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A participatory, farmer-led approach to changing practice around antimicrobial use on UK dairy farms

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Abstract

This research aimed to understand how a participatory approach based on the Danish Stable Schools helped to achieve practical, farmer-led changes to reduce reliance on antimicrobials. Five Farmer Action Groups (FAGs) were established across South West England and followed for 2 years as they worked together to discuss how to reduce antimicrobial use (AMU) on their farms. Medicine Reviews and benchmarking were carried out on each farm to assess any change in AMU. A practical Action Plan was co-produced at each meeting for the host farm to work on to reduce reliance on AMU. All farms implemented at least one recommendation from their Action Plan within a year with an average implementation of 54.3%. Many recommendations were still ongoing at the end of the study. The majority of participating farms (n=27) reduced highest priority critically important antimicrobial (HPCIAs) use over the 2 years. Participants spoke highly of the project and benefited from the sharing of knowledge at each meeting. The exchange of knowledge on herd health during the farm walks and facilitated discussions empowered farmers to change practices; they gained confidence from the group learning experience. The FAGs developed a sense of solidarity from going through a process of change together. Knowledge gaps were identified by the participating farmers, particularly on HPCIAs. This highlighted issues around knowledge mobilisation between veterinarians and farmers at the time of the study. A key component of the FAGs were the facilitators who supported the knowledge mobilisation and helped build a sense of solidarity within the FAGs. There is potential for this approach to be scaled-up across the country. Funding for facilitation that can be readily accessed by farmers and training facilitators to support new groups is a primary proposal that has emerged from this research.

Author's Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

SIGNED: .... DATE:..........................

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This Thesis has been a labour of love. Writing a thesis and all the work that goes into it was not something I would have envisaged myself doing several years ago but with the love, support and guidance of some of the best people I know, here it is!

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Dedication

This thesis is dedicated to all the dairy farmers that had the fortunate (or not so fortunate) experience of being part of this PhD. Without you, this project would never have worked or been nearly as fun! The thirty of you who formed the Farmer Action Groups were the most inspiring, resourceful, passionate and dedicated people I have had the honour of working with. It is for these reasons I will dedicate this thesis and the rest of my time and effort into supporting the farming community.

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"If they can make penicillin out of mouldy bread, they can sure make something out of you"
Mohammad Ali

Chapter One: Introduction

1.a. Overview

This thesis locates itself at the intersection between different disciplines and epistemologies in a strategy to influence and inspire change on farms. In doing so, it does not fit neatly into any one discipline but takes the strengths and insights from each of them to explore and understand how farmers and aligned industries can collaborate in the face of the global challenge of AMR. This inter-disciplinary research traverse's challenging terrain where different philosophical perspectives and research styles diverge. Nevertheless, this study on knowledge, farmer action and empowerment, reveals novel pathways to creating practical change in farming with farmers. The methodological approach adopted in this research has been driven by the implicit inter-disciplinarity of the research questions and the results have emerged directly from empirical insight. This thesis aims to further efforts to co-ordinate and collaborate different bodies of thought with an overriding goal of change.

Reducing the overuse and misuse of antimicrobials is of the utmost importance in the fight to slow the development of antimicrobial resistance (AMR) (1). Antimicrobials are commonly used to treat food-producing animals in the UK and there is a risk that their use in farming drives antimicrobial resistance in human health (2-5). The provision and sale of antimicrobials to UK farmers is strictly by veterinary prescription as they are Prescription Only Medicines (POM-V) but the collection, storage and administration of antimicrobials to individual animals on most UK farms is overseen by the farmer. Farmers in the UK can treat animals by administering antimicrobials, as stipulated in Schedule Three of the Veterinary Surgeons Act 1966. Veterinarians will of course administer treatments when on farm, but they prescribe based on 'recent working knowledge' of the farm and herd/flock and are not present for most treatments. The Royal College of Veterinary Surgeons' 'code of professional conduct' states with regards to veterinary prescribing;

a. *"the animal or herd must have been seen immediately before prescription or,*
b. *recently enough or often enough for the veterinary surgeon to have personal knowledge of the condition of the animal or current health status of the herd or flock to make a diagnosis and prescribe"*

The responsibility for safeguarding an animal's health and wellbeing lies with the farmer, as the owner of the animal set out in Schedule One of the Welfare of Farmed Animals (England) Regulations 2007. UK farmers are therefore making decisions on disease identification and suitable treatments on a regular basis. UK farm assurance regulation stipulates that annual herd/flock health plans are created in collaboration with the veterinarian and reviewed regularly, which will outline specific disease management strategies and treatment protocols that farmers are obliged to follow (6). This process of purchasing and administering antimicrobials in the UK differs to other countries, particularly in Europe, where the veterinarian commences and oversees most, if not all, treatments using antimicrobials. For this reason, understanding and influencing the decision-making processes around administering antimicrobials on UK farms is prudent.

Consequently, in recent years there has been increasing pressure on the farming industry to reduce antimicrobial use (AMU) (5) often through specific interventions to influence and change practices around use of antimicrobials and prevention of disease (7-9). Reducing levels of disease and improving animal health can have an indirect impact on reducing AMU and forms the basis of the World Health Organisation's Global AMR Action Plan (1). This thesis investigates an innovative approach to changing farm practices around disease prevention and AMU in the UK dairy sector. The research is funded by the Agriculture and Horticulture Development Board for Dairy (10) who have a direct interest in the approach and its outcome as a knowledge exchange organisation.

There has been extensive work examining farmer behaviour change and influencing practices on farms. Many interventions and initiatives have focused on a top-down approach, either through regulation, legislation or traditional agricultural extension methods. Although previous and existing initiatives have been successful in part at changing farm practices, these have also revealed gaps in the ability to encourage long-lasting changes that farmers value and therefore fully embrace. There is increasing literature calling for more participatory, bottom-up approaches to change farming practices (11, 12), such as Participatory Action Research through which farmers take the lead and take ownership of the problems and solutions. This is in combination with a growing recognition that for complex challenges with multiple factors and interacting stakeholders, innovative solutions and insights from disciplines such as the social sciences are needed (13-17).

An essential element in many participatory approaches is the role of facilitation. There are a number of contemporary examples that have documented the importance of a facilitator (18) and their pivotal part in establishing and supporting groups going through a process of change (19). This study was helped significantly by the inclusion and close collaboration with an AHDB Dairy facilitator who played a key part in supporting knowledge mobilisation, co-ordinating participatory activities to build commonality and guiding farmers through the learning journey, which has contributed to the success of a bottom-up approach to reduce reliance on antimicrobials. Moreover, the AHDB Dairy facilitator had a huge part to play in recruiting farms to the study by acting as a familiar and respected community member.

This thesis supports the principle that farmers have a wealth of experience relevant to the challenges they face on farm and an expertise that should be more widely recognised (20). Farmers possess valid knowledge related to their farming context, which is vital for generating practical, long-term solutions (13, 21). One example initiative that successfully harnessed farmer knowledge to solve a complex challenge was the Stable School model (22). Stable Schools were part of a farmer-led research project to reduce AMU on organic dairy farms in Denmark (22). The Stable Schools were inspired by Farmer Field Schools (22) and involved small groups of dairy farmers meeting on each other's farms to share common experiences. The Stable Schools helped participant farmers improve the way they farmed to reduce the use of antimicrobials (22). The participant farms demonstrated a 50% reduction in treatments with no detriment to animal health and welfare; the approach was consequently adopted into Danish agriculture policy as a way of helping farmers reduce AMU (23, 24). This thesis draws lessons from the implementation of this approach in the South West of England and explores how it could be scaled-up.

The Stable School approach was adapted specifically for this study and re-named Farmer Action Groups (FAGs). Five FAGs were established for the research and followed over the course of two years. Investigation into how the FAGs helped support farmers and the changes in practice that followed are the focus of this thesis. The collective actions and outcomes from the Farmer Actions Groups were chosen as the focus of the analysis rather than exploring individual participant farmer attitudes and backgrounds as determinants for change on individual farms. This was in line with the Stable School model, which emphasized the collective learning experience as the key ingredient in supporting changes to farm practice (22). This research was interested in the nature of collective action and how that transpired as change on farm.

This study has revealed three main determinants for the adoptability of such an approach, which are explored in depth. These were: the process of recruiting and establishing FAGs, the dynamics of participation and farmer-led action through the process of Action Planning. Recruiting and engaging farmers in a bottom-up initiative, such as the FAGs benefits from optimising existing networks and pivotal community members. The use of Gatekeepers to access the farming community and improve recruitment outcomes was prioritised for this study. Gatekeepers were firstly, veterinarians due to their close relationship with farmers and AHDB Dairy due to their extensive existing contacts in the industry. Participation in the study was characterised by the development of a spirit of solidarity between farmers and the mobilisation of knowledge. Understanding how knowledge is generated in such a project and how it is mobilised can support changes to practice on farm. Also highlighted were the concerns within the veterinary profession about farmer knowledge, which came to light during recruitment. The implication of these findings is explored later in this thesis.

This thesis builds on our knowledge of participatory, farmer-led approaches. Its aim is to improve our understanding of how to effectively support farmers through a process of innovation and change. The findings have implications for others designing and implementing farmer-led initiatives. The focus on knowledge mobilisation and ensuring farmers have relevant knowledge at their fingertips is a key finding. The importance of fostering a sense of solidarity in a farmer-led project is shown to have wide-ranging benefits. The FAGs demonstrated the potential of a bottom-up project in encouraging and supporting changes to farm practice (particularly around disease prevention) and the opportunity it gave participants to improve. This project aimed to empower farmers and succeeded in improving their confidence and capacity to make changes. This thesis will be of importance to policy makers formulating future agriculture policy on knowledge exchange, farming practice and antimicrobial stewardship (AMS).

1.b. Research aims

A combination of quantitative and qualitative data - collected via the framework of a Participatory Action Research (PAR) methodology - has been used in this research to answer the following research questions:

What lessons can be learnt from the experiences of adopting the Stable School approach to an innovative and original model of Farmer Action Groups in the UK:

1. To encourage changes in practice on farm
2. To reduce the use of and need for antimicrobials based on a PAR methodology
3. To replicate the approach on a wider scale.

This study aimed to triangulate its findings by collecting data in multiple ways, using qualitative and quantitative techniques, thereby learning how the approach helped participating farmers reduce the use of and need for antimicrobials. This thesis does not attempt to compare the participatory approach with other types of interventions in an empirical way. Instead, this research seeks to understand how to support changes in practice on farms and how the FAG approach could be applied on a wider scale. The determinants of this method's adoptability will add to our knowledge on participatory, bottom-up ways of working and aims to not only enhance understanding on participatory, farmer-led approaches but to directly influence policy in this area.

1.c. Thesis outline

This thesis is split into seven chapters with this first chapter introducing the research and an overview of the rest of the thesis.

Chapter Two explores the relevant literature in depth and identifies gaps in our knowledge which have informed the research questions. The global issue of AMR and AMU in farming was the trigger for this study and provided context and goal-orientated action for the development of a participatory methodology. A review of the different approaches taken to change practice on farm and the relative merits of each approach is included. An overview of the relevant behaviour change literature and Participatory Action Research literature is described next - this has informed the study conceptually and methodologically. The chapter ends with a detailed review of the Stable School approach that was adapted for this study.

Chapter Three consists of the methodology used to approach the research questions, design the study and analyse the data. It contains a description of the author's theoretical framework. It describes the methods used in the FAG project - how the groups were established and facilitated and how the various types of data were collected and analysed.

Chapter Four is the first results chapter and outlines the outcomes of the recruitment phase of the study and the relative merits of each recruitment approach. Implications related to the results of recruitment and applicability of FAGs are discussed.

Chapter Five deals with participation in the FAG project and details the results from interviews with farmers and veterinarians. The rationales for participation in a farmer-led project are discussed and the concerns veterinarians had with the approach are presented. The key elements of this participatory project from the participants' perspective are detailed, analysed and discussed.

Chapter Six is the last results chapter and presents the outcomes that were achieved on participating farms, particularly in terms of AMU. The changes in practice from both the Action Planning process and the Medicine Review process are described and analysed. Significantly different methods and empirical techniques are included in the same chapter due to the commonality that links them via triangulation – results that demonstrate changes to practice. A discussion on how the FAGs helped support farmers to change their practices around preventing disease and reducing AMU is presented and the limitations also explored.

Chapter Seven brings together all the findings and situates them in the UK and European agricultural contexts. An appetite for farmer-led approaches across Europe, the timing of new agricultural policy in the UK and the success of other bottom-up, farmer-led initiatives has paved the way for the results of this thesis to have not only relevance but influence on future policy. Chapter Seven solidifies this discussion and presents a list of recommendations for future projects as well as suggestions for policy makers and advisors in agriculture.

Chapter Two: The Literature Review

The literature chosen in this chapter covers AMU in farming, various initiatives to change practice on farm, human behaviour change, Participatory Action Research (PAR), Farmer Field Schools (FFS) and the Stable School approach. The literature presented in this chapter has informed the study objectives and methods, highlighted gaps in knowledge and provided examples of how a change in practice around AMU on dairy farms can be achieved. This literature review aims to outline the context for this study and begins with the problem of AMR. The relevant literature on AMR reduction strategies from across the world are discussed, including an overview of AMU in UK farming. Potential gaps where a novel methodology could help influence and change practices in this area are discussed. A participatory methodology that prioritizes farmer know-how is identified as one potential solution. In order to understand how participatory methodologies can achieve a reduction in AMU, it is necessary to understand two areas of the literature that help inform the approach conceptually and methodologically, from design and implementation to analysis of data: PAR and behaviour change. Examples of PAR in action are reviewed to aid understanding and reveal gaps in the existing literature.

2. a. The AMR problem

AMR is a momentous global concern with estimates predicting that by 2050, 10 million people a year could be dying from drug-resistant infections such as tuberculosis (1). AMR is not a new problem and reports from as early as 1969 warned about the impending crisis from the overuse and misuse of antimicrobials (25). There is much debate about the transmission routes of AMR and the role agriculture plays in perpetuating the problem (26-28). Nevertheless, it is accepted that a reduction in AMU is a positive step in slowing the development of AMR, particularly in the farming industry where misuse in the form of prophylactic treatments has been commonly practiced (5, 29). This was the global challenge that acted as the trigger for this research and has prompted many authorities and policy makers to search for novel tools and strategies to avoid an "antibiotic apocalypse" as described by Dame Sally Davies, the Chief Medical Officer (30).

Since the release of the Review on Antimicrobial Resistance (5), the UK agricultural industry has been under increasing pressure to reduce the usage of antimicrobials in food-producing animals. Despite this, antimicrobials are still used inappropriately, such as the use of Highest Priority Critically Important Antimicrobials (HPCIAs) on dairy farms (31, 32). The World Health Organisation

(1) has developed a list of HPCIAs which are to be protected for use in human health care as they are either a last resort for the treatment of potentially life-threatening bacterial diseases in humans or, there exists substantial risk that zoonotic bacteria could develop resistance to certain classes of antibiotics from their use in food-producing species (33). Consequently, there are strong international efforts to reduce or restrict the use of these classes of antibiotics in food-producing animals. It is generally accepted in the UK farming industry (e.g. by the likes of National Office for Animal Health, the Responsible Use of Medicines in Agriculture Alliance) that HPCIAs should be reduced if not eliminated from food production (34, 35) and that many farming practices could change in order to also reduce total AMU. The dairy industry in particular is the focus of this research not least because of the historical reliance on blanket dry cow therapy (i.e. the prophylactic use of antibiotics for dry cows) and the frequent and significant use of HPCIAs on dairy farms (36) Reducing AMU requires a change in the practices of prescribing, using and disposing of these critical medicines (17, 31, 32, 37, 38). New strategies to change practices around the ways in which antimicrobials are used and the amounts of antimicrobials used are therefore required. Bringing about lasting change on farms, however, is not always straightforward and involves tackling complex interrelations and influencing both attitudes and behaviour.

Previous research has suggested the need for a fresh approach to bringing about long-lasting, successful change on farms (11, 13, 16) especially in the context of improving herd health and thus obviating the need for antimicrobials on UK dairy farms (39, 40). There are multiple initiatives to tackle AMR and AMU across the globe and research in agricultural extension and farmer behaviour change has demonstrated that a bottom-up approach that places farmers at the forefront can be successful and better suited for these complex challenges. This literature review and wider thesis examines why a bottom-up approach is better suited for the complex challenge of reducing AMU and how such an approach works in the UK and international context.

2. b. AMU in farming

Antimicrobials are important medicines in livestock production and are necessary to treat bacterial infections, thus playing a part in safeguarding the health and welfare of cattle under farmer and veterinary supervision. In the UK, antimicrobials are prescription-only medicines (POM-V) and the responsibility for their appropriate use lies with the veterinarian prescribing them (41).

Veterinarians often prescribe antimicrobials at a population level based on recent working knowledge of the specific farm and without seeing the individual animal to be treated (41). This means farmers are permitted to administer antimicrobials to their animals under the direction of a prescription without having the veterinarian present. It follows therefore, that farmers are key actors in the daily treatment decision making on farms in the UK and, as such, should be central to changes in AMU in farming. For this reason, changing the practices of UK dairy farmers is the focus of this research.

There are multiple approaches that have been taken to slow the development of AMR and tackle AMU in farming. Many countries across the world have implemented AMR reduction strategies at a governmental level, which include commitments to change practices in the human, animal and environmental sectors (42). This is a recognition of the role multiple industries and sectors play in slowing the development of AMR. The majority of efforts have focused on large-scale, top-down changes involving regulation or government involvement, which has revealed certain limitations with such approaches. These include lack of knowledge about the consequences of certain recommendations, such as reducing certain antimicrobial classes on levels of AMR through co-selection, problems with compliance in all sectors and industries (43) as well as a lack of measurable outcomes when it comes to making changes (44). Furthermore, various strategies have adopted different tactics to AMU data collection and measurement, which can be argued is an essential starting point for monitoring change (45) but can lead to lack of comparison across countries (46). The intricacies of using data to stimulate changes in practice are explored later in this chapter.

Examination of the different national strategies to slow AMR can help identify techniques and tools that may be successful in the UK. Many countries have taken a holistic approach and recognised the One Health aspect of the AMR challenge when formulating their responses (35). In Kenya for instance, the One Health National Action Plan and Policy on AMR was created in 2017 (47). Kenya's focus on One Health encompasses raising awareness of the issue, strengthening the evidence base, as well as reducing infections and improvements to preventative health care in humans and animals; however, quality data collection mechanisms have yet to be put into place. Also in 2017, India launched their first National Action Plan on AMR (2017 - 2021), which assigns various agencies and organisations - from health and education to livestock and the environment - targets and actions to change prescribing practices and behaviour (48). At this stage, these National Action

Plans are a commitment to do something on the issue with it possibly being too early to see any meaningful behaviour change or reductions in AMU or AMR. It is worth highlighting that they are encompassing all actors in their strategies, including farmers, but their inception and implementation is from a position of top-down.

In contrast to Africa and India, Europe has focused on and developed relatively advanced data collection mechanisms borne out of the AMR crisis in order to measure progress and stimulate large-scale change. Since 2010, the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project has been collecting AMU data from pharmaceutical sales across a selection of European countries (49, 50). The aim of this project was to harmonise approaches used across the EU when collecting and measuring antimicrobial consumption data and to measure trends over time. Although the work to collect this data across several different countries is commendable, there is a paucity of data at the point of actual usage i.e. at the veterinary or farm level. Furthermore, data collection on its own is arguably not enough to change practices and drive responsible AMU. For instance, many countries in Europe have gaps in their antimicrobial sales data and stock numbers (which are needed to collate the figures in the ESVAC report), despite this harmonised data collection and monitoring system existing across Europe. Usage has not dropped substantially for some higher users, such as Italy and Spain (50), even with the publicly available growing data comparing AMU between European countries.

A world-leading example in the collection and monitoring of AMU data is Denmark's 'VetStat'. This database pulls information from pharmacies, veterinary practices and feed manufacturers. Key information such as farm identifiers, animal species, stock categories by age, product type, volume or amount, indication, as well as date of purchase and prescribing veterinarian is recorded (51). The database then calculates AMU using the measurement Animal Daily Doses (ADD) for different species and production systems, which allows further modelling of links between usage and AMR (52). Tracking changes in AMU related to AMR is arguably a key goal, as stated in human antibiotic stewardship interventions (45). 'Vetstat' is filling the gap in understanding and monitoring actual usage data at a more detailed level than national sales data can do currently.

Another laudable example of using data to drive changes exists in the Netherlands, where large reductions in national AMU in the food-producing sectors has been achieved through a government-led policy and a data-centric approach. In 2010, the Dutch government demanded a 50% reduction in AMU by 2013. This galvanised the industry to act and a suite of actions were taken. Using data-centric approaches to drive changes in practice the Dutch adopted a daily dose metric called Animal Daily Doses (ADD) to measure every farm's AMU, which is produced by a central database called 'Medirund' (53). The use of a centralised database is similar to Denmark's 'VetStat' and avoids farmers having to input data, which in the UK has been suggested is a significant challenge (54). In the Netherlands, veterinarians are required to upload medicine sales data onto the database within two weeks of prescribing/administering antimicrobials on farm (53). 'Medirund' then produces a farm report for the veterinarian and farmer every quarter. The ADD figure is presented in a traffic light system, which depicts whether the usage is appropriate compared to set standards. If a farm's ADD falls into the red category (>8), the farmer and veterinarian are required to implement significant changes within a fixed time period (53). Failure to do so could result in the farmer being penalised by the milk buyer and the veterinarian losing their position on a register of veterinarians. This approach has been viewed positively by the industry in the Netherlands and farmers have benefited from the automatic benchmarking reports (see Appendix 14 for an overview from a farmer study tour to the Netherlands). The closer partnership between the veterinarian and farmer has also been seen as productive and is supported by work in the United States on veterinarian-led benchmarking with farmers (55).

The Dutch farming industry superseded their target and reached a 56% reduction by 2013, but the reduction has since plateaued (53). This was a positive step towards AMU reduction nationally and was achieved through top-down mechanisms (i.e. government intervention in veterinary prescribing). There have now been calls for tailored interventions to reduce usage further (39), which has led the country to focus on the behaviour and attitudes of veterinarians as key actors in the prescription of antimicrobials. From examining examples such as these, this thesis supports the suggestions for tailored interventions and initiatives to reduce usage further. In the UK context though, farmers need to be included as central actors as well as veterinarians, because of their role in administering antimicrobials and their in-depth understanding of the context in which such medicines are used.

The varying approaches to AMU data collection and analysis developed internationally highlight not only the importance of this area in instigating change around AMU at both national and local levels (44-46, 56, 57) but also that one perfect solution has not yet been found. It also reveals that despite harmonised systems across multiple countries based on national sales data, there is a lack of actual usage data at the farm level and this is needed before more meaningful and targeted advice based on such data can be made (56).

The aforementioned are examples of national level strategies to reduce AMR through reduced AMU. They are top-down in nature due to either governmental involvement in implementation, the introduction of regulation and/or the compulsory large-scale collection of data as demonstrated by ESVAC. These types of large-scale, top-down approaches do not involve the farmer as a key actor in deciding how to design and implement strategies. Even in the Netherlands where the closer partnership between farmer and veterinarian has been successful, farmers still had little input into the design of the intervention, and little say in the choice of antimicrobials used on their farms. Farmers in the UK are key decision-makers in the choice and usage of antimicrobials on farms, therefore it was the intention of this research to explore the inclusion of farmers as essential key actors in order to allow further meaningful reductions in AMU to occur.

A more detailed look at the differing data collection systems that exist between European countries is pertinent to improvements in this field but beyond the remit of this study. Medicine data collection and analysis featured in the method for this study as a tool for changing practices (Chapters Three and Six). However, this was a small part of the overall study and participatory project, so further discussion on the literature in this area is not warranted. A detailed review of how the UK has responded to the AMR crisis in farming, what mechanisms exist to change practice (including an overview of the benchmarking process and where further action and change is needed) is discussed below.

2.b.i. UK farming industry response to AMR

Significant changes to antimicrobial prescribing and usage - particularly in the pig and poultry sectors (36, 58) - have been occurring in the UK since the Government's AMR Strategy was released in 2013, followed by the O'Neill reports in 2015 and 2016. The UK government's AMR Strategy was jointly created between the Department of Health and the Department for Environment, Food and Rural Affairs (DEFRA) and consisted of three key aims: 1) improve knowledge and understanding of AMR; 2) conserve and steward the effectiveness of existing treatments; 3) stimulate the development of new antibiotics, diagnostics and novel therapies. The overarching goal of the Strategy was to slow the development and spread of AMR, and the Strategy recognised that a cross-disciplinary team made up of the medical profession, veterinarians, researchers, environmentalists, industry and government was needed to tackle the global issue (60).

In response to this Strategy, various industry bodies came together including the Responsible Use of Medicines in Agriculture (61) Alliance, which created a separate taskforce to help the individual food-producing sectors achieve a reduction in AMU through target-based action (36). The publication of the government's AMR strategy alongside the O'Neill report and the lack of government intervention or top-down regulation - which contrasted with the activity of other countries like the Netherlands - culminated in the farming industry spearheading reductions in AMU with impressive results (36). Since then, the UK has released its next AMR Strategy, 'Tackling AMR 2019-2024: The UK 5-year National Action Plan'. This document sets out another three key overarching aims (Pgs. 7 - 8):

- Reducing the need for, and unintentional exposure to, antimicrobials;
- Optimising use of antimicrobials;
- Investing in innovation, supply and access. (62)

Pertaining to usage in food-producing species, the 2019 - 2024 Strategy aims to *"reduce UK antibiotic use in food-producing animals by 25% between 2016 and 2020 and define new objectives by 2021 for 2025"* Pg. 7 (62). This ambitious target means strategies to reduce AMU on farms, such as this research, are increasingly important.

The most recent Veterinary Antibiotic Resistance and Sales Surveillance Report (VARSS) puts AMU in food-producing animals in the UK at 37 milligrams/kilogram Population Correction Unit (mg/PCU), which is a 40% reduction since 2013 when the report began. This value has also superseded the RUMA industry targets (Figure 1) (36). AMU in the dairy sector only is estimated to be at 17 mg/PCU with a small fraction of that being from HPCIA use (58). The industry has been applauded for the action it has taken and the significant reductions it has made in recent years (35).

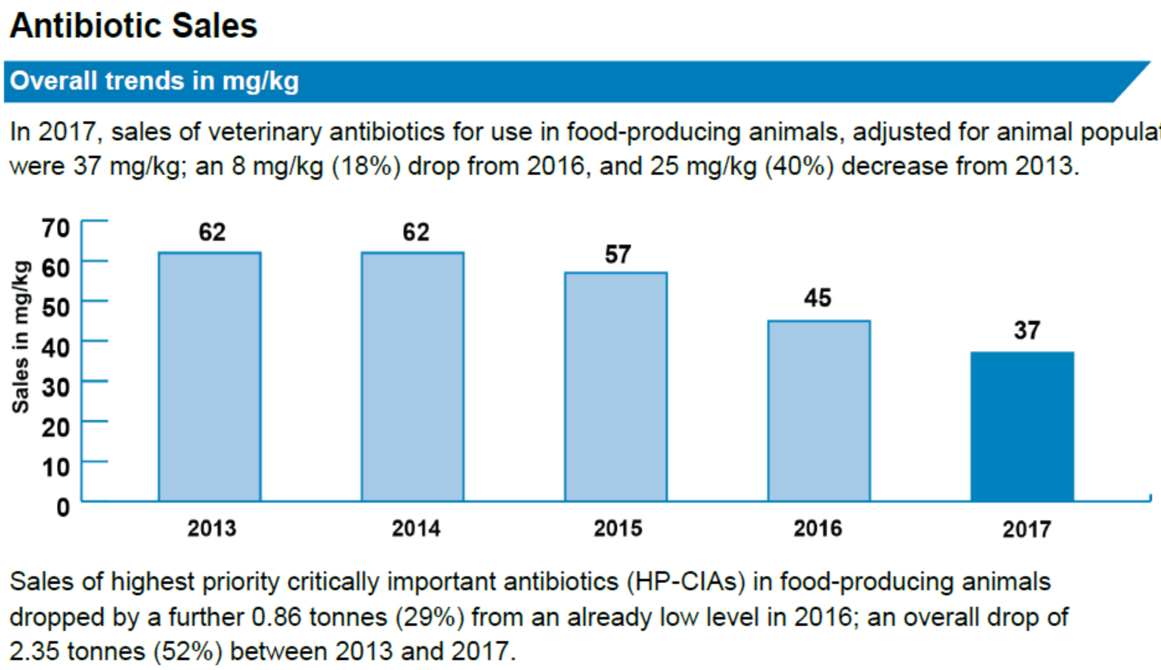


Figure 1- UK antibiotic sales for food-producing species, taken from the VARSS 2017 report

The poultry sector has almost eliminated HPCIA usage from poultry production and meat poultry has reduced their total AMU by 80% since 2014 (36)(). The pig industry launched an electronic recording system for medicine usage, which has now been rolled out and adopted across the industry providing clarity and valuable data on medicine usage in this sector (https://emb-pigs.ahdb.org.uk/) . This makes data collection and tracking of AMU reductions easier, which can then be used to stimulate changes in practice with producers. Yet it is recognised that roll-out of data tools such as this with little space for farmers to develop systems based on their own needs could result in poor quality data that is fabricated at the point of entry (54). Technology adoption on farms is an area where researchers have focused substantial efforts in order to increase the adoption and appropriate use of technological solutions by farmers, with arguably little success (13, 14, 63). The lack of technology adoption on farms when delivered in a traditional agricultural extension fashion with one-way knowledge transfer has led to work categorising farmers as either 'Early adopters and Innovators' or 'Laggards' in an attempt to understand this complex behaviour (64). The development of initiatives or programmes in a similar manner to previous technology dissemination that does not build the central user and key stakeholder into their development and implementation, will potentially make the same mistakes.

A further limitation with the UK's AMU reduction success is that the reporting is only based on national sales of antimicrobials and there is a paucity of data on actual usage on farm for many species at a representative level across the UK. The measurements or metrics used for UK national reporting are limited by the data available to calculate them, such as unknown target species for products licensed for multiple species. The population coverage for some species (such as cattle), which Figure 1 data reflects is also less than adequate (36). For instance, the data for beef cattle covers ~5% of all beef enterprises in the UK and for dairy represents ~30% of the national herd. Compared to the poultry sector, which has data for ~90% of the national flock, the UK cattle industry has substantially more to do in order to improve the representativeness of AMU data. Issues with representative and accurate AMU data, particularly at the local level where antimicrobials are being used, is a similar problem encountered across the world as previously mentioned and many European countries are working on improving the detail and representativeness of their national data (56). Innovative approaches that encourage improved medicine recording by farmers, so that actual usage data can be reliably collected could be effective, hence this research attempted to use AMU data in a way that was of value to participating farmers.

The next section addresses the commonly practiced process of benchmarking. In terms of responsible AMU, benchmarking can be a key step in encouraging changes to practice and is frequently used in human health care as part of AMS programmes (45). In the author's own experience as a practicing veterinarian, benchmarking can be a useful tool to initiate discussions between veterinarian and farmer. A recent study by Sumner and colleagues also recommended benchmarking for improved discussions and improvements to practices on farms (55).

2.b.ii. Benchmarking

Benchmarking AMU is widely practiced in human health care and is a necessary measure of the impact of AMS interventions in hospitals and community settings (45). Ibrahim and colleagues argue that process outcomes should be measured as a minimum (i.e. prescribing changes during an intervention) and that these can be compared to other physicians and hospitals via benchmarking in order to stimulate best practice and ongoing improvements (45). These authors also state that process outcomes are not enough to assess whether the benchmarking has resulted in action. Clinical outcomes measurements (i.e. levels of resistance or re-admissions to hospitals) are also needed to evaluate an intervention's impact and justify its viability as an initiative (45). For this study, it would have been ideal to be able to measure AMR levels on farms alongside AMU, however this was not possible within the time frame and budget of the project.

