, sheep anthelmintics, dog anthelmintics, cat anthelmintics and dog & cat anthelmintics* [Online]. Available: http://www.bva.co.uk/News-campaigns-and-policies/Get-involved/Migrated-Assets/VMD_Cattle_Pig_Sheep_Dog_and_Cat_28_09_07_pdf/. [Accessed 27/05/2015]

CARROLL, C., RICK, J., LEAVISS, J., FISHWICK, D. & BOOTH, A. 2013. A qualitative evidence synthesis of employees' views of workplace smoking reduction or cessation interventions. *BMC Public Health,* 13**,** 1-10.

CASIDAY, R., CRESSWELL, T., WILSON, D. & PANTER-BRICK, C. 2006. A survey of UK parental attitudes to the MMR vaccine and trust in medical authority. *Vaccine,* 24**,** 177-184.

CATTERALL, M. & MACLARAN, P. 1997. Focus Group Data and Qualitative Analysis Programs: Coding the Moving Picture as well as Snapshots. *Sociological Research Online* [Online], 2. Available: http://www.socresonline.org.uk/2/1/6 . [Accessed: 28/05/2015]

CHAMBERS, M. A., CARTER, S. P., WILSON, G. J., JONES, G., BROWN, E., HEWINSON, R. G. & VORDERMEIER, M. 2014. Vaccination against tuberculosis in badgers and cattle: an overview of the challenges, developments and current research priorities in Great Britain. *Veterinary Record,* 175**,** 90-96.

CHECS. 2015. *Cattle Health Certification Standards* [Online]. Available: http://www.checs.co.uk/ [Accessed 18/05/2015 2015].

CHRISTLEY, R. M. & PERKINS, E. 2010. Researching hard to reach areas of knowledge: Qualitative research in veterinary science. *Equine Veterinary Journal,* 42, 285-286.

COOGAN, P. F. & ROSENBURG, L. 2004. Impact of a Financial Incentive on Case and Control Participation in a Telephone Interview. *American Journal of Epidemiology,* 160**,** 295-298.

CRAWSHAW, W. M. & CALDOW, G. L. 2015. Field study of pneumonia in vaccinated cattle associated with incorrect vaccination and Pasteurella multocida infection. *Veterinary Record,* 176**,** 434.

CRESSWELL, E., BRENNAN, M. L., BARKEMA, H. W. & WAPENAAR, W. 2014. A questionnaire-based survey on the uptake and use of cattle vaccines in the UK. *Veterinary Record Open,* 1 [Online]. Available: http://vetrecordopen.bmj.com/content/1/1/e000042.full?sid=c560c5c6-0104-4255-b38a-e7859c2f4a26. [Accessed 28/05/2015]

CRESSWELL, L., RICHENS, I., ARCHER, S., BREEN, J., HUXLEY, J., RANDALL, L., REMNANT, J., WAPENAAR, W., BIGGS, A., KERBY, M. & STATHAM, J. 2013. Veterinary vaccination advice and perceived farmer compliance on UK dairy farms. *Livestock,* 18**,** 166-174.

CROMBIE, I. K. 2010. *The Pocket Guide to Critical Appraisal,* London, BMJ Publishing Group.

CROSS, P., WILLIAMS, P. & EDWARDS-JONES, G. 2009. Differences in the perceptions of farmers and veterinary surgeons about the efficacy of mitigation strategies for controlling bluetongue. *Veterinary Record,* 165**,** 397-403.

DAIRYCO. 2015. *Healthy Feet Programme* [Online]. Available: http://www.dairyco.org.uk/technical-services/healthy-feet-programme/#.VS5bptzF_HU [Accessed 15/04/2015 2015].

DAWSON, S. 2007. Guidelines for the vaccination of dogs and cats. *Journal of Small Animal Practice,* 48**,** 483-483.
DAY, M. J. 2006. Vaccine side effects: Fact and fiction. *Veterinary Microbiology,* 117**,** 51-58.
DAY, M. J. 2011. Vaccination of dogs and cats: no longer so controversial? *Veterinary Record,* 168**,** 480-482.
DAY, M. J., HORZINEK, M. C. & SCHULTZ, R. D. 2010. WSAVA Guidelines for the Vaccination of Dogs and Cats. *Journal of Small Animal Practice,* 51**,** e1-e32.
DE BRIYNE, N., ATKINSON, J., BORRIELLO, S. P. & POKLUDOVÁ, L. 2014. Antibiotics used most commonly to treat animals in Europe. *Veterinary Record,* 175**,** 325.
DEAN, R., PFEIFFER, D. & ADAMS, V. 2013. The incidence of feline injection site sarcomas in the United Kingdom. *BMC Veterinary Research,* 9**,** 1-6.
DEAN, R. S., PFEIFFER, D. U. & ADAMS, V. J. 2012. Feline vaccination practices and protocols used by veterinarians in the United Kingdom. *The Veterinary Journal,* 194**,** 113-117.
DEFRA 2010. *Map of livestock populations in 2000 and 2010 across England* [pdf]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/183109/defra-stats-foodfarm-landuselivestock-june-detailedresults-livestockmaps111125.pdf. [Accessed: 27/05/2015]
DINGWALL, R. 1997. Accounts, Interviews and Observations. *In:* MILLAR, G. & DINGWALL, R. (eds.) *Context & Method in Qualitative Research* 1ed. UK: SAGE Publications Ltd. pp.51-65.
DUNCAN, C., DALE, V. H. M. & PEAL, M. J. 2011. Clinical veterinary students' perceptions of a 'Day one' skills guide. *Veterinary Record,* 169, 13. [Online]. Available: http://veterinaryrecord.bmj.com/content/169/1/13.full?sid=98976356-1737-4ebc-a6ab-772aa55ec741. [Accessed: 28/05/2015].
DUVAL, D. & GIGER, U. 1996. Vaccine-Associated Immune-Mediated Hemolytic Anemia in the Dog. *Journal of Veterinary Internal Medicine,* 10**,** 290-295.
ELBERS, A. R. W., GORGIEVSKI-DUIJVESTEIJN, M. J., VELDEN, P. G. V. D., LOEFFEN, W. L. A. & ZARAFSHANI, K. 2010a. A socio-psychological investigation into limitations and incentives concerning reporting a clinically suspect situation aimed at improving early detection of classical swine fever outbreaks. *Veterinary Microbiology,* 142**,** 108-118.
ELBERS, A. R. W., KOEIJER, A. A. D., SCOLAMACCHIA, F. & RIJN, P. A. V. 2010b. Questionnaire survey about the motives of commercial livestock farmers and hobby holders to vaccinate their animals against Bluetongue virus serotype 8 in 2008-2009 in the Netherlands. *Vaccine,* 28**,** 2473-2481.
ELLIOTT, J., SNEDDON, J., LEE, J. A. & BLACHE, D. 2011. Producers have a positive attitude toward improving lamb survival rates but may be influenced by enterprise factors and perceptions of control. *Livestock Science,* 140**,** 103-110.
ELLIS-IVERSEN, J., COOK, A. J. C., WATSON, E., NIELEN, M., LARKIN, L., WOOLDRIDGE, M. & HOGEVEEN, H. 2010. Perceptions, circumstances and motivators that influence implementation of zoonotic control programs on cattle farms. *Preventive Veterinary Medicine,* 93**,** 276-285.
ENTICOTT, G., FRANKLIN, A. & VAN WINDEN, S. 2012. Biosecurity and food security: spatial strategies for combating bovine tuberculosis in the UK. *The Geography Journal,* 178**,** 327-337.

ENTICOTT, G. & VANCLAY, F. 2011. Scripts, animal health and biosecurity: The moral accountability of farmers' talk about animal health risks. *Health, Risk & Society,* 13**,** 293-309.
EQUATOR. 2015. *Library for health research reporting* [Online]. Available: http://www.equator-network.org/. [Accessed 05/01/2015 2015].
EVERITT, S. 2011. *Clinical Decision Making in Veterinary Practice.* PhD, University of Nottingham.
FEI 2012. *International Helath Requirements- Vaccinations Section*. [Online]. Available: http://www.fei.org/system/files/IHR-Vaccinations.pdf. [Accessed 27/05/2015]
FINE, P. 2014. Science and society: vaccines and public health. *Public Health,* 128**,** 686-692.
FISH, R., AUSTIN, Z., CHRISTLEY, R., HAYGARTH, P. M., HEATHWAITE, L. A., LATHAM, S., MEDD, W., MORT, M., OLIVER, D. M., PICKUP, R., WASTLING, J. M. & WYNNE, B. 2011. Uncertainties in the governance of animal disease: an interdisciplinary framework for analysis. (Special Issue: Interdisciplinary perspectives on the management of infectious animal and plant diseases.). *Philosophical Transactions of the Royal Society of London,* 366**,** 2023-2034.
FLATEN, O., LIEN, G., KOESLING, M., VALLE, P. S. & EBBESVIK, M. 2005. Comparing risk perceptions and risk management in organic and conventional dairy farming: empirical results from Norway. *Livestock Production Science,* 95**,** 11-25.
FLEISS, J. L., LEVIN, B. & CHO PAIK, M. 2003. The Measurement of Interrater Agreement. In: *Statistical Methods for Rates and Proportions.* 3rd ed. New Jersey, USA: Wiley. Ch. 18.
FLOERSCH, J., LONGHOFER, J., L., KRANKE, D. & TOWNSEND, L. 2010. Integrating Thematic, Grounded Theory and Narrative Analysis: A Case Study of Adolescent Psychotropic Treatment. *Qualitative Social Work,* 9**,** 407-425.
FRIEDMAN, D. B., KANWAT, C. P., HEADRICK, M. L., PATTERSON, N. J., NEELY, J. C. & SMITH, L. U. 2007. Importance of prudent antibiotic use on dairy farms in South Carolina: a pilot project on farmers' knowledge, attitudes and practices. *Zoonoses and Public Health,* 54**,** 366-375.
GANANN, R., CILISKA, D. & THOMAS, H. 2010. Expediting systematic reviews: methods and implications of rapid reviews. *Implementation Science,* 5**,** 56.
GARFORTH, C. J., BAILEY, A. P. & TRANTER, R. B. 2013. Farmers' attitudes to disease risk management in England: A comparative analysis of sheep and pig farmers. *Preventive Veterinary Medicine,* 110**,** 456-466.
GELLIN, B. G., MAIBACH, E. W. & MARCUSE, E. K. 2000. Do parents understand immunizations? A national telephone survey. *Pediatrics,* 106**,** 1097-1102.
GERRARD, E. 2012. Worming- sending reminders and maintaining compliance. *Veterinary Nurses Times,* 12.
GETHMANN, J., ZILOW, V., PROBST, C., ELBERS, A. R. W. & CONRATHS, F. J. 2015. Why German farmers have their animals vaccinated against Bluetongue virus serotype 8: Results of a questionnaire survey. *Vaccine,* 33**,** 214-221.
GIGERENZER, G. 2014. Breast cancer screening pamphlets mislead women. *British Medical Journal,* 348, 25.
GLANZ, J. M., WAGNER, N. M., NARWANEY, K. J., SHOUP, J. A., MCCLURE, D. L., MCCORMICK, E. V. & DALEY, M. F. 2013. A Mixed Methods Study of Parental Vaccine Decision Making and Parent-Provider Trust. *Academic Pediatrics,* 13**,** 481-488.

GORDON, M., ROBERTS, H. & ODEKA, E. 2007. Knowledge and attitudes of parents and professionals to neonatal BCG vaccination in light of recent UK policy changes: a questionnaire study. *BMC Infectious Diseases,* 7, [Online]. Available: http://www.biomedcentral.com/1471-2334/7/82. [Accessed: 28/05/2015]

GOWDA, C., SCHAFFER, S., DOMBKOWSKI, K. J. & DEMPSEY, A. F. 2012. Understanding attitudes toward adolescent vaccination and the decision-making dynamic among adolescents, parents and providers. *BMC Public Health,* 12, [Online]. Available: http://www.biomedcentral.com/1471-2458/12/509. [Accessed: 28/07/2015].

GRAPHPAD. 2015. *QuickCalcs, GraphPad Software, Inc.* [Online]. http://www.graphpad.com/quickcalcs/. [Accessed 06/01/2015.]

GRINDLAY, D. J. C., BRENNAN, M. L. & DEAN, R. S. 2012. Searching the veterinary literature: a comparison of the coverage of veterinary journals by Nine bibliographic databases. *Journal of Veterinary Medical Education,* 39**,** 404-412.

GRINDLAY, D. J. C., DEAN, R. S., CHRISTOPHER, M. M. & BRENNAN, M. L. 2014. A survey of the awareness, knowledge, policies and views of veterinary journal Editors-in-Cheif on reporting guidelines for publication of research. *BMC Veterinary Research,* 10, [Online]. Available: http://www.biomedcentral.com/1746-6148/10/10. [Accessed: 28/05/2015].

GUNN, G. J., HEFFERNAN, C., HALL, M., MCLEOD, A. & HOVI, M. 2008. Measuring and comparing constraints to improved biosecurity amongst GB farmers, veterinarians and the auxiliary industries. *Preventive Veterinary Medicine,* 84**,** 310-323.

HABACHER, G., GRUFFYDD-JONES, T. & MURRAY, J. 2010. Use of a web-based questionnaire to explore cat owners' attitudes towards vaccination in cats. *Veterinary Record,* 167**,** 122-127.

HALL, J. & WAPENAAR, W. 2012. Opinions and practices of veterinarians and dairy farmers towards herd health management in the UK. *Veterinary Record,* 170**,** 441. [Online]. Available: http://veterinaryrecord.bmj.com/content/170/17/441.full?sid=220e9fc7-9ff1-4c94-adfc-5653ea32286a. [Accessed: 28/05/2015].

HALLIDAY, J. E. 1989. Attitudes towards farm diversification: results from a survey of Devon farms. *Journal of Agricultural Economics, UK,* 40**,** 93-100.

HANNES, K., BOOTH, A., HARRIS, J. & NOYES, J. 2013. Celebrating methodological challenges and changes: reflecting on the emergence and importance of the tole of qualitative evidence in Cochrane reviews. *Systematic Reviews,* 2 [Online]. Available: http://www.systematicreviewsjournal.com/content/2/1/84. [Accessed: 28/05/2015].

HANSEN, K. M. 2006. The effect of incentives, interview length and interviewer characteristics on response rates in a CATI-study. *International Journal of Public Opinion Research,* 19**,** 112-121.

HATTON, P. 1990. The use of the screening technique as a method of rapidly estimating vaccine efficacy. *Public Health,* 104**,** 21-25.

HEFFERNAN, C., NIELSEN, L., THOMSON, K. & GUNN, G. 2008. An exploration of the drivers to bio-security collective action among a sample of UK cattle and sheep farmers. *Preventive Veterinary Medicine,* 87**,** 358-372.

HENDRICK, M. J. 2011. Musings on feline injection site sarcomas. *The Veterinary Journal,* 188**,** 130-131.

HENDRICK, M. J., GOLDSCHMIDT, M. H., SHOFER, F. S., WANG, Y. Y. & P., S. A. 1992. Postvaccinal sarcomas in the cat: epidemiology and electron probe microanalytical identification of aluminium. *Cancer Research,* 52**,** 5391-5394.
HESSE-BIBER, S. 2004. Unleashing Frankenstein's Monster? The Use of Computers in Qualitative Research. In: Hesse-Biber, S. N. & Leavy, P., eds. 2004. *Approaches to qualitative research: A reader on theory and practice.* New York: Oxford University Press. pp. 535-545.
HEUER, C., BENSCHOP, J., STRINGER, L., COLLINS-EMERSON, J., SANHUEZA, J. & WILSON, P. 2012. Leptospirosis in New Zealand- Best Practice Recommendations for the use of vaccines to prevent human exposure. Massey University: Institue of Veterinary, Animal and Biomedical Sciences, Massey University.
HIGGINS, H. M., HUXLEY, J. N., WAPENAAR, W. & GREEN, M. J. 2013. Proactive dairy cattle disease control in the UK: veterinary surgeons' involvement and associated characteristics. *Veterinary Record,* 173**,** 246. [Online]. Available: http://veterinaryrecord.bmj.com/content/173/10/246.full?sid=220e9fc7-9ff1-4c94-adfc-5653ea32286a. [Accessed: 28/05/2015]
HIGGINS, H. M., HUXLEY, J. N., WAPENAAR, W. & GREEN, M. J. 2014. Quantifying veterinarians' beliefs on disease control and exploring the effect of new evidence: A Bayesian approach. *Journal of Dairy Science,* 97**,** 3394-3408.
HOBSON-WEST, P. 2003. Understanding vaccination resistance: moving beyond risk. *Health, Risk & Society,* 5**,** 273-283.
HOBSON-WEST, P. 2005. *Understanding resistance to childhood vaccination in the UK: Radicals, Reformists and the discourses of risk, trust and science.* PhD, The Univeristy of Nottingham, UK.
HOBSON-WEST, P. 2007. 'Trusting blindly can be the biggest risk of all': organised resistance to childhood vaccination in the UK. *Sociology of Health & Illness,* 29**,** 198-215.
HORSEMAN, S. V., ROE, E. J., HUXLEY, J. N., BELL, N. J., MASON, C. S. & WHAY, H. R. 2014. The use of in-depth interviews to understand the process of treating lame dairy cows from the farmers perspective. *Animal Welfare,* 23**,** 157-165.
HUDSON, C. 2011. Understanding the factors affecting dairy cow fertility. *Veterinary Record,* 168**,** 299-300.
HUSBAND, J. 2005. Strategies for the control of milk fever. *In Practice,* 27**,** 88-92.
INTERNATIONAL CAT CARE (ICC). 2013. *How to give your cat a tablet* [Online]. http://www.icatcare.org/advice/how-guides/how-give-your-cat-tablet. [Accessed 27/02/2015 2015].
JACOBSON VANN, J. C. & SZILAGYI, P. 2005. Patient reminder and recall systems to improve immunization rates. *Cochrane Database of Systematic Reviews* [Online]. Available: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD003941.pub2/abstract. [Accessed: 28/05/2015]
JANSEN, J., RENES, R. J. & LAM, T. J. G. M. 2010a. Evaluation of two communication strategies to improve udder health management. *Journal of Dairy Science,* 93**,** 604-612.
JANSEN, J., STEUTEN, C. D. M., RENES, R. J., AARTS, N. & LAM, T. J. G. M. 2010b. Debunking the myth of the hard-to-reach farmer: effective communication on udder health. *Journal of Dairy Science,* 93**,** 1296-1306.
JICK, H. & HAGBERG, K. W. 2010. Measles in the United Kingdom 1990–2008 and the effectiveness of measles vaccines. *Vaccine,* 28**,** 4588-4592.