Benchmarking has also been used widely in the farming sector for many years and with great success (55, 65-68). It is a useful tool for monitoring progress against measurable parameters, which can then be used as a basis for improvements. Benchmarking can help guide farmers on how to reduce costs, improve profitability and solve challenges such as biodiversity loss (69). Benchmarking is defined by Robert Camp (1989) as *"the search for those best practices that will lead to the superior performance"(70) .* In this participatory study, benchmarking AMU was prioritised because it's 1) a measure of the impact of the research method on farm practices and 2) a learning tool for farmers as they sought to improve and change practices around medicine use. Thus, benchmarking AMU was aimed at helping farmers *"search for those best practices that will lead to superior performance"* i.e. reduced AMU.

Benchmarking works on the assumption that positive changes will occur once an individual or organisation realises where they need to change and are already motivated to change. This may be true for some individuals on some topics (71) but relying solely on the process of benchmarking may not be enough to motivate individuals to change a practice or behaviour. A suite of tools and improved communication needs to occur alongside benchmarking, which can be seen in the Netherlands where the veterinarian and farmer developed a closer partnership through quarterly AMU benchmarking (Appendix 14) and through mastitis reduction programmes (72).

The success of benchmarking has been enhanced when there is discussion on the specifics of the results, including following-up on the discussions and how certain results can be achieved (55). Farmers that compare poorly on certain parameters may be motivated to change once they realise how they compare to others, but they may also become overwhelmed or disheartened by that new information, or simply ignore it (73). A sensitivity and awareness to the information needs of farmers and how advice and support is delivered is necessary (74). A system of support alongside benchmarking is preferable, which considers the context and specific conditions that make one farmer/farm compare less favourably to another at one point in time i.e. there is not 'one size fits all' advice (73, 75) . In this research, benchmarking was used in combination with other behavioural change tactics, such as facilitation and peer support.

In summary, despite the potential for benchmarking AMU data to help drive change in reducing AMU, it is still only one part of the solution. The use of antimicrobials is complex and varied (22) and necessitates a closer look at disease prevention and herd health (40). Antimicrobials are essential medicines for treating sick animals, therefore, trying to reduce sick animals in the herd and the likelihood of disease is a fruitful quest in slowing down AMR.

The dairy industry in the UK has made a concerted effort to reduce endemic diseases (e.g. the 'BVD-free' England campaign, Johnes Action) and to improve preventative health care (e.g. the #ColostrumIsGold campaign), all with the added aim of reducing the need for antimicrobials. These attempts to change practices around animal health and consequently, the use of antimicrobials, were initially without regulation and have been voluntarily led by the industry. Nevertheless, these schemes and initiatives are still trying to change farming practice in a top-down manner with little focus on farmer-owned solutions and ideas and as such there has been limited success. Diseases such as Bovine Viral Diarrhoea (76) have not been eliminated - most recent estimates put BVD herd prevalence between 20.5% - 65% with the percentage of cattle vaccinated for BVD between 41% - 82% (76). There is still evidence of poor practice when it comes to calf-rearing and colostrum management too (77). Endemic disease in dairy farming is still very much an issue. Until these arguably excessive levels of disease and low vaccination rates are tackled, AMU will still be necessary. It follows therefore, that fresh approaches to reducing endemic disease are needed.

Industry-led measures delivered by veterinarians, such as the BVD-free campaign and national initiatives pushed by retailers and processors, such as eMB (the electronic Medicine Book for the pig industry), come from a top-down position of knowledge transfer (i.e. advisor-led or retailer-led) as opposed to bottom-up (i.e. farmer-led). The degree of autonomy for farmers in these initiatives or campaigns is debateable and, to the author's knowledge, the opportunity for farmers to input into their design and delivery is virtually non-existent. This is a potential gap, therefore, for a fresh approach to changing practices that empowers farmers in the decision-making process, one that could have more of an impact on endemic disease control and hence reduce AMU (13, 21, 78-80).

2. c. Programmes and initiatives to change practice on farms

This section reviews examples of different approaches to bringing about change on farms. Many examples of initiatives aiming to influence farm practice in the UK can be categorised as advisor-led rather than farmer-led, which it is suggested, may contribute to their relative lack of success. There exists a gap in the literature, particularly in the veterinary field, on farmer-led participatory approaches as an intervention mechanism to change behaviour or practices on farms. This section provides some example initiatives that have begun to fill that gap and the potential pros and cons of each. This research aimed to build on work in this area and learn from the failings of past advisor-led interventions as well as learning how to improve and continue existing participatory initiatives.

As discussed previously, the crisis of AMR necessitates improving when and how antimicrobials are used in farming. Responsible AMU is a vague and poorly defined term and often refers to common practice and legal expectations rather than rigorous scientific evidence. An example is the recommendation to "*Create practice-based protocols for common infections based on clinical judgement and up to date knowledge"* (81). Clinical judgement is variable and not always based on robust evidence, often relying on SPCs which are also not always based on robust clinical trials (82).

Responsible use of antimicrobials is at least partially dependent on the context in which they are used. The use of antibiotics to treat a case of *Streptococcus uberis* mastitis for instance, where the cow is inappetant and showing symptoms, is justified to protect her health and welfare. On a different farm with a similar pathogen causing more mild signs of mastitis and no signs of ill health in the cow, antibiotics might not be immediately necessary - allowing the cow to self-cure could be an option. Both these examples demonstrate responsible AMU but one farm's approach to the disease could be very different to the other. Therefore, the farm situation, environment, case specifics and the individual farmer need to be considered. An appreciation and exploration of on-farm practices, protocols, farmer knowledge and the decision-making process is fundamental before a good understanding of responsible use can be delineated. It thus follows that investigation of the context in which antimicrobials are used is an essential first step before - or at least in tandem with - attempting to change behaviours or practices around usage.

Many studies have focused on changing attitudes in order to change behaviour (83, 84), but the focus on attitudes alone has been criticised as narrow (15) and assumes all behaviour is rational and voluntary. This, it is reasoned, misses fundamental aspects of what constitutes behaviour and how it can be influenced. Previous attempts have also assumed that the person influencing the changing of practices has all the solutions and relevant ideas (79). It does not allow the farmer - who arguably has a great appreciation of her/his locale and context - to contribute and solve the challenge of reducing AMU on her/his farm (80) (pgs. 81 - 82). This is where a participatory, farmer-led approach has the potential to be successful because of the prioritisation of the knowledge and capacity of those implementing a change (i.e. the farmers themselves) rather than imposing a change on farmers (21). The potential of such an approach in the area of AMS and farming makes it an appropriate methodology for a project that aims to change farm practices in order to reduce the need and use of antimicrobials.

There have been many schemes and initiatives to change farming practice in the agricultural sector, such as addressing challenges with local ecosystem services (e.g. Natural England's Farm Clusters initiative) or farm animal health and welfare (e.g. Action Johnes, AHDB's Healthy Feet programme, Hennovation, etc.). Some of these specific cases will be explored later in this chapter. Further examples include national agri-environmental schemes (85) such as Natural England's Environmental Stewardship scheme where farmers are paid for services they perform for the benefit of nature and the local environment; indeed, agri-environment schemes are the second pillar to the Common Agricultural Policy (CAP), co-financed by the EU (86). Currently in England there are 58,000 AES agreed upon and £400 million a year is paid to farmers and land managers in return for farming in an environmentally sensitive manner (86). There have been many successes, such as increases in certain rare farmland species. Land in AES covers large portions of National Parks and the schemes also encourage farmers to have school visits to help children learn about nature and farming (86). However, there are some significant limitations, such as some species of wildlife decreasing in numbers substantially on land under AES compared to land not in a scheme. The Natural England evaluation report on AES says; *"the free-choice design of the entry level stewardship means that, despite high levels of uptake, the balance of options selected within many agreements is not ideal for achieving the desired outcomes*" (pg. 6), which suggests improvements are needed to link what farmers are doing to improve the land with wider requirements or needs (86). These results indicate that this approach to changing farm practice is not wholly adequate, despite attempts to allow farmers' knowledge and experience to guide the changes and improvements made i.e. decide on options adopted under the scheme. The poor outcomes suggest more is needed to support certain practices and encourage environmentally friendly farming in ways that might not be farmers' first choice.

An example of the different approaches taken to influence, motivate and enforce change on farmers was given by Barnes and colleagues (12). The authors describe a spectrum of interventions for water quality management used in the House of Lords Review of behaviour change. On one end of the spectrum are the more 'Budge' interventions using regulation and enforcement. The opposite end has the 'Nudge' interventions where maximising social norms and establishing best practice farms was recommended. The authors argue that in the context of water quality management, for example, using enforcement (the 'budge') created negative attitudes and behaviour and thus required more regulation to control and change (12). The authors conclude by saying they would like to see a *"group-information sharing approach",* which they predict would raise social norms and increase voluntary adoption of water management strategies (12). This is in line with bottom-up principles and a participatory approach.

EU-level initiatives, such as the Agricultural European Innovation Partnership (EIP-AGRI) have attempted to develop sustainable farming and forestry through the mantra of "*achieve more and better for less*" *(pg. ix)* (87). This multi-actor initiative funded through CAP and Horizon2020 was built on the Interactive Innovation Model, which describes innovation as a process of discovery occurring sequentially and from the bottom-up (Pg. 30) (87). It is non-linear, flexible, prioritises knowledge of end-users and therefore differs substantially to traditional forms of knowledge transfer practiced by agricultural extensionists (14). EIP-AGRI focuses on collaboration and linking multi-actor networks to share best practice and complement variable types of knowledge (referred to within EIP-AGRI as Thematic Networks). Thematic Networks have brought together multiple groups of farmers and related industries (referred to as Operational Groups) across member states to stimulate best practice, foster innovation and optimise the outputs from these groups. Operational Groups are an EIP-AGRI mechanism that allows farmers, producers, advisors and researchers to work collaboratively on farm-relevant challenges and to stimulate innovation and changes in practice. There is significant effort in furthering understanding and application of such a bottom-up approach (i.e. Operational Groups/farmer groups) as a way of improving the sustainability of farming across Europe (87). More on EIP-AGRI, Operational Groups and their relevance to the FAG project and inspiring change in farming is explored further in Chapter Seven.

Traditionally, however, large-scale, widespread changes to farming practice have been brought about in a top-down manner, for example, through regulation and/or legislation. The outlawing of the conventional battery cage in 2012 (Directive 1999/74EC) brought confined rearing of hens in poultry farming to a swift conclusion across many countries. However, the unintended consequences of top-down legislation, such as bans are not always immediately obvious. While the outlawing of the battery cage for laying hens was a great success for laying hen welfare, there are issues with alternative systems and laying hen welfare is not always optimal (88), prompting further work using bottom-up approaches in some instances (89).

A further example of less than satisfactory outcomes from legislation as a behaviour change tool is the legal obligation for UK farmers to record all medicines administered on farm, including batch numbers and individual animal identification (90). This requirement is a source of considerable irritation for farmers, hence is frequently poorly implemented (54). The poor compliance with this regulation makes this type of top-down tool for encouraging best practice with regards to medicine recording on farm less favourable to policy makers.

Another tool for policy to change behaviour is the use of penalties, including those enforced by industry. An example of relevance here is penalties for excessively high somatic cell counts (SCC) in milk from milk buyers. Although milk penalties partly influence farmers' decision making on mastitis management (91), it can be argued that mastitis is still a significant health and production problem for the UK dairy industry despite the existence of these penalties. Furthermore, advisor-led interventions in combination with the aforementioned tactics can still lack a significant impact on farm practices or struggle to enhance compliance with best practice as expected (92).

While these top-down approaches to on farm change can create large-scale behavioural changes quickly, their value and long-term success is reduced through unpopularity or poor compliance (54), as well as their outcomes sometimes leading to unintended consequences, as shown by Barnes and colleagues (12). Top-down change does have a role to play to a certain extent, but further strategies are needed to drive long-term change at the farm level (11), especially on complex issues involving human interactions and decision making.

Top-down approaches include traditional agricultural extension and advisory services (13, 74). Advisors assume the position of expert knowledge-provider and focus on the transfer of this knowledge to the user of the advice (i.e. the farmer) (13). The farmer has little if no say in the knowledge creation or movement. Examples of the limitations of traditional, advisor-based interventions can be seen with lameness reduction initiatives. There are many studies on preventing lameness in the UK dairy industry (93-96) and structured programmes to help farmers tackle the issue e.g. the Healthy Feet programme (95, 97). The Healthy Feet programme began as a project into reducing lameness on dairy farms through tailored veterinary support. Despite the reported improvements in farmers' knowledge on lameness and a reduction in the disease on the participating farms, the advisor-led programme demonstrated no difference in lameness levels between the intervention and the control herds, which questions the effectiveness of this advisor-led approach (95). There are multiple factors influencing behaviour and practice on farms, and unless these factors are well understood and embraced, the success of traditional advisor-led approaches will be limited.

The sustainability of top-down approaches, to include advisor-led initiatives, in creating a change in practice on farm is questionable. They can be unpopular, poorly adhered to, lead to unintended consequences or simply fail to have the effect that was intended. Part of the problem is the movement of expertise and knowledge in a unidirectional way; this passive transfer of knowledge and technical expertise has been called into question in previous years (13, 14, 21, 98, 99). It has also been recognised by the World Bank and the Food and Agricultural Organization of the United Nations (FAO) that long-lasting sustainable changes in farming are not possible without farmer participation in their development (100, 101). Furthermore, the 'one size fits all' method of giving advice to elicit behaviour change has been shown to be flawed by many studies (83, 102-104) and has a role to play in the poor uptake of veterinarian advice on farm, such as on Johnes disease control (105) and veterinary herd health planning (37). A fresh approach to creating change on farm is necessary and there are many disciplines and methodologies that can contribute knowledge to this area, such as the social sciences and areas of behaviour change and participatory research.

It is clear that there have been many attempts to change or influence farming practice with variable success, albeit with a relative lack of longitudinal, controlled intervention studies (11, 106). The following section will critically review some specific examples, namely:

- The Mastitis Diagnosis and Control Plan (MDCP) commonly referred to as the Mastitis Control Plan
- The Healthy Feet programme
- The Game and Wildlife Conservation Trust Farmer Clusters
- Soil Association's Innovative Farmers
- Hennovation
- Alcoholics Anonymous

Although the last example is obviously not related to farming, it has some distinct similarities to the proposed methodology for this study and was the basis of the nickname given to the project by some participating farmers. These examples have been chosen due to their relevance to the study focus on UK dairy farming. The stark contrast between the first two examples - which were randomised controlled intervention trials - and the subsequent four highlight the different ways change on farms can be achieved and reveal shortcomings of the first two. The following section analyses strengths and the limitations of the various programmes as related to changing practices and how potentially fresh approaches (such as bottom-up, farmer-led projects) could improve outcomes on farm.

Mastitis Diagnosis and Control Plan (MDCP)

The MDCP aimed to reduce the incidence of clinical mastitis and SCC in English and Welsh dairy herds with a mastitis incidence that was above the national average. Herds were selected from a convenience sample using National Milk Records and based on regional divisions were paired with a similar farm and randomly allocated to a control or intervention group (106). The intervention was in the form of a detailed assessment of risk-based practices for the control of mastitis delivered by specialist veterinarians. It was then structured into an Action Plan of deliverables for the farmer to implement over the course of the study. Compliance with the recommendations and measurement of the incidence of mastitis and SCC were used as indicators of the efficacy of the intervention. Of the 26 intervention farms, eight complied with more than two-thirds of the recommended changes and nine complied with one to two thirds of the recommended changes (106). There was a 21% decrease in SCC on intervention farms compared with control farms and the median mastitis incidence after the intervention was 0.75 cases per cow-year on the intervention farms and 0.94 cases per cow-year on the control farms (106). Based on these results the intervention was scaled-up by AHDB Dairy in 2009 (then called the DairyCo Mastitis Control Plan).

This was the first controlled intervention trial for reducing clinical mastitis in the UK (106). It demonstrated that a reduction in mastitis was possible with a suite of recommendations and could be achieved relatively quickly. The lower compliance rates with the recommendations were associated with less change in mastitis levels on intervention farms, so the conclusion was drawn that full compliance with the MDCP was needed for it to be successful, and this required motivation and encouragement of the farmer to implement the changes (106). Little consideration, however, was given in the MDCP to the farmers' needs, perceived challenges or the context in which they were working, which is arguably necessary if the aim is to change practices and behaviour (107).

Furthermore, the differences in the level of compliance between control and intervention farms was variable (i.e. some intervention farms made very little improvement in their mastitis incidence and some control farms implemented many changes and saw reasonable improvements in mastitis) (106). The apparent lack of difference between intervention and control farms echoes the results of the Healthy Feet project; the authors of the MDCP suggest this was down to variation in compliance with the recommendations.

In 2016, an additional study was carried out to evaluate the performance and management data of over 200 herds that had participated to some degree in the Dairy Mastitis Control Plan (108). The authors of this work identified multiple key farm practices that were not being followed or implemented in order to reduce or control mastitis. In some groups, fewer than 20% of farms were following recommended strategies known to reduce mastitis and SCC (108). The study by Down and colleagues illustrates that despite the promising results from the earlier intervention, many mastitis-related management practices were not being carried out on farm. This suggests that the veterinary advisor-led intervention was not as effective at instigating changes to practice related to mastitis as had been anticipated.

Healthy Feet project

The Healthy Feet project (later rolled out and called the Healthy Feet programme) was a further example of a controlled intervention trial aiming to influence farmer behaviour to reduce the incidence of lameness on UK dairy farms (97). This project wanted to ensure the knowledge provided as part of the intervention was implemented in practice (95). Farms were allocated to either a Monitoring Only group where the levels of lameness were measured over time with no intervention or support (i.e. the control group) or the Monitoring and Support group, which received the intervention in the form of specialist advisory input based on facilitation, motivational and social marketing techniques. The evaluation found no difference in lameness prevalence between the two groups and concluded that the farms that did not receive the advice and support still managed to reduce lameness over the years of the project (95). It was assumed this was influenced by external sources, such as the veterinarian or the AHDB introduced mobility scoring system (95).

The Healthy Feet project evaluation highlights the challenges in changing farmer behaviour in practice (particularly around lameness) and the limitations with designing control studies on multi-factorial problems in commercial environments with high degrees of uncertainty. A farmer-led, participatory approach, in contrast, is situated within the farmer's sphere of influence and responds to the demands of that sphere of influence, such as the socio-political context (21) and individual responses to uncertainty (14).

The next two examples are radically different from the aforementioned programmes in that they focus on farmer-centred change that is led and implemented by farmers. These are the principles this research aimed to harness to reduce AMU on UK dairy farms.

The Game and Wildlife Conservation Trust (109) Farmer Clusters initiative

The Farmer Clusters initiative approached changing practices on farm in a very different way to a controlled intervention trial. Farmer Clusters focus on working together in small groups alongside a conservation advisor - *"farmers and land managers can work cohesively together in their locality, enabling them to collectively deliver greater benefits for soil, water and wildlife at a landscape scale" (109)*. Farmer Clusters concentrate on collaborative working between farmers and conservationists and are supplemented by existing agri-environmental schemes in the UK. Several Farmer Clusters exist across the country with funding coming from the Natural England Facilitation fund to support the groups and pay for the conservation advisor. Changes implemented on farms and in their local area include increases in pollinator-friendly plants to support bee populations, increases in numbers of certain rare bird species and closer collaboration between water companies and farmers to reduce herbicide contamination of water sources (109).

Some drawbacks of this approach are that it is reliant on the Natural England facilitation fund and the farmer-led environmental measures implemented might not always be in line with external interests (86). The benefits, however, are that farmers decide on how they are going to improve biodiversity on farms based on their intimate knowledge of the land and with external support from conservation advisors (20). This arguably results in greater compliance to and maintenance of environmentally beneficial practices (110). The measures are of their own creation, which increases the sense of buy-in and pride taken to implement the changes, which has been reported is a motivating factor in influencing change on farm (94). This synergy between farmers and external support has been shown to result in improved capacity to foster change (18, 20).

Innovative Farmers

The Soil Association began a similar scheme called Innovative Farmers in 2015, which is based on the Farmer Field School Model (discussed later in this chapter). Innovative Farmers is a not-for-profit membership network where groups of farmers come together - with the help of a partner researcher - to work on a solution to a shared problem (111). The groups, named farmer field labs, pool their knowledge and resources and decide on a research question. The researcher(s) then helps them design a trial to answer that question. The farmer field lab runs the trial with the help of a facilitator. At present 50 of these field labs are running in the UK (111). The field labs are dependent on a partner research organisation helping farmers design trials and measure experimental outcomes, but the emphasis is on the farmers taking the lead. The farmers decide on the issue to tackle and adopt practices to trial in which they see value. The main limitation is like the Farmer Clusters in that the groups still need a facilitator and a research organisation to ensure the trials follow scientific method. This arguably misses the point though, as bottom-up, participatory approaches should encourage and complement all forms of knowledge and epistemological positions – by shaping the farm trials to fit the prevailing scientific paradigm of positivism, they fundamentally miss out on local ways of knowing (14). Nonetheless, the knowledge exchange is two-way; the researchers gain valuable field lab opportunities and the opportunity to test interventions alongside farmers, and farmers get research solutions tailored to their specific needs.

Hennovation

A third example of farmer-led change and practice-led innovation is an EU wide collaborative research project called Hennovation. Hennovation was a multinational Thematic Network that consisted of six consortium partners, 19 multi-actor networks across five European countries and was funded under the Horizon2020 topic of 'Innovative, Sustainable and Inclusive Bio-economy' (89). Hennovation aimed to reduce the gap between research and practice as well as learn how innovation and knowledge exchange could be better supported. The networks consisted of Operational Groups of laying hen producers and aligned industries and they worked on two specific areas of concern – feather pecking and the transport and use of end-of-lay hens (89). The networks focused on finding practical solutions to these challenges and with the help of a network facilitator, the groups went through a five-step process over ~18 months (18). The five steps consisted of innovation identification, generation of innovative ideas, action planning and resource mobilization, practical development/testing and finally, implementation and up-scaling.

A key finding from Hennovation was the crucial role the facilitators had in supporting and guiding the producers through the five-stage process. The characteristics of the facilitators had an influence on the outcome (18). The structured training the facilitators received as part of the project revealed the difficulties the facilitators experienced in moving their networks between certain stages of the innovation cycle and encouraging the networks to use their own knowledge and expertise to generate innovation (18). Some groups defaulted to traditional mechanisms of passive knowledge transfer and relied heavily on external experts for advice, rather than prioritising farmer know-how.

The reliance on external support, such as facilitation or external experts is a similar limitation to Innovative Farmers and Farmer Clusters. The need for and use of facilitators is an integral support mechanism in farmer-led participatory structures, which could be seen as a general drawback or, conversely, highlights the importance of getting professional facilitation right to maximise the potential of farmer networks and groups (89). A further limitation to participatory, bottom-up approaches is their diverse, flexible and iterative nature (112). Van Dijk and colleagues state that the fluid nature of practice-led innovation networks can make them difficult to facilitate and manage as well as challenging for scientists to measure in traditional, positivist, scientific trial-based ways, which potentially acts as a further barrier for adoption by policy makers and authorities (18).

The final example described here is not related to farming but is similar in the principles it adopts to help individuals traverse a process of change. In addition, this research project earnt the nickname *"Antibiotics Anonymous"* due to the similarities the participants felt it had to Alcoholics Anonymous (AA).

Alcoholics Anonymous

AA is a peer-to-peer support organisation consisting of five million members in 181 countries and is intended to help those suffering alcohol use disorders (AUD), facilitate full remission and increase the quality of life of sufferers (113). AA is a *"fellowship of men and women who share their experience, strength and hope with each other that they may solve their common problem and help others to recover from alcoholism"* (113). The AA ethos demonstrates many similarities with farmer groups aiming to change practices and behaviour. These networks provide a space to share collective knowledge and support with a shared goal or purpose – in AA this is abstinence from alcohol, but it could be reducing excessive medicine use, for instance. Kelly and colleagues (2009) describe the process of changing behaviour around alcohol dependency as multi-factorial and by *"facilitating adaptive changes in the social networks of participants",* continual abstinence from alcohol can be achieved (114). A similar mechanism exists in participatory farmer groups that aim to encourage and support farmers through a process of change. The reliance on the *"social networks of participants"* is the basis of the peer support demonstrated in the Operational Groups within EIP-AGRI, Farmer Clusters and the foundation for the FAGs in this study. In a Cochrane systematic review however, the efficacy of being in the AA on reducing alcohol use and achieving abstinence was not demonstrated (115). Existing studies had many limitations, such as confounding variables and the authors of the review concluded that there wasn't enough experimental evidence on the effectiveness of such programmes (115). This is a common limitation when trying to evaluate participatory, peer support initiatives using a positivist paradigm; it fails to cope with complex systems where multiple uncertainties exist and cannot be controlled (14).

A further limitation related to participatory projects but also research projects involving people in general, which is given little attention in the literature, is recruitment of participants. Recruiting farmers to all types of research has been shown to have a low success rate (e.g. response rates to questionnaires have commonly ranged between 28% to 14.8% (116, 117)). The enrolment rate to the healthy feet project was 25.3% via telephone recruitment and sampling was from a population of farms that were initially contacted through four milk buyers (n=782 farms). Only the farms that expressed an interest were enrolled by telephone so the 25.3% is likely to be an over-estimation (118). Randomised control trials also suffer recruitment issues, as demonstrated by the creation of the Recruitment Project launched by the Clinical Trials Transformation Initiative (CTTI), a public-private partnership whose mission is to improve the quality and efficiency of clinical trials. The number of clinical trials that are delayed or terminated due to failing to recruit enough of a sample is substantial, with figures from 2011 stating 19% of trials that were delayed or terminated were down to recruitment issues (119). Recruiting to research is evidently not a farmer-specific problem.

Recruitment can be viewed as a two-step process - deciding *who to recruit* and then *how to access them.* Miller and Bell discuss in detail the ethical quagmire that surrounds recruitment in qualitative research and the ongoing reflective process of consent (120). Simply having a research plan reviewed by an ethical committee and signed consent at the start of a study does not go far enough, they argue, to ensure the participants are truly aware of the research direction and their role in it. Qualitative research is an iterative process, and the goals and outcomes are changeable. Participatory research is no different and requires a process of reflection and agency to ensure participants are truly participating of their own accord (i.e. without coercion).

The use of 'Gatekeepers' is an established method of recruitment and has been utilised in sociological and anthropological studies for decades, providing a trusted and practical link to groups that a stranger such as a researcher, would potentially not be well received in (121). Gatekeepers were deemed appropriate for recruitment to this study based on the author's experiences working with dairy farmers and the literature suggesting farmers could be 'hard-to-reach' or 'laggards' (64, 73, 104). The Gatekeepers for this project were firstly veterinarians and then AHDB Dairy (namely the project facilitator).

Snowballing is another technique used in qualitative research to maximise the recruitment reach. This process relies on one or two participants the researcher knows or already has a connection with (sometimes the Gate-keeper), mentioning the project to other potential candidates and recruiting them on behalf of the researcher; people initially recruited are used as informants to find more eligible participants (122).

The limitations to these forms of recruitment is that bias or selectivity can creep into the sample. If the initial participants or Gatekeepers recruit from only their network or community then the sample is skewed. There are examples from Farmer Field Schools where Gatekeepers in particularly powerful positions in a community, such as in religious groups, affected the sample representativeness or inclusivity for minority groups (101). Some Gatekeepers may, knowingly or not, coerce participants to participate or exclude some members of a group. To overcome the bias in the Snowballing method, 'Chains of Referral' or multiple Snowballs have been used, where *"multiple networks are strategically accessed to expand the scope of investigation beyond one social network"* (122). This makes the sampling more inclusive.

Through reviewing several examples of changing practice on farm - including a more abstract comparison with the AA - the gaps in the veterinary literature for more farmer-led, participatory approaches to reduce disease and hence AMU have become apparent. EIP-AGRI Operational Groups, Farmer Clusters, Innovative Farmers and Hennovation are well-established cases of where a farmer-led approach has supported and encouraged changes to practice on farms. These cases have informed the research methodology and the conceptual framework by 1) revealing the important role of the facilitator in supporting the movement of knowledge in a peer group structure and (59) the value and importance of varying epistemologies. Although the selected examples are varied and tackle very different issues, their comparison highlights how and why traditional, advisor-led interventions are limited in influencing farm practice. Changes to practice on farms can sometimes be brought about by top-down mechanisms as described earlier, but they have a limit and do not fare as well with complex situations involving human decision-making, complex behaviours and high levels of uncertainty (14, 123). Understanding complex situations, the importance of contextual factors and how best to influence them also requires reviewing what is known about behaviour change and the proposed methodology of this study – Participatory Action Research (PAR).

2. d. Behaviour change and PAR: informing the research methodology

Durable reductions in AMU necessitate a change in practice and behaviour i.e. a change in prescribing behaviour (37) and a change in the decision making and administration of antimicrobials for animals (38). Reducing AMU also demands a closer look at why antimicrobials are needed in the first place and what preventative measures can be put in place to obviate their use. For dairy specifically, this could be improvements in hygiene at calving time, at milking, changes to feeding practices, investment in vaccination and biosecurity strategies, all of which are recommendations from RUMA and the National Office for Animal Health (NOAH) (61). All of these improvements and changes to farm practice require human intervention and decision making around their execution, which is why understanding and influencing human decision making and behaviour was of the utmost importance for the work presented here.

Despite a wealth of research examining farmer behaviour (15, 16, 105, 124-126) as well as the relationship between the veterinarian and farmer (83, 84, 127-129) there is still considerable debate around designing effective behaviour change interventions in farming (95, 105, 130). In seeking to improve our understanding of farmer behaviour and what influences practices on farm, recognition of some of the limitations of traditional top-down mechanisms for achieving on-farm change are needed. Increasingly, researchers are turning to qualitative research methods and methodologies as well as inter-disciplinarity working in response to a lack of desirable and hard-hitting results (110). These varying perspectives - it has been argued - could be better placed to answer the how and why questions around behaviour and practice change in farming contexts (131) (Pgs. 1 - 14). Semi-structured in-depth interviews or focus groups are examples of techniques used in qualitative research to understand complex issues that traditional quantitative techniques struggle to answer (131, 132). Furthermore, PAR is a related approach that is rooted in bottom-up, community-led philosophies as a successful way to support changes in practice. PAR is being increasingly employed in agricultural research with promising results (79, 80, 99, 133-135). The following section will therefore review the two principal conceptual and methodological literatures that have directly informed this thesis and the adopted research strategy. The first of these is behaviour change theory and, in particular, its deployment in research on farming practice. The second is PAR.

2.d.i. Behaviour change in farming

There are numerous theories and frameworks to help understand human behaviour and practice, both at individual and societal levels, as well as how this can be changed. In this thesis, social-psychological theory will be touched upon at an individual level, illustrated with The Theory of Planned Behaviour (TPB) (136, 137). Approaches that centre on the process of change - which Government Social Research argues is critical if the aim is to make *"behaviour happen differently"* – will also be explored along with frameworks used in organizational psychology, such as Wenger's Communities of Practice. These theories are used and applied in the UK and/or have featured in agricultural research, so they deserve to be discussed here. The TPB has featured frequently in the agricultural science literature (15, 116, 124), in its current form as well as in its former guise - the Theory of Reasoned Action (137). There are a great many approaches to the modelling and prediction of human behaviour and a comprehensive review is not feasible in the context of this research (for a comprehensive review see (138)). As a result, this review will only address those that have informed the current study.

TPB is a psychological theory that connects a person's beliefs with their intention to perform a behaviour (136). It states that to change a person's behaviour one must first understand their intention to perform this behaviour. Such intention will be influenced by their attitudes towards the outcome, their perception of what others around them think of the behaviour (subjective norms) and how well they can implement the behaviour (perceived behavioural control) (136).

Although widely-used in the agricultural literature (up to 49% of papers in a recent systematic review on farmer decision-making used TPB (11)), TPB has been frequently criticised for not considering habitual behaviours as a crucial influencing factor too (15). Additionally, studies that use TPB assume that the person's beliefs and attitudes are the only thing guiding their behaviour and that behaviour is governed by rational voluntary thought (15, 107, 138). It is known, however, that there are many other elements affecting behaviour - such as daily interactions with other people and even animals (107) - which will vary substantially between people and are dependent on contextual factors. External factors such as market forces, the political backdrop and environmental conditions must also be considered if aiming to change behaviour. Studies using TPB often neglect the role of context and social environment on a person's behaviour (11, 138).

An example of a relevant study investigating farmer decision making around AMU on UK dairy farms is by Jones and colleagues (2015), where the criticisms of TPB and a lack of qualitative inquiry limited the depth of investigation gained (116). This study examined the factors affecting dairy farmers' attitudes towards AMU and offered practical solutions to reducing usage via changing attitudes (116). The use of TPB was potentially restrictive as it focused on attitudes only as a way to change behaviour with no consideration of context. The study used questionnaires for data collection on farmers' attitudes to AMU, which is arguably limited when answering questions where best practice might be known and reported but not actually performed. Although the study had an approximate 28% response rate (0.75% of UK farm population) and found that farmers were more likely to reduce AMU due to financial reasons, growing pressure from the media and their peers also played a role (116). In contrast, other studies have demonstrated that finance is a secondary factor in farmer behaviour and decision making, with pride and job satisfaction having more of an influence (94). Furthermore, the authors did not elaborate on how or why these factors impacted on actual decision making, something a more qualitative inquiry might have revealed. Questionnaires and the TPB can be good at documenting an intention to perform a behaviour, but are limited in furthering our understanding of how contextual factors influence behaviour and practice, which is fundamental if attempts to change practices on farm are to work (16).

A further study by Beedell and colleagues (2000) attempting to understand farmer behaviour towards conservation practices was also based on the TPB (124). These authors used the TPB to relate the differences in behaviour between farmers involved with conservation organisations and those who were not to their attitudes towards conservation practices. The authors documented that farmers who were more aware of conservation practices and felt more pressure from *"referent"* organisations performed more (or intended to perform more) conservation-friendly practices (124). These authors also reported the limitations of using questionnaires on farmer-estimated behaviours and that TPB may "*not be fully sufficient to explain all of the systematic variance in behaviour (136) but [that it] offer[s] a useful starting point"* (124). Although Beedell and colleagues published this work almost two decades ago, similar barriers and limitations to individual farmer-reported behaviours are still being documented (116, 117). A recent systematic review also suggested that researchers should move away from TPB when looking at influencing farm practice and farmer decision making (11). Due to these frequent and numerous criticisms, TPB was not used in this research as a methodology or to interpret the findings.

An example of the depth of understanding that can be gained using qualitative inquiry can be found in work by Vaarst and colleagues (2002), which aimed to generate further understanding of farmers' motivations and perceptions of disease (specifically mastitis) by using in-depth interviews rather than questionnaires (91). These authors found four main factors influencing farmer decision making when treating cows for mastitis:

1) disease severity (if severe then more likely to call the veterinarian to treat a cow, as per the rules in Denmark)

2) cow level factors (which included, for instance, previous cases of mastitis, SCC patterns and yield)

3) herd level factors (such as replacement rates and bulk tank SCC goals in line with contract requirements)

4) the role and position of stockmanship

Perceived control over treatment and management was a major factor in treatment selection by dairy farmers (91) - this is an oft-neglected aspect of the TPB. Financial elements did not feature highly other than in herd-level factors when considering SCC goals, in contrast to the study by Jones and colleagues (116). The study used interviews as opposed to questionnaires, which provided a richness of data around the motivations and barriers to managing mastitis. It revealed a multi-factorial array of elements that farmers juggle when looking at a case of mastitis.

A final example of qualitative research techniques and social science methodologies being used to better understand the factors involved in the treatment of farm animals is work by Burton and colleagues (107). Through a series of in-depth interviews with farm owners, share milkers and stock people, the importance of social interactions between different members of staff on farm animal welfare was revealed (107). The authors identified a gap in animal welfare research where social science insights could help with understanding interactions between animals and humans. These authors suggested that although there is evidence that practical changes to improve animal welfare can result from an attitudinal change, an appreciation of the broader context is needed - how do the stock people think, feel and interact on a daily basis when treating and managing their animals (107)? Appreciating the on-farm context is a necessary step in influencing on farm practices, they argue. Nevertheless, the study did not account for contextual factors beyond the farm such as wider social and institutional factors that influence behaviour.

These four studies demonstrate the varying depths of knowledge and understanding that can be achieved using qualitative methods along with a conceptual underpinning beyond TPB to understand behaviour and farm practices. There is a clear need for more refined research approaches in order to fully understand farmer behaviour and to shed light on how best to encourage genuine change in farmer practices, particularly before the growing issue of AMR (11, 12, 16, 73, 139). PAR is a methodology that could fill this gap in the veterinary and farming literature and in many areas of the world it is a well-accepted model for bringing about change (13, 19, 21). PAR has the potential to encompass the missing elements from previously discussed studies aiming to change farm practices, such as using qualitative research approaches as a line of inquiry to harness farmer knowledge and experience (140), empowering farmers in creating solutions (141), recognising the contextual factors that affect farmer decision making (110) and challenging the habitual nature to many practices through peer support and peer pressure (142). A critical element to PAR as a way of changing practices is empowering individuals or communities with knowledge (19, 78). This next section will take a detailed look at the role of Knowledge, Knowledge Exchange and knowledge equity in agriculture and how it features in changing practices on farms.

2.d.ii. Knowledge

Critical to any analysis of social change to include farming change is an understanding of knowledge and information flows (21, 78, 79, 123). Knowledge acquisition and exchange is central to changing practices on farms and has a critical role in agricultural innovation (21, 100). Curry and Kirwan argue for the need and role of local, tacit knowledge in solving complex issues relating to the environment and food production (135). Ingram additionally puts forward the case for sustainable farming practice being much more complex and demanding on the skills and knowledge of farmers, which requires the development of supportive mechanisms to assist farmers that need to change practices (143). Scoones and Thompson's (1994) seminal work on developing the "Farmer First" model encompasses the idea that agriculture is a social complex system that should prioritise the farmer's voice and ultimately challenges the imbalance of knowledge within agriculture by asking what is acceptable knowledge (21)?

Knowledge comes in different forms and is dependent on an individual's perspective and epistemological paradigm (14). The knowledge commonly associated with veterinary and agricultural science is largely positivist and empirical. Positivistic approaches aim to generalize about phenomenon over time and between different contexts with a focus on discovering one objective truth about the natural world (144). Adopting a social science approach requires an openness to other understandings of knowledge, knowledge generation and knowledge transfer (21). Epistemology is important here because it determines how researchers frame their study design, as well as how they interpret and apply their results. In a paper looking at PAR in consumer research, ontology and epistemology were highlighted as integral philosophical pillars to consider when doing PAR (123). One question asked by this research was, 'How do farmers create knowledge to enact change?'.

Moreover, there is a critical interplay between the subjects (e.g. the researcher and the farmers) and the object being studied (e.g. mobilisation of knowledge and farming change) in this research. This interaction and inter-dependency between object and subject make positivist perspectives of knowledge generation largely inappropriate. Researchers of PAR view knowledge as context-dependent, evolving and uncertain (14, 98). The role of the researcher in a participatory methodology as an 'outsider' will influence the development and application of the research by engagement and collaboration with the participants, the 'insiders'; the researcher is an integral participant in a PAR methodology (19, 145). On the contrary, more conventional, positivist knowledge generation often fails to account for the context in which observations are made and the role of the researcher and how that informs the interpretation of the research (14). A more 'constructivist' approach acknowledges that knowledge and information are context-dependent (social, cultural, historical) and generated differently by different people as they engage with the world (144).

The concept of Knowledge Exchange in farming seeks to recognise that practical changes can be achieved by taking a constructivist view point and by avoiding top-down flows of expertise and knowledge (21, 63, 123). Encouraging the sharing of experience, information and expertise in a two-way flow of knowledge within constituted communities or groups - particularly where more traditional forms of knowledge dissemination have been problematic, for example in remote rural areas (101) - was considered an effective approach that this research examined in the context of reducing AMU on UK dairy farms.

2.d.iii. The evolution of Agricultural Extension

After World War Two, there was an increased demand on agriculture to produce vast amounts of food and feed a growing population (13, 14). There was a focus on technology and research as the primary way to increase the productivity of global agriculture, with iconic developments in farming machinery and shifts in farming practice to monoculture crops (13). It was believed that if farmers were educated in and convinced of the benefits technology could have for their farms and for farming productivity, then they would simply adopt these technological solutions and change practices accordingly i.e. the Transfer of Technology model (13). Farmers that take on board this new knowledge or technology are described as ‘Innovators’ and ‘Early adopters’, while those that do not adopt new technologies are given arguably derogatory labels, such as ‘Laggards’ (64)! This ethos shaped and guided Agricultural Extension worldwide and was largely effective, particularly in Europe and the U.S.

The Transfer of Technology (TOT) model was the framework of knowledge movement in Agricultural Extension and perpetuates the one-way, top-down flow of knowledge and specifically technology, from generator to user. As Lacy describes based in “Crop Check” clubs in Australia - *“Farmers were still the missing link in the communication chain” (63)*. According to Lacy (2011);

> *“knowledge gained through the experiential learning of researchers, packaged and transferred to the farmer, misses the vital ingredient – the opportunity for the farmer to formulate his/her own questions, explore, learn and gain understanding in terms of his/her own world view.” (63)*

The movement of knowledge from research institutes to farmers is characteristically top-down in nature and assumes that the knowledge generated in research institutions is not only relevant to farming but also applicable on farms (13). It is recognised in several disciplines, however, (e.g. education, health and consumer research) that many *"valid paths exist for creating knowledge and social change"* (123). The one way transfer of one perspective of knowledge has been discounted as not fit for purpose when it comes to complex, resource-challenged environments with high levels of uncertainty (14, 100). It has limited success in changing modern farm practices facing rapidly evolving, complex challenges (13, 19, 80) or to continually move and apply one type of knowledge and research to target users of that knowledge i.e. farmers (100). Additionally, studies looking at innovation adoption rarely accounted for contextual factors as a reason for non-adoption due to a positivist perspective as mentioned previously (80).

These criticisms of TOT, Knowledge Transfer and the practice of Agricultural Extension have led to the adoption of alternative, bottom-up approaches that put the *"farmer-first-and-last (FFL)"* (13). This drive to adopt novel and innovative participatory methodologies with groups of farmers being central to the process of finding solutions to complex challenges, can also be seen in other disciplines like psychology and medicine, where the use of patient-centric techniques is expanding (e.g. Motivational Interviewing) (146). Participatory approaches, such as PAR offer a framework and alternative bottom-up methodology that responds to the aforementioned criticisms described in this chapter to influence and shape practices on farm around AMU.

2.d.iv. PAR

PAR is a qualitative research methodology option that's primary purpose is to impart social change (132). In this doctoral thesis, PAR is used to assist farmers in changing their practices around AMU against a backdrop of increasing pressure to reduce, refine and replace antimicrobials in farming. One succinct definition of PAR used in community health that is of relevance here is given below:

> *"PAR seeks to understand and improve the world by changing it. At its heart is collective, self-reflective inquiry that researchers and participants undertake, so they can understand and improve upon the practices in which they participate and the situations in which they find themselves. The reflective process is directly linked to action, influenced by understanding of history, culture, and local context and embedded in social relationships.*

> *The process of PAR should be empowering and lead to people having increased control over their lives" (147)*

Action is at the centre of PAR and manifests in this research as changes in practice around reducing AMU. PAR involves the researcher and the community members or participants collaborating and working together to seek to improve their situation (132). Kock and colleagues describe PAR as *"a disciplined inquiry that seeks a focused effort to create knowledge that is necessary for people to take action"* (148). It is a social investigation, a dynamic educative process (132) that can be traced back to the work of Kurt Lewin (1944) who wrote "*people would be more motivated about their work if they were involved in the decision-making about how the workplace was run"* (145). PAR is not just an approach that aims to create change and action on shared issues, however – it explores and attempts to understand the action and thus fosters learning and new knowledge (132). PAR is an approach, an initiative, a methodology and a research process, which aims for *"researchers and oppressed people to join together in solidarity to take collective action both in short and long term, for radical social change"* (149) (pg.29).

PAR has numerous different and confusing nomenclature (132, 145). The overarching term for this type of methodology is Action Research or Participatory Research, although both terms have been used to describe different approaches within the same methodology (123). Examples of terms commonly used in the fields of health, education, community work and agriculture in addition to PAR are; Community Based Research, Participatory Action Learning or Participatory Rural Appraisal. There have been many typologies of participatory processes and activities and attempts to define and categorise them based on the depth of participation or the level of action (14, 150, 151). One well-established example is Arnstein's Ladder of Participation, which depicts participatory activities in a continuum from no participatory elements and little autonomy for local people, to full citizen control and power over crucial decision-making processes (150). This typology was based on citizen involvement in town planning and urban development (150). When looking at the level of participation in the FAG project as part of this study compared to the Ladder of Participation as described by Arnstein, one can position the FAGs reasonably high on the ladder due to the emphasis on a PAR methodology and the principles of empowerment (Chapter Three).

PAR is considered an alternative type of research compared to traditional, positivist approaches, partly because it does not attempt to prove objective truths or linear cause and effect relationships (145) but rather pursues knowledge for social action (123). PAR is based on ontological and epistemological assumptions vastly different to a positivist paradigm (79, 132). The PAR approach is rooted in the 'critical consciousness' of the researcher, which is described as an openness to new and other people's ideas and a willingness to challenge them (149). Paulo Freire's work in Brazil in the 1970s challenged the social relationships in the education sector. He described the expectation of a 'good' student is to be quiet and do as they're told, i.e. a *"culture of silence",* which highlighted the dominance and power in pedagogical teaching (123, 132). Ozanne and Saatcioglu (2008) take his work and describe one paradigm of PAR as Community Based Research based on Freire's work, which requires *"conscientization"* of those involved, particularly the researcher (123). This is the process of going from an observer of social phenomenon to an actor that can encourage and instigate social transformation (145).

PAR requires participants to be fundamentally central to the research (79, 99). Participants should not be present simply to be studied and observed in an empirical way, but rather should have a say in the design of the research, the direction of the study and, importantly, synthesis of the findings and results of the research (19). It is argued that, from a philosophical viewpoint, the varied perspectives and realities of those involved in PAR provides a realistic analysis of social phenomenon and can improve applicability of research (21). Pretty (1995) goes as far as to say, *"the view that there is only one epistemology (that is, the scientific one) has to be rejected"* (14). Sumane and colleagues use the constructivist paradigm to illustrate the importance of knowledge coming from individuals in their specific context (79). These authors argue that local knowledge - and hence farmer knowledge - matters. Chambers states in 'Beyond Farmer First' *"Rural people's knowledge is in contrast 'situated', differing both by locality and by group and individual, and differing in its modes of experimenting and learning: different people know different things in different places, and learn new things in different ways*" (98). The idea that traditional, experiential knowledge has a crucial role to play in solving complex issues is well recognised in various farming communities (78) and is proposed as an equal but different route of knowledge empowerment and problem-solving (i.e. different to positivist, scientifically-derived evidence).

PAR is a way to create social change and action on a shared issue, which has been used in many areas of farming with success (79, 80, 135, 152, 153). The use of PAR in livestock production is well documented in rural communities worldwide, particularly lower income countries in Africa, Asia and Indonesia (154). Conroy describes PAR first beginning as Rapid Rural Appraisal (29), a method in which researchers aimed to collect a great deal of information about the rural community quickly and cost-effectively (80). RRA went through various reiterations as Participatory Situation Analysis (PSA) and Participatory Technology Development (PTD). Researchers and practitioners of these methodologies soon realised that the people affected by the research had more to say when they *participated in* the research rather than being the *subject of* the research (13, 151). Prompting an attitude shift and self-reflective inquiry resulting in a change in practices on UK dairy farms is well positioned to benefit from a participatory approach (11) and in particular on AMU, as also noted by Vaarst and colleagues in Denmark with the formation of Stable Schools (22). A further example of using complementary knowledges and participatory approaches in farming can be seen in the 'CropCheck' project in Australia that began in the 1980s and ran for several years (63). The authors describe their participatory methodology as *"a form of adaptive research. The adaptive research is carried out with farmers (rather than on farmers) in farmer fields and this ensures legitimacy and credibility of the checks and the management package" (63).*

Participatory approaches prioritise the changes participants want to see and arguably understand in greater depth than external bodies, hence the result is enhanced ownership of the solutions and personal investment in the outcomes (19, 148). PAR can provide the basis for creating livestock development programmes (80), which have livestock owners at the heart of any change strategy and builds on their perspectives of the challenges they face. PAR, therefore, constitutes a major part of the author's theoretical perspective and hence the theoretical framework in this thesis.

To illustrate PAR principles in practice, the next section will describe and appraise a widely adopted participatory, farmer-led approach based on farmer knowledge, experience, and - as Lacy puts it - *"adaptive research" (63).* This example forms the foundation to the study design in this research project. It was also the inspiration for the Stable Schools - the Danish model that the method in this research was based on.

2.d.v. PAR in action: The Farmer Field Schools

A specific application of PAR were the Farmer Field Schools (FFS) begun in the 1980s by the Food and Agricultural Organization (FAO) with the first series of evaluations in 2013 (154). FFS are estimated to have reached 12 million farmers in over 90 countries and attempted to achieve discovery-based experiential learning for farmers in less developed countries (154). The main focus of the FFS in the beginning was on improved use of pesticides through integrated pest management (3) but also to empower traditionally disadvantaged farmers, such as women and to enable communities to develop skills to make them more resilient to changes in farming practice and the environment. There were mixed results but by and large, FFS were deemed to be a success and have since been re-launched with many renaming themselves as Pastoralists Field Schools (101).

The FFS were designed to have three stages: Inception (where facilitators were trained and the groups and curriculum established), Training and Trialling (the training of the farmers through regular sessions held on farm land to trial and experiment with new ideas and practices), and, finally, Dissemination (whereby the groups were expected to spread the new skills and knowledge they had gained throughout the community and more widely) (154). The Training and Trialling stage was the part where farmers identified farm-specific challenges, decided how they were going to tackle them and reflected on the trial results and learning, which fits with the PAR principles of self-reflective inquiry and the cyclical process of knowledge generation (145). This was farmers doing participatory research and creating field labs where they were in control of outcomes (13, 101, 123).

The majority of FFS projects had objectives that focused on production, food security and social/community issues (154). They were established to be flexible and tailored to specific contexts; the main drive was a participatory approach to farmer learning and, as much as possible, to involve the communities in which the FFS were to be set-up in from Inception. Multiple FFS reported that when indigenous knowledge was incorporated into the FFS there was an increased sense of ownership as well as increased knowledge on IPM practices (154). Due to the success seen from using this approach in many different countries, the model of farmer-led learning has since been scaled-up by the FAO and has inspired other projects in countries such as Denmark and the UK (22, 155).

Nonetheless, FFS did not fully achieve the desired objectives right away, particularly of knowledge dissemination and empowering disadvantaged communities. Firstly, the Inception phase lacked adequate training of facilitators (154). Feedback from various projects was the need for a well-trained and committed facilitator for the groups and facilitation was variable within and between countries (101). The FFS targeted mainly well-off farmers in the communities in which they worked and, although this was seen as advantageous in aiding dissemination, it did not help achieve the goal of empowerment for disadvantaged groups, such as farmers (154). The initial phase of FFSs lacked documentation of when/where they worked well but had more records of when they did not go to plan, which made evaluating the programme challenging (154). There were also problems with attendance and drop-out when farmers could not see any returns on their time (154). Participatory approaches like this are difficult to evaluate and time consuming for participants; this is one drawback of PAR (132). Dissemination was one of the main problems with FFS, in that existing groups felt there was a lack of assistance once the facilitators withdrew and farmers were expected to continue to share skills (154). These reported drawbacks helped to inform the approach taken by this research - the focus on the quality of facilitation was recognised and optimised for this study (Chapter Three).

Despite the aforementioned drawbacks, the FFS have had a positive impact for many communities involved and have been continued by the FAO, but with adaptations. For instance, farmers in Ghana benefited from the FFS by having "*acquired enhanced status within their community",* which fits with the empowerment goals set out from project inception and PAR principles (154). Farmers in India reported having gained new knowledge on IPM practices as a result of the FFS. The FFS have now been further modified with the previously mentioned results in mind and with help from international partners, such as the European Union, United Nations Educational, Scientific and Cultural Organisation (UNESCO), the World Bank Group and the International Livestock Research Institute (ILRI). There has been much more emphasis on facilitation training, supporting facilitators throughout the projects and disseminating learning into the community (101). This is a positive example of the iterative process of PAR and how initial feedback and evaluation of a process can help it be re-born into a much more successful initiative, based on the experiences of the participants.

An important application of a participatory methodology that serves as the final focus of this literature review and a key building block for this research was the Stable School model. The format, results and limitations of the Stable Schools will be explored. The adaptation of the Stable School model for this study is included in Chapter Three.

2. e. Stable Schools

Inspired by the FFS methodology and in line with a participatory approach, Vaarst and colleagues began collaboratively working with dairy farmers in Denmark using a bottom-up approach to improve animal health (140), albeit with some adaptations. In Denmark it was noted that:

> *"use of antimicrobial drugs varies widely in different herds and is complex, many different approaches can be taken. It was therefore decided that the main approach was to design individual farm and herd strategies through a participatory process using farmer groups for mutual advice and common learning"* (22).

These farmer groups were similar to the FFS in theory but were adapted for the Danish organic dairy farmer and called Stable Schools, which is an example of taking methods and techniques used in different contexts and innovatively using them elsewhere (19).

The Stable Schools began as small groups of organic dairy farmers that met at regular intervals to share knowledge and best practice. They aimed to reduce AMU through a bottom-up approach to learning, instead of through a traditional top-down advisory pathway provided by veterinarians (22). In contrast to the FFS - where on-farm trials comparing one method of land management or animal husbandry to another was the focus - Stable Schools worked by sharing existing knowledge and experience about farming and helping one another improve through peer-to-peer support (22).

The Stable Schools met every month on one another's farm to discuss reducing AMU. Each group consisted of five to eight organic dairy farms. The farms belonged to the same milk company and were all keen to reduce the need for antimicrobials before being made to (22). The meetings involved a farm walk led by the host farmer and then a group discussion examining the host farm's data. A facilitator would ensure everyone in the group contributed a positive comment about the system or approach that the farmer used and then a suggestion on how the host farm could improve (22). These discussions were distilled into an Action Plan that the host farmer could then work on before hosting another meeting a second time, six months later. Everyone in the group hosted twice in a one year period; a group of six farmers would meet on one another's farm once every month for six months, then repeat the process so that after 12 months there had been 12 meetings. After everyone had hosted twice and the goal of antibiotic reduction had been achieved, the Stable Schools were deemed to have reached their natural conclusion (24).

The Stable Schools were a success in Denmark, as evidenced by an ~50% reduction in treatments using antibiotics with no detriment to herd health, welfare or production (23). Consequently, they were adopted into agricultural legislation as part of the obligatory animal health service in Denmark (24). Danish dairy farmers now have a choice when it comes to their animal health service of either having the veterinarian out more often each year or participating in a Stable School (24). Vaarst and colleagues, however, were critical of the government's approach of adopting Stable Schools into legislation and disagreed with it being made compulsory (albeit with a choice of two options). They argued that it detracts from the voluntary element of participation and contradicts the philosophy of empowerment in a participatory, farmer-led approach - it should remain the farmers' free choice to take part (24). The concern being that compulsory participation would affect the function and nature of shared learning in the Stable School (24).

Stable Schools and the methods used in this research have many similarities with Wenger's Community of Practice (CoP) framework (156), which is of relevance here because of the social structure and common learning that occurs in both a Stable School and a CoP. Communities of Practice are groups of people in any kind of organisation *"who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (156)*. The Stable Schools were a group of peers (their "*organisation"* could be their milk company or their farming group) that shared a concern about the overuse of antimicrobials in dairy farming (22). The farmers worked together to help each other solve this shared problem and interacted on an ongoing basis via monthly meetings. It is this knowledge-based social structure that has been chosen as one solution to reducing reliance on antimicrobials in dairy farming in the UK. Both Stable Schools and CoP focus on the collective action from a group of people and the sharing of knowledge and expertise within this structure. The research presented in this thesis also focuses on the combined outputs from the Farmer Action Groups, rather than investigating the individual characteristics and attitudes of farmers as determinants for change., which has been extensively researched in the fields of veterinary science and agri-environmental schemes. Rose and colleagues argue that there are a lack of studies focusing on successfully changing behaviours (11)and Dwyer and colleagues put forward to policy how change on farm could be better achieved based on a wealth of literature (157). Stable Schools are one successful example of changing farm practice in a bottom up manner with promising results and replication in other countries.

A key difference between CoP and Stable Schools is the longevity of the knowledge sharing structure - CoP are often long-term mechanisms that evolve and re-shape over time (156), whereas Stable Schools are goal-orientated and finite, so once the goal has been achieved, they come to a natural conclusion (24). The potential for the methods used in this research to take elements of both and evolve into a CoP is something that will be discussed in later chapters.

The Stable Schools have been adapted for this research with UK dairy farmers to reduce AMU because of evidence to suggest that the Stable Schools are appropriate for the UK context too. AHDB Dairy - the project funders - already have experience of delivering the Stable School model in the UK (140) and a substantial amount of the UK farming population are already engaged with similar discussion groups (158). Recent work in the UK with retailers at the time of this project's inception has also demonstrated the potential for farmer-led action on this specific issue (141).

2.e.i. Limitations of a participatory, farmer-led approach

There are drawbacks to consider when using farmer-led, participatory approaches, as they are adapted and implemented in practice in slightly different and contrasting ways (e.g. Stable Schools vs. Innovative Farmers vs. Hennovation). Firstly, there can be substantial variation in delivery and quality. As alluded to when reviewing the FFS, the training and ability of the facilitator can directly affect the outcome and performance of the group. If the facilitator is not adequately trained in participatory approaches (i.e. they are able to facilitate as opposed to advise) or their commitment to the process wanes, the potential of the approach will be diminished (101, 154). The facilitator has to be committed to the process and believe in farmer expertise in order to foster the learning atmosphere and encourage farmers to share knowledge (18). Some of the networks in the Hennovation project commented on relying on traditional top-down methods of advising, which clearly is not what the approach is about (18). Facilitators need to be trained to be catalysts of the methodology (148).

Secondly, there may be an issue with the approach being accepted in the wider farming community due to the tensions that exist between the different epistemological perspectives. Advisors with certain perspectives (e.g. a positivist, reductionist scientific outlook) could clash with the PAR principles of complementary ways of knowing and learning in agriculture, leading to lack of collaboration between these diverse bodies of thought (14, 78). A striking example is the existence of the Oxford Farming Conference alongside but not in collaboration with the Oxford Real Farming Conference, both which happen simultaneously each year. The reliance on farmers' experiential knowledge in the FFS and Stable Schools and a potential lack of scientific training could be seen as a drawback or sign of lower quality by some advisors or industry bodies (21). This could then jeopardise the adoption or acceptance of the approach in the wider community. Innovative Farmers and Hennovation surmount this potential issue by involving researchers and advisors to guide the groups' trials and innovations (89).

Additionally, this difference in knowledge also makes evaluating the impact and efficacy of these approaches more challenging than evaluating more traditional epidemiological study designs, such as controlled trials. Without meaningful measures of change and added value from farmer-led interventions, policy makers may be less likely to fund and adopt these types of approaches into policy (11, 15). Approaches such as Innovative Farmers, Hennovation and Farmer Clusters have successfully assisted farmers with the scientific knowledge aspects by linking them with researchers and advisors trained in trial design and experimentation (89). Farmer Clusters have also gained support from policy by the provision of the Natural England Facilitation Fund. These are but a few examples of synergy between the different knowledge types resulting in collaboration and thus practical implementation of ideas on farms as led by farmers.

Finally, this participatory process relies on voluntary participation of farmers. Recruitment of participants has been shown to be difficult (132) and arguably, farmers are even more challenging to recruit based on the frequent descriptions about their lack of engagement with advisors and research (64, 104). This perceived lack of interest could jeopardise the approach ever working and/or result in skewed samples of only engaged, proactive participants, which means the applicability of the approach is limited. Recruiting farmers to field-based research is already known to result in skewed samples (92). A participatory, farmer-led approach is therefore at risk of being difficult to adopt due to initial start-up challenges. Participatory approaches are also time consuming (both to run and to participate in); this may present a further barrier to adequate participation and therefore meaningful adoption (132). In the UK particularly, lack of time is often voiced as a reason by farmers for not engaging or participating (95) so this may further reduce the potential of this sort of approach in the UK context.

2. f. Conclusion

Previous research has suggested the need for a fresh approach to bring about meaningful change on farms (11-14, 16), particularly in the context of reducing excessive AMU on UK dairy farms (17). Despite the increasing pressure to reduce AMU, many dairy farms still use HPCIAs (31). There are, however, multiple initiatives and ways to tackle AMR across the globe. Research in Agricultural Extension and farmer behaviour change has demonstrated that a bottom-up, participatory approach with farmers' knowledge and experience creating solutions to complex farm-specific challenges can be successful.

This research assesses the potential of peer support through FAGs to achieve practical, farmer-led changes to improve herd health and welfare and reduce AMU. FAGs were modelled on Stable Schools that drew inspiration from FFS – an example of PAR in action. PAR informs the theoretical framework of this research and was used as a template for the study design, implementation and analysis.

Chapter Three: The Methodology and Methods in the Farmer Action Group project

3.a. Introduction

Chapter Three details the methodological approach adopted for this research and the methods used to establish and facilitate the FAGs. The chapter begins with the theoretical framework that informed and shaped the study design, data collection, analysis and interpretation. The Stable School model formed the building blocks for this research and as such a description of how and why the Stable School model was adapted for the UK dairy industry is included. The adaptation of the Stable School approach started by changing of the name of the groups from Stable Schools to Farmer Action Groups. UK cattle are kept in sheds when housed - as opposed to stables - so the original Danish name was deemed inappropriate for UK dairy farming. The active learning process described in the Stable Schools was also thought to be better reflected in the new name of Farmer Action Groups. Following this, the chapter outlines how recruitment of farms and farmers – an arguably essential first step in a participatory, farmer-led project - was approached. This proved to be challenging and raised questions about the methodology's application in the UK dairy sector and is further explored in Chapter Four. The operationalisation of the FAGs is then described alongside the methods of data capture and analysis. The methods used in this study provide a blueprint for how a participatory, farmer-led approach was optimised through the pioneering FAG method, which aimed to identify and mobilise relevant and innovative farmer knowledge leading to empowerment and action.

3.b. Theoretical framework

The theoretical framework for this study was based on the principles and practices of PAR. The following section outlines the theory behind the methodology and the literature that informed the perspective of the author of this thesis.

A PAR approach to doing research comes from a desire to empower disadvantaged communities, to relinquish control over the research process and to co-design and co-create research with local people (19, 98, 99). As discussed in Chapter Two, PAR aims to reveal and challenge inequalities in power, such as access to resources or knowledge (19).

A key element of PAR as a theoretical framework lies in the beliefs, perspectives and attitudes of the researcher as they engage with the research activities and interpret the findings (19). The 'object' of reducing AMU in a bottom-up manner was being studied by the 'subject' i.e. the primary researcher and participants. At the same time, the 'subject' was influencing and shaping the outcome through participation, facilitation and knowledge support; the 'object' was also shaping the perspective of the 'subject' through ongoing interaction. The blurring of the divide between the object and subject, which is ideally maintained in conventional research to reduce bias, is what makes PAR an appropriate methodological lens in which to situate this research allowing for enhanced understanding of how a participatory bottom-up approach can result in practical on-farm change.