JOHNSON, G. L. 1960. Value problems in farm management. *Journal of Agricultural Economics,* 14**,** 1.
KALER, J. & GREEN, L. E. 2013. Sheep farmer opinions on the current and future role of veterinarians in flock health management on sheep farms: a qualitative study. *Preventive Veterinary Medicine,* 112**,** 370-377.
KAWASAKI, J. L. 2004. Agriculture journal literature indexed in life sciences databases. *Issues in Science and Technology Librarianship,* 40.
KHAMSI, R. 2015. *Is the Anti-Vaccination Movement Spreading to Pet Owners?* [Online]. http://nymag.com/daily/intelligencer/2015/02/anti-vaccine-movement-spreading-to-pet-owners.html: New York Media LLC. [Accessed 16/03/2015 2015].
KNIGHTS, C. B., MATEUS, A. & BAINES, S. J. 2012. Current British veterinary attitudes to the use of perioperative antimicrobials in small animal surgery. *Veterinary Record,* 170**,** 646.
KRISTENSEN, E. & ENEVOLDSEN, C. 2008. A mixed methods inquiry: How dairy farmers perceive the value(s) of their involvement in an intensive dairy herd health management program. *Acta Veterinaria Scandinavica,* 50**,** 50-50.
KRISTENSEN, E. & JAKOBSEN, E. B. 2011. Danish dairy farmers' perception of biosecurity. *Preventive Veterinary Medicine,* 99**,** 122-129.
LASTEIN, D. B., VAARST, M. & ENEVOLDSEN, C. 2009. Veterinary decision making in relation to metritis- a qualitative approach to understand the background for variation and bias in veterinary medical records. *Acta Veterinaria Scandinavica,* 51 [Online]. Available: http://www.actavetscand.com/content/51/1/36. [Accessed: 28/05/2015].
LATHAM, C. E. & MORRIS, A. 2007. Effects of formal training in communication skills on the ability of veterinary students to communicate with clients. Veterinary Record, 160, 181-186.
LAYARD, R. & GLAISTER, S. 1994. Introduction. *In:* LAYARD, R. & GLAISTER, S. (eds.) *Cost-Benefit Analysis.* 2 ed. Great Britain: Cambridge University Press. pp. 1-56
LEACH, K. A., WHAY, H. R., MAGGS, C. M., BARKER, Z. E., PAUL, E. S., BELL, A. K. & MAIN, D. C. J. 2010. Working towards a reduction in cattle lameness: 1. Understanding barriers to lameness control on dairy farms. *Research in Veterinary Science,* 89**,** 311-317.
LEASK, J., CHAPMAN, S., HAWE, P. & BURGESS, M. 2006. What maintains parental support for vaccination when challenged by anti-vaccination messages? A qualitative study. *Vaccine,* 24**,** 7238-7245.
LEASK, J. & MCINTYRE, P. 2003. Public opponents of vaccination: a case study. *Vaccine,* 21**,** 4700-4703.
LOWE, P. 2009. *Unlocking Potential: A report on veterinary expertise in food animal production*. [pdf] http://webarchive.nationalarchives.gov.uk/20130402151656/http://archive.defra.gov.uk/foodfarm/policy/animalhealth/vservices/pdf/lowe-vets090806.pdf. [Accessed: 28/05/2015].
LYNN, P. 2001. The Impact of Incentives to Personal Interview Surveys: Role and Perceptions of Interviewers. *International Journal of Public Opinion Research,* 13**,** 326-336.
MAGALHÃES-SANT'ANA, M. 2014. Ethics teaching in European veterinary schools: a qualitative case study. *Veterinary Record,* 175**,** 592.

MAIR, T. S. & WHITE, N. A. 2008. The creation of an international audit and database of equine colic surgery: Survey of attitudes of surgeons. *Equine Veterinary Journal,* 40**,** 400-404.
MARKOWITZ, L. E., TSU, V., DEEKS, S. L., CUBIE, H., WANG, S. A., VICARI, A. S. & BROTHERTON, J. M. L. 2012. Human papillomavirus vaccine introduction – The first five years. *Vaccine,* 30, Supplement 5**,** F139-F148.
MASON, M. 2010. Sample Size and Saturation in PhD Studies Using Qualitative Interviews. *Forum Qualitative Sozialforschung/Forum: Qualtitative Social Research,* 11.
MATEUS, A. L. P., BRODBELT, D. C., BARBER, N. & STÄRK, K. D. C. 2014. Qualitative study of factors associated with antimicrobial usage in seven small animal veterinary practices in the UK. *Preventive Veterinary Medicine,* 117**,** 68-78.
MAY, S. A. 2008. Modern Veterinary Graduates Are Outstanding, But Can They Get Better? *Journal of Veterinary Medical Education,* 35**,** 573-580.
MAYHEW, A., MULLINS, T. L. K., DING, L., ROSENTHAL, S. L., ZIMET, G. D., MORROW, C. & KAHN, J. A. 2014. Risk Perceptions and Subsequent Sexual Behaviors After HPV Vaccination in Adolescents. *Pediatrics*, 133, 1-8.
MCMURRAY, R., CHEATER, F. M., WEIGHALL, A., NELSON, C., SCHWEIGER, M. & MUKHERJEE, S. 2004. Managing controversy through consultation: a qualitative study of communication and trust around MMR vaccination decisions. *The British Journal of General Practice,* 54**,** 520-525.
MCVEY, S. & SHI, J. S. 2010. Vaccines in veterinary medicine: a brief review of history and technology. (Special Issue: Immunology: function, pathology, diagnostics, and modulation.). *Veterinary Clinics of North America, Small Animal Practice,* 40**,** 381-392.
MEADOWS, D. 2010. A study to investigate the use and application of BVDV vaccine in UK cattle. *Cattle Practice,* 18**,** 202-215.
MELIA, K., M. 1997. Producing 'Plausible Stories': Interviewing Student Nurses. *In:* MILLAR, G. & DINGWALL, R. (eds.) *Context & Method in Qualitative Research.* UK: SAGE Publications Ltd. pp. 26-36.
MELLANBY, R. J., RHIND, S. M., BELL, C., SHAW, D. J., GIFFORD, J., FENNELL, D., MANSER, C., SPRATT, D. P., WRIGHT, M. J. H., ZAGO, S. & HUDSON, N. P. H. 2011. Perceptions of clients and veterinarians on what attributes constitute 'a good vet'. Veterinary Record, 168, 616.
MERIAL. 2015. *Purevax (Merial U.S.)* [Online]. http://cats.merial.us/catproducts/purevax/Pages/default.aspx: Merial Limited. [Accessed 21/04/2015 2015].
MILLAR, G. 1997. Introduction: Context and Method in Qualitative Research. *In:* MILLAR, G. & DINGWALL, R. (eds.) *Context & Method in Qualitative Research.* UK: SAGE Publications Ltd.
MITCHELL, A. J. & SELMES, T. 2007. Why don't patients take their medicine? Reasons and solutions in psychiatry. *Advances in Psychiatric Treatment,* 13, 336-346.
MOHER, D., LIBERATI, A., TETZLAFF, J., ALTMAN, D. G. & GROUP, T. P. 2009. *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. *PLoS Medicine,* 6. e1000097.
MOON, K. & BLACKMAN, D. 2014. A Guide to Understanding Social Science Research for Natural Scientists. *Conservation Biology* [Online]. Available: http://onlinelibrary.wiley.com/doi/10.1111/cobi.12326/pdf. [Accessed: 28/05/2015]