Using PAR as a theoretical framework for the project design, implementation and analysis accounted for the integral participation of the primary researcher in the study (the author of this thesis). The role of the primary researcher as the 'outsider' when recruiting farms, facilitating meetings, collecting data and deciding on the analysis - and what this meant for the participants and the approach - will have shaped the outputs and is an integral part of PAR (159). Recruitment was a crucial first-step in this PAR project as it tackled the fundamental question of 'for whom and by whom is this research for?' (14, 19). Recruiting participants involves identifying target communities in which to practice PAR and as such it explores the divisions and hierarchies that exist in these communities. A PAR framework engages with these socio-political structures and challenges the inequalities in them (132).

As discussed in Chapter Two, there are many terms used to describe PAR and similar approaches (123). Cornwall and Jewkes (1995) state however, that the *"innovative nature of participatory methodologies makes them ill-suited to rigid prescription of their roles"* (19). There are also many critiques of participatory approaches concerning the politics of power, imbalance of knowledge and issues around community and capacity, as well as what specifically makes research 'participatory' or indeed PAR (123, 149). Some critiques regard community empowerment through PAR as an extension of neoliberal agendas and control that puts too much emphasis on individuals to improve their own situation (160). Much conventional research claims to be or could be claimed to be 'participatory'. Cornwall and Jewkes (1995) state that most health-based research involving patients is participatory, as patients are required to engage and participate to some degree in the research (19). Biggs describes a participatory continuum from 'contractual' research, where participants are required to take part in researcher-controlled experiments, to 'collegiate' whereby researchers and local people work together as colleagues with different skills to offer i.e. mutual learning (151). The focus in Biggs' typology on participation rather than action, which is another defining principle of PAR as discussed in Chapter Two, reveals the challenges around power and control in conventional research (149). At the collegiate end of the continuum, researchers relinquish the decision-making processes and *"devolve ownership of the process to those whom it concerns"* (19). In this study the aim was for farmers to take ownership of the data and collective analysis as well as the outputs on farm as a result of mutual learning.

A defining characteristic of what makes research PAR, rather than simply claiming it is participatory or includes methods which involve local actors, is the deliberate emphasis on the beneficiaries of the research being the participants themselves. Thus, the deliberate focus in PAR is on research questions of *"for whom and by whom"* (14, 19). This research was focused on how a bottom-up approach fostered action and change on farm and how this could benefit farmers i.e. for whom this research benefits. It was funded by the UK dairy farming levy board – AHDB Dairy – and as such needed to have a practical benefit to the dairy farming industry, not just farm advisors or academics.

In this study, through a cycle of data collection and analysis, self-reflective inquiry and knowledge exchange, the PAR methodology aimed to empower and embolden farmers to reduce, refine and replace AMU on their farms. This iterative and reflective cycle is part of the practice of PAR (145, 148) although not without criticism. PAR is not simply a matter of adopting methods that allow for participation, which is only at the collaborative level according to Biggs' continuum (151). The important part of the theoretical framework in the research presented here, is the researcher's attitude and methodological approach to conducting and interpreting the learning process of the FAGs. The value and expertise of the participants was fundamental to the author's interpretations, as much control of the research process as possible was afforded to them[1] and the research was implemented in such a way as to have maximum benefit for the participants.

One of the strengths of PAR is that it allows practitioners to innovatively adapt methods used in different contexts and in novel ways by local people (19). Cornwall and Jewkes (1995) describe the process of actively doing the research as the distinguishing facet of PAR, not an emphasis on

[1] This did not include, however, activities such as completing a doctoral thesis and research outputs such as publications, which was completely led and executed by the primary researcher. For more on doing PAR as a PhD see 112. Klocker N. Doing Participatpry Action Research and Doing a PhD: Words of Encouragement for Prospective Students. Journal of Geography in Higher Education. 2012;36:149 - 63.

outcomes (19). This at first appears in contrast to the idea that PAR is a perspective, an outlook on the practice of social change, as mentioned previously. Furthermore, the focus on the process of PAR and not the outcomes is arguably restrictive when trying to evidence the value of an approach to policy makers or when community capacity is so low that to prioritise research process over outcomes that could improve a community's situation is unrealistic and unreasonable (160).

A PAR methodology strives to enable a community to decide on its own problems and work together to find solutions to those shared problems (14, 99). It could be argued that the FAGs do not meet the criteria of *"full and active participation of the community at all levels of the entire research process"* (161)(Pg. 160) as the community of farmers did not decide on the goal of reducing AMU or design the project from its inception. However, the FAGs were designed with these key principles as foundations to the methodological framework (e.g. using Action Planning and techniques such as mapping to prioritise farmer identified challenges at the farm level). The idea that communities doing PAR always have to self-mobilise and cannot benefit from external help is an argument of where one stands on the continuum of PAR (145).

The positionality of the researcher and facilitator in the PAR methodology

The PAR methodology adopted in this study aimed to foster a sense of collective action between farmers. The researcher and facilitator acted as catalysts to support this, so farmers could share best practice and embolden each other in a peer support network to implement changes on farm (19, 149). In this study, facilitation included co-setting agendas, mobilising knowledge in innovative ways to help initiate change and facilitating and fostering support amongst participants. The relationships developed between the researcher, facilitator and participants were not only an important part of the approach (159) but helped create an equitable space as described by Koch and colleagues (148).

The researcher or facilitator in PAR is not a by-stander or an impartial observer of the method but an active participant who fosters discussions between and with the other participants as a participant themselves, as discussed in Chapter Two when Macguire (1987) describes PAR as *"oppressed people and researchers to join in solidarity"* (149)(pg. 29). The inter-dependency between researcher, facilitator and participant fostered mutual learning in the FAGs based on the diverse skills and knowledges from a range of participants. The relationships between the researcher, facilitator and the participants ultimately impacted on AMU and practices around herd health, as discussed in this thesis.

There was an assumption of trust between participants and the researcher that is described as essential in participatory approaches (14) and community based research (159). Knowledge and data shared in the FAGs was deemed to be of a certain quality by participants, partly because the primary researcher was from a university institution and was a veterinarian so had access to the relevant knowledge, and partly due to repeated engagement allowing trust to develop over time (19). The researcher was an outsider, as defined by Kerstetter and colleagues (2012), at the beginning of the research (159). Over the period of the study, their positionality changed to become more of an insider – rapport grew, and the researcher/facilitator became participants in the mutual learning alongside the farmers. This consequently had an influence on the perspective of the researcher, who Selener describes as a *"committed participant, facilitator and learner in the research process, which fosters militancy, rather than detachment".* (161).

The project was also funded by AHDB Dairy and facilitated partially by an AHDB employee, so certain expectations from farmers that influenced their interaction with the study would have existed as well as a base level of trust in the project because of the positionality of the facilitator and AHDB in their community. These elements of trust and familiarity have been described as pivotal in practicing PAR or community-based research by others (14, 142, 159, 162). On the contrary, external input in the form of a researcher/facilitator with a pre-conceived research agenda could be seen as a key criticism of these approaches for not being truly participatory (150). Nonetheless, Cornwall and Jewkes (1994) argue, that at the start of a project despite the researcher aiming to relinquish power and control over the research process (which is the fundamental purpose of PAR), the participants could have low confidence in what they know and can do (19). A first step is to restore the balance and create *"spaces in which people can be empowered to engage in a process through which they can identify and confront their problems"* (19). External actors, such as facilitators, are in fact, integral members of a farmer-led group and can create these "spaces" for mutual learning, demonstrated in Pastoralist Field Schools or the Hennovation project (18). As such, the role of outsiders as participants enhances and supports goals of action, which should be the end result of a PAR methodology. The researcher and facilitator's openness to the diversity of knowledge and relinquishing control is what makes this research PAR.

The host farm environment was a further actor in the creation of ideas that contributed to changes in practice, which supports the idea that local context and personal situation is crucial in knowledge production (79). Even from a practical viewpoint, the author learnt from the farmer participants throughout the project and at meetings (e.g. on topics such as grassland management, calf feeding, housing design), which is a working example of the two-way flow of knowledge and mutual learning. This study presents a PAR theoretical perspective in action.

FAGs and The Ladder of Participation: Evaluating the methodology

It is the view of the author of this thesis that the degree of autonomy and empowerment of farmers created by participating in the FAGs was similar to Delegated Power on the Arnstein Ladder of Participation (Table 1). The opinions, ideas and solutions that the farmers generated through the mutual group learning were enacted on their farms as they saw fit i.e. they had autonomy in decision-making, which is congruent with the level of Delegated Power as described by Arnstein. Their participation was not a token effort and they were not simply listened to and then given no say or stake in the outcomes i.e. Consulting (150). The researcher did not simply mine the farms for information and ideas then use that for an external research agenda, which would be somewhere between Consultation and Placation on the Ladder (Table 1) and more akin to an earlier form of PAR called Rapid Rural Appraisal (29). RRA was designed to collect lots of data about a community, which the researcher was often not part of, quickly and cost-effectively with no involvement of the community in the research design or analysis. This process is situated more closely to Placation and 'token' participation; it fails to prioritise a community's own identified challenges and solutions, which is arguably the embodiment of true agency and participation.

However, as mentioned previously the FAGs were part of a research project established and managed by an external body, which could be argued lessens the degree of power and autonomy in its design and execution required to satisfy the upper level of the Ladder. Due to the nature of the participatory research though, the researcher was a participant rather than an external organisation or body that used the notion of participation to further their own agenda as described by Arnstein (150). This comes back to the attitude of the researcher being fundamental and their desire to relinquish control over the research process. The farmers and the researcher developed together, and the subsequent outcomes were used by the farmers on their farms in a way they thought was best suited - not according to the researcher's own interests.

At the local farm level, the degree of participation was similar to the top level of Citizen Participation (Table 1). The issue here is that the farmers did not identify the problem of reducing AMU themselves and they did not select and self-mobilise into a FAG themselves. External input in the form of a facilitator was needed at the start, as well as for the data collection, which was significant in terms of knowledge exchange and knowledge mobilisation as discussed later in this thesis. Therefore, the second highest level on the Ladder - Delegated Power - is more suitable as a participatory typology for this study.

At a national level, however, the degree of input the farmers had in promoting the adoption of the FAG approach more widely is further down the participatory ladder at the Placation or Partnership level. Their opinions were heeded as to the future of the project, but this did not obviously impact decision-making structures, such as whether the project funders will use the approach in their future work. It could be argued that farmers do not have the responsibility or autonomy to negotiate with the relevant power structures that would allow the approach to be applied on a wider scale. This is the role of the researcher in relaying the overall project to policy makers and funding bodies. Therefore, dependent on which level of power one refers to when talking about action (local or national), the level of participation will vary and as such the critique of how truly participatory a project is should be adjusted.

Table 1– Arnstein's Ladder of Participation (modified for this thesis)

Citizen participation	Full meaningful participation in changing situation and full negotiating power to input into decision-making processes
Delegated power	Substantial negotiating power in decision-making is given to people but they are not in full control of process
Partnership	Those in power begin to share decision-making responsibilities and effective negotiations involving those not in power begin
Placation	People are given some power in negotiating change and in decision-making but to no real effect
Consulting	Power structures refer to and ask opinions of people, but these are not heeded, and they have no negotiating power in decision-making
Informing	People are told about changes to their situation but not asked for input or have no negotiating power in the decision-making
Therapy	People have no negotiating power in decision-making and powerful others will attempt to adjust their opinions and values to agree with their own agenda
Manipulation	People may appear to participate in advisory committees/panels organised by those in power but the creation of these is under false pretences and they have no power in any decision-making

3.c. Methodology: Adapting the Stable School methodology for UK dairy farmers

The Stable Schools were adapted to the UK context through the novel Farmer Action Group approach because of 1) differences that exist between the dairy sectors in Denmark and the UK, 2) the fact that the Stable Schools originally were focused only on organic dairy farmers while this research involved all dairy farm systems, and 3) the challenges posed during recruitment (Chapter Four).

The original Stable School model has been adapted in seven different ways. Firstly, the recruitment of dairy farmers to the FAGs was done using a multi-pronged approach making use of Gatekeepers, such as veterinarians (see 3.d.). The Stable Schools recruited from only one milk company (22). The Stable Schools were only aimed at organic dairy farms whereas the FAGs were open to any UK dairy farm in the South West.

Secondly, FAG meetings were held every six to eight weeks and were flexible as to when they occurred, which was a direct result of feedback from the recruitment phase. Farmers stated that meeting every month like the Stable Schools would be too arduous.

The members of each FAG were geographically proximal to each other so as to reduce travel time to each meeting, which was listed as a drawback of the Stable Schools from Danish participants (22). The Stable Schools were distributed more widely over the country (Denmark) whereas the FAGs were concentrated in South West England. Consequently, most farmer participants in the FAGs spent no more than 30 minutes driving to a meeting.

The FAGs featured Medicine Reviews and benchmarking as a way of measuring progress during the project and as a discussion aid when reflecting on farm practices around AMU. The process of creating the Medicine Reviews is explored in later in this Chapter. The Medicine Review was not a feature of the Stable Schools. Instead the Stable School authors utilised a centralised comprehensive farming database that allowed third party access for provision of farm data to monitor progress during the project (23). This comprehensive database made collection of herd health data and key performance indicators arguably easier for an external researcher to collect. In this research, all herd-level data had to be collected directly from the farmers by the primary researcher and there was substantial variation in quality and type as well as source of data. Herd-level data was based around Farm Assurance requirements and included milk production figures, somatic cell counts, mastitis prevalence, lameness rates, mortality rates, cull rates and basic fertility parameters dependent on farm system. Although these herd health parameters were collected for the first year of the project, these data were not collected again due to poor data quality to track any changes, which was another divergence from the Stable School project (23).

A significant knowledge gap, not explicitly noted in the Stable Schools, was identified during the FAG project that participants felt was integral to their progress on reducing AMU. This was pertaining to knowledge on HPCIAs. Information on HPCIAs was provided to the groups by the primary researcher who was present at every meeting.

The primary researcher was a veterinarian and assisted the project facilitator (i.e. the AHDB Dairy facilitator mentioned previously and returned to later in this Chapter) in the first phase of meetings. Hence two external people were present at the first phase meetings and only the researcher was present at the second phase meetings. This contrasted with the Stable Schools as they had one facilitator for all groups who was a cattle production advisor, had only one year of training and no group facilitation experience (22). Other projects using similar approaches utilised existing facilitators within the industry, which has implications for the success of farmer groups because of variation in facilitator style and influence (18).

The final adaptation due to initial drop-out from the FAGs was the inclusion of discussion tool activities to engage participants and help them reflect on their practices in order to reduce the need for and use of antimicrobials (see 3.e). This was informed by the researcher’s conceptual framework and the literature on PAR, as discussed previously.

3.d. Recruitment to the FAGs

Recruitment to the FAG project was a challenge and, while this is well known in qualitative research and within farming (163, 164), this research was particularly designed to be policy-relevant, so investigating and understanding these challenges was both necessary and applicable.

3.d.i. Ethical and theoretical considerations

This participatory project involved extensive recruitment of UK dairy farms from April 2016 - January 2017 and continuing engagement of farmer participants throughout the study. Various modes of recruiting dairy farms were adopted with variable results. In this section, the experience of recruiting farms to research, how this was approached and the ethical considerations around sampling are examined.

As discussed in Chapter Two, there are ethical considerations such as informed consent to navigate when recruiting and then the issue of reaching target groups that may be hard-to-access, especially coming from outside of the target community as a researcher (165). Recruiting farmers adds to these challenges, as demonstrated in previous studies with low recruitment rates (see Chapter Two) and the suggestion that farming is saturated with requests to participate in studies, questionnaires, and experiments (20). Due to these issues, the use of Gatekeepers was prioritised to improve recruitment outcomes. This section of the chapter describes how recruitment was decided upon and executed, making use of Gatekeepers and Chains of Referral to reach as many potential participants as possible.

Due to the participatory nature of the project and from evidence in the literature stipulating that projects of this nature are time-consuming (132) and require participants to be engaged and committed (80), the author anticipated recruitment to the project to be challenging. The veterinary experience of the author and familiarity with the industry meant that recruiting farms was to be done in multiple ways to improve outcomes. The author had experience of organising farm walks with clients before commencing this study and had first-hand experience of the time constraints on farmers and some of the reasons for not wanting to attend a meeting. This background was helpful in designing a recruitment strategy and informed the research on engaging with farmers.

3.d.ii. Sampling

The number of participants recruited was a convenience sample - the participants volunteered and were self-selecting. There was likely selectivity in the sample due to use of Gatekeepers and Chains of referral. This is explored further in the thesis when looking at the rationales for participation and the adoptability of the approach in future policy (Chapters Five and Seven).

Aims of recruitment

1. Establish four to five FAGs across South West England
2. Have enough dairy farmers in each group to stimulate discussion and ideas around AMS so as to be of benefit to the participants (five to eight farmers/FAG)
3. Have enough dairy farm participants in total to provide adequate data for triangulation (N= 25)
4. Recruit dairy farmers not participating in a FAG for semi-structured interviews (N=15)

Establishing four to five FAGs was chosen due to previous work with the Hennovation project (89) and the Stable Schools (22). Accounting for the loss of farmers from the project (and farming) as well as the anticipated difficulty in recruitment were factors in selecting five groups as opposed to just four (like in the Stable Schools). If a group disbanded or did not want to meet regularly enough to fit in with the project timeline (as experienced in the Hennovation project), then the amount of data generated from only three or four groups might have been too low and meaningful conclusions would not have been possible. For these reasons, establishing five FAGs was decided to be a suitable sample size. Due to project time and budget constraints, more groups was deemed to be beyond one researcher's capacity (the author).

Due to the recommended number of five to eight farms per group from the Stable School project, it was calculated that with five groups, a minimum of 25 farms were necessary in total for the study. A further minimum sample of 15 farms that were not involved in the groups was decided as a starter for recruitment for interviews (166), but the exact interview sample number was dictated by ongoing analysis of the interviews and deciding whether data saturation had been reached (167).

3.d.iii. Criteria for recruiting to the FAGs - who to recruit?

Initial criteria for recruitment was deliberately broad to increase the number of potential farm participants and to have a range of dairy farming systems participating:

1) They had to be a dairy farm as the project was focusing on AMU on dairy farms and was funded by AHDB Dairy
2) They had to be located in South West England
3) They had to be at least 18 years old
4) They had to be able to communicate in English

The highest density of dairy farms in England is in South West (168). To maximise the variety of participants and ease of recruitment, it was decided to recruit locally in the South West. This was also a practical consideration as Bristol Vet School where the researcher was based was in North Somerset, which kept travelling time to and from farms under three hours and was practical for attending the group meetings.

Being able to communicate effectively in English was deemed necessary for this project. In the author's experience, there are many non-English speaking workers on dairy farms and if they were unable to communicate adequately, this was deemed a barrier to the participatory nature of the FAGs. However, the author acknowledges that non-English-speaking farm staff will be administering treatments to dairy cows and calves, and some workers will also be making decisions on medicine use. By excluding on language grounds, a potentially rich source of experience was being excluded from some farms. Therefore, if a herd manager had non-English-speaking workers, they were encouraged to bring them along to meetings to learn and contribute (which did occur on some farms).

Geographical location of farm participants within the South West was an important factor in recruitment. Research from the Stable Schools project highlighted the travelling time to the meetings was a potential barrier to participation (22). Pastoralist Field Schools also note that creating groups in local areas was preferable (101). Therefore, it was decided to organise farm participants in a group proximal to each other, keeping average travelling time to meetings to less than 30 minutes. Although attempts to be as inclusive as possible were made when recruiting, this restriction might be seen as a limitation of the recruitment strategy. Geographical restrictions may have excluded potential participants if they were not in the correct geographical region. Verbal feedback from farmers not in the developing geographical areas of a FAG confirmed this to be true.

Other factors not chosen as selection criteria

The FAGs were heterogeneous in structure; they encompassed different farming systems. It was considered whether to have groups in similar and specific areas of farming (such as an only organic FAG, an only robotic-milkers FAG, only high yielders, etc.). However, work on reducing AMU has shown that integration of conventional and organic dairy farms works well in a participatory setting (141) and the Stable Schools also benefited from the mutual learning across different dairy farm systems (22). Thus, it was considered that different farming systems could learn from each other. For this reason, the heterogeneity of the farming sector was reflected in the diversity of the farms in each FAG. Also, by restricting recruitment by the system of farming/calving pattern/yield/etc., further difficulty in recruiting enough participants to the project was anticipated.

It was also considered whether it would be easier to use existing farmer groups to recruit participants, and whether 'hijacking' an existing group and giving them a new approach to the issue of AMU would be successful. Existing farmer groups refers to already established networks or groups of farmers that meet regularly on a specific subject or theme. This could be a grassland group or a high-yielding dairy cow group. This strategy did risk adding more of a time burden on the farmers if a new group was in addition to their existing commitments, which is a limitation to this way of recruiting.

Ultimately, it was decided that using existing groups would not work as they would be harder to run in a truly participatory way. If the existing group were used to having external speakers, for instance, and suddenly this changed to focus on the knowledge coming from within the group of farmers (as it ideally should in a participatory peer-to-peer learning environment), there might have been issues with participation and consequently the research outcomes. Hennovation experienced some challenges with certain groups where a dependency on external experts occurred (18).

Due to establishing the groups in a small geographical area to minimise travelling time to and from meetings, it was likely participants would know each other prior to participation in the project. This was potentially a benefit because it could improve social cohesion in the group and enhance the peer-to-peer learning process (132). Familiarity and good inter-relationships help with the building of trust - an essential element of participatory groups (159). Conversely, existing tensions or poor relations between neighbouring farms could have posed a problem and been a barrier to recruitment. This was something the author would not have been in a position to necessarily know about. However, the Gatekeepers can play a pivotal role here through discussions with the farming community and identifying these tensions and either avoiding or easing them (122, 165).

3.d.iv. Modes of recruitment

Recruitment was approached in a multi-pronged fashion to maximise the number of potential participants reached and to reduce bias (Figure 2). The use of Gatekeepers was adopted as a method of recruitment for this project because of the realisation that the target group of dairy farmers could be hard-to-access; the researchers were based in an academic institute with little day-to-day contact with the target audience. The Gatekeepers for this project were primarily veterinarians and AHDB Dairy (namely the project facilitator). Using AHDB Dairy and other industry contacts would inevitably introduce an element of bias and selectivity to recruitment, but their extensive networks in the farming community was seen as advantageous to satisfy the sampling criteria and numbers. The bias of using AHDB is discussed further in Chapter Five and Seven.

Veterinarians specialising in farm work were identified as Gatekeepers for recruitment of dairy farms to this project due to their close relationship with farmers and trusted position as farm advisors (127, 128). Veterinarians must complete an annual herd health plan for all dairy farmers as part of Red Tractor Farm Assurance standards and they are the only profession that can prescribe Prescription Only Medicines- Veterinary (POM-V; e.g. antimicrobials) to animals under their care, as stipulated by the Royal College of Veterinary Surgeons. Veterinarians are an efficient way to reach as many dairy farmers as possible due to their pre-existing networks, especially those regarded as 'hard-to-reach' (73, 105), which helps to make the recruitment process more inclusive. Thus, it is logical to assume veterinarians were appropriate Gatekeepers for this project.

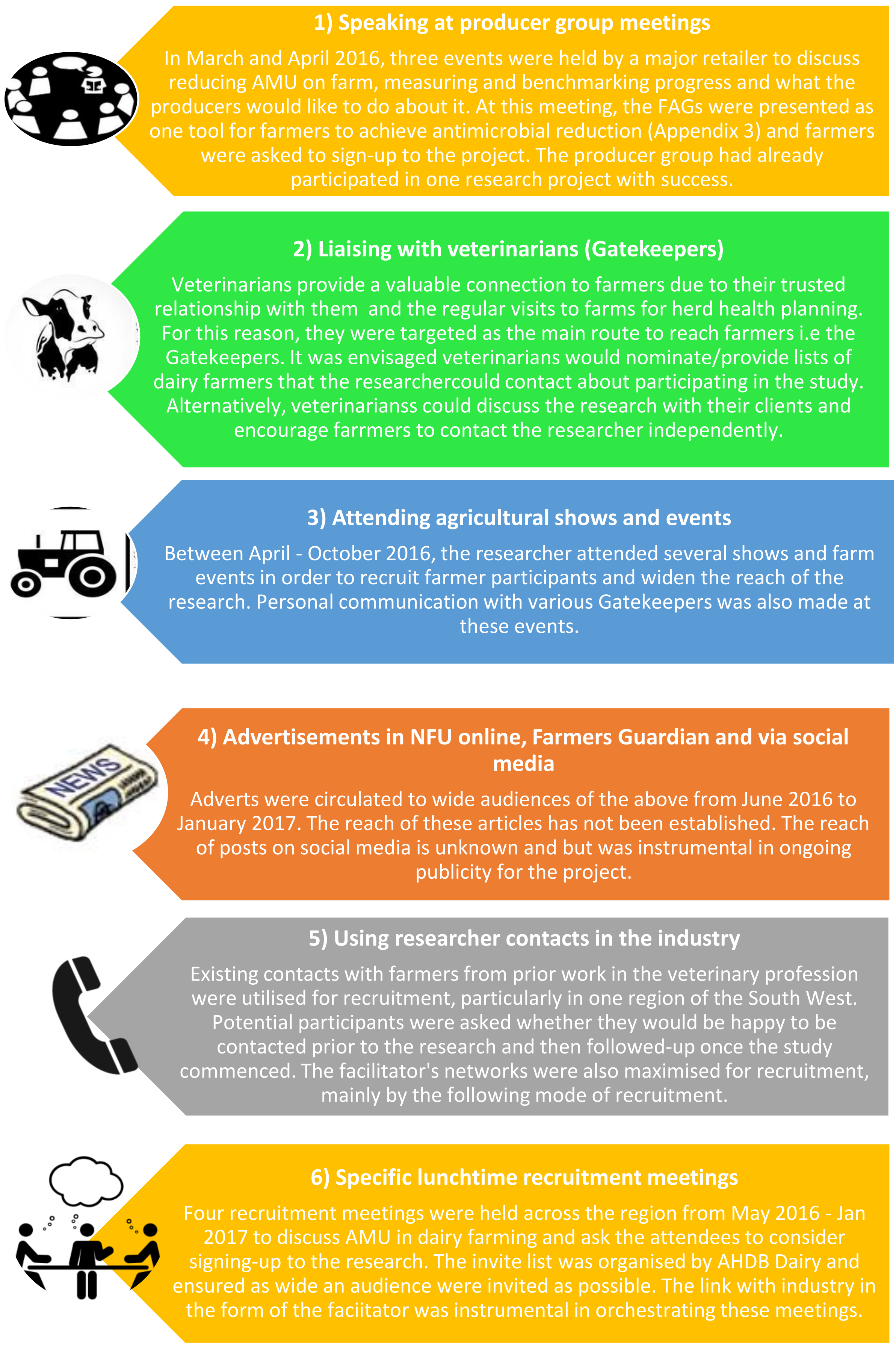


Figure 2- Modes of recruitment of farms to the FAG project

3.e. Methods: Farmer Action Groups

3.e.i. Operationalisation and format

FAGs were inspired by and structured on Stable Schools implemented in Denmark (22). Five FAGs were established for this study with an average of six farms in each group (range five to eight). This number was based on the Stable Schools work, which reported the optimum group size to be between five and eight farms (22). This number aimed to create enough discussion and idea generation at each meeting but was not too large so as to be difficult to manage (22).

FAGs operated in two phases of meetings. In Phase One, each participant in the group hosted the rest of the group on their farm for the first time. This occurred in sequence until everyone in the group had hosted once. The order was decided upon by the group. In Phase Two, each participant hosted their group again for a second time to evaluate any changes made and reflect on any learning from the first phase. Meetings occurred approximately every four to eight weeks with frequency increasing towards the end of the project to ensure everyone participating had the chance to host their group twice on their farm.

The meetings took place from July 2016 - June 2018. The primary researcher was present at all meetings and an external facilitator from AHDB Dairy facilitated the first phase of meetings. The external facilitator was working as a Knowledge Exchange manager for the project funders at the time of the study but due to a change in circumstances was unable to facilitate the Phase Two meetings. The primary researcher took on this role in Phase Two.

There were 58 meetings in total; 60 meetings were planned but one farmer moved farms before hosting a second time and another postponed his second meeting indefinitely. Thirty farms took part for the whole period of the project and hence were included in the final analysis. The 30 farm participants were spread over the five different FAGs in different regions of South West England (Figure 2). Each FAG was a separate entity and the only time all 30 farm participants met each other was at a finale meeting at the end of the project (July 2018). The following sections provide a step-by-step account of the method for this study and the operationalisation of the FAGs. This will provide the recipe for others in the industry to use if wanting to adopt a participatory, farmer-led approach to instigate change on farms.

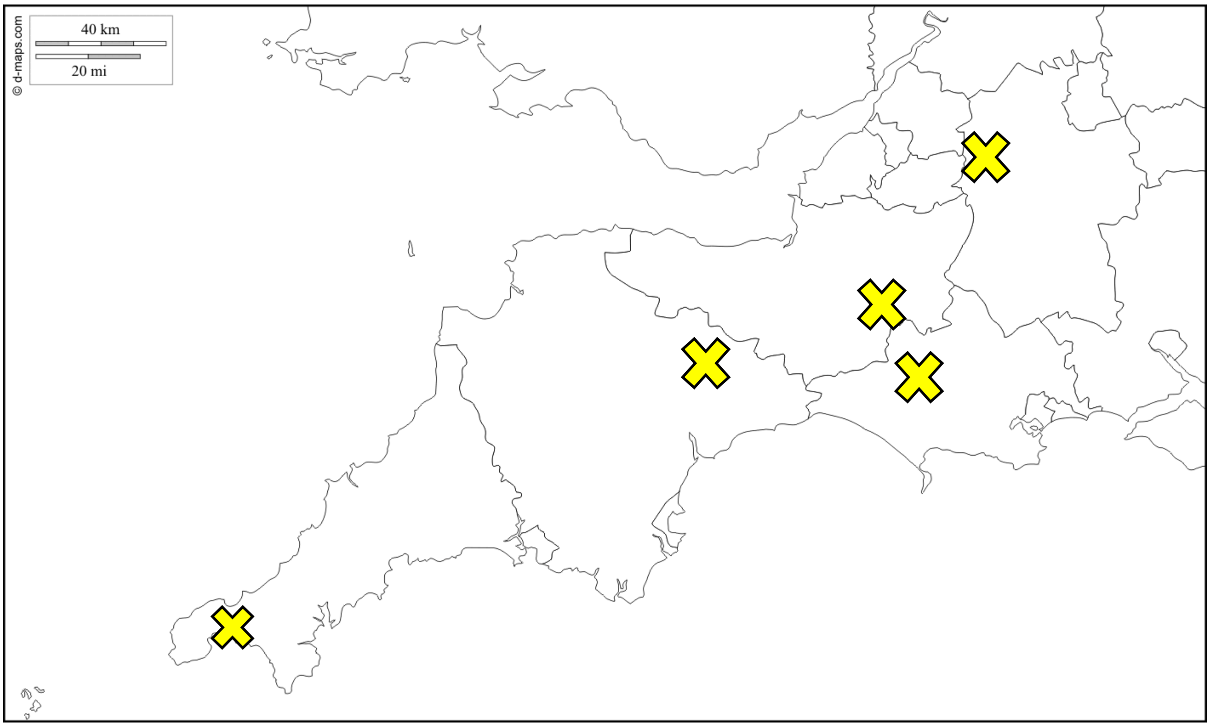


Figure 3- Map of South West England depicting approximate locations of each FAG in the study

The pre-visit

As part of the operationalisation of the groups and to assist in building rapport with the farmers, the primary researcher visited each participant on farm prior to them hosting for the first time. This was called the 'pre-visit' and allowed the primary researcher to not only collect relevant data pertinent to the research (i.e. medicine records, herd health parameters) but co-create an agenda with the farmer identifying areas they wanted to discuss at the subsequent meeting. Building an element of trust is described as pivotal in building relationships for a productive learning environment (99, 159). It also ensured the consent process was fully informed and the farmer was aware of her/his role in the research (165). It was at the point of the pre-visit that the primary researcher made it clear that her role in the project was as the researcher, not as their veterinarian. Despite being a veterinarian and available at the meetings to facilitate the knowledge sharing, she was not in a position to give advice on matters that their veterinarian could advise on.