MOORE, D. A., KLINGBORG, D. J., BRENNER, J. S. & GOTZ, A. A. 2000. Motivations for and barriers to engaging in continuing veterinary medical education. *Journal of the American Veterinary Medical Association,* 217**,** 1001-1006.
MORGAN-DAVIES, C., WATERHOUSE, A., MILNE, C. E. & STOTT, A. W. 2006. Farmers' opinions on welfare, health and productition practices in extensive hill sheep flocks in Great Britain. *Livestock Science,* 104**,** 268-277.
MORGAN-DAVIES, C., WATERHOUSE, T. & WILSON, R. 2012. Characterisation of farmers' responses to policy reforms in Scottish hill farming areas. *Small Ruminant Research,* 102**,** 96-107.
MUELLER, K. 2011. Diagnosis, treatment and control of left displaced abomasum in cattle. *In Practice,* 33**,** 470-481.
NADIS. 2014. *National Animal Disease Information Service* [Online]. http://www.nadis.org.uk/. [Accessed 01/10/2014 2014].
NERLICH, B. & WRIGHT, N. 2006. Biosecurity and Insecurity: The Interaction between Policy and Ritual During the Foot ad Mouth Crisis. *Environmental Values,* 15**,** 441-462.
NEWCOMER, B. W., WALZ, P. H., GIVENS, M. D. & WILSON, A. E. 2015. Efficacy of bovine viral diarrhea virus vaccination to prevent reproductive disease: A meta-analysis. *Theriogenology,* 83**,** 360-365.e1.
NHS. 2014. *The NHS vaccination schedule* [Online]. http://www.nhs.uk/Conditions/vaccinations/Pages/vaccination-schedule-age-checklist.aspx. [Accessed 26/09/2014 2014].
NHS. 2015. *NHS Persistent Cough Campaign* [Online]. http://3weekcough.org/. [Accessed 15/05/2015 2015].
NICE 2009. *Reducing differences in the uptake of immunisations- Appendix C: The evidence.* [Online] http://www.nice.org.uk/guidance/ph21/chapter/appendix-c-the-evidence. [Accessed: 28/05/2015]
NOAH. 2014. *Overview: Legal Category* [Online]. http://www.noahcompendium.co.uk/Compendium/Overview/-42802.html. [Accessed 12/01/2015 2015].
NOAH. 2015. *The NOAH Compendium* [Online]. http://www.noahcompendium.co.uk/Compendium/Overview/: The National Office of Animal Health. [Accessed 26/02/2015 2015].
O'CONNOR, A. M., WELLMAN, N. G., RICE, M. & FUNK, L. 2010. Characteristics of clinical trials assessing antimicrobial treatment of bovine respiratory disease, 1970-2005. *Journal of the American Veterinary Medical Association,* 237**,** 701-705.
OIE. 2015. *2011: Global Rinderpest Eradication* [Online]. http://www.oie.int/en/for-the-media/rinderpest/: OIE. [Accessed 07/03/2015 2015].
PAGE-JONES, S. & ABBEY, G. 2015. Career identity in the veterinary profession. *Veterinary Record*, 176, 433. [Online]. Available: http://veterinaryrecord.bmj.com/content/176/17/433.full?sid=d08483d1-d3ed-4f39-8272-20b9636a7e25. [Accessed: 28/05/2015].
PATON, N. 2013. Cattle vaccination: decision making in herd health planning. *In Practice,* 35**,** 77-84.
PIKE, T. 2008. Understanding behaviours in a farming context: Bringing theoretical and applied evidence together from across Defra and highlighting policy relevance and implications for future research. *Defra Agricultural Change and Environment Observatory Discussion Paper*.

PRITCHARD, K. 2010. *Awareness and Understanding of On-farm Biosecurity Amongst Bovne Practitioners and Veterinary Students.* BVMedSci, The University of Nottingham, UK.
PRITCHARD, K., WAPENAAR, W. & BRENNAN, M. L. 2015. Cattle veterinarians' awareness and understanding of biosecurity. *Veterinary Record*, 176, 546.
PUBLIC HEALTH WALES, 2015. *Measles outbreak: data* [Online]. www.wales.nhs.uk/sitesplus/888/page/66389. [Accessed 13/03/2015]
RCVS. 2011. Day One Skills- Essential Competencies Required of the Veterinary Surgeon [Online]. https://www.rcvs.org.uk/document-library/day-one-skills/. Available: https://www.rcvs.org.uk/document-library/day-one-skills/ [Accessed 20/08/2015 2015].
RCVS. 2015. *Choosing a veterinary practice* [Online]. http://findavet.rcvs.org.uk/find-a-vet/choosing-a-veterinary-practice/. [Accessed 09/02/2015 2015].
ROBINSON, N. J., BRENNAN, M. L., COBB, M. & DEAN, R. S. 2015. Investigating preventive medicine consultations in first opinion small animal practice using direct observation. *Manuscript submitted for publication*.
RUMA 2007. *Responsible use of vaccines and vaccination in dairy and beef cattle production* [pdf]. Available: http://www.ruma.org.uk/guidelines/vaccines/long/cattle%20vaccine%20long.pdf. [Accessed: 28/05/2015].
SALISBURY, D. M., BEVERLEY, P. C. L. & MILLER, E. 2002. Vaccine programmes and policies. *British Medical Bulletin,* 62**,** 201-211.
SARGEANT, J. M., ELGIE, R., VALCOUR, J., SAINT-ONGE, J., THOMPSON, A., MARCYNUK, P. & SNEDEKER, K. 2009. Methodological quality and completeness of reporting in clinical trials conducted in livestock species. *Preventive Veterinary Medicine,* 91**,** 107-115.
SARGEANT, J. M., THOMPSON, A., VALCOUR, J., ELGIE, R., SAINT-ONGE, J., MARCYNUK, P. & SNEDEKER, K. 2010. Quality of Reporting of Clinical Trials of Dogs and Cats and Associations with Treatment Effects. *Journal of Veterinary Internal Medicine,* 24**,** 44-50.
SAYERS, R. G., SAYERS, G. P., MEE, J. F., GOOD, M., BERMINGHAM, M. L., GRANT, J. & DILLON, P. G. 2013. Implementing biosecurity measures on dairy farms in Ireland. The Veterinary Journal, 197, 259-267.
SCANNELL, J. W. & BRUCE, A. 2015. Antibiotics: expect to use less, more responsibly. Veterinary Record, 177, 168-170.
SCHERK, M. A., FORD, R. B., GASKELL, R. M., HARTMANN, K., HURLEY, K. F., LAPPIN, M. R., LEVY, J. K., LITTLE, S. E., NORDONE, S. K. & SPARKES, A. H. 2013. 2013 AAFP Feline Vaccination Advisory Panel Report. *Journal of Feline Medicine and Surgery,* 15**,** 785-808.
SCIMAGO. 2015. *Country search. World Report (Subject area: Veterinary)* [Online]. http://www.scimagojr.com/countrysearch.php?area=3400&country=&w=world: SCImago. [Accessed 07/01/2015 2015].
THE SCOTTISH GOVERNMENT 2011. *Bovine Viral Diarrhoea (BVD): Consultation on mandatory annual screening test. Phase two of the eradication scheme.*[Online]. Available: http://www.gov.scot/Publications/2011/01/17111217/0. [Accessed 27/05/2015].
SILVERMAN, D. 1997. The Logics of Qualitative Research. *In:* MILLAR, G. & DINGWALL, R. (eds.) *Context & Method in Qualitative Research.* UK: SAGE Publications Ltd.

SIM, J. & WRIGHT, C. C. 2005. The Kappa Statistic in Reliability Studies: Use, Interpretation, and Sample Size Requirements. *Physical Therapy,* 85**,** 257-268.

SINGH, S. K., KAUL, P. N. & RASHMI, S. 2009. Factors leading to change in farmers' attitude towards artificial insemination. *Indian Research Journal of Extension Education,* 9**,** 39-42.

SNEDEKER, K. G., CAMPBELL, M. & SARGEANT, J. M. 2012. A systematic review of vaccinations to reduce the shedding of *Escherichia coli* O157 in the faeces of domestic ruminants. *Zoonoses and Public Health,* 59**,** 126-138.

SOK, J., HOGEVEEN, H., ELBERS, A. R. W., VELTHUIS, A. G. J. & OUDE LANSINK, A. G. J. M. 2014. Expected utility of voluntary vaccination in the middle of an emergent Bluetongue virus serotype 8 epidemic: A decision analysis parameterized for Dutch circumstances. *Preventive Veterinary Medicine,* 115**,** 75-87.

SPENCER, L., RITCHIE, J., LEWIS, J. & DILLON, L. 2003. *Quality in qualitative evaluation: A framework for assessing research evidence*. [pdf] London: Cabinet Office. Available: http://www.civilservice.gov.uk/wp-content/uploads/2011/09/a_quality_framework_tcm6-38740.pdf. [Accessed: 28/05/2015]

STATHAM, J. & GREEN, M. 2015. Cattle veterinary services in a changing world. *Veterinary Record,* 176**,** 276-280.

THEURER, M. E., LARSON, R. L. & WHITE, B. J. 2014. Systematic review and meta-analysis of the effectiveness of commercially available vaccines against bovine herpesvirus, bovine viral diarrhea virus, bovine respiratory syncytial virus, and parainfluenza type 3 virus for mitigation of bovine respiratory disease complex in cattle. *Journal of the American Veterinary Medical Association,* 246**,** 126-142.

THOMSEN, P. T., GIDEKULL, M., HERSKIN, M. S., HUXLEY, J. N., PEDERSEN, A. R., RANHEIM, B. & WHAY, H. R. 2010. Scandinavian bovine practitioners' attitudes to the use of analgesics in cattle. *Veterinary Record,* 167, 256-258.

TOMA, L., STOTT, A. W., HEFFERNAN, C., RINGROSE, S. & GUNN, G. J. 2013. Determinants of biosecurity behaviour of British cattle and sheep farmers—A behavioural economics analysis. Preventive Veterinary Medicine, 108, 321-333.

TONG, A., SAINSBURY, P. & CRAIG, J. 2007. Consolidated criteria for reporting quantitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care,* 19**,** 349-357.

TOWNSEND, E. 2013. *An anlysis of the arguments used to campaign against companion animal vaccination from readilty availiable internet sources.* BVetSci. University of Nottingham, UK

UZAL, F. A. 2012. Evidence-Based Medicine Concerning Efficacy of Vaccination Against Clostridium chauvoei Infection in Cattle. *Veterinary Clinics of North America: Food Animal Practice,* 28**,** 71-77.

VAARST, M., PAARUP-LAURSEN, B., HOUE, H., FOSSING, C. & ANDERSEN, H. J. 2002. Farmers' choice of medical treatment of mastitis in Danish dairy herds based on qualitative research interviews. *Journal of Dairy Science,* 85**,** 992-1001.