Figure 4 illustrates the process the researcher went through for each farm participant in Phase One of the project. At each pre-visit, a questionnaire was completed to structure the data collection on farm (Appendix 5). The questionnaire aimed to capture the essential data needed to complete the Medicine Reviews (described later in this chapter) and to collect data to track herd health parameters, as in the Stable Schools (23). However, as discussed earlier in this chapter, the adaptations to the Stable School method meant that collection of herd health parameters for comparison between Years One and Two was abandoned. The validity of the UK on-farm data was considered to be poor compared to that of the Stable Schools' herd data and was deemed less valuable to the participants compared to the Medicine Review data, discussed later in this chapter.

Co-creation of the agenda

An approximate agenda was agreed with the farmer participant prior to hosting, which highlighted areas the farmer wanted to discuss with the group. The facilitator then used the agenda to help the group keep to time and to ensure they were familiar with the farmer-identified key areas and thus could frame questions accordingly (see Appendix 15 for an example agenda). The remit of the discussion was not fixed; farmers were encouraged to explore a variety of topics related to farming and herd health as well as AMU. This was steered by the farmers and quickly became apparent led to more productive discussion than keeping the focus narrowly on AMU.

Phase One - Hosting

One key part of the project for each participating farm was hosting the FAG on their farm so they could showcase how they managed their herd and ask for input from a group of farmers on things they could improve. The first phase of the project involved each FAG member hosting their group for the first time. The host farmer was encouraged to lead a farm walk and to cover all areas of farm management. They were asked to identify one to two areas they deemed to be their strong points and one to two areas they wanted to improve or saw as a challenge. These issues did not have to relate to AMU necessarily; this was partly the role of the facilitator to ask probing questions into farm practices and challenge farmers on their reasons for using antimicrobials.

The key output from hosting in Phase One was the production of a farmer-led Action Plan, described later in this chapter. This was then re-visited in the Phase Two meetings. In between hosting the first and second time, the farmer participants would attend the rest of the group meetings and share ideas and knowledge on other group members' farms. Attendance at meetings was deemed crucial to the success of the project by the researcher, and both researcher and facilitator took an active role in encouraging attendance at each meeting (such as regular emails and texts reminding participants when and where the next meeting was and inclusion of varied group activities and prizes to maintain interest). The sharing of ideas and experience between farmers, as demonstrated in the Stable Schools, would only work if there was enough 'critical mass' at each meeting (i.e. enough farmers present to share knowledge).

Facilitation

One key element of PAR and many farmer-led initiatives discussed in the previous chapter is facilitation (18, 21, 148). Facilitators feature in many participatory projects and their role and quality can vary substantially (18). The literature describes the key role the facilitator has in supporting groups such as these (112, 169, 170). The facilitator holds a unique position to help the group meet their shared objectives. In this project, an external facilitator worked with the researcher to help establish and facilitate the groups in first phase of the project. The facilitator had less of a logistical role (e.g. communicating meeting times and locations, preparing material) than the literature describes due to the research setting of the project and the fact that the researcher managed the logistics of the FAGs.

Facilitators can act as knowledge brokers (20, 89) and have a pivotal role in inspiring confidence in participants, as well as initiating and managing projects (19). In Phase One of the project, an experienced facilitator was involved in the recruitment of the farm participants and the facilitation at the meetings. The facilitator was employed by the project sponsors (10) and was familiar with the Stable School methodology as she had been using it in her work with UK dairy farmers. This had been a result of training by AHDB Dairy as well as the facilitator's own education. She had a Masters in Calf Health and Welfare and several years' experience in the dairy industry running farmer meetings. The researcher and facilitator met through the project sponsors and were encouraged by AHDB Dairy to work together on this project.

The facilitator's role at each meeting included but was not limited to starting the meeting, ensuring everyone got to speak and was heard, keeping the group together and on time during the farm walk, asking probing questions of the farmer's practices (see examples below) and distilling the discussions around an Action Plan onto paper for the host farmer. The facilitator held farmers to account and would challenge thinking and practices frequently. Their role in recruitment is described earlier in this chapter and in Chapter Four.

Below are a few examples of facilitator questions that occurred during meetings. These were generated spontaneously by the facilitator but were guided by the agenda that the primary researcher and host farmer co-created before the meeting (Figure 4), therefore the scope of the questions was not narrowly on AMU but issues of relevance to the hosting farm. These questions were also in response to the discussions on the farm walk and the ideas the farmers contributed.

- Why do you think waste milk is better for calves than milk powder?
- Do you think your lame cows are in pain?
- Why do you give X for treating Y?
- What do you think is the reason for the increase in mastitis cases?
- What does the group think of this shed?
- Does the group have any thoughts on the calf rearing protocols described?

The primary researcher took on the role of facilitator in the Phase Two meetings due to the AHDB-employed facilitator having a change of circumstances. Consequently, the primary researcher was facilitating *and* researching the process of farmer-led change in Phase Two. Due to the veterinary experience of the primary researcher, she had an important role to play in knowledge brokering during meetings (i.e. filling farmer-identified knowledge gaps based on veterinary knowledge of medicines).

The synergy between the AHDB Dairy-employed facilitator and the primary researcher was an unexpected aspect of the meetings and maintaining the engagement of farmers. Without the AHDB Dairy facilitator, the study would have failed to recruit enough farms. Her role in recruitment is discussed further in Chapter Four. Her skill as a facilitator is re-visited in Chapter Seven.

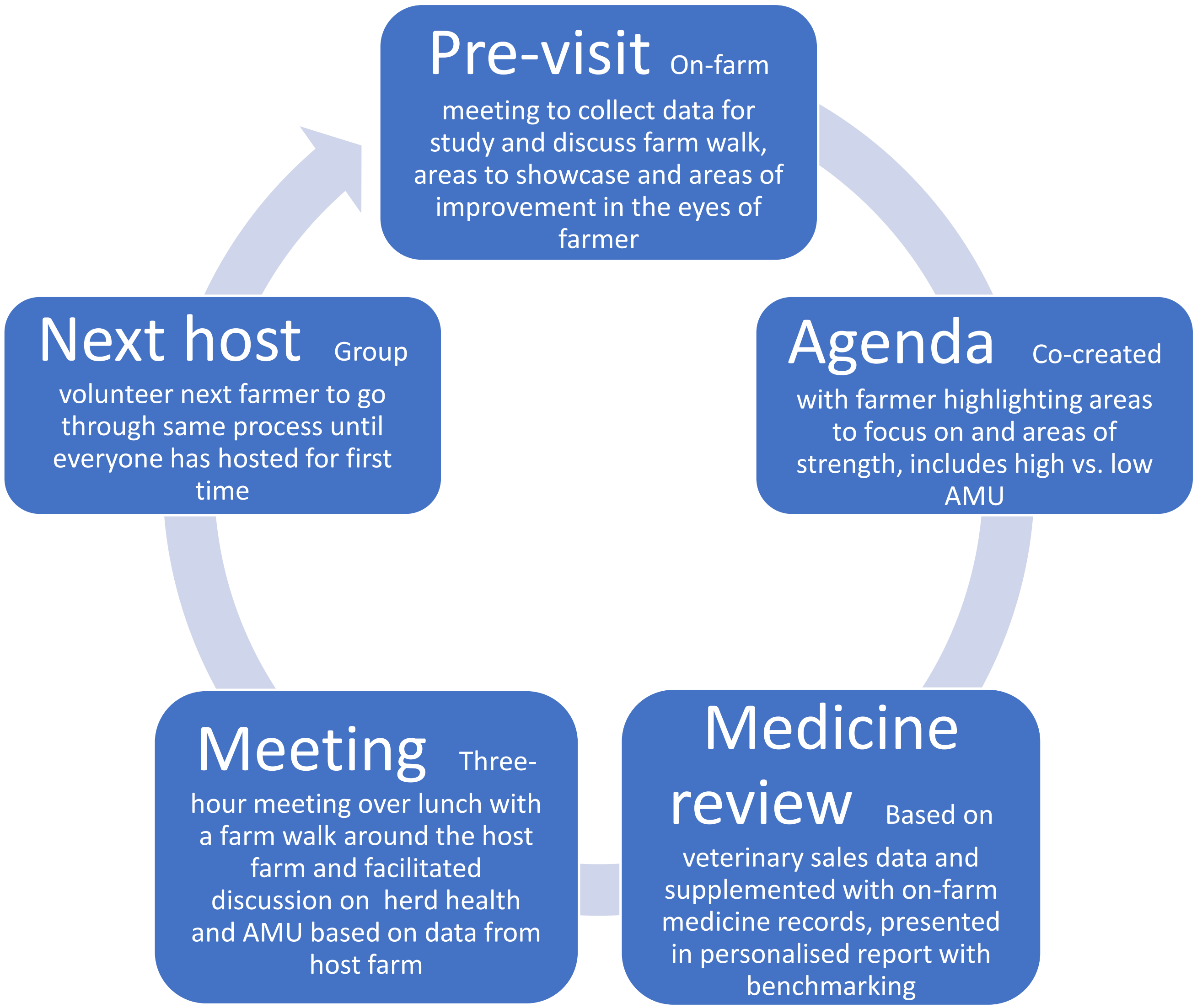


Figure 4 - Phase One process for FAG method: co-creation of agenda, data collection and meeting process

Overview of meeting format

Each meeting lasted approximately three hours, included a farm walk and ran over lunch time (11 am - 2pm). This decision came from the researcher's own experiences of running farmer meetings in the dairy sector. Lunchtime meetings were between morning and afternoon milking, so fitted in with the dairy farmer's schedules. The facilitator's experiences of running farmer meetings for several years also indicated this was the most appropriate time and duration. Feedback from farmers during the project confirmed that this was the most convenient time for them as well. Food was provided as routine at each meeting and was a scheduled part of the meeting format; this again came from the author and facilitator's experience of running farmer meetings. The farm walk was designed to be led by the host farmer with minimal facilitatory input (i.e. keeping the group together and asking questions pertaining to AMU if the discussion strayed off topic for more than 10 minutes). The meeting format was similar for each farm and remained the same between Phases One and Two. The only difference was there were no 'pre-visits' in Phase Two (Figure 3); this was instead replaced with a semi-structured interview to assess any changes to practice and implementation of the Action Plan. Semi-structured interviews were used to evaluate the effect of Stable Schools on farm practice too (22).

'Catch-up' session

The meetings began with a group session (either indoors or in a shed) where each farmer participant either introduced themselves (if it was the first meeting) or shared with the group what had been happening on farm since the previous meeting. This was supplemented with questioning from the facilitator and primary researcher regarding any treatments or AMU. This acted as a 'catch-up' session and set the precedent for the subsequent discussion to be interactive and informal. This method of beginning a meeting has been shown to help when fostering dialogue and identifying challenges as described in Hennovation (18).

Medicine Review session

The 'catch-up' session was followed by a brief discussion (~10 - 15 minutes) on antimicrobials and measuring AMU. This discussion focused on the Medicine Review for each hosting farm with the Medicine Review presented to the group (example in Appendix 10), with the consent and prior approval of the host farmer. Benchmarking was also carried out as a tool for the group discussion. Benchmarking has been demonstrated as a useful tool in driving behaviour change (Chapter Two) and was a technique used by the author previously in veterinary practice. 3.e.iv discusses the Medicine Review process further. The primary researcher ran this session and used it to discuss how to measure AMU and what the provided Medicine Reviews contained. The researcher also started to introduce the topic of HPCIAs and the impending restriction on the usage of certain products in farming, stemming from the O'Neill report (5). This part of the meeting was initially to help explain the Medicine Reviews the researcher had produced for each participant (e.g. what the different metrics meant, what was excessive or inappropriate use, what the different medicine categories meant, providing trade name examples), but it quickly became apparent that knowledge on antimicrobial classification, including HPCIAs, was lacking and further information about this was requested by the participants. This process of reflection on what the participants wanted and required from the Medicine Review process helped the project to evolve to be as farmer-focused as possible. More on this knowledge gap can be found in Chapters Five and Six.

The farm walk

Farm walks have been shown to be an effective format for knowledge exchange in farming (171). The Stable Schools also featured farm walks and used farm data to help the group work together to improve each host farm (22, 23). The experience of the primary researcher and facilitator in running farm walks prior to the study also enforced the idea that these were a good basis for farmer learning.

After the Medicine Review session, the host farmer led the group on a farm walk. This lasted approximately 60 - 90 minutes. In Phase One of the project, the farm walk aimed to cover the whole farm system and to demonstrate to the group the environment within which the host farmer was working. It was also an opportunity to showcase areas the farmer participant was proud of and areas they wanted to improve.

Action Planning

The farm walk ended with lunch and a sit-down discussion on what the group had learnt from the host farmer. This next part of the meeting was a key step of the process; the discussion was facilitated to co-produce a farmer-led Action Plan of practical ways for the host farmer to reduce the need for and use of antimicrobials on their farm. An example Action Plan can be seen in Appendix 11 alongside the meeting summary report. The Action Plan was the fundamental output from each meeting in Phase One. The host farmer was able to accept or disregard suggestions and, once finalised, the Action Plan was written up as part of the meeting summary report by the primary researcher. The host farm could then work on implementing the recommendations over the subsequent months.

The meetings ended with a volunteer to host the next meeting and approximate date. Once everyone in the group had hosted for the first time, the second phase of meetings commenced. Phase One lasted approximately one year depending on the group, number of farms in the group and how frequently they met. Phase Two was an opportunity to reflect and evaluate how much of the Action Plan had been actioned and whether there was any benefit seen from implementing any of the farmer-led suggestions to reduce AMU on farm. Phase Two followed a similar meeting format to Phase One with a slightly shorter farm walk and more time spent discussing changes made to farm practice to reduce AMU. The post-lunch discussion focused on the host farm's Action Plan and what had been tackled, what had been disregarded or failed and why. This was discussed as a group and further suggestions/improvements invited.

Discussion tools

The discussion after lunch involved a variety of novel tools and exercises to stimulate discussion and refresh ideas. These types of activities are widely documented in Livestock Action Research and Community-Based Research (80, 99), as well as forming the building blocks of Participatory Rural Development (172). They were designed in collaboration with the primary researcher and the facilitator. The facilitator took a lead role in executing the activities. Examples included:

1. **Use of sticky notes on posters-** Farmer participants were encouraged to write ideas on sticky notes and place them on a wall poster (Figure 5) categorised as in Table 2. The suggestions were then read out and discussed as a group.

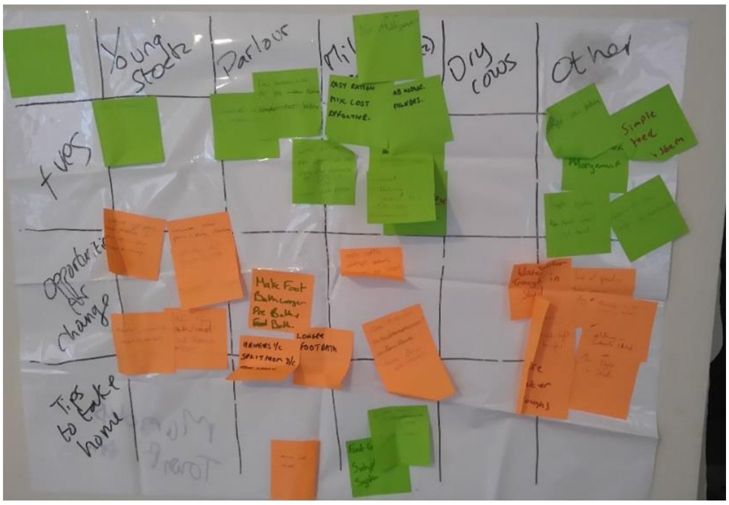


Figure 5- Example of discussion tool 'sticky notes on posters'

2. **Mapping of the farm walk-** A volunteer farmer participant was asked to draw a map of the farm walk they had just been on, directed by the rest of the group. The host could pass comment at the end on the accuracy of the illustration. The group were then asked to place colour-coded stickers on the illustration representing things the host was doing well and areas that could provide opportunity to reduce AMU.

Figure 6- Examples of discussion tools ' Mapping exercises'

3. **Score chart exercise-** Each farmer participant was given a score chart with areas of the farm walk printed down one side, including a blank section. Participants were then asked to rate the areas of the farm on a scale of 1 - 10 (1= awful; 10 = absolutely excellent), giving optional reasons beside the score. The score charts were then collected, scores added up on a poster and discussed. All scores were anonymous and the lower scoring areas were focused on for the Action Plan.

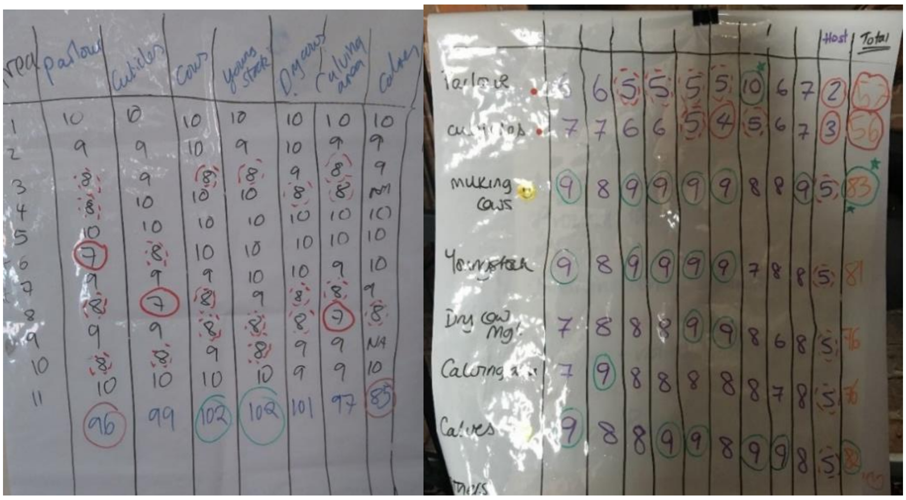


Figure 7- Examples of discussion tool 'Score chart exercises'

4. **Ping Pong ball ranking exercises-** Several labelled bowls were displayed representing a different area of the farm walk, with an optional 'other'. The farmer participants were then asked to place colour-coded balls into the bowls reflecting things the host farm was doing well and opportunities for change regarding herd health and AMU.

Figure 8- Examples of discussion tools 'ping pong ball exercises'

Table 2- Example sticky notes discussion tool

Areas of farm walk	Things going well	Opportunities for change	Tips to take home
Parlour			
Cubicles/sheds			
Calf house			
Pastures			
Calving shed			

3.e.ii. Data capture and analysis

In this next section, the process of collecting and analysing the various types of data for the study is addressed. Qualitative and quantitative data were collected in order to answer the research questions. The collection and analysis of the qualitative data is described first. The subsequent chapter sections on Medicine Reviews and Action Plans deal with how the quantitative data was collected and analysed. The qualitative data were used to assess how the Stable School methodology adapted for the UK context helped foster a change in practices on participating dairy farms. The data collection and analysis also aimed to further learning on how this method could be adopted in a wider context.

The different types of data collected via different techniques was interpreted in tandem to enhance the conclusions drawn- this is called triangulation. Triangulation refers to the process whereby the veracity of individual findings is improved by two or more different methods reaching the same conclusion (99). This technique is widely used in social sciences and stems from the use of triangulation in navigation to pinpoint a location based on two known points in space.

The data collected during the running of the Farmer Action Groups included:

1. qualitative data from the group discussions at the meetings using an audio-recording device and transcriptions of a select number of meetings
2. qualitative data from semi-structured interviews with each farmer participant using an audio-recording device and verbatim transcriptions
3. quantitative and qualitative data from the co-creation and implementation of the Action Plans, collected at semi-structured interviews with participants
4. quantitative data from Medicine Reviews for each farm in the FAG project

Qualitative data from the FAG meetings

An encrypted audio-recording device (Olympus Digital Voice Recorder DS-3500) was used to capture the conversations and ideas shared at each FAG meeting. The 'catch-up' session, Medicine Review session, the farm walk and Action Planning discussions were recorded and listened to by the primary researcher within three weeks of each meeting (these recordings comprised of approximately three hours of audio per meeting). The farmer participants provided signed consent at the start of the project for the recording to take place and were aware of the role it played in the researcher's work. They were continually reminded about the recordings being made and were encouraged to ask the researcher to turn off the audio-device if they were concerned at any point. This never occurred during the meetings but happened during one interview.

The total amount of audio data collected from the FAG meetings was approximately 174 hours. The primary researcher was present for all 58 FAG meetings and listened back to the audio file for each meeting as part of compiling a meeting summary report for participants. The primary researcher then transcribed a further ten meetings for formal analysis - a total of 30 hours of FAG meetings were transcribed and analysed by the primary researcher using the software package NVIVO version 11 (QSR International, Australia). This number of meetings was chosen for formal analysis as it represented meetings on various participating farms with different hosts/attendees and across the five different FAGs. It also captured data from the first meetings where farmers did not know each other and were perhaps more unsure of the approach. There was a substantial wealth of information in each meeting to address the research questions; each meeting provided evidence of knowledge sharing, learning, peer support and discussion around animal health and AMU. Data saturation was evident after analysis of only five meeting transcripts by the primary researcher. These first five transcripts were done at the time of the meetings (2016 – 2017) but a further five were also transcribed towards the end of the project (2018) to ensure no new material was identified and to examine the data for any new elements that had been thrown up by the interview data (see 3.e.iii).

The complementary meeting summary reports were also used alongside the transcriptions of the meeting audio. These provided a further source of quotes from the meetings that were not transcribed and analysed formally. The meeting reports are records of farmer commitments to change practices (which complements the Action Plan data) and provided further examples of the peer-to-peer learning at each meeting.

Field notes were also taken by the primary researcher during each meeting and variable forms of feedback from farmers were collected after each meeting (Figure 9). These sources were not analysed formally.

Figure 9 - Example feedback after a FAG meeting

All these data sources informed the author's understanding of the process and influenced ongoing facilitation of the project. The role of these other sources of data was to develop the method in an iterative fashion and help generate meeting summary reports after each meeting. An example meeting summary report can be found in Appendix 11.

Formal qualitative data analysis

Thematic analysis was chosen as the preferred analytical approach due to:

1. the type and richness of data that was collected (i.e. detailed group discussion transcripts), which meant a wealth of subject matter was covered in the meeting transcripts, some not strictly relevant to the research questions. Using thematic analysis allowed structured organisation of the topics covered for targeted analysis
2. the overall purpose of the qualitative inquiry to explore how this approach supported farmers and change on farm, so by organising the wide-ranging discussions into topics, further analysis to explore commonalities and themes was possible
3. its use in other related studies (20, 91).

Thematic analysis works on the principle of organising rich data sets by identifying sub-topics, then examining these organised data sets for patterns, relationships and common ideas, referred to as themes (167). By following the principles of thematic analysis, the coding of transcripts was performed in a two-step process. Firstly, 'topic coding' where content from the transcripts answering the research questions was identified and organised. The overall research questions (see Chapter One) and the theoretical perspective of PAR formed the framework used for the first stage of coding and organising the data. A deductive approach to qualitative data analysis was then used to ask qualitative data specific questions for targeted interrogation (167), such as: 'What practices did farmers change as a result of learning from their peers in a FAG and how are these related/different?', 'What examples are there of knowledge exchange and mutual learning and how did it help?', 'How have farmers supported each other and why?', 'How has facilitation helped and why?', 'What was the role of the different aspects of the FAGs?'. A series of 'nodes' or categories were created in NVIVO labelled, for example, as 'Knowledge Exchange', 'peer support', 'Farm walks', 'Medicine Reviews', 'AMS' etc. (Figure 10). The coded text (i.e. a phrase, sentence, statement or paragraph) from the transcripts was then placed into the relevant 'node' in preparation for the next step in thematic analysis.

	Name	Files	References	Created On	Created By	Modified On	Modified By
2	Why joined project	14	39	26/09/2018 11:48	LM	08/03/2019 09:26	LM
3	Why carried on participating	9	15	26/09/2018 11:49	LM	17/10/2018 14:38	LM
4	Best bits	13	38	26/09/2018 11:49	LM	17/10/2018 14:38	LM
5	improvements to FAGs	11	26	26/09/2018 11:49	LM	08/03/2019 12:05	LM
6	Antimicrobial stewardship	25	186	26/09/2018 11:49	LM	08/03/2019 14:20	LM
7	Action Plans	1	1	26/09/2018 11:50	LM	26/09/2018 12:43	LM
8	Implementation	16	156	26/09/2018 12:47	LM	08/03/2019 13:37	LM
9	Co-creation	20	79	26/09/2018 12:47	LM	08/03/2019 15:06	LM
10	Disregards	17	69	26/09/2018 13:13	LM	08/03/2019 14:30	LM
11	Medicine reviews	23	137	26/09/2018 11:50	LM	08/03/2019 13:52	LM
12	Facilitation	19	93	26/09/2018 11:50	LM	08/03/2019 14:31	LM
13	Farm walks	13	29	26/09/2018 11:50	LM	17/10/2018 14:20	LM
14	Peer support	10	123	05/03/2019 17:34	LM	08/03/2019 15:06	LM
15	Other members of group	15	45	26/09/2018 11:51	LM	08/03/2019 09:26	LM
16	The industry	14	54	26/09/2018 11:51	LM	08/03/2019 13:57	LM
17	Vets	25	109	26/09/2018 11:51	LM	08/03/2019 14:17	LM
18	Changes in practice	12	187	26/09/2018 12:43	LM	06/03/2019 13:19	LM
19	Reasons to not change	23	131	12/10/2018 12:30	LM	08/03/2019 15:05	LM
20	Reasons to change	24	114	12/10/2018 12:30	LM	08/03/2019 13:58	LM
21	Attributed to FAGs	23	133	12/10/2018 12:31	LM	08/03/2019 13:37	LM
22	Being forced to change	18	26	12/10/2018 12:32	LM	08/03/2019 14:20	LM
23	Change talk	21	70	12/10/2018 12:35	LM	08/03/2019 14:26	LM
24	Their farm	15	53	26/09/2018 12:56	LM	08/03/2019 14:00	LM
25	Top down	18	64	26/09/2018 13:31	LM	08/03/2019 13:37	LM
26	Bottom up	20	39	26/09/2018 13:31	LM	08/03/2019 13:41	LM
27	Hosting	10	24	26/09/2018 13:39	LM	15/10/2018 16:43	LM
28	Other farmer groups	17	59	26/09/2018 14:34	LM	08/03/2019 09:48	LM
29	Farmer expertise	14	74	26/09/2018 14:42	LM	07/03/2019 13:44	LM
30	Need for external help	17	53	18/10/2018 12:47	LM	08/03/2019 13:36	LM
31	Examples of farmer know how	22	93	18/10/2018 12:47	LM	08/03/2019 13:49	LM
32	Benefits of farmer knowledge	14	40	18/10/2018 12:53	LM	08/03/2019 14:07	LM
33	Denial of expertise	7	18	18/10/2018 12:55	LM	08/03/2019 09:22	LM
34	Engaging farmers	11	52	26/09/2018 16:04	LM	15/10/2018 16:59	LM
35	Practical ideas	11	23	22/10/2018 14:55	LM	07/03/2019 13:35	LM
36	Farmer attitudes	14	26	22/10/2018 14:55	LM	08/03/2019 14:18	LM
37	AHDB	4	4	22/10/2018 14:56	LM	07/03/2019 16:21	LM
38	Top down	8	14	22/10/2018 14:56	LM	08/03/2019 10:42	LM
39	Not one size fits all	7	11	22/10/2018 17:45	LM	08/03/2019 13:59	LM
40	Time poor farmers	4	5	22/10/2018 17:47	LM	08/03/2019 13:39	LM
41	Beauties	11	19	26/09/2018 16:23	LM	08/03/2019 14:18	LM
42	Knowledge exchange	10	139	05/03/2019 17:36	LM	08/03/2019 14:22	LM

Figure 10- Two screenshots of coding workbook from NVIVO showing 'nodes' used to thematically analyse meeting transcripts

A mainly deductive approach was chosen over an inductive approach because of the wealth of subject matter covered in the discussions at each meeting, much of which was not strictly related or pertinent to the study aims. A deductive approach allowed a focused and in-depth exploration of the various processes at play when instigating and supporting changes in practice by focusing on specific areas of the method (e.g. Action Planning). It also allowed targeted analysis of semi-structured interview transcripts, which were conducted to answer specific questions (see 3.e.iii). An inductive approach could have been used to reveal further nuances and build theory out of the data (and certainly was used to follow unexpected findings that had direct relevance to the study, such as knowledge gaps and veterinarians). However, as the study was designed to foster change on farm, to learn and explore how each aspect of the approach helped and to demonstrate this to potential policy makers, a more precise analysis to understand the nature of the approach and how it brought about change was needed.

Once all the transcripts had been coded and organised into the relevant 'nodes', the second step in thematic analysis, called 'coding on' occurred (167). This second step takes a more analytical stance and links the coded text by a commonality, relationship or theme. It is sometimes referred to as axial coding (131) and involved interrogating the first set of codes/references, asking questions like: 'Can they be further grouped?', 'What relates them?', 'How do they differ?', 'What causes these comments/topics?' and 'What is the consequence of these comments/topics?'. This second step involved:

1. Reading through each of the 'nodes' containing coded text/references categorised by topic e.g. Action Planning
2. Asking the questions outlined above and making memos in NVIVO in response
3. Interrogation of the coded data (i.e. exploring how each reference differs, what relates them and what are the common themes linking them) resulted in a series of 'spider diagrams' created by the primary researcher
4. From these diagrams, minor themes or descriptors were established that grouped and explained the coded text/references within and between the 'nodes'. For example, social learning described codes in the nodes of 'farm walk', 'highlights' and 'Medicine Reviews'. Peer-to-peer support and peer pressure covered codes in the 'nodes' of 'Medicine Reviews', 'Knowledge exchange', 'Action Planning' and 'changes in practice'.

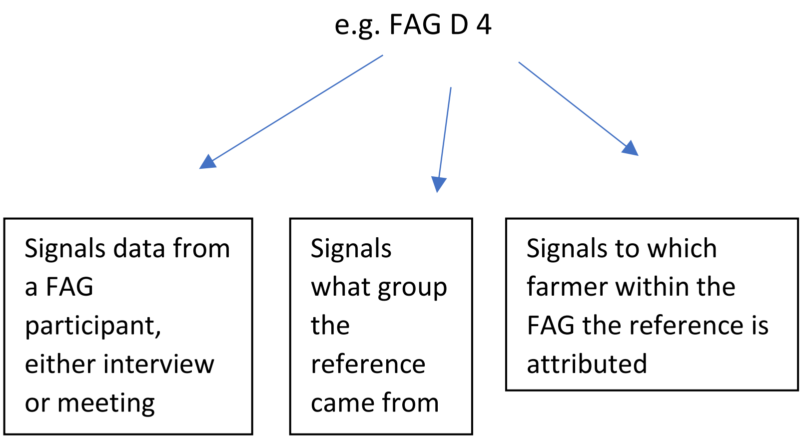
5. The major themes were established as the overarching relationship between minor themes that were developed from the analysis of the meeting transcripts and all 40 interview transcripts. For instance, the minor themes of practical learning, social learning, sharing of experience in a two-way manner, mutual learning, peer support, knowledge gaps on HPCIAs and perceived imbalances in knowledge sharing of non-participants were related and linked by the major theme of Knowledge Mobilisation i.e. the movement and flow of knowledge amongst actors.