VEERU 2003. *Vaccine use in organic cattle and sheep systems: Development of a decision support tool based on risk assessment.* [pdf] London: Defra. Available: http://orgprints.org/6776/1/OF0310_2169_FRP.pdf. [Accessed: 28/05/2015.

THE VETERINARY TIMES. 2015. In brief: Leptospirosis threat. *Veterinary Times,* 45**,** 2.

VMD. 2015. *Adverse Reactions Reporting: Report a Suspected Adverse Event* [Online]. https://www.vmd.defra.gov.uk/adversereactionreporting. [Accessed 15/05/2015 2015].

WHO. 2014. *Poliomyelitis, Fact sheet number 114* [Online]. World Health Organisation. Available: http://www.who.int/mediacentre/factsheets/fs114/en/ [Accessed 13/10/2014 2014].

WHO. 2015a. *Antimicrobial resistance, Fact sheet number 194* [Online]. Available: http://www.who.int/mediacentre/factsheets/fs194/en/ [Accessed 19/05/2015 2015].

WHO. 2015b. *Global Alert and Response (GAR): Smallpox* [Online].. Available: http://www.who.int/csr/disease/smallpox/en/ [Accessed 07/03/2015 2015].

WHO. 2015c. *Immunization, Vaccines and Biologicals: Vaccines and diseases* [Online]. Available: http://www.who.int/immunization/diseases/en/ [Accessed 21/05/2015 2015].

YARWOOD, J. 2006. Communicating vaccine benefit and risk – lessons from the medical field. *Veterinary Microbiology,* 117**,** 71-74.

YARWOOD, J., NOAKES, K., KENNEDY, D., CAMPBELL, H. & SALISBURY, D. 2005. Tracking mothers attitudes to childhood immunisation 1991-2001. *Vaccine,* 23**,** 5670-5687.

ZIPPRICH, J., WINTER, K., HACKER, J., XIA, D., WATT, J. & HARRIMAN, K. 2015. Measles outbreak- California, December 2014- February 2015. *MMWR-Morbidity & Mortality Weekly Report,* 64**,** 153-154.

Appendices

Appendix 1: Cattle vaccines currently listed in the National Office of Animal Health presented alphabetically by pathogen(s), name and legal category (NOAH, 2015)

Pathogen(s)	Vaccine name	Legal category
Bluetongue 8	Bovilis BTV8	POM-V
Bluetongue 8	Zulvac 8 Bovis	POM-V
BRD complex: BRSV, BVD, IBR, PI3	Rispoval 4	POM-V
BRD complex: BRSV, BVD, PI3	Rispoval 3	POM-V
BRD Complex: BRSV, *Mannheimia haemolytica,* PI3	Bovilis Bovipast RSP	POM-V
BRD complex: BRSV, PI3	Rispoval RS+PI3 Intranasal	POM-V
BRD complex: IBR, PI3	Imuresp RP	POM-V
BRSV	Rispoval RS	POM-V
BVD	Bovela	POM-V
BVD	Bovidec	POM-V
BVD	Bovilis BVD	POM-V
Clostridial disease	Bravoxin 10	POM-VPS
Clostridial disease	Covexin 8	POM-VPS
Clostridial disease	Covexin 10	POM-VPS
Clostridial disease	Tribovax T	POM-VPS
Clostridium chauvoei	Blackleg Vaccine- Zoetis	POM-VPS
Clostridium chauvoei	Blackleg Vaccine- MSD	POM-VPS
Coxiella burnetii (Q fever)	Coxevac	POM-V
IBR	Bovilis IBR marker inactivated	POM-V

IBR	Bovilis IBR marker live	POM-V
IBR	Hiprabovis IBR marker live	POM-V
IBR	Rispoval IBR-Marker inactivated	POM-V
IBR	Rispoval IBR-Marker live	POM-V
IBR	Tracherine	POM-V
Leptospirosis	Leptavoid-H	POM-VPS
Leptospirosis	Spirovac	POM-VPS
Lungworm	Bovilis Huskvac	POM-V
Mannheimia haemolytica	Pastobov	POM-V
Mastitis: *Staphylococcus aureus,* coliforms and coagulase-negative staphylococci	Startvac	POM-V
Neonatal diarrhoea: Rotavirus, coronavirus, *E.coli*	Lactovac	POM-VPS
Neonatal diarrhoea: Rotavirus, coronavirus, *E.coli*	Rotavec Corona	POM-VPS
Neonatal diarrhoea: Rotavirus, coronavirus, *E.coli*	Trivacton 6	POM-VPS
Pasteurella haemolytica	Rispoval Pasteurella	POM-V
Ringworm	Bovilis Ringvac	POM-V
Salmonella dublin and S. typhimurium	Bovivac S	POM-V
Schmallenberg virus	Zulvac SBV	POM-V

Appendix 2: List of studies included in ‘Methods used to research farmers’ attitudes toward cattle production: A rapid review’ (Chapter 2)

1. Arias, J.L.P. & Spinka, M. 2005. Associations of stockpersons' personalities and attitudes with performance of dairy cattle herds. Czech Journal of Animal Science, 50(5): 226-234.
2. Basarir, A. & Gillespie, J. M. 2007. Eliciting farmers' goal hierarchies: comparing the fuzzy pair-wise method with the simple ranking procedure. International Journal of Agriculture and Biology, 9(2): 257-263.
3. Bell, N.J., Main, D.C.J., Whay, H.R., Knowles, T.G., Bell, M.J. & Webster, A.J.F. 2006. Herd health planning: farmers' perceptions in relation to lameness and mastitis. Veterinary Record, 159(21): 699-705.
4. Benjamin, L.A., Fosgate, G.T., Ward, M.P., Roussel, A.J., Feagin, R.A. & Schwartz, A.L. 2010. Attitudes towards biosecurity practices relevant to Johne's disease control on beef cattle farms. Preventive Veterinary Medicine, 94(3/4): 222-230.
5. Bertenshaw, C. & Rowlinson, P. 2009. Exploring Stock Managers' Perceptions of the Human-Animal Relationship on Dairy Farms and an Association with Milk Production. Anthrozoos, 22(1): 59-69.
6. Bock, R.E., Blight, G.W., Kingston, T.G. & Vos, A.J.D. 1995. A survey of cattle producers in the Boophilus microplus endemic area of Queensland to determine attitudes to the control of and vaccination against tick fever. Australian Veterinary Journal, 72(3): 88-92.
7. Boivin, X., Marcantognini, L., Boulesteix, P., Godet, J., Brule, A. & Veissier, I. 2007. Attitudes of farmers towards Limousin cattle and their handling. Animal Welfare, 16(2): 147-151.
8. Brownlie, T.S., Weir, A.M., Tarbotton, I., Morton, J.M., Heuer, C. & McDougall, S. 2011. Reproductive management of dairy herds in New Zealand: Attitudes, priorities and constraints perceived by farmers managing seasonal-calving, pasture-based herds in four regions. New Zealand Veterinary Journal, 59(1): 28-39.
9. Cardoso, S.P. & James, H.S., Jr. 2012. Ethical frameworks and farmer participation in controversial farming practices. Journal of Agricultural & Environmental Ethics, 25(3): 377-404.