All coding was done in NVIVO version 11 (QSR International, Australia). Double coding was performed on a random transcript with a colleague to ensure the topic coding was being adhered to in a deductive manner and was not following a more inductive approach and straying from answering the research questions. Discussion on the analytical coding, grouping of minor themes and the commonalties and themes linking the data was carried out with the author's supervisory team at the end of the analysis (November 2018).

3.e.iii. Semi-structured interviews

Semi-structured interviews were carried out with 27 farmer participants during the project after they had hosted for the first time in Phase One (June 2017 - June 2018). All interviews were audio-recorded and 16 were transcribed verbatim by an external company (Bristol Transcription Services). These 16 interviews were formally analysed using thematic analysis between February 2018 – October 2018. This number was chosen since data saturation was reached by interview 16. Data saturation was met as deemed by the interviewer before formal analysis was performed due to the re-occurrence of similar ideas/themes and the lack of novel data emerging. Interviews continued despite this in order to assess each farm's Action Plan within the scheduled interview visit (see section 3.e.v on Action Plans) but were not transcribed verbatim or analysed formally. Interviews lasted between 30 minutes and two hours. They were done on farm by the primary researcher and involved either the main farm manager or one or two extra team members (herdsmen or family members). The 16 interviews involved 15 farmers from 12 different participating farms. The topic guides followed by the interviewer is included in Appendix 6 and these interviews are referred to from herein as participant interviews.

Referencing of the qualitative data from the meeting transcripts or interview transcripts in the text of this thesis will be described herein as:



Interviews were carried out in order to understand the farmer participants' views on the project from a more personal angle (not in a group context), which was in line with the evaluative approach taken in the Stable Schools (22) and provided another source of data to fit with the principles of triangulation. The rationale for interviewing the participants was also to capture why they had joined the project in the first place and what made them carry on participating (Chapter

Five). The researcher wanted to understand how the farmer participants found working with other farmers from their perspective and what they thought were the key elements of this approach. Crucial themes around recruitment and engagement had come to the fore at the start of the study and issues around the movement of knowledge were materialising from the meetings, which had direct relevance to the research questions of how this approach supported farmers and what lessons can be learnt in order to scale-up the approach. These interviews also provided initial determinants of the relative success of the approach and captured whether changes in practice on farm had occurred and how these related to participation, arguably vital aspects of a PAR methodology working to enact change.

Interviews with those not in a FAG

Ten farmers that did not participate in the FAGs were also asked to participate in an interview to explore reasons for non-participation and their views on a farmer-led approach. This was done in order to optimise learning around recruitment and participation for future farmer-led projects and to answer the third research question about the adoptability of the approach on a wider scale. Understanding the perspectives of those who did not want to participate or who were not involved from the start was deemed to be of direct relevance. The farmer interviewees that were not in a FAG fell into one of the following three categories:

1) Not recruited in the first place due to geographical location (referred to as non-participants, NPX when using quotes in the text from these interviews)

2) Withdrawn after a year because of lack of participation in project despite signing up (referred to as withdrawals, WDX when using quotes in the text from these interviews)

3) Dropped out of the project after trialling at least one meeting (referred to as drop-outs, DOX when using quotes in the text from these interviews)

Interviews of the above groups of farmers took place between August 2016 - March 2018, so throughout the project duration. This was due to 1) interviewing four distinct groups of farmers (participants, non-participants, drop-outs and withdrawals) and the total number of interviews being quite high so taking substantial time, 2) drop-outs/withdrawals occurring at different times in the project timeline and 3) using the findings from the already commenced FAG meetings to inform the direction of the study. This follows the iterative principles of qualitative research where initial findings influence and inform study design and further social query as well as following the cyclical self-reflective process of PAR (145) . The decision to interview drop-outs and withdrawals was not taken until a year into the study.

Six dairy farmers who were not participants in the FAG project due to being in different geographical regions to the established groups were interviewed between August 2016 – March 2017. Two of these were initially pilot interviewees but due to the relevance of the data and low numbers of farmers that were not in a FAG that were interviewed in total, they were included in the formal analysis.

All participants in the research were free to leave the study at any time without having to give a reason, as per University of Bristol Faculty of Health Sciences Ethical Review Committee guidelines (see Participant Information Sheet, Appendix 2). This meant that finding out why farmers did not want to be in the project or what might have made them leave required additional follow-up. This was done by email; the primary researcher asked ten farmers who had dropped out or were withdrawn after a year whether they wanted to participate in an approximately one-hour semi-structured interview to share their thoughts on the project and why they chose to stop participating. This interview was completely voluntary, and some farmers decided not to respond to the email requests (n=6). No follow-up email was sent. Four farmers did respond and were happy to participate in an interview. The primary researcher conducted the interviews on farm between January 2017 - March 2018. A summary of the attributes of the farmer interviewees not in a FAG is presented in Appendix 12.

A final sub-set of interviews were with 14 farm animal veterinarians. These took place in veterinary practices and at a national veterinary conference between October 2016 – October 2017. A description of their attributes is in Appendix 12 along with the topic guide in Appendix 9. All veterinarians were asked for their thoughts on a farmer-led approach, their experience of farmer groups, creating change on farms and the notion of farmer expertise. Quotes from veterinarians in the text are referred to by 'VX'. The decision to interview veterinarians was made due to the difficultes in recruiting via veterinarians (the project Gatekeepers) and the concerns they had about the approach (Chapter Four and Five). Nine of the interviewed veterinarians had been approached by the primary researcher during recruitment and asked for assistance in recruiting farms, one of which had successfully recruited two farms, seven had reportedly tried but no farmers were recruited and one was openly cynical of the approach.

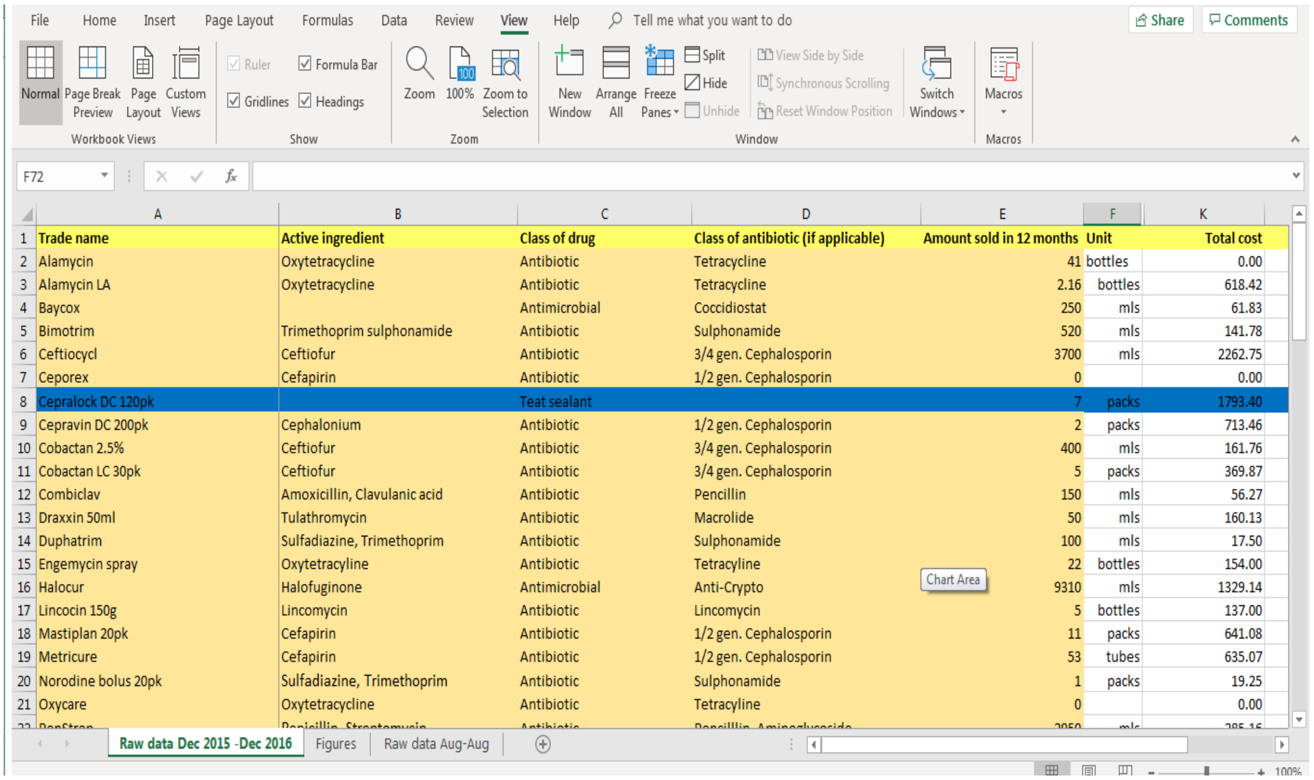
The same approach to interview data analysis as described for the FAG meetings transcripts was followed and the results assessed and reflected on in parallel in an integrative approach (167). Findings from the interviews and FAG meetings were integrated to inform the final analysis and findings from the study in tandem. This is in line with the principles of triangulation whereby different methods and aproaches to the same questions are performed and re-inforce the conclusions. Comments raised in the initial interviews were fed into FAG meeting discussions and vice versa. For instance, comments and views on farmer expertise, AMS or the best way to recruit and enagage farmers were relayed to the FAGs and to interviewees to evaluate their response and stimulate discussion.

3.e.iv. Medicine Reviews

The Medicine Reviews consisted of quantitative data. Initially designed to measure a change in AMU over time, they became far more applicable as participatory tools to foster discussion at the FAG meetings. Thirty Medicine Reviews were conducted, one for each participant farm. Each review covered two consecutive 12-month periods - from the start of the project through to the end - in order to measure and assess any changes or reduction in AMU. Twelve months was chosen as an adequate time period for the reviews due to covering all four seasons, allowing for differing disease prevalence and thus differing AMU patterns (173). By following two consecutive 12-month periods, any changes in AMU could be observed. Due to the time constraints of the project, only two years' worth of medicine data was able to be collected and processed.

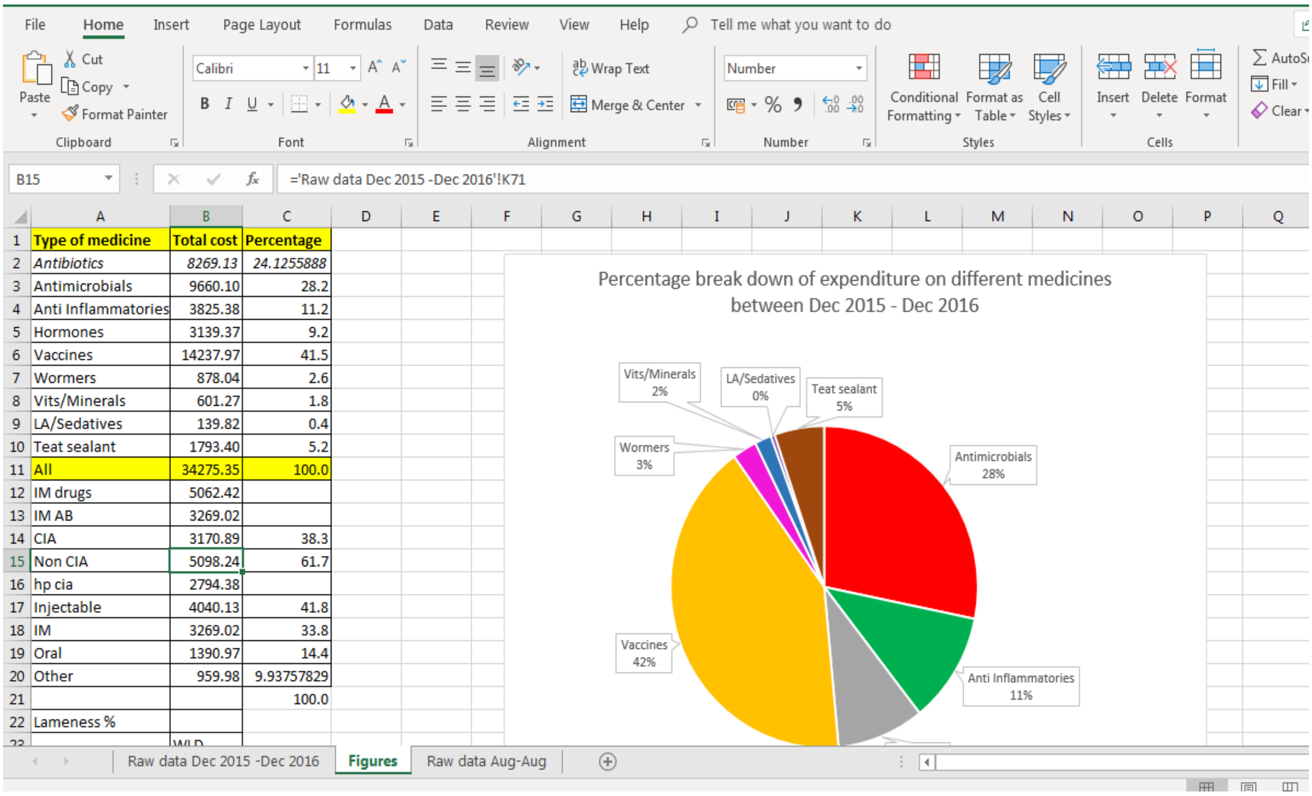
Veterinary prescription data was the basis for the reviews, with the exception of three farm participants where it was impossible to obtain veterinary prescription records for reasons the veterinarians were unwilling to disclose (the reason for this was not firmly established). These Medicine Reviews were therefore based on farm medicine records only. Using veterinary prescription data for 27 of the reviews reflected the amount of antimicrobial *sold* to farm rather than what was actually used (173). Nevertheless, veterinary prescription data is a fair proxy of AMU (56) and was the most reliable data for the majority of farm participants at the time of starting the project. On-farm medicine records were also obtained for each farm participant so as to increase the level of detail and accuracy of the review (173). These data were useful for collecting modal course lengths, daily doses and allocation of certain medicines to certain categories of stock (e.g. to determine injectable antibiotics that were used for calves versus adult cows, compared to assuming all farms followed the product data sheet recommendations). These data were collected and interpreted in collaboration with the farmer participant at the start of the project at the pre-visit (Figure 3). For example, the primary researcher and farmer would go through the medicine book together clarifying which medicines were used in which animal and discuss where to find certain information, such as health parameters or production figures.

The veterinary prescription data for the 27 farmer participants was provided by 15 veterinary practices from across South West England. This data was provided in various formats such as Microsoft Excel for Office 365 spreadsheets, PDF documents and scanned images, and also included expenditure for each product sold. All raw data was kept confidential and not shared more widely than the research group. Signed consent was provided by the farmer participants for the primary researcher to collect the data and veterinary practices were encouraged to liaise with the farmers participating in the project. Data were then processed and inputted into Microsoft Excel for Office 365 as a count of the number of each antimicrobial sold to the farm (number of bottles and therefore millilitres, number of tubes and/or units) and the total expenditure on each group of medicines (Figure 9).



	Trade name	Active ingredient	Class of drug	Class of antibiotic (if applicable)	Amount sold in 12 months	Unit	Total cost
2	Alamycin	Oxytetracycline	Antibiotic	Tetracycline	41	bottles	0.00
3	Alamycin LA	Oxytetracycline	Antibiotic	Tetracycline	2.16	bottles	618.42
4	Baycox		Antimicrobial	Coccidiostat	250	mls	61.83
5	Bimotrim	Trimethoprim sulphonamide	Antibiotic	Sulphonamide	520	mls	141.78
6	Ceftiocycl	Ceftiofur	Antibiotic	3/4 gen. Cephalosporin	3700	mls	2262.75
7	Ceporex	Cefapirin	Antibiotic	1/2 gen. Cephalosporin	0		0.00
8	Cepralock DC 120pk		Teat sealant		7	packs	1793.40
9	Cepravin DC 200pk	Cephalonium	Antibiotic	1/2 gen. Cephalosporin	2	packs	713.46
10	Cobactan 2.5%	Ceftiofur	Antibiotic	3/4 gen. Cephalosporin	400	mls	161.76
11	Cobactan LC 30pk	Ceftiofur	Antibiotic	3/4 gen. Cephalosporin	5	packs	369.87
12	Combiclav	Amoxicillin, Clavulanic acid	Antibiotic	Pencillin	150	mls	56.27
13	Draxxin 50ml	Tulathromycin	Antibiotic	Macrolide	50	mls	160.13
14	Duphatrim	Sulfadiazine, Trimethoprim	Antibiotic	Sulphonamide	100	mls	17.50
15	Engemycin spray	Oxytetracyline	Antibiotic	Tetracyline	22	bottles	154.00
16	Halocur	Halofuginone	Antimicrobial	Anti-Crypto	9310	mls	1329.14
17	Lincocin 150g	Lincomycin	Antibiotic	Lincomycin	5	bottles	137.00
18	Mastiplan 20pk	Cefapirin	Antibiotic	1/2 gen. Cephalosporin	11	packs	641.08
19	Metricure	Cefapirin	Antibiotic	1/2 gen. Cephalosporin	53	tubes	635.07
20	Norodine bolus 20pk	Sulfadiazine, Trimethoprim	Antibiotic	Sulphonamide	1	packs	19.25
21	Oxycare	Oxytetracyline	Antibiotic	Tetracyline	0		0.00

Figure 11 - Example raw data input workbook in Microsoft Excel for counting antimicrobial usage per farm



	Type of medicine	Total cost	Percentage
2	*Antibiotics*	*8269.13*	*24.1255888*
3	Antimicrobials	9660.10	28.2
4	Anti Inflammatories	3825.38	11.2
5	Hormones	3139.37	9.2
6	Vaccines	14237.97	41.5
7	Wormers	878.04	2.6
8	Vits/Minerals	601.27	1.8
9	LA/Sedatives	139.82	0.4
10	Teat sealant	1793.40	5.2
11	All	34275.35	100.0
12	IM drugs	5062.42	
13	IM AB	3269.02	
14	CIA	3170.89	38.3
15	Non CIA	5098.24	61.7
16	hp cia	2794.38	
17	Injectable	4040.13	41.8
18	IM	3269.02	33.8
19	Oral	1390.97	14.4
20	Other	959.98	9.93757829
21			100.0
22	Lameness %		

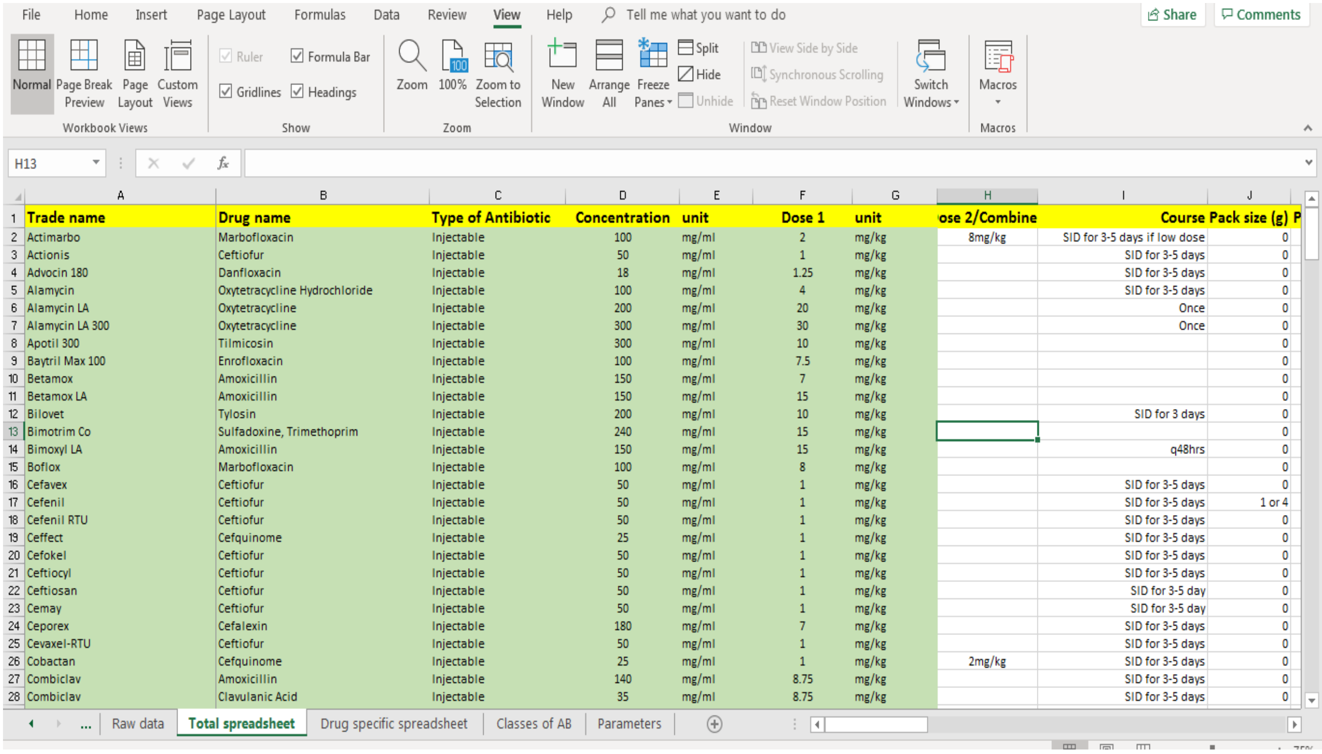
Figure 12 - Example expenditure calculations workbook in Microsoft Excel, one completed per farm

Costings were done as part of the Medicine Review process, which tallied percentage expenditure on different types of medicines per year, pence per litre (PPL), percentage expenditure on HPCIAs versus non-HPCIAs and percentage expenditure on different forms of antimicrobials (i.e. intra-mammary, injectable, oral, other). The presentation of this type of data was becoming more commonplace in the industry at the time of the study (31) and helped stimulate discussion amongst farmers.

Data from the initial questionnaire (Appendix 5) carried out with each farmer participant in the pre-visit (Figure 3) included details about stock numbers (total number of calves in the year and average number of adult stock in the year) and annual milk production (as sold). This was recorded in Microsoft Excel for Office 365 along with the Medicine Review data. Categories of stock were chosen based on the Danish categories (52) which were deemed the most similar to the UK dairy sector in 2016 and were the most feasible for data collection.

- Calves= <12 months old
- Youngstock= >12 months old and not yet milking
- Adults= milking stock (dry and lactating)

Figure 11 shows part of the Medicine Review template used to calculate the various AMU metrics selected for this study. This template was created by the primary researcher and lists all licensed antimicrobial products for cattle in the UK from the VMD database. Data from Summary of Product Characteristics (SPCs) was used to input active ingredients, routes of administration, concentrations, dosages, course lengths and pack sizes/volumes. Where a range of values was given on the SPC, for instance for dosing, the median figure was taken. At the time of starting this study, no such spreadsheet or template was available in the UK.



	Trade name	Drug name	Type of Antibiotic	Concentration	unit	Dose 1	unit	ose 2/Combine	Course	Pack size (g)
2	Actimarbo	Marbofloxacin	Injectable	100	mg/ml	2	mg/kg	8mg/kg	SID for 3-5 days if low dose	0
3	Actionis	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 days	0
4	Advocin 180	Danfloxacin	Injectable	18	mg/ml	1.25	mg/kg		SID for 3-5 days	0
5	Alamycin	Oxytetracycline Hydrochloride	Injectable	100	mg/ml	4	mg/kg		SID for 3-5 days	0
6	Alamycin LA	Oxytetracycline	Injectable	200	mg/ml	20	mg/kg		Once	0
7	Alamycin LA 300	Oxytetracycline	Injectable	300	mg/ml	30	mg/kg		Once	0
8	Apotil 300	Tilmicosin	Injectable	300	mg/ml	10	mg/kg			0
9	Baytril Max 100	Enrofloxacin	Injectable	100	mg/ml	7.5	mg/kg			0
10	Betamox	Amoxicillin	Injectable	150	mg/ml	7	mg/kg			0
11	Betamox LA	Amoxicillin	Injectable	150	mg/ml	15	mg/kg			0
12	Bilovet	Tylosin	Injectable	200	mg/ml	10	mg/kg		SID for 3 days	0
13	Bimotrim Co	Sulfadoxine, Trimethoprim	Injectable	240	mg/ml	15	mg/kg			0
14	Bimoxyl LA	Amoxicillin	Injectable	150	mg/ml	15	mg/kg		q48hrs	0
15	Boflox	Marbofloxacin	Injectable	100	mg/ml	8	mg/kg			0
16	Cefavex	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 days	0
17	Cefenil	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 days	1 or 4
18	Cefenil RTU	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 days	0
19	Ceffect	Cefquinome	Injectable	25	mg/ml	1	mg/kg		SID for 3-5 days	0
20	Cefokel	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 days	0
21	Ceftiocyl	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 days	0
22	Ceftiosan	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 day	0
23	Cemay	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 day	0
24	Ceporex	Cefalexin	Injectable	180	mg/ml	7	mg/kg		SID for 3-5 days	0
25	Cevaxel-RTU	Ceftiofur	Injectable	50	mg/ml	1	mg/kg		SID for 3-5 days	0
26	Cobactan	Cefquinome	Injectable	25	mg/ml	1	mg/kg	2mg/kg	SID for 3-5 days	0
27	Combiclav	Amoxicillin	Injectable	140	mg/ml	8.75	mg/kg		SID for 3-5 days	0
28	Combiclav	Clavulanic Acid	Injectable	35	mg/ml	8.75	mg/kg		SID for 3-5 days	0

Figure 13 - Template Excel spreadsheet containing all Veterinary Medicine Directorate cattle licensed antimicrobials and their Summary of Product Characteristics

The data from the total amount or number of antimicrobials used on each participant farm (Figure 9) was then transferred to a separate sheet in the Medicine Review workbook for calculation into AMU metrics. This sheet presented each farm's AMU in the following metrics:

1. Cow Calculated Courses (CCC)
2. Animal Daily Doses (ADD)
3. Milligrams of antimicrobial per 1000 litres of milk (mg/1000L)
4. Milligrams of antimicrobial per kilogram biomass (mg/kg)
5. Grams of antibiotics from intramammary tubes per cow per year (g of AB/cow/yr)

Metric 1. was being used by a retailer group and several veterinary practices at the start of the project (141). Metrics 2. and 3. were included at the direct request from participant farmers. Metric 2. was also used for farm AMU reporting in the Netherlands and after a study tour with some of the farmer participants to the Netherlands in October 2016 (Appendix 14), this was chosen as a preferred metric for the Reviews. Metrics 4. and 5. were used in the VARSS report (36, 58) although some adaptations to the calculations were made for this project.

These metrics were chosen because they were already in wide use in the industry (173) and/or were being used to measure national AMU in the UK (58) as well as other countries in Europe, such as the Netherlands and Denmark (51-53). Many retailers, processors and veterinary practices have decided upon their own metric to measure and benchmark producers' AMU in attempts to encourage best practice. In an effort to clarify and assess the relative pros and cons of the different metrics, Mills and colleagues (which includes the author) compared the most popular or widely used metrics in the dairy sector using data from farms in this study to see how much these metrics varied (173). There are pros and cons to all AMU metrics, and it is recommended that the limitations of each metric along with what each metric accounts for is made explicit.

The different metrics in common use can be grouped into three categories: (1) metrics based on the weight of the antimicrobial, usually in mg; (59) metrics based on daily doses; (3) metrics based on course doses. Regardless of which metric is used, the numerator reflects the amount of antimicrobial sold to or used on a farm, which can be collected from the farm medicine records or veterinary sales data (or pharmaceutical sales as is the case with the VARRS report). It is recognised that on-farm medicine records are extremely variable in quality and often under-represent what is actually used (32), whereas veterinary sales data represents a fair proxy of actual use (31). This variation in quality of records is a major barrier to responsible AMU and a source of concern for policy makers and retailers trying to demonstrate responsible AMU in the supply chain (54).

The denominator of most metrics represents the population at risk of treatment and poses another challenge in terms of quality data and accurate stock information. The denominator is commonly the biomass of animals at risk of treatment in a year (number of animals multiplied by weight). It can alternatively be a production output, such as litres of milk. Defining the population at risk is not straightforward, even with the British Cattle Movement Service (BCMS) theoretically having this data for each farm or County Parish Holding (CPH) number. Currently, third party access to BCMS data is required and this can be difficult to obtain (i.e. was not possible for this research). At the time of writing, BCMS is transitioning to a new service called the Livestock Information Programme (LIP), which could prove to be an excellent opportunity to copy advanced data systems such as 'VetStat'. It is the view of the author that by developing improvements to medicine recording using centralised databases and reducing the need for information direct from farmers, then the accuracy and ease of AMU data collection can be maximised.

There were three main adaptations made for the Medicine Reviews compared to national reporting:

1) using different denominators when calculating the metrics compared to national figures (particularly Metric 4.). VARSS and ESVAC used cattle weights established from slaughter data to represent treatable weight (36). The standard UK cattle weight used was 425 kg and only accounted for adult stock numbers. For the FAG project, the researcher decided to use the Dutch weights, which the farmer participants felt were more representative of UK farm stock at time of treatment:

- 100kg= average weight of a calf <12 months old
- 300kg= average weight of young stock >12 months old but not yet calved
- 600kg= average weight of an adult milking cow (52)

2) Due to being able to allocate average weights for three distinct categories of stock on a standard dairy farm, the Medicine Review metrics also included calf numbers in the calculations and, where possible, allocated certain antimicrobials to calves only. This information came from the on-farm medicine records, discussions with farmer participants and SPC data. For example, newer antibiotics used almost exclusively to treat respiratory disease are only licensed for use on calves and non-milking stock. Therefore, it was possible to only divide the amount used by the stock biomass at risk of treatment (i.e. calves), producing a more accurate depiction of AMU. Where this level of granularity was not available, for example with use of products licensed to treat more than one stock category, it was assumed that most of the use was on adult stock due to increased volumes per dose for the correspondingly larger biomass of adults. The allocation of AMU to the youngstock category with an average weight of 300 kg was very rarely used in the 30 Medicine Reviews as this group of animals did not receive many treatments.

3) HPCIAs for this project were defined as fluoroquinolones, 3rd and 4th generation cephalosporins and macrolides, as per WHO guidelines (33). It was noted and acknowledged by the author that during the project's evolution, the European Medicines Agency (EMA) - therefore the VMD, RUMA and the National Office for Animal Health (NOAH) – issued a classification of HPCIAs including only fluoroquinolones and 3rd and 4th generation cephalosporins (174). In response to this, the primary researcher altered the classification in the reviews to exclude macrolides as HPCIAs in line with the EMA. This happened during Phase One and all Medicine

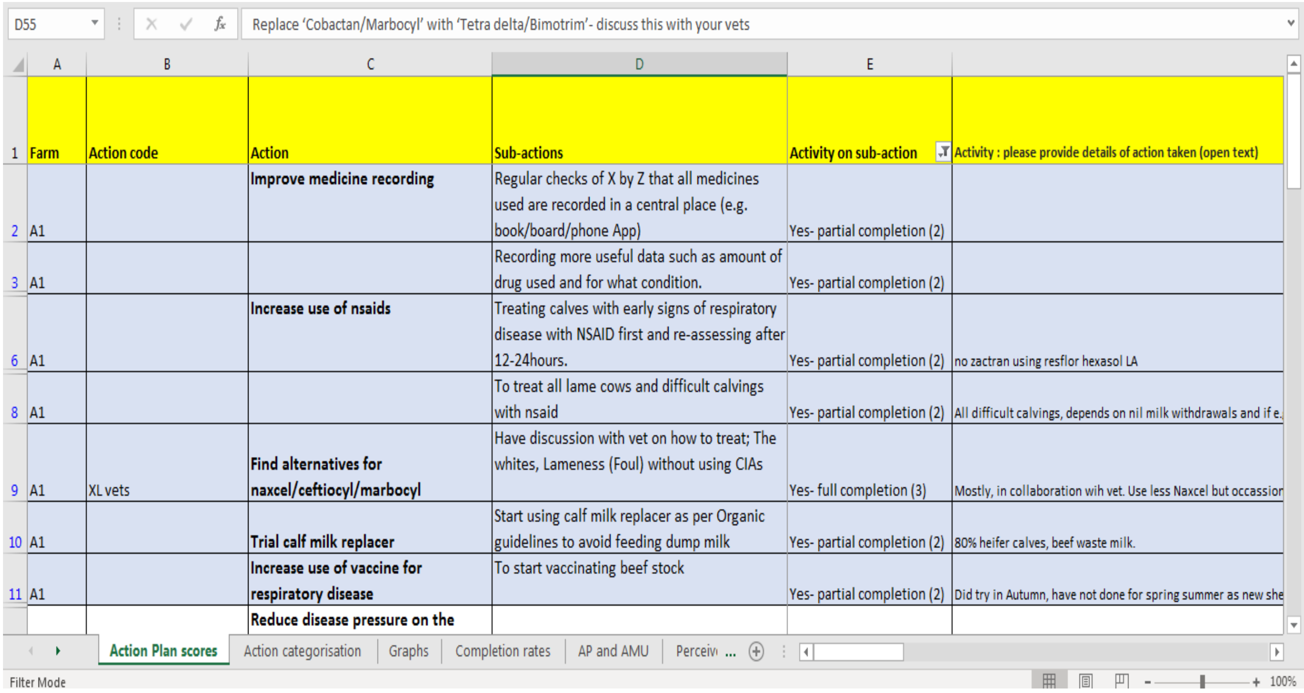
Reviews stated which antimicrobials were HPCIA. It was emphasized that macrolides are certainly still CIAs and some organisations regard them as HPCIA (175). Also, during the project, the WHO updated their guidelines to include colistin as HPCIA (although this medicine is not used in UK dairy farming so will not be further mentioned).

Once AMU had been calculated, the data were compiled into a farmer-friendly report for discussion at the FAG meeting (Appendix 10). After the first 12-month review, AMU for each farm participant was also benchmarked against the other farmers in the same FAG (Chapter Six). Benchmarking has been shown to be effective in instigating a change in practice (Chapter Two) and was used to help recruit farmers to the project. Benchmarking of AMU across the first year was used in discussions in Phase One FAG meetings. Once Phase Two commenced, the second 12-month reviews were compiled and presented in a new report that compared Year One with Year Two. A paired t-test was performed on the AMU data to check for statistical significance between the two years of the study.

3.e.v. Action Plans

The Action Plans were a further indicator of the impact of the FAG project. Thirty Action Plans were co-created by the farmer participants (one per host farm). These were a direct outcome of Phase One meetings from the facilitated discussion after the farm walk. The use of the discussion tools (as described earlier) and the skill of a facilitator was maximised to help each farmer group co-create a series of practical steps to help the host farmer reduce the need for and use of antimicrobials. It is important to add that the Action Plans were farmer-led; the researcher and facilitator had minimal input into the recommendations suggested in the process of Action Plan development. The input they did have was to either remind the group of the host farm's Medicine Review data highlighting areas of high AMU, suggesting they speak with their veterinarian about medicine changes or reminding farmers of the discussions that were had on the farm walks, which was a particular tactic adopted by the AHDB Dairy facilitator. The knowledge and experience of the group of farmer participants was the source of the Action Plan. For this reason, it was deemed crucial to have good attendance at each meeting to increase the number, variety and quality of recommendations for the host farm's Action Plan.

Phase Two meetings were focused on evaluating the host farm's Action Plan and assessing how well it had been implemented. The period between each farm participant hosting for Phase One and then Phase Two varied between eight and twelve months and was the time the farmers had to implement the practical steps from the Action Plan. At each semi-structured interview with the farmer participants, the researcher would ask the farmer about their Action Plan and what they had actioned/implemented. They were given a series of 'drop-down' answers to choose from on a spreadsheet: 'fully completed', 'partially completed', 'not yet completed but hope to', 'not at all' and 'don't know'. Participants were also asked if they perceived any benefits from implementing each specific recommendation and were asked to elaborate. These data were captured in Microsoft Excel for Office 365 and each answer was allocated a numerical score (Figure 12).


D55 | Replace 'Cobactan/Marbocyl' with 'Tetra delta/Bimotrim'- discuss this with your vets

	A	B	C	D	E	
1	Farm	Action code	Action	Sub-actions	Activity on sub-action	Activity : please provide details of action taken (open text)
2	A1		**Improve medicine recording**	Regular checks of X by Z that all medicines used are recorded in a central place (e.g. book/board/phone App)	Yes- partial completion (2)	
3	A1			Recording more useful data such as amount of drug used and for what condition.	Yes- partial completion (2)	
6	A1		**Increase use of nsaids**	Treating calves with early signs of respiratory disease with NSAID first and re-assessing after 12-24hours.	Yes- partial completion (2)	no zactran using resflor hexasol LA
8	A1			To treat all lame cows and difficult calvings with nsaid	Yes- partial completion (2)	All difficult calvings, depends on nil milk withdrawals and if e.
9	A1	XL vets	**Find alternatives for naxcel/ceftiocyl/marbocyl**	Have discussion with vet on how to treat; The whites, Lameness (Foul) without using CIAs	Yes- full completion (3)	Mostly, in collaboration wih vet. Use less Naxcel but occassior
10	A1		**Trial calf milk replacer**	Start using calf milk replacer as per Organic guidelines to avoid feeding dump milk	Yes- partial completion (2)	80% heifer calves, beef waste milk.
11	A1		**Increase use of vaccine for respiratory disease**	To start vaccinating beef stock	Yes- partial completion (2)	Did try in Autumn, have not done for spring summer as new she
			Reduce disease pressure on the			

Figure 14- Example Action Plan assessment spreadsheet in Microsoft Excel

At the Phase Two meetings, the FAG was asked to rate the benefit observed/envisaged for each practical step on the host farm's Action Plan, as well as discussing what had been implemented, what hadn't and why. The facilitator would then ask for ideas to improve or expand the Action Plan for the host farmer, creating a 'Re-Action Plan' - this was not evaluated or followed in the same way as the initial Action Plan. The comments and ideas from the group discussion were collated into the meeting summary reports in the same way as for Phase One meetings.

To assist the discussion and reflection on the host farm's Action Plan in Phase Two meetings, a card sorting exercise was done based on the individual recommendations from the Action Plan. Each individual recommendation was described on a card and the cards were shared out amongst the FAG. The participants would then discuss the individual recommendations based on the host farm's explanation of what they had done after going on the farm walk. The group would then decide which of the following categories the recommendations fell into: Success, Ongoing, Disregarded, Disaster. These categories were chosen by the primary researcher after the initial interviews with participants discussing their Action Plans.

In summary, the FAG project used a number of different methods and was based on the Stable School model. The approach to the study design and implementation followed the concepts of PAR and aimed to empower farmers with knowledge and confidence to change practices on farm around AMU. Recruitment of farms was performed in a multi-pronged fashion and made use of Gatekeepers to enhance recruitment reach, namely veterinarians and an AHDB Dairy facilitator, who assisted in establishing the FAGs. The role of facilitation in coordinating and guiding the participatory process was integral to the study design. The FAG meetings occurred in two phases; Phase One focused on the co-creation of an Action Plan and Phase Two allowed for reflection on one another's practices and assessment of the Action Plan's implementation. Medicine Reviews were carried out in order to assess any change in AMU over the course of the project but more importantly evolved as a learning aid and discussion tool around reducing AMU between participants. Quantitative and qualitative data was collected and analysed for this study and through the process of triangulation, conclusions drawn that verified and support one another. The next three chapters present the results from recruiting farms, their participation in the project and the outcomes on their farms to reduce the use of and need for antimicrobials.

Chapter Four: Recruitment to the Farmer Action Group project - Results and Discussion

4.a. Introduction

Chapter Four describes the outcome of recruiting dairy farmers to the FAG project. The different approaches taken and the outcome from each of these is described. The process of recruitment was expanded and explored as part of the research because of the challenges it posed when establishing the FAGs. The recruitment phase took longer than anticipated and the chosen Gatekeepers for this study (veterinarians) had concerns about the approach, which could explain the lack of success found using veterinarians as Gatekeepers (which is also explored further in Chapter Five). Understanding of why this was so therefore stands to improve the research and the applicability of farmer-led approaches more widely. The demographics of the participating farms are presented in this chapter with some additional discussion of those that withdrew or dropped out of the study. Results from this chapter will be a valuable resource for those working in agricultural knowledge exchange and extension.

Recruitment to the FAG project occurred between April 2016 – January 2017. Recruitment is referred to as *"the process whereby the researcher identifies and invites participants to join the study"* (176) and it is distinct from both engagement and participation. Recruitment for this study involved identifying, accessing and persuading farmer participants to join the research project. It was the first step in the PAR methodology of answering the question of 'for whom is this research for' by getting participants signed up and involved. Engagement can be viewed as the next step once recruitment has taken place. In this case, engagement involved keeping the interest of the participants maintained and interacting with them in order to add value in return for their engagement with the project outcomes. Their interaction with each other in the social setting of the FAGs was also a fundamental aspect of participation and adding value, as discussed in the next chapter. This then builds into the concept of participation, which has many definitions and is conceptualised differently by different groups (14, 99). Participation is defined and conceptualised for this project in Chapter Five. There have been attempts to develop a typology of participation, some include the process of recruitment (14, 150, 151), which was discussed in more detail in Chapter Two. Recruitment to the FAG project was the prelude to this participatory project and is the focus of this chapter.

Recruitment to the original Danish Stable School project was relatively straightforward and involved one subset of farmers - organic dairy farmers from a single milk company (22). The farmers were part of the same private milk company and were already interested in the subject of reducing AMU on farm. The farmers wanted an alternative way of reducing AMU without being made to have their veterinarian visit their farm more frequently as part of the Danish animal health service (22, 102). The group recruited from had a clear objective and motivation to tackle the issue by themselves, which consequently made recruiting farmers easier for the Stable School project.

Recruitment to the FAG project differed to the Stable Schools in two fundamental ways. On the one hand, recruitment was not limited to one milk company and, on the other, participants were not necessarily encouraged to participate by their milk buyers. The FAG participants were not doing anything different and were not being made to do anything different around responsible AMU at the time of recruitment. This is a critical difference, and given the particular challenges experienced in recruiting to the FAG project, will be specifically addressed below.

Recruitment of farms to voluntary UK initiatives has been shown to be challenging with variable levels of success (95, 164, 177). The same is found elsewhere in the world too (178) and was described in early work by Burgess and colleagues when initiating and running small groups to explore local perspectives of open spaces in and around Greenwich, UK (179). Recruitment of participants to qualitative research projects is a significant challenge, which Archibald and Munce (2016) claim is often under-reported and left to inexperienced researchers to carry out (163). Various strategies exist to overcome this specific difficulty, such as using Gatekeepers and Snowballing/Chains of Referral, but there are limitations to each of these with implications for study design, as described previously.

Archibald and Munce (2016) suggest that recruitment to qualitative studies suffers from a variety of issues that reduce success or affect study design, such as saturation of certain populations with requests to take part in studies , a mis-understanding of the target population by researchers, bias and selectivity of using existing networks and perceived time burden or lack of benefit in taking part, to name but a few (163). They call for more transparency in reporting how participants and samples are recruited, which would not only guide future researchers facing the daunting aspect of recruiting but would also improve the quality of study design (163). Techniques such as Snowballing and Gatekeeping are widely adopted recruitment methods in qualitative research (122), but a limitation to using existing networks to recruit participants is that they produce skewed or biased samples, as discussed in Chapter Two. Acknowledgement of the limitations to the various sampling strategies and how they impact on the type and demographic of participants is important for interpretation.

The issues they describe are specifically relevant to the recruitment of farmers in that the farming sector is a heavily studied and researched community (20, 98). Saturation is likely with many projects or initiatives arguably failing to prove a benefit for farmers (e.g. questionnaire surveys) or lack of acknowledgement of the concerns or needs of the target community (11).

4.b. Recruitment of farms to the FAGs

Various methods were used to recruit farms, and some were more successful than others. This has been echoed in other studies recruiting participants to small groups to explore perspectives on local open spaces:

"The practical problems in recruitment are large and take up a substantial amount of time and effort. We found it necessary to adopt a variety of strategies in response to the different circumstances in the different localities." (179)

Gatekeepers were used to access farms across South West England, alongside the techniques of Snowballing and Chains of Referral to maximise recruitment reach. The aim was to be as inclusive as possible and to ensure enough farm participants were recruited for the study (Chapter Three). Despite this, the groups were limited by geographical location to minimise travelling time to meetings. Chapter Three details the recruitment methods used and why they were chosen. This chapter deals with the results of recruiting, what was learnt through the process of recruitment and implications for future participatory projects.

4.b.i. What was the most successful approach when recruiting dairy farms to the FAG project?

Specific lunchtime recruitment meetings in collaboration with AHDB Dairy

Specific meetings to recruit participants were organised and run by the primary researcher and facilitator in collaboration with AHDB Dairy, the project funders. The recruitment meetings were aimed at encouraging local dairy farmers to find out more about AMR and discuss in an informal setting what they could do to reduce AMU. This study was then proposed as a way to help farmers reduce and rationalise AMU before legislation or other top-down measures would be put in place, as has become evident with the introduction of the Red Tractor Farm Assurance guidelines in June 2018 (6).

The facilitator used the extensive contacts of AHDB Dairy as the basis of the invite list and targeted dairy farms in the approximate regional areas within which the FAGs were to be established (Chapter Three). Burgess and colleagues describe selecting participants based on initial meetings and chose to not recruit participants that seemed *"overbearing, too talkative and unwilling to listen"* (179). Such specific and exclusive criteria were not adopted for this study for concerns of limiting numbers but initial meetings to meet farmers was adopted as a similar tactic. There were five recruitment meetings held between May 2016 and Jan 2017. Table 3 details the five separate recruitment meetings (RM) that were held prior to starting each regional FAG.

Table 3- Number of invitees to recruitment meetings and number recruited as a result

Recruitment meeting (RM)	Date	Number of farms invited	Number of farms attended	Number of farmers attended	Number of farms signed up	Drop outs/ Withdrawals
1 Wiltshire	27/05/16	209	7	9	3	1
2 Devon	25/08/16	195	15	19	9	1
3 Somerset	12/01/17	306	9	12	6	1
4 Dorset	13/01/17	207	9	10	5	3
5 FAG Cornwall[1]	13/09/16	153	11	15	12*	5
Totals		1070	51	65	35	11
Percentage			**4.8%**	**-**	**68.6%**	**31.4%**

*One farm signed up but could not make the first meeting; [1]The first FAG meeting was the RM

Table 3 shows how many farms were invited via the facilitator's network as an AHDB employee to one of the five meetings (n=1070) and then how many farms attended the meeting (4.8%; n= 51). Of the 51 farms that came to an initial recruitment meeting, 68.6% signed-up to the project (n=35). However, 31.4% of those that signed up at a RM dropped out or were withdrawn from the project because of lack of attendance over the duration of the study (August 2016 – June 2018). According to AHDB Dairy figures, there were 13,355 dairy farms in the UK as of June 2015, so approximately 8% (n=1070) of UK dairy farms were targeted via this recruitment method and only in the region of South West England. The number of dairy farms in just South West England as of June 2015 was 2,997, therefore approximately 35.7% of dairy farmers in the South West were targeted via this recruitment method (168).

Participants were able to withdraw from the project at any point without having to give a reason (as stipulated in the consent process; Chapter Three). Some participants were lost along the way and it was not always possible to determine why they dropped out of the project. Attempts were made to follow up drop-outs and withdrawals via email and explore their reasons through semi-structured interviews, the results of which are explored in Chapter Five.

Recruitment via adverts, articles and social media

Three participants contacted the researcher directly as a result of an 'NFUonline' advert**.** It is assumed the influence of the advert was widespread, but the exact numbers could not be ascertained. The National Farmers Union is an agricultural and horticultural representational body covering two thirds of agricultural land in England and Wales and has approximately 55,000 members (180).

Two of the participants that responded to the 'NFUonline' advert participated in the FAGs for the duration of the project and the remaining one withdrew early in the study. Initial feedback from this participant was that the FAGs were not adding anything to their business; they wanted similar farms to themselves in the group, which were not initially present. This sentiment was echoed later by other drop-outs and is explored further in the next chapter.

Further articles and adverts yielded no more participants. They were published after the main period of recruitment (i.e. April - October 2016) so would have potentially been of less influence on the recruitment process. There were no farmers recruited via social media (Twitter and Facebook) and a potential limitation with these is their excessively wide reach - due to the project criteria of geographical proximity of participants in the FAGs, priority was given to local recruitment methods. Any farms that may have wanted to participate in the project outside the developing regions for each FAG were not recruited**.**

Recruitment via contacts in the industry/utilising existing networks

The primary researcher had access to a network of dairy farms in Cornwall from previous veterinary work in the industry. Eleven potential farm participants were contacted from this network. Seven of these (63.6%) were initially interested in participating in the study but only four (36.4%) participated for the entire duration of the project. These farmer participants knew the primary researcher because she used to be their veterinarian - there was an element of rapport already, which helps with recruitment. Kumar (2002) and Conroy (2005) state a trusted member of the community can help with recruitment to participatory projects (80, 99) and veterinarians are seen as trusted advisors to farmers (128, 181).

In summary, the most successful method of recruitment in terms of numbers of farms reached and signed up was specific lunchtime recruitment meetings in collaboration with the project funders, AHDB Dairy. Thirty-five farm participants were signed up to the project as a result of five specific recruitment meetings from an invite list of 1070 farms, using the existing network of an AHDB Dairy facilitator. Her involvement in co-ordinating the invite list was crucial in encouraging potential participants to attend. Four participants (from a pool of 11) signed up to the project and participated for its duration based on existing relationships with the primary researcher and three farmers contacted the researcher in response to an online advert through the NFU, although only two remained in the project for its duration. Technically, the number of drop-outs/withdrawals was greatest when recruiting through specific recruitment meetings (n=11) , however, as a proportion across all three aforementioned approaches, approximately a third of those that were approached and signed up, dropped out or were withdrawn after a year. This suggests that regardless of which approach you use (recruitment meetings, NFU adverts or existing networks), approximately a third will drop-out/withdraw.

There is a gap in the literature of studies that report on the drop-out from participatory group research. One study by Burgess and colleagues from the Greenwich Open Space project discusses recruitment and membership of small groups used to explore local issues. When comparing this study's recruitment figures with Burgess and colleagues, they also found a regional difference in numbers recruited. For instance, they had a pool of over thirty people for one group but only managed to recruit 12, and only eight of them attended the first meeting (179). In another group they recruited potential 20 members but ended up with 10, and in the group where they experienced the most recruitment issues, the gender balance was most marked towards mainly males (179). The study from Burgess and colleagues may have been from over 30 years ago but little has been documented since on the success of different ways of recruiting to small group studies, especially in the environmental and farming literature. More illumination on recruitment strategies and outcomes in participatory studies could occur to aid analysis and understand drop-out from projects.

4.b.ii. What was the least successful approach when recruiting dairy farmers to the FAG project?

Speaking at specific retailer farmer meetings

Advertising the FAG project at three regional farmer meetings to discuss plans for reducing AMU within a specific farmer group aligned to a major retailer did not yield any farm participants. Approximately 80 farmers attended these three meetings and although some interest was shown in the project at the meetings, no farmers requested to sign up. This pool of farmers was already engaged with AMS polices (141) and on speaking with various producers in the pool after the events, they voiced time as a major limiting factor to joining another project. There was a concern that the monthly proposed meetings for the FAG project were too frequent. This feedback was incorporated into the project design and consequently meetings were held every six to eight weeks.

Farmers also described a sense of saturation when it came to farmer discussion groups and meetings, as this quote from a veterinarian with clients in the producer pool illustrates:

> *"The group does contain a number of premium supermarket producers who are under pressure to reduce their antibiotic usage and we have already had several meetings on the subject over the last 12-18 months, so it is not a new subject for them." VET EMAIL 1*

This was a producer group that was proactive and progressive by default of their contract. Nevertheless, they already had multiple events and meetings to attend and could not fit in another such as the FAG project. This may be why recruitment via this method was so poor compared to the Stable School project and is further supported by Archibald and colleagues (163).

Another reason why this route of recruitment was less effective than anticipated was the communication structure within the producer group. All contact with the farmers was made through a designated veterinarian and two farmer representatives, who essentially acted as Gatekeepers. It is recognised that using Gatekeepers to recruit participants is prone to bias (165) and that Gatekeepers may have their own agenda and biases (whether consciously or not), which makes fully inclusive and fair recruitment difficult to achieve.

The results of this recruitment method contrast with the approach used in the Stable Schools and may be partly due to differences in milk buyers and milk supply chain structures between countries (182). The Stable Schools recruited from one milk company's producer pool but had better success. Milk buyers and retailers in the UK can have a significant role to play in driving changes in practice on UK dairy farms (183), demonstrated by the adoption of Johnes control strategies (184). Retailers and processors are recognised by others in the industry, such as veterinarians, as having the ultimate say in what does/does not happen on farms:

> *"I think all this recent Johne's drive, it's been successful because more people have joined it, but they've joined it because MILK BUYER and MILK BUYER have said, 'Look, if you don't do it, I'm gonna deduct 8p off your litre.' And that's the best incentive for a farmer. Farmers, even if they know hidden losses or obvious losses due to certain diseases, it's sometimes very difficult to get them to do something about it, for the reasons we've mentioned. Threatening them with a penalty is always a good idea – not coming from us – we want to be on their good side. We want to say, 'Right, the dairies are threatening to take some money away from you. Sit down with me and I'll help you get through it.'" V11*

For this reason, it might be assumed that farmers will respond to milk buyers' and retailers' demands and wishes. If these bodies were to promote or encourage participation in projects such as the FAGs, then more farmers may have joined in a shorter space of time. Furthermore, farmers that might not have been interested or disengaged with AHDB might have tried it, with surprising results (89). The involvement of retailers and other large corporates in the food supply chain may also hinder the participatory nature of a farmer-led project and could be detrimental (24). More research is needed to elucidate the effect of retailer involvement in motivating attendance.

Recruitment via veterinarians

Veterinarians were the chosen Gatekeepers for the study - as discussed previously they provide a trusted link to many farmers and help overcome access issues. *Direct* recruitment from a veterinary practice in this study meant the farmer participant contacted the researcher to join the project as a direct result of their veterinarian telling them about the project. *Indirect* recruitment from a veterinary practice meant a list of potential dairy farmers was provided to the researcher by the veterinarian and they were subsequently approached to participate by the researcher.

Sixteen veterinary practices were contacted to help with recruitment and become Gatekeepers to the study. This number of practices were chosen so as to give an even coverage over the main counties in the South West (Cornwall, Devon, Somerset, Dorset, Wiltshire). Veterinary practices were selected based on their geographical location (i.e. in South West England) and whether they specialised in dairy cattle. Practices with a good relationship with the researchers were prioritised.

Only one veterinary practice recruited one farmer *directly*. A further one practice attempted to recruit farmers *directly* but was unsuccessful. One practice provided a list of five farmers that the researcher could contact to join the project (i.e. *indirect* recruitment). From this practice, only two farms were successfully recruited. Four farmers were additionally recruited from the primary researcher's previous veterinary client base.

Overall, four practices (25%) responded favourably to the project and assisted in recruitment, albeit with some concerns about the methodology (Chapter Five). Six practices (37.5%) responded positively to the request to recruit farms to the project but no farms were recruited. Four practices (25%) did not respond and only two practices (12.5%) responded negatively to the request to recruit farms to this project. Responding negatively was defined as expressing concern about the project and farmers' knowledge on responsible AMU *and* offering no help with recruitment. Out of the thirty farm participants in the FAG project, only three were recruited via veterinarians acting as Gatekeepers[2]. Table A1 in Appendix 1 details the outcome of liaising with each veterinary practice for recruitment.

Several veterinarians had reservations about the project, particularly over the risk of poor practice and misinformation spreading between farmers in the group meetings. For example, one veterinarian wrote in an email to the author:

> *"I agree the peer-to-peer method of learning is effective but MUST be guided quite carefully or myths/incorrect information can get perpetuated and become "facts" to a group. I see it a lot with our spring grazing dairies who have a lot of discussion groups facilitated by X and when they stray into veterinary topics can certainly go off on the wrong direction if someone in the group holds firm views that are "wrong"! So a veterinary-facilitated group should have a real benefit as they could be guided more with evidence-based knowledge." VET EMAIL 2*

[2] **T**wo of these were contacted by the primary researcher after being approached by their veterinarian (indirect recruitment) and then came to a regional recruitment meeting to find out more about the project, so these could also be included in recruitment through the lunchtime meetings although they were accessed through their veterinarian. This figure does not include the researcher's previous clients.

This is a justified concern and one that is likely to be present in the industry already (143, 170). Nonetheless, it raises questions about who decides what correct and valuable knowledge or advice is. The assumption that malpractice could spread assumes farmers knowledge is somehow less valid than veterinary knowledge. This idea is explored further in Chapter Five.

The original recruitment strategy was to ask veterinary practices for a list of dairy clients that the researchers could contact; however, this was generally unsuccessful. As the author is a veterinarian and appreciated the time constraints on veterinarians, it was deemed desirable to avoid asking the veterinarians to do too much extra work, such as explaining the research project to their farming clients to the extent that was necessary (i.e. informed consent). Therefore, the suggestion that veterinarians provided a list of dairy farms that the author could contact to explain the research was prioritised instead. Unfortunately, veterinarians involved in the project were worried about data protection and passing on clients' details to the researcher.

> *"XXX is a bit concerned about us giving you data in future because of data protection stuff - I suspect you may know more on this, but she thinks that we will need to get written consent from each client ourselves too." VET EMAIL 3*

Related to commercial sensitivity, veterinarians also voiced concern about 'allowing' clients to participate in research with farmers from other practices. There was apprehension that other veterinary practices (often close competitors) were involved in the project and that they might 'steal' clients. It was proposed to the researchers that a FAG could consist of only one practice's clients. Another veterinary practice even suggested being the only practice involved in the project. Both these suggestions had to be rejected due to limiting the inclusivity of recruitment and the potential for biasing the results. Sensitivity to the commercial interests of veterinary practices should be considered when using veterinarians as Gatekeepers and exploring this avenue to recruit farmer participants.

These comments from veterinarians suggest that despite the advantages of the close farmer-veterinarian relationship (ability to access many dairy farms and target certain individuals to improve inclusivity), there are also drawbacks. These comments prompted the researchers to interview farm animal veterinarians to further explore these issues (Chapter Five).

Recruitment via agricultural shows and events

No farmer participants were recruited via this method, which suggests it is not an effective method to recruit dairy farmers to participatory research projects in the UK. Table 4 details the events attended and their potential reach. The events, however, did prove beneficial in liaising with Gatekeepers (specifically veterinarians).

Table 4 - List of different agricultural events attended by the primary researcher

Event	Date	Potential number of farmers reached
Grasslands farm walk (Wiltshire)	04/05/16	~100
National Milk Records Gold Cup day	25/05/16	NA
Royal Cornwall Show	09-11/06/16	NA
AHDB Women in Dairy talks	26/07/16	21
Duchy Young farmers Enterprise group workshop	31/08/16	15
The South West Dairy Show alongside AHDB Dairy	Oct 2016	NA

Liaising with Gatekeepers has been shown by Miller and colleagues to be helpful in approaching 'hard-to-reach' groups (165). Nevertheless, attending farm shows and events was essentially like 'cold-calling' where no prior relationships with participants existed. The primary researcher was unknown to many of the groups spoke to at the various agricultural events, so the element of trust that is so pivotal in participatory groups (159)and the farmer-veterinarian relationship (127) were both missing. Due to these results, this method cannot be recommended as an effective way to recruit to farmer-led projects in England.

4.b.iv. How did participants hear about the project?

The most common way farmers heard about the project as well as a leading factor in why they signed up to the study were the AHDB Dairy recruitment meetings.

"*I think it was a flyer that came through the post with AHDB." FAGW1*

"Because we only heard about it through AHDB." FAGD2

> *"Yeah, it's definitely AHDB that got me involved." FAGW3*

> *"What made you actually sign up in the first place? …It was that meeting [Recruitment meeting] wasn't it?...[]...I think that inaugural meeting you had at the xx was the first time it really flagged up to me what we were doing I think, seriously." FAGDe2*

Farmers voiced that the recruitment meetings were informative and a persuasive factor in joining the project. AHDB's network was important in reaching as many farmers as possible. The levy body was a familiar name which is funded by the farming community so there was an element of 'getting something back' by signing up. The collaboration between the researcher and the AHDB Dairy project facilitator was a further factor in the success of the recruitment meetings; farmers that knew the facilitator were persuaded to join the project. The facilitator had an existing network in certain areas and many farmers had met her before and commented on her skills and character as a positive factor.

> *"…from the farmers' point of view, she's very good at control, and she's very good at channelling your energy into what you've got to go out of it. You know that having an objective and meeting your objective at the end, she's brilliant at that." FAGW3*

> *"I've once been to a talk and compared to her colleagues she was much better at keeping us on track." FAGW4*

This supports the idea that a pivotal community member is influential when recruiting farmers to participatory projects (11). Gatekeepers not only have existing networks to call upon when recruiting but act as a familiar face for farmers, which can help if farmers are uncertain about signing up. This uncertainty is explored further in Chapter Five.

Some participating farmers also helped encourage more farmers to join the project (i.e. Snowballing), which further supports the idea of using existing networks and having a trusted member of the community involved in recruitment.

> *"I was over at PARTCIPATING FARMER with somebody else, and PARTICPATING FARMER said, I'm sure it was him and he said, 'Can we join you?'" FAGW4*

The extent of the technique of Snowballing in recruitment was not fully captured and assessed. However, this work provides evidence that some farmers mentioned joining the project amongst their own networks and provided a reason for some to sign up.

4.b.iv. Who was recruited? Participant farm demographics

Thirty dairy farms from South West England participated in the FAG project for the whole duration of the study from July 2016 – June 2018. Details of the participant farms are shown in Table 5, with key herd parameters correct at the time of starting the project in 2016. Many farm parameters - such as herd size - changed over the course of the two years that data were collected. These herd parameters were not followed for changes or analysed over the course of the study after initial data collection but were used to describe the population of participants.

Table 5 - Demographics of participating farms

Farm participant	**Organic (O) vs. Conventional (C)**	**Calving pattern**	**Milking herd size**	**Cow breed**	**Farm owner (FO) vs. Farm worker (FW)**	**Av. Milk production per cow per year (L)**
A1	O	AYR	180	H-F	FO+FW	9000
A2	C	Seasonal	590	X-breed	FO	7000
A3	C	AYR	149	H-F	FO	7718
A4	C	AYR	138	H-F	FO+FW	7500
A5	C	Seasonal	230	Holstein	FO	11,795
B1	C	Spring	140	X-breed	FO	6750
B2	C	Autumn	330	X-breed	FW	5575
B3	C	AYR	68	Holstein	FO	9476
B4	C	Spring	198	X-breed	FW	5120
B5	C	Spring	125	Jersey	FO	3700
B6	C	Seasonal	130	H-F	FO	6000
B7	C	AYR	120	H-F	FO	7600
C1	C	Spring	259	X-breed	FO	4350
C2	C	Autumn	265	X-breed	FO	6500
C3	C	Seasonal	100	H-F	FO	9000
C4	C	Autumn	257	H-F	FO	8500
C5*^	C	AYR	165	Holstein	FO	11,000
C6	C	AYR	89	H-F	FO	8855
C7	O	AYR	270	H-F	FO	8279
C8^	C	AYR	294	Holstein	FO	11,200
D1^	C	AYR	489	Holstein	FW	10,500
D2	C	AYR	240	H-F	FW/FO	8225
D3	C	Spring	120	X-breed	FO	5500
D4	C	AYR	141	H-F	FO	8400
D5	C	AYR	284	H-F	FO	8000
E1^	C	AYR	210	Holstein	FO	10,200
E2	C	Spring	222	X-breed	FO	3700
E3	C	Dual	350	X-breed	FW	6500
E4*^	C	AYR	122	Holstein	FO	10,500
E5	C	AYR	93	H-F	FO	8200

*robotic milking system; ^zero grazing; H-F= Holstein Freisian; X-Breed= Cross breed; AYR= All year-round calving pattern; FO= representative from farm, responsible for farm including tenant farmers; FW= representative from farm, employed as staff

All thirty farm participants hosted a FAG on their farm twice between August 2016 – June 2018, except two farms that only had one meeting on each of their farms.[3] Only two organic dairy farms were recruited to the study; this is a major difference to the Stable Schools which were comprised only of organic dairy farms initially.