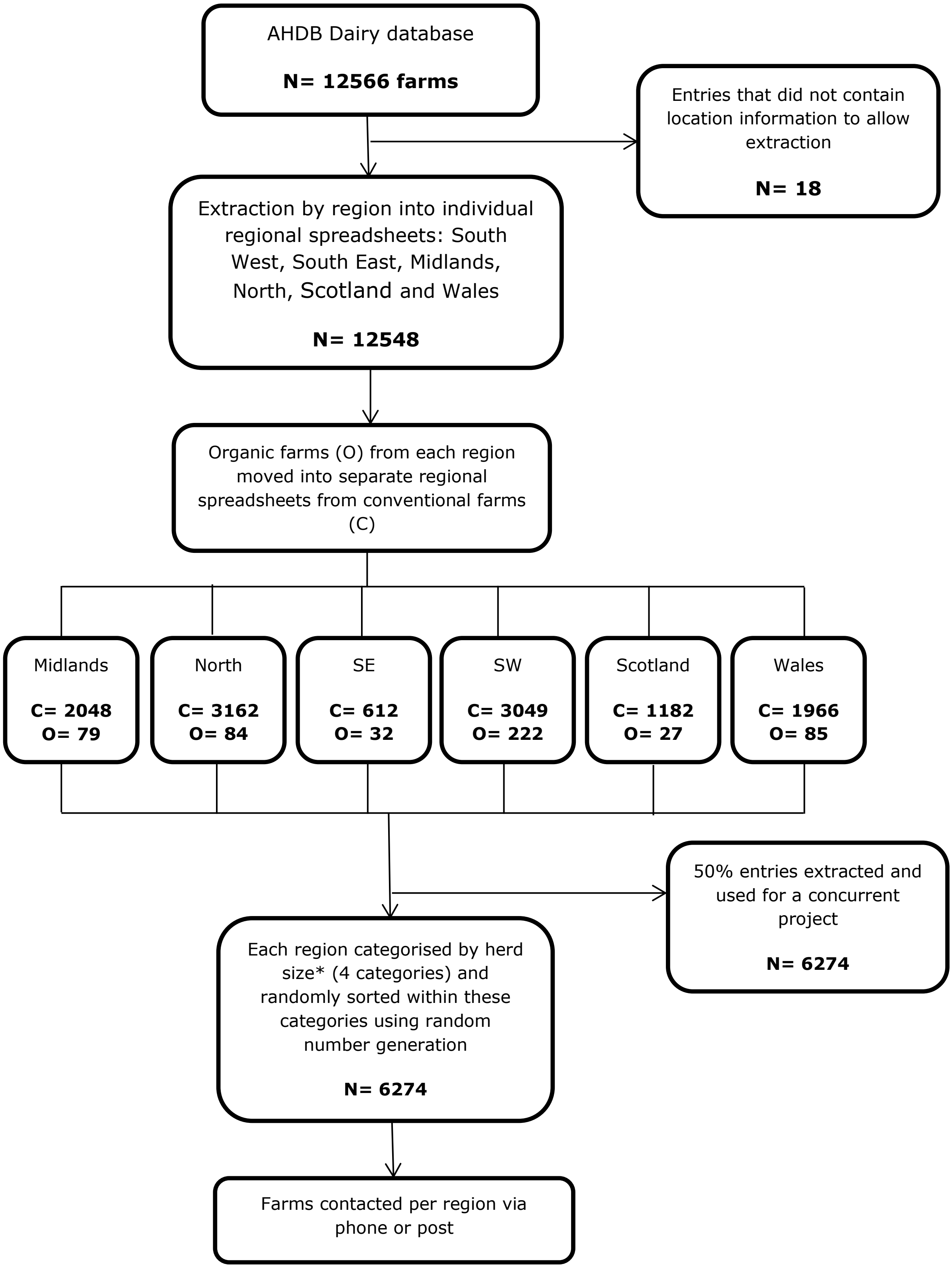
10. Dana, S.S. & Kanbid, B.R. 1998. Impact of knowledge on attitude of livestock owners towards artificial insemination in cattle. Indian Veterinary Journal, 75(6): 572-573.
11. Dockes, A.C. & Kling-Eveillard, F. 2006. Farmers' and advisers' representations of animals and animal welfare. (Special issue: Ethics in animal agriculture.). Livestock Science, 103(3): 243-249.
12. Elbers, A.R.W., De Koeijer, A. A., Scolamacchia, F. & Van Rijn, P.A. 2010. Questionnaire survey about the motives of commercial livestock farmers and hobby holders to vaccinate their animals against Bluetongue virus serotype 8 in 2008-2009 in the Netherlands. Vaccine, 289.
13. Ellis-Iversen, J., Cook, A.J.C., Watson, E., Nielen, M., Larkin, L., Wolldridge, M. & Hogeveen, H. 2010. Perceptions, circumstances and motivators that influence implementation of zoonotic control programs on cattle farms. Preventive Veterinary Medicine, 93(4): 276-285.
14. Enticott, G., Maye, D., Ilbery, B., Fisher, R. & Kirwan, J. 2012. Farmers' confidence in vaccinating badgers against bovine tuberculosis. Veterinary Record, 170(8): 204.
15. Flaten, O., Lien, G., Koesling, M., Valle, P.S. & Ebbesvik, M. 2005. Comparing risk perceptions and risk management in organic and conventional dairy farming: empirical results from Norway. Livestock Production Science, 95(1/2): 11-25.
16. Friedman, D.B., Kanwat, C.P., Headrick, M.L., Patterson, N.J., Neely, J.C. & Smith, L.U. 2007. Importance of prudent antibiotic use on dairy farms in South Carolina: a pilot project on farmers' knowledge, attitudes and practices. Zoonoses and Public Health, 54(9): 366-375.
17. Gottardo, F., Nalon, E., Contiero, B., Normando, S., Dalvit, P. & Cozzi, G. 2011. The dehorning of dairy calves: Practices and opinions of 639 farmers. Journal of Dairy Science, 94(11): 5724-5734.
18. Green, A.L., Carpenter, L.R., Edmisson, D.E., Lane, C.D., Welborn, M.G., Hopkins, F.M., Bemis, D.A. & Dunn, J.R. 2010. Producer attitudes and practices related to antimicrobial use in beef cattle in Tennessee. Javma-Journal of the American Veterinary Medical Association, 237(11): 1292-1298.
19. Hall, D.C., Knight, T.O., Coble, K.H., Baquet, A.E. & Patrick, G.F. 2003. Analysis of beef producers' risk management perceptions and desire for further risk management education. Review of Agricultural Economics, 25(2): 430-448.
20. Halliday, J.E. 1989. Attitudes towards farm diversification: results from a survey of Devon farms. Journal of Agricultural Economics, UK, 40(1): 93-100.

21. Heffernan, C., Nielsen, L., Thomson, K. & Gunn, G. 2008. An exploration of the drivers to bio-security collective action among a sample of UK cattle and sheep farmers. Preventive Veterinary Medicine, 87(3/4): 358-372.
22. Hoe, F.G.H. & Ruegg, P.L. 2006. Opinions and practices of Wisconsin dairy producers about biosecurity and animal well-being. Journal of Dairy Science, 89(6): 2297-2308.
23. Howards, W.H. & Cranfield, J. 1995. Ontario beef producers attitudes about artificial-insemination. Canadian Journal of Agricultural Economics-Revue Canadienne D Economie Rurale, 43(2): 305-314.
24. Huxley, J.N. & Whay, H.R. 2007. Attitudes of UK veterinary surgeons and cattle farmers to pain and the use of analgesics in cattle. Cattle Practice, 15(2): 189-193.
25. Jervell, A.M. 1993. Farmers' attitudes to milk quota policy in Norway. Sociologia Ruralis, 333-4
26. Kielland, C., Skjerve, E., Osteras, O. & Zanella, A.J. 2010. Dairy farmer attitudes and empathy toward animals are associated with animal welfare indicators. Journal of Dairy Science, 93(7): 2998-3006.
27. Klaas, I.C., Bjerg, B., Friedmann, S. & Bar, D. 2010. Cultivated barns for dairy cows - an option to promote cattle welfare and environmental protection in Denmark? Dansk Veterinaertidsskrift, 93(9): 20-29.
28. Koyubenbe, N., Miran, B., Konca, Y., Yaylak, E., Uzmay, A. & Candemir, M. 2010. Farmers' preferences for organic milk production in Izmir, Turkey. Asian Journal of Animal and Veterinary Advances, 5(1): 24-33.
29. Kumar, R. & Tripathi, H. 2011. Sustainability of crossbreeding practice perceived by the dairy farmers in Midwestern plain zone of Uttar Pradesh. Journal of Applied Animal Research, 39(3): 257 - 260.
30. Lensink, J., Boissy, A. & Veissier, I. 2000. The relationship between farmers' attitude and behaviour towards calves, and productivity of veal units. Annales De Zootechnie, 49(4): 313-327.
31. MacLeod, N.D. & Taylor, J.A. 1994. Perceptions of beef cattle producers and scientists relating to sustainable land use issues and their implications for technology transfer. Rangeland Journal, 16(2): 238-253.
32. Maller, C.J., Hemsworth, P.H., Ng, K.T., Jongman, E.J., Coleman, G.J. & Arnold, N.A. 2005. The relationships between characteristics of milking sheds and the attitudes to dairy cows, working conditions, and quality of life of dairy farmers. Australian Journal of Agricultural Research, 56(4): 363-372.
33. Morgan-Davies, C., Waterhouse, T. & Wilson, R. 2012. Characterisation of farmers' responses to policy reforms in Scottish hill farming areas. Small Ruminant Research, 102(2-3): 96-107.

34. O'Brien, G.N. & Cole, D.J. 2004. Evaluation of dairy farmer interest in an extended lactation system. Animal Production in Australia, 25128-131.
35. Oladele, O.I. 2011. Determinants of constraints to livestock identification and trace-back system use for disease monitoring among cattle farmers in Botswana. International Journal of Applied Research in Veterinary Medicine, 9(2): 143-153.
36. Oladele, O.I. & Rantseo, K. 2010. Determinants of cattle farmers' perceived relevance of livestock technologies in Botswana. Livestock Research for Rural Development, 22(5): 88.
37. Palmer, S., Fozdar, F. & Sully, M. 2009. The effect of trust on West Australian farmers' responses to infectious livestock diseases. (Special Section: Biosecurity and livestock farming.). Sociologia Ruralis, 49(4): 360-374.
38. Potterton, S.L., Green, M.J., Millar, K.M., Brignell, C.J., Harris, J., Whay, H.R. & Huxley, J.N. 2011. Prevalence and characterisation of, and producers' attitudes towards, hock lesions in UK dairy cattle. Veterinary Record, 169(24): 634.
39. Radder, S.K. & Bhanj S.K. 2011. Perceptions of dairy farmers of Gadag district in northwestern part of Karnataka state, India regarding clean milk production. Veterinary World, 4(2): 79-81.
40. Raju, D.T., Pochaiah, M. & Reddy, G.V.K. 1993. Constraints in the adoption of crossbred cows. Indian Journal of Dairy Science, 46(9): 415-419.
41. Rao, B.S., Kherde, R.L. & Rao, S.V.N. 1990. A study on the attitude of dairy farmers towards dairy production technologies. Indian Journal of Animal Production and Management, 6(3): 145-149.
42. Sawarkar, S.W., Borkar, M.M., Upadhye, S.V. & Jadhao, S.B. 2001. Characteristics of dairy owners, their awareness, adoption and constraints in adoption of artificial insemination practices in Vidarbha region. Indian Journal of Dairy Science, 54(4): 194-202.
43. Schulz, L.L. & Tonsor, G.T. 2010. Cow-calf producer preferences for voluntary traceability systems. Journal of Agricultural Economics, 61(1): 25.
44. Singh, S.K., & Kaul, P.N. 2002. The effect of communication on attitudes of farmers towards artificial insemination. Indian Veterinary Journal, 79: 196 – 198
45. Singh, S.K., Kaul, P.N. & Rashmi, S. 2009. Factors leading to change in farmers' attitude towards artificial insemination. Indian Research Journal of Extension Education, 9(3): 39-42.

46. Sorge, U., Kelton, D., Lissemore, K., Godkin, A., Hendrick, S. & Wells, S. 2010. Attitudes of Canadian dairy farmers toward a voluntary Johne's disease control program. Journal of Dairy Science, 93(4): 1491-1499.
47. Spooner, J.M., Schuppli, C.A. & Fraser, D. 2012. Attitudes of Canadian beef producers toward animal welfare. Animal Welfare, 21(2): 273-283.
48. Tebug, S.F., Chikagwa-Malunga, S. & Wiedmann, S. 2012. On-farm evaluation of dairy farming innovations uptake in northern Malawi. Livestock Research for Rural Development, 24(5).
49. Thombre, B.M., & Pawar, B.R. 1995. Opinion of rural farmers towards crossbred cattle. 20(7): 10 - 12.
50. Vaarst, M., Paarup-Laursen, B., Houe, H., Fossing, C. & Andersen, H.J. 2002. Farmers' Choice of Medical Treatment of Mastitis in Danish Dairy Herds Based on Qualitative Research Interviews. Journal of Dairy Science, 85(4): 992-1001.
51. Vaarst, M. & Sorensen, J.T. 2009. Danish dairy farmers' perceptions and attitudes related to calf-management in situations of high versus no calf mortality. Preventive Veterinary Medicine, 89(1-2): 128-133.
52. Venkatasubramanian, V., & Fulzele, R.M. 1996. Constraints perceived by dairy farmers of Tamil Nadu. Journal of Dairying, Foods and Home Sciences, 15(1): 23 - 29.
53. Weary, D.M., Schuppli, C.A. & Keyserlingk, M.A.G.V. 2011. Tail docking dairy cattle: responses from an online engagement. Journal of Animal Science, 89(11): 3831-3837.
54. Winsten, J.R., Richardson, A., Kerchner, C.D., Lichau, A., & Hyman, J.M. 2010. Barriers to the adoption of management-intensive grazing among dairy farmers in the Northeastern United States. Renewable Agriculture and Food Systems, 26(2): 104 - 113.
55. Young, I., Hendrick, S., Parker, S., Rajic, A., McClure, J.T., Sanchez, J. & McEwen, S. A. 2010. Knowledge and attitudes towards food safety among Canadian dairy producers. Preventive Veterinary Medicine, 94(1-2): 65-76.
56. Young, I., Rajic, A., Hendrick, S., Parker, S., Sanchez, J., McClure, J.T. & McEwen, S. A. 2010. Attitudes towards the Canadian quality milk program and use of good production practices among Canadian dairy producers. Preventive Veterinary Medicine, 94(1-2): 43-53.
57. Zepeda, L. 1990. Predicting bovine somatotropin use by California dairy farmers. Western Journal of Agricultural Economics, 15(1): 55-62.

Appendix 3: Flow chart describing selection and recruitment of farmers from the AHDB Dairy database



* Herd size categories: 'HS Cat' as 2= <50, 3= 50-149, 4= >=150, = missing value. "=IF(L2 = '*', 1, IF(L2<50, 2, IF(L2<150, 3, 4)))".

Appendix 4: Postal invitation (Farmer)

School of Veterinary Medicine and Science
The University of Nottingham
Sutton Bonington Campus
Sutton Bonington
Leicestershire, LE12 5RD

June 2013

Dear Sir/Madam,

Would you like your voice to be heard?

The School of Veterinary Medicine and Science in Nottingham invites you to **share your views on disease control.**

We would like to speak to as many **dairy farmers with as wide a range of herd sizes and types as possible** over the next three months.

The **interview lasts less than an hour** and can be arranged **at a time and place that suits you**. We'll be asking questions about your opinion and experience with disease control.

If you make the decisions regarding disease control on your farm we would greatly welcome your participation in this study.

Your opinions will help us to **inform future advice, research and policy to improve animal health.**

If you are interested or have any questions please return the enclosed form using the stamped, addressed envelope, email me at svxir@nottingham.ac.uk or phone on 07779000412.

All participants will be given **the chance to enter a prize draw for a £100 voucher** of their choice.

Many thanks,

Imogen Richens

PhD Student at the School of Veterinary Medicine and Science

For further information about this project please contact the research supervisor Dr Wendela Wapenaar at wendela.wapenaar@nottingham.ac.uk or on 0115 951 6260.

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

☐ Yes, I am interested in being interviewed. Please contact me with more information.

My name is: ______________________________

We would be grateful if you would confirm the details of your preferred method of contact. This will only be used in the organisation of the interview.

☐ Telephone: ______________________________

☐ Email: ______________________________

☐ Post: ______________________________

____

☐ No, I am not interested thank you.

If there is a specific reason why you are unable to/do not wish to participate we would be grateful if you could let us know.

____

____

____

Many thanks,

Imogen Richens

Appendix 5: Further information letter (Farmer)

UNITED KINGDOM · CHINA · MALAYSIA

School of Veterinary Medicine and Science
Sutton Bonington Campus
Sutton Bonington
Leicestershire
LE12 5RD
Email: svxir@nottingham.ac.uk
Phone: 07779000412

Dear,

Thank you very much for your interest being interviewed as part of my PhD study investigating dairy farmers' opinions of disease control. The purpose of the study is to collect dairy farmers' attitudes and opinions on disease control to help inform future advice, research and veterinary care.

I am writing to you to give further information regarding the interview.

The interview lasts less than an hour and is informal. I'll be asking questions about your opinions and experiences with disease control. Everything you say will be anonymous and confidential.

If you have any queries or problems closer to the day then please don't hesitate to email me at svxir@nottingham.ac.uk or ring me on 07779000412.

As a thank you all participants will be given the chance to enter a prize draw for a £100 voucher of their choice.

Once again, thank you very much for giving up your valuable time and I look forward to seeing you on. As I understand plans can change at the last minute, I will contact you the day before to confirm the time of the interview.

Kind Regards,

Imogen Richens

PhD Student at the School of Veterinary Medicine and Science

For further information about this project please contact the research supervisor Dr Wendela Wapenaar at wendela.wapenaar@nottingham.ac.uk or on 0115 951 6260.

Appendix 6: Consent form (Farmer)

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Consent form

Title of the study: Implementation of vaccination strategies on UK dairy farms: Understanding challenges and perceptions.

Purpose of the study:
A qualitative study to investigate the motivators and barriers to implementing vaccination strategies on UK dairy farms. This information will be collected using interviews with UK dairy farmers.

Consent:
This consent form is a formal way of indicating that you agree to participate in this study and that you understand that any information collected by the researchers:

- Will be anonymous and treated confidentially, you will not be able to be identified in the completed study
- Will be recorded using voice recorders and you can request for them to be switched off at any point
- Will only be accessed by people involved in the project
- Will be used for a research study and may be written in a report for publication or presented at research conferences or meeting
- That you can request to see any information written down/recorded/kept during the process of data collection and a copy of the completed study

I understand that if I would like to withdraw my contribution I have up to seven days after the interview to do so.

Participant

Name:... Signature:...................................
Date:.................................

Researcher

Name:... Signature:...................................
Date:..................................

Thank you very much for participating in this study.

If you have any queries regarding this study, please speak to the researcher directly or contact them via e-mail or phone (details above).

Please tick here if you would like to receive a summary of the study results, and indicate how you would like to be contacted

☐

Appendix 7: Question guide for the farmer interviews

<u>Background</u>

1. Tell me a bit about yourself and your farm

<u>Theme 1: 'What do you do?'</u>

1. I'm interested in the opinions of dairy farmers about vaccination. How do you use vaccines on your farm, if you use them at all?

    a. How do you choose which vaccines to use?
    b. Why do you not use vaccines for other diseases?[1]
    c. How do you go about organising vaccinating your cattle?
    d. How do you get your information about vaccination?
    e. To what extent do you see vaccination as an important tool to control disease on your farm?

<u>Theme 2: 'The vet'</u>

2. Is anyone else involved in the decision to vaccinate?
    a. Did your vet offer any other advice with regards to the problem?
    b. Why do you think they recommended vaccination?
    c. Can you tell me about your relationship with your vet?

<u>Theme 3: 'Why do/don't farmers vaccinate?'</u>

1. In general, what do you think the reasons are for vaccinating dairy cows?
2. In general, what do you think the reasons are for not vaccinating dairy cows?

    a. How effective do you think vaccines are?
    b. How do you know it works?
    c. Have you ever seen any side-effects you think were due to vaccination?
    d. Can you think of anyone 'off farm' that has an influence on vaccinating dairy cows?
    e. Where do you think responsibility does lie with regards to disease control on dairy farms?
    f. Where should responsibility lie with regards to disease control on dairy farms?
    g. And with regards to vaccination?

<u>Theme 4: 'What would you change?'</u>

1. All things considered is there anything that would cause you to change what you do on your farm?
2. Is there anything that would make vaccinating your cows easier?
3. Is there anything you don't like about vaccinating?
4. Is there anything you think I've missed, got wrong, or that you would like to add on the topic of vaccination in dairy cows?

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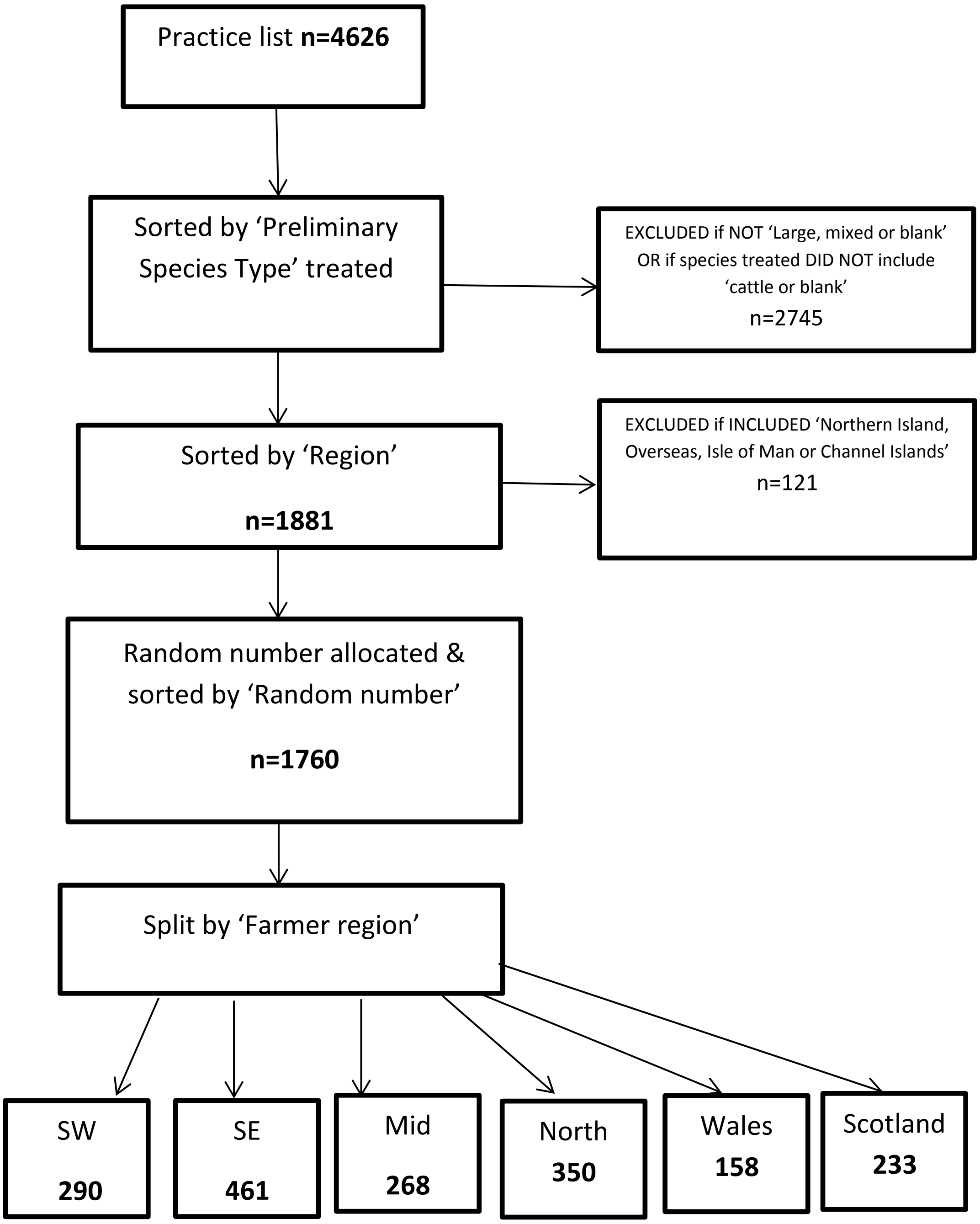
[1] This question was added after a number of interviews were conducted.

Appendix 8: Flow chart describing veterinary practice selection from the RCVS practice database



Appendix 9: Email invitation (Veterinary Surgeon)

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

Dear

My name is Imogen Richens and I am a PhD student at Nottingham School of Veterinary Medicine and Science. I spoke to one of your receptionists earlier who advised me to forward on these details by email.

As part of my research investigating attitudes and opinions surrounding disease control on British dairy farms I am looking to recruit farm animal and mixed practitioners to take part in some informal interviews. The interview shouldn't last longer than an hour and I can come to the practice at a time convenient to you. Lunch will be provided as a small thank-you for your time.

I am hoping to be conducting interviews in your area in the week beginning 27th January 2014.

If you are interested in participating, would like some more information or have any questions please don't hesitate to contact me using the contact details below.

Many thanks,

Imogen Richens

PhD Student, School of Veterinary Medicine and Science
The University of Nottingham,
Sutton Bonington Campus,
Sutton Bonington,
Leicestershire
LE12 5RD
Email: svxir@nottingham.ac.uk
Mobile: 07779000412

Appendix 10: Further information letter (Veterinary Surgeon)

School of Veterinary Medicine and Science
Sutton Bonington Campus
Sutton Bonington
Leicestershire
LE12 5RD
Email: svxir@nottingham.ac.uk
Phone: 07779000412

Dear ,

Thank you very much for your interest in being interviewed as part of my PhD study investigating farm animal veterinary surgeons' opinions of disease control on dairy farms. The purpose of the study is to collect farm animal veterinary surgeons' attitudes and opinions on disease control to help inform future advice, policy, research and veterinary care.

I am writing to you to give further information regarding the interview.

The interview lasts less than an hour and will be informal. I'll be asking questions about your opinions on and experiences with disease control on dairy farms. Everything you say will be anonymous and confidential.

If you have any queries or problems closer to the day then please don't hesitate to contact me by email at svxir@nottingham.ac.uk or mobile on 07779000412. Lunch will be provided, so please let me know if you have any dietary requirements.

Once again, thank you very much for giving up your valuable time and I look forward to seeing you on…

Kind Regards,

Imogen Richens

PhD Student at the School of Veterinary Medicine and Science

For further information about this project please contact the research supervisor Dr Wendela Wapenaar at wendela.wapenaar@nottingham.ac.uk or on 0115 951 6260.

Appendix 11: Consent form (Veterinary Surgeon)

Consent form

Title of the study: Implementation of vaccination strategies on UK dairy farms: Understanding challenges and perceptions.

Purpose of the study:
A qualitative study to investigate the motivators and barriers to implementing vaccination strategies on UK dairy farms. This information will be collected using interviews with UK veterinary surgeons.

Consent:
This consent form is a formal way of indicating that you agree to participate in this study and that you understand that any information collected by the researchers:

- Will be anonymous and treated confidentially, you will not be able to be identified in the completed study
- Will be recorded using voice recorders and you can request for them to be switched off at any point
- Will only be accessed by people involved in the project
- Will be used for a research study and may be written in a report for publication or presented at research conferences or meeting
- That you can request to see any information written down/recorded/kept during the process of data collection and a copy of the completed study

I understand that if I would like to withdraw my contribution I have up to seven days after the interview to do so.

Participant

Name:... Signature:...................................
Date:.................................

Researcher

Name:... Signature:...................................
Date:..................................

Thank you very much for participating in this study.

If you have any queries regarding this study, please speak to the researcher directly or contact them via e-mail or phone (details above).

Please tick here if you would like to receive a summary of the study results, and indicate how you would like to be contacted

Appendix 12: Question guide for the veterinary surgeon interviews

Questions

1. Can you just tell me a bit your background and the practice?

What are the strategies?

2. **How does disease control fit into the day to day work you do?**
3. **What do you feel is the role of vaccination?**
4. **How do you think other vets deal with vaccination?**
    a. Where do you think you fit within that?
    b. Are there situations when your advice differs?
    c. Does the practice have protocols/set strategies?

How are the strategies formed and implemented?

5. **How does the topic of vaccination usually get raised?**
    a. Who usually raises the topic of vaccination?
    b. Why would you advise a farmer to start vaccinating? (could you give me an example?)
    c. Are there situations in which you would advise against vaccination? (could you give me an example?)
    d. When would you advise a farmer to stop vaccinating? (could you give me an example?)
6. **How do you think farmers see vaccination?**
    a. Do you think there is a reason that those farmers don't vaccinate?
    b. Are there ways of overcoming this?
7. **How do the vaccines get distributed?**

General wrapping up questions

8. **How well do you feel vaccines work in practice?**
9. **How informed do you feel about vaccination?**
    a. How/where/when did you learn about vaccination strategies?
    b. How do you keep up to date?
10. **In an ideal world how would you design and implement vaccination strategies?**
    a. What stops you doing that?
    b. Do you feel there are differences with the human medical field?
    c. Small animal/equine?

11. Is there anything that you think I've missed, got wrong or you'd like to add?