Farms with a range of calving patterns were recruited to the study, which reflected the different types of calving management in the UK dairy industry. Almost 70% were all-year-round (AYR) calving herds and 33.3% were block calving herds (spring, autumn or dual), which reflects slightly more block calving herds compared to national figures. In the UK in 2017, 19% of dairy herds were block calving and 81% were AYR (10). These figures are predicted to move towards more block calving herds in the near future (10).

The average number of milking cows on recruited farms was 212; the national average in England in 2017 was 150, so the average herd size of study farms was slightly larger than the national average. This could be a result of recruiting in just the South West of England where there are more dairy farms, or it could be a result of the types of farmers interested in a project on AMU. The invite list co-ordinated by the AHDB Dairy facilitator did selectively target larger herds in the hope they were more likely to engage with discussion groups and potentially more interested in reducing AMU. This was a decision made by the facilitator and was not evaluated further.

The average milk yield per cow per year (2015/2016) for recruited farms was 7821 litres, which is lower than the UK average for 2015 which was 7849 (185). The fact that study herds tended to produce less milk but have slightly larger herds on average may be an artefact of having a block calving herd bias participating. Block calving herds in the UK tend to have lower yields and based on extensive pasture-based systems (10).

The majority of farmers representing the participant farms at FAG meetings were the farm owners. Where farm workers were the recruited participants in the project, 43% of them either left the farm or were made redundant during the project duration. This result is of interest for further adoptability of this approach because recruitment may need to be targeted towards farm owners

[3] This was because one participating farmer moved to another job on a different farm in a different area (E3) and the other farm wanted to postpone hosting a second time indefinitely as he was struggling to fit it in before the project ended (B7). One farm exited the dairy industry completely in 2018 but had hosted twice by the close of the project (D3). Two participating farm workers were made redundant before the end of the project (D1 and B2). Luckily, the farms they worked on had already hosted twice by the time they left their jobs. Unfortunately, the farms they moved to could not be involved in the project due to lack of time to fit in a further two visits per new farm.

in order to ensure continued participation. It also follows that farm owners have more control and decision-making capacity on farm than farm workers so implementing changes to management is more likely.

As a backdrop to the recruitment phase, the annual farmgate milk price crashed just before the study commenced due to a fall in global wholesale prices. This left the average farmgate milk price at 23.7 pence per litre for 2016 when recruitment began compared to 31.5 pence per litre in 2014. The Brexit referendum also occurred during the recruitment phase (June 2016). The socio-political background is likely to have had an effect on farmer capacity to join a participatory project on reducing AMU (186) but the effect of this has not been evaluated.

Drop-outs and withdrawals

Some farms left the study before hosting in Phase One and were not included in the final figure of 30 participant farms. These were referred to as drop-outs or withdrawals. Drop-outs were further defined as farms that signed up to the project and attended at least one meeting (i.e. a FAG meeting) and then dropped out. These differ to farms that withdrew from the project in that withdrawals were defined as farms that signed up to the study but did not attend any FAG meetings. By October 2017 these withdrawal farms were assumed to be not participating, whether the researchers had been informed by the farmers or not. Table 6 illustrates that each FAG had at least one farm drop-out or withdraw. The majority of these were early in the project (within a year of starting). If there had been no drop-outs or withdrawals, 44 farms would have been recruited and participating across the five FAGs.

Table 6 - Number of participants in each FAG and percentage loss from each FAG

FAG	Number of farm participants by end of project (June 2018)	Number of drop-outs/ withdrawals	Percentage loss (%)
FAG 1	5	3	37.5
FAG 2	7	5	41.7
FAG 3	8	1	11.1
FAG 4	5	1	16.6
FAG 5	5	4	44.4
Total	30	14	

Some drop-outs and withdrawals provided reasons why they left the project, and these ranged from time commitments to concerns over commercial sensitivity (explored further in Chapter Five). The Dorset and Cornish FAGs had the highest percentage loss of participants. One reason for this could be there was not a specific RM held for the Cornish group because lots of interest was shown initially and the author had her own veterinary network in the area. However, the invite list for the Cornish FAG was still expanded using AHDB networks for their first meeting as a FAG in the same way as a RM, which could have resulted in inviting farms that were not prepared to commit to a research project and therefore were lost from the study.

Figure 15 demonstrates that nearly half (48%) of all farms that the primary researcher contacted via telephone or communicated with face-to-face participated in the FAGs for the study duration. Communication via telephone or face-to-face refers to the primary researcher having obtained contact details for or met potential participants as a result of recruitment through the methods discussed previously. Of those recruited in this way, 14% tried the project but then dropped out for a variety of reasons. The rest of the farms that were contacted by the researcher either signed-up but never participated (i.e. withdrawal) or declined from the outset.

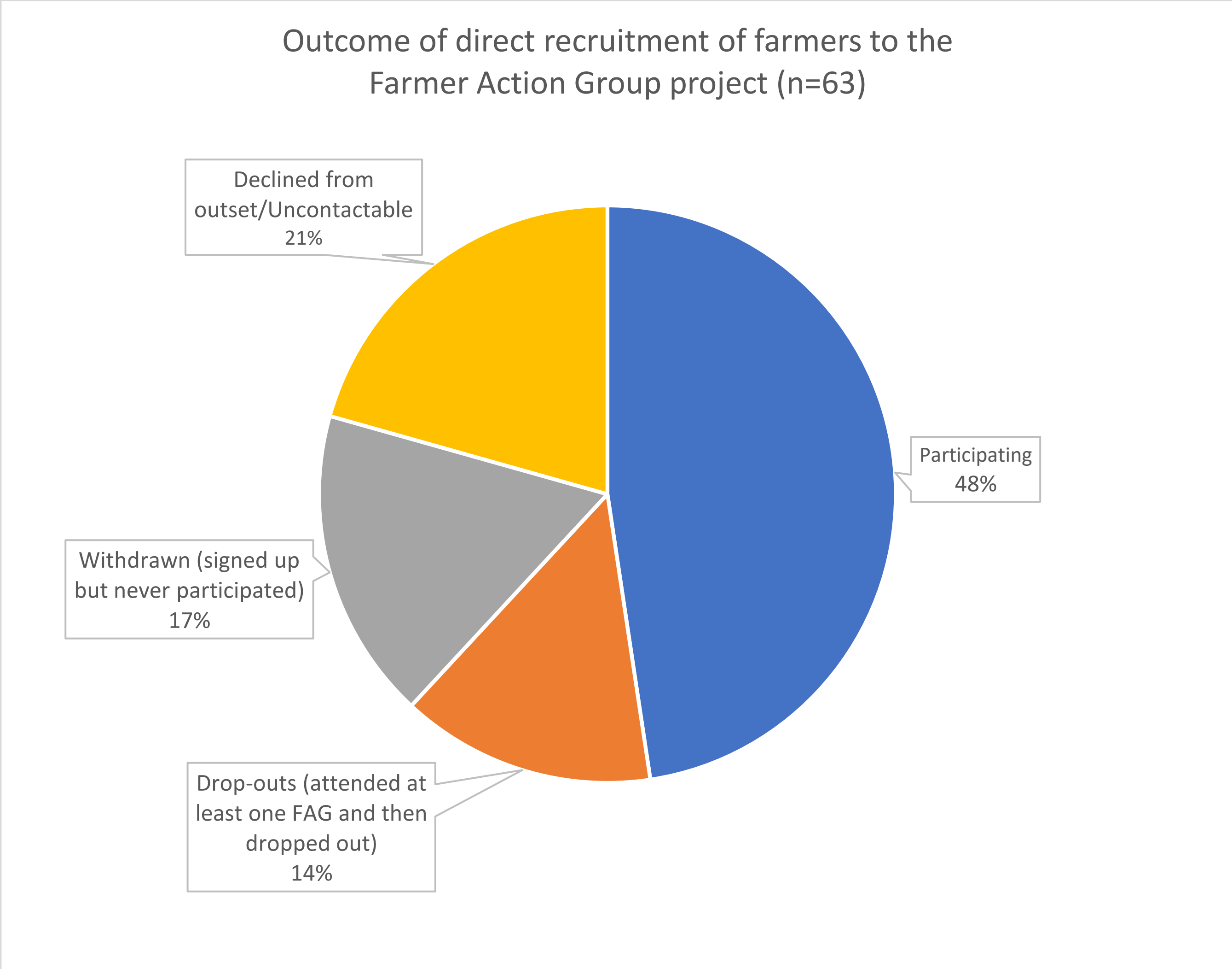


Figure 15- Outcome of recruitment of farmers across all methods of recruitment

4.c. Conclusions

The process of recruiting farms to this study and the feedback gained from those that decided not to participate influenced the establishment and running of the FAGs in three crucial ways:

i) The timing and frequency of meetings to not be too much of a burden on farmers
ii) The way in which knowledge between participants was facilitated
iii) The process of collecting and measuring farm AMU

Meeting frequency

A key recommendation from the recruitment phase pertained to the frequency of the FAG meetings. The Stable Schools consisted of a farm meeting every month. This was frequently described by farmers during the recruitment phase to this study as too frequent and too much of a time commitment. Veterinarians also voiced the time commitment as potentially off-putting for their clients. Due to project funding and a fixed timescale to complete the research, the meetings and data collection had to be completed by August 2018. This meant that meetings had to be held at all times of the year to allow all 30 participants to host twice. The frequency of meetings increased towards the end to allow for this despite initial meeting frequency being set as every six to eight weeks.

Managing the balance of knowledge between farmers

Farmers that withdrew or dropped out of the FAG project listed being ‘way ahead’ of other farmers, not gaining anything for their business from those present at meetings and sceptical of farmer knowledge as reasons to not participate (Chapter Five). Many of the participating farmers felt that they *were* learning and gaining valuable tips from their peers and there was lots of benefit from sharing knowledge. It follows that recognising this knowledge differential and managing it so that all participants see a benefit to sharing their knowledge (by receiving something in return) is key to maximise recruitment and continual participation. The findings during recruitment around the value of knowledge highlighted to the primary researcher that this was an area to be explored further. This realisation of the differential in knowledge between dairy farmers and how it affected recruitment was something the researcher had not expected and did not account for when recruiting. This is, however, something Archibald and Munce (2015) state is a key consideration when recruiting to qualitative research; understanding participants, behaviours and differences is a component of a successful recruitment strategy and an area where the researcher was potentially ignorant (163). This meant that when facilitating the groups, stressing the different skills farmers had and could learn from became important, as well as the commonality that linked them (i.e. they all used antibiotics on their farms). The Medicine Review also became more significant, because it was a tool that different farming systems could use to see the link between their systems.

The facilitator and the researcher developed discussion tools to help participants focus on farming practices that they could learn from and adapt. Both were conscious of the initial drop-out rate and the repetitive nature of the project. The concern was that if the farmers visited each other once in the first phase and had doubts over the value of learning from each other due to the knowledge differential, they would not attend meetings in Phase Two. Meeting attendance and the continual engagement of the farmers for both phases is discussed later in Chapter Five.

The best method of recruiting dairy farms from the findings of this study was holding specific recruitment meetings in collaboration with well-respected personalities and a well-known body (in this case, the project funders, AHDB Dairy). AHDB's familiarity with the target community (i.e. dairy farms in the South West) and pivotal position in the sector as the national levy board helped persuade dairy farmers to join the project. Involvement of AHDB added an element of trust that offset any uncertainty about joining the study, especially considering the time commitment. By working closely with the facilitator, the extensive network of farms available to AHDB Dairy employees was utilised for recruitment ensuring as many dairy farms as possible were targeted which made the process as inclusive as possible. However, in the author's own experiences as a veterinarian, AHDB is not perceived favourably by all in the dairy sector and those that do not view AHDB in a positive light may have been less inclined to respond to their invites to this project.

Using the existing networks of the primary researcher and facilitator also improved recruitment outcomes and benefited from the element of trust and familiarity that other work has shown is important (11, 80, 159). This touches on the importance of the facilitator in establishing and facilitating farmer groups, such as the FAGs and is elaborated on in the next three chapters. Interestingly, the online advert with the NFU also yielded results and did not have the help of a trusted figure to encourage farmers to join the project. Nonetheless, the very act of the NFU being behind such an advert may have helped with persuading farmers to join the study in much the same way as the involvement of AHDB helped with the recruitment meetings.

Utilising veterinarians as Gatekeepers was not as successful a recruitment method as hoped or described in the literature (165) although three participants were recruited from initial veterinary involvement. Veterinarians revealed that they had concerns with the methodology and were worried about the risk the project posed to their own practices, which is explored in the next chapter. A sensitivity to the needs and concerns of Gatekeepers is necessary to ensure the recruitment strategy is optimized.

As discussed in this chapter, the influence of Gatekeepers can significantly impact recruitment outcomes and the veterinarians in this study were no different. The position of Gatekeepers and significant others involved in recruiting farmers can pose problems for inclusivity and accessing ‘unknown’ groups. If farmers could self-mobilise into FAGs with no input from an external body, the issues surrounding Gatekeepers (trust, familiarity, selectivity) would be largely irrelevant as these would be accounted for and mitigated against by the farmers themselves. Nevertheless, making use of existing networks in the industry with the help of Gatekeepers is a valid and effective way of recruiting (122) despite the recognised selectivity that can affect a sample. Additionally, the influence and reputation of the project facilitator played a key part in the outcomes listed in this chapter and without their involvement, recruitment to the FAGs may have failed to reach adequate numbers.

Recruiting to farmer-led activities such as the FAGs differs to other farmer recruitment for research in that much more is being asked of the farmers than simply completing a questionnaire or participating in a single focus group. The time commitment for the FAG project was substantial and required farmers to spend three to four hours about every six weeks with other farmers discussing how each other could improve and reduce AMU. This could be perceived as off-putting and would have had an effect on recruitment regardless of the strategy. However, this emphasizes the perceived value participating farms must have seen in the project to sign-up and stay engaged for the duration of the project. It also confirms the need to be clear what the benefits to the farmer or farm are when recruiting to such a project, which will allow for improved recruitment rates despite the time demand.

Chapter Five: Participation in the Farmer Action Group project
Results and discussion of participation

5. a. Conceptualisation of participation

This chapter explores and develops the concept of *participation* in the context of a farmer-led approach to change practices around AMU. How participation is defined and measured has implications for the applicability of Stable Schools in the UK and the adoptability of the approach on a wider scale. The degree of participation in the FAGs and understanding this in more depth emerged as an important part of the success of the approach during the study. For these two reasons, a chapter on participation in the FAGs is included in this thesis.

Participation is a critical and defining component of any Participatory Action Research (PAR). It is also an unavoidable and indispensable step in the execution of a bottom-up, farmer-led project. Participatory approaches are built around the mobilisation of local knowledge and experience held by local people around shared issues (19). The how and why of participation is of interest here. Once established, how did farms and farmers participate in the FAGs? Who are the participants - farmers or their farm? What factors are likely to encourage that participation and what factors are likely to impede or inhibit it? What do farmers get from their participation and does this ultimately justify the method? Understanding these aspects of FAGs is important if the broader methodology is to be scaled up and reproduced.

Critically, participation in a farmer-led project is voluntary. This is in line with the Stable School methodology and in keeping with the many voluntary initiatives in UK agriculture. To be effective and to maximise their potential (both in terms of operation and output), PAR requires voluntary engagement and commitment (24). Nevertheless, as examined in the previous chapter, the process of recruiting farms to the FAGs was challenging and revealed several limitations. Voluntary and self-selecting engagement in structures, such as FAGs will not suit everyone (Chapter Four). Strategies that improve engagement and hence participation are relevant and important to develop if a farmer-led approach is to be scaled up.

Firstly, this chapter aims to define participation in the context of this research and conceptualise the phases of participation that have contributed to the operation and output of the FAGs. A definition of participation in relation to PAR that is relevant here is:

> *"the collective effort by the people concerned to pool their efforts and whatever other resources they decide to pool together, to attain objectives they have set for themselves. In this regard, participation is viewed as an active process in which participants take initiatives and actions stimulated by their own thinking and by deliberations over which they exert effective control"* (99).

Participation is a dynamic process that for this research could be divided into three distinct phases: engagement, interaction and development. These three phases (defined below) allowed participants to 'be part of the FAGs', something that happened iteratively, not necessarily sequentially (Figure 14).

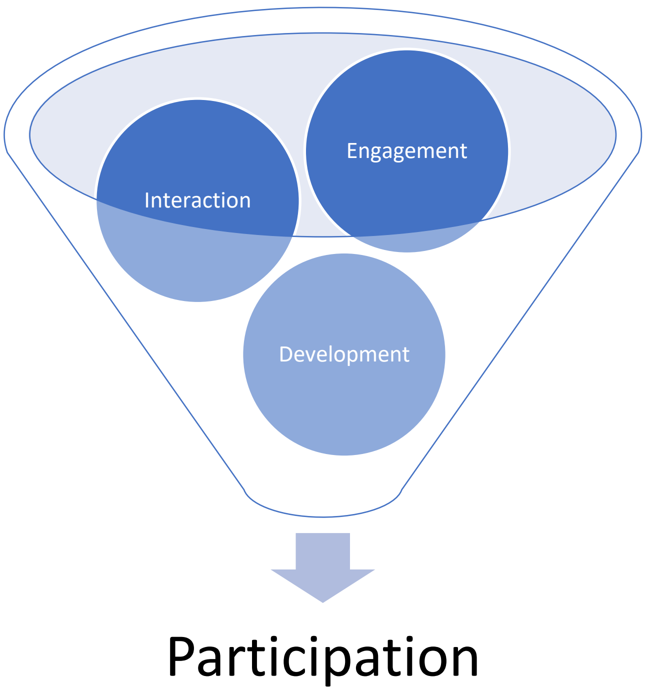


Figure 16- Active process of participation

The first stage, Engagement, can be direct with the process itself (i.e. participants signing up to the project) or indirect between participants (i.e. participants recruiting peers from their own networks). For this study, engagement was an initial first step when recruiting farms to the project (Chapter Four). Engagement can also be a phase that happens throughout a farmer-led approach and requires constant attention to maintain overall participation, as described in this chapter. To measure engagement, straight-forward numbers of attendees at meetings or interest shown in a project can be useful. A farmer-led, participatory approach like FAGs cannot practically proceed without engagement from farmers. Knowing why participants engaged with the project can help improve strategies to engage more of the community and improve adoptability.

Engagement has also been discussed in the context of farmer participation in Agri Environmental Schemes (85) in the UK. Mills and colleagues (2017) discuss the myriad of factors that influence farmer environmental decision-making, such as the perceived value in different sources of information, relationships with advisors, other farmers and the networks they belong to (187). They also found different farmers fall into different categories with respect to their willingness to adopt AES, ability to adopt (i.e. economical, structural and biophysical factors) and engagement with advice and local governance structures. When these three factors are maximised then *"sustained and durable environmental management"* can occur (187). Interestingly, those that were the least engaged with AES were the most socially isolated farms, lacked external information and were concerned about losing control of the decision-making process. The authors describe these farmers as the hardest to influence (187). Understanding the range of values farmers have and the different factors involved in their willingness to adopt, ability to adopt and engagement with schemes can help to improve further participation in initiatives, such as the FAGS.

The second phase of participation characterised in this study is Interaction. Interaction consists of contributions from participants, communication amongst participants and involvement in the process. Degrees of interaction can vary between participants and will differ depending on project objectives (as described in Communities of Practice) (156). In this study, interaction between participants occurred at every FAG meeting. Interaction with the mechanisms of the FAGs also occurred over the course of the whole project when co-creating Action Plans and discussing benchmarking results. Interaction in this project was measured and analysed by capturing farmers' experiences of being participants and their attitudes towards participation. Essentially, an element of interaction occurs throughout the process of participation.

Development involves some form of progressive change or action – as an individual or a collective - which can help develop the PAR and empower participants. The development phase comes about through the previous two stages - by engaging with other participants, discussing and innovating together through interaction with one another, reflection on existing practices (in the case of the FAGs) results in improvements and changes on farm. In terms of a farmer-led approach, this could include farmers shaping the way recruitment and engagement happens, which would improve the participation process further. In the example of the recent *Hennovation* project, it could also be the design and trialling of new ideas as a group (18) (Figure 17), which fits in with the principles of a PAR methodology where participants take ownership of the process and are actively developing as they participate.

Figure 17- The Hennovation cycle discussed in (18) as part of an EIP-AGRI thematic network

Development in terms of farm development pathways has been explored as a concept to understand farmer engagement with environmental management (188). The authors use the notion of farm continuity as a framework to understand why and when farmers might sign up and participate in environmental schemes and practices (188). They describe three main farm development pathways that broadly follow 1) farms with a traditional outlook and values with little emphasis on productivity, 2) farms with a combination of traditional values and a desire to be productive, and a belief that the two can go hand-in hand, and 3) farms with a more commercial trajectory where the identity of the farm is as a food producer not an environmental steward. Each trajectory aims to prolong and continue the farm economically and/or for family succession reasons. The inherent values farmers hold on these farm development trajectories will shape whether they see joining a scheme as an opportunity to continue the farm or a survival strategy, depending on where their farm is in its life cycle. For instance, at one point in time where finances are tight and the market conditions are poor, a farm on a more commercially minded trajectory may not be interested in an AES or may see it as a survival option economically. An appreciation of these fluid pathways that wax and wane over time can help optimise participation and recruitment of farmers at different points in time.

Recruitment and therefore engagement with the project, were mostly dealt with in Chapter Four of this thesis. This chapter briefly discusses engagement at the meetings and then examines the interaction between participants, their interaction with the participatory mechanisms and their development as they participated in the FAG project. In the context of recruitment or attendance at meetings, a participant will be defined as a farm, regardless of how many farmers from each farm attended. When referring to interaction and development (particularly in the analysis of the qualitative data), a participant will be defined as a farmer because the experiences and narratives are individually determined. Development of the participants, at a farm level and individual level is explored further in Chapter Six with the analysis of the Action Plans, changes in practice and AMU.

In this study, participation was categorised and measured by (1) the number of farm participants recruited (Chapter Four), (59) meeting attendance figures and (3) qualitative data documenting the participants' experiences of the process and examining why they engaged, and how have they interacted and developed within their FAG. The first set of empirical results in this chapter illustrates the number of meetings, the level of attendance (which as previously described for this study was a component of participation) and how this varied over the study period. Although the relationship between attendance and engagement cannot be taken uncritically, attendance is widely used, for example, in the context of education, as a likely indicator of engagement (189). This chapter will also examine reasons for engagement and continued participation from the semi-structured interview data. The qualitative data were collected through semi-structured interviews and through audio recordings of each FAG meeting (Chapter Three). This data was analysed using thematic analysis outlined in Chapter Three and additionally used to assess how to optimise participation in future farmer-led approaches. The perspectives of farmers that chose to not participate were also examined, which has further informed the optimisation of the participatory approach.

The chapter then moves onto explore the participatory impacts of the FAGs - what the farmer participants valued and gained from participation in the project as well as the perspectives of those who chose to not participate. Identifying two critically important positive factors in participation, the chapter discusses how the mechanism of the FAGs created, first, a sense of solidarity amongst the participants and, secondly, permitted the vital mobilisation of knowledge.

Coming at the analysis of the FAGs from a slightly different angle and drawing upon a series of additional interviews with veterinarians, the chapter then analyses and balances veterinarian responses to the FAG approach as a mechanism for improved AMS with those of the participants. The concerns around the mobilisation and use of farmer knowledge expressed by the veterinarians interviewed have significant implications for the wider applicability of the FAG approach and speak to a wider body of literature about the relationship between knowledge and power. A discussion of the farmer-identified knowledge gaps from participation in the study and the importance of knowledge mobilisation in empowering farmers and bringing about change on farm concludes the chapter.

5. b. Engagement and Attendance

The FAG project was constructed around two distinct phases. Phase One was where each farm hosted for the first time and co-created an Action Plan with input from the group. Phase Two consisted of each farm hosting a second time (eight to twelve months after the first time), with the group re-visiting the host's Action Plan and evaluating any changes made to farm practice to reduce AMU. Every farm participant hosted their FAG on their farm at least once and attended some if not all of the meetings on the other group members' farms (Chapter Three for methods).

Table 7 illustrates the mean and median percentage attendance across all FAG meetings in all five FAGs. A participant was defined at the farm level for the attendance figures. A farm was said to have 'attended' if one or more farmers from that farm turned up to a meeting.

Table 7- Level of attendance across all FAG meetings in Phases One and Two

Farmer Action Group	**Total number of meetings**	**Mean percentage attendance (%)**	**Median percentage attendance (%)**
Wiltshire	10	82.0	80.0
Devon	16	83.6	90.6
Cornwall	13	69.2	69.2
Somerset	10	74.0	80.0
Dorset	9	73.3	77.8
Totals	58	76.4	80

Mean percentage attendance across all five FAGs was 76.4%. An average farm participant attended just over three-quarters of the meetings for their FAG. Median attendance was 80% across all five FAGs. Considering the meetings were held at all times of year on a variety of different farms, this is a high percentage attendance and indicates a good level of engagement. Some participants had 100% attendance (n=2) and the majority of participants (n=27) had over 60% attendance over the course of the project. The lowest attendance was 38.5% for one participant farm who did not host a second time in Phase Two due to time constraints. The project lasted approximately 18 months for each FAG, depending on the size of the group.

Arguably, attendance cannot be uncritically and simplistically equated with engagement, which brings with it an array of values, motivations and rationales. Attendance indicates presence but not necessarily productive and useful engagement and learning (189). Using attendance as a marker of engagement is further complicated by the manner in which each was recorded. The attendance of a farm participant with only one member of staff present would be considered the same as a farm participant with several staff members represented. However, the farm with several staff members was technically more able to attend the meetings as they had more 'personnel' available to go. Generally, the individuals who represented a farm and came to meetings were the same individuals throughout the project.

Attendance variation

Attendance at meetings fluctuated throughout the project duration. At particularly busy times of the year - generally between April and September, which was when many farmers were cutting grass and harvesting - full group attendance was less likely. Farmers generally informed the author when they were unable to make a meeting and usually provided a reason. A common reason was being busy with silaging and harvesting. Two of the lowest attended meetings (with only two participants including the host) were in August and one was in February. Due to the substantial number of block-calving herds in the project (n=10), spring (February to March) and autumn (August to September) were also busy times, which subsequently affected attendance. Four of the block-calving farms missed meetings and stated this was because they were busy calving. Nonetheless, there were some block-calving farms who carried on attending throughout their busiest calving periods. One of those in particular had 100% attendance over the course of the project and was a spring block-calving herd - they even hosted during peak calving time!

In order to avoid falls in attendance, the Phase Two meetings placed an increased emphasis on activities that provided specific value to the farmer participants (such as group learning exercises, recapping the mechanisms of AMR or informal quizzes to reinforce learning about HPCIAs). The anticipated fall in attendance was in response to feedback during the recruitment phase that the meetings may be repetitive. Feedback from one farmer who dropped out of the project also highlighted the repetitive nature of the project, as seen below:

> *"Yeah because I could see it all going right the way round in a circle again right until this time next year and I thought that's going to be a lot of hours of our time that we probably the second visit you won't learn as much as the first." DO2*

Attendance at the FAG meetings did not vary substantially between Phases One and Two. Median attendance was the same at both Phase One and Two meetings at 80%, and mean attendance was 78% and 75% for Phase One and Two, respectively. There were very few reservations expressed by participants about the value of the Phase Two meetings in this research, a finding similar to that of the Teagasc report, which found only 11% of their respondents described recurring meetings as "stale" or repetitive (190).

As the meetings progressed, the farmer participants got to know one another better, despite their initial reservations:

> *"It sounded quite interesting. It was a bit daunting because there were lots of people there and I didn't know any of them." FAGDe6*

This particular respondent became an integral part of the group despite not knowing anyone at the start. He missed the first meeting and came along to the second, which he refers to in the above quote. This uncertainty about the project and who was involved affected attendance at the beginning of the study for some participants. The first meeting for two of the FAGs had over 20 people present, which was many more than planned. This was partly because of the facilitator widening participation using their own networks (as discussed in the previous chapter). This had an impact on participants and put some farms off continuing with the project.

> *"I was... honestly; I thought I don't know whether I really want to carry on, after the first meeting. There was too many people there running their mouth but not actually willing to back anything up." FAGC3*

Luckily, this participant did remain in the project once attendance stabilised and the group became smaller. Drop-outs, when they occurred, did so after attending a maximum of two meetings. Once the groups met for the third time, the members in the FAG were established with little change.

One critical factor in encouraging attendance that emerged from the research was the anticipated benefit of going to visit other farms. A 'gentlemen's agreement' was established that if farmers attended when a certain farm hosted, then the host farmers should return the favour and attend the other group members' meetings. Hosting a FAG was a valued experience for participants as that was when they received the most input about how they could improve. A recent Teagasc study reported similar findings with 87% of respondents stating that hosting was 'beneficial/very beneficial' (190). For many participants in this study, there was always something that could be gleaned from seeing other farms and talking to other farmers, regardless of how many meetings were actually attended. The return on the participatory investment was clear.

> *"Yeah, even if you only pick one little thing up in a period, you are learning, aren't you?" FAGW4*

Ultimately, even low levels of attendance, engagement, and hence participation resulted in learning that would support a change in practice. This fluctuation in participation is further supported in the Communities of Practice model, which describes a group of core members in a Community of Practice that participate the most and a secondary band of participants that engage less frequently but provide dynamism through fluctuating membership (156). Although it was beyond the scope of this study to seek to measure or compare the degree of learning related to the level of participation of individual farmers, other studies such as the aforementioned Teagasc report (190) and work by Hennessy and Heanue (191) and Grey and Gordon (189) have done so.

However, there was some evidence that attendance would suffer when host farms were perceived as being significantly different from those of other FAG members (e.g. an extensive grazing herd compared to an indoor-reared herd). In such cases, the shared knowledge and ideas generated were not so highly valued and attendance would drop, especially if combined with meetings at busy times of the year. One high-yielding, Holstein farmer revealed his disappointment with the level of attendance when they hosted:

> *"I was a bit disappointed how many turned up. Especially because a lot of it seems to be the [x] area. I've got to travel at least an hour to get there." FAGC3*

The aforementioned participant was the furthest away farm for the group to travel to which was perceived as an additional barrier to attending meetings. Furthermore, the farmer was conscious that many in his FAG had different farm systems to his own -many of the farms in his group were block-calving, low-yielding herds - thus the perceived value in learning from one another was reduced.

> *"Then there's the other group is the grazing group, which is low yielding, which is no good to me...[] ...because if I went there and said, push a bit more milk, they'd be no, no, no, you've got to have more cows for less milk. Well to me that doesn't add up." FAGC3*

This farm also hosted one of their meetings in August, which as discussed was a month when attendance was generally poor. Unfortunately, this meant the host farmer lost out and received less input for his Action Plan. Like with the Stable Schools, travelling time to meetings was a further factor in whether farmers attended each other's meetings. This was particularly pertinent in the Cornish FAG.

> *"Trouble is the meetings are all at least an hour away and I can spend more time in the car driving up there and back than I do at a meeting. It is tricky to find time in the mornings to get to these meetings because they start at 11." FAGC5*

The combination of the timing of the meeting, being the furthest away and the being the only high yielding all-year-round herd in the FAG meant this farm suffered a lack of attendance when they hosted.

In summary, the fluctuation in attendance was partially due to seasonality and the farming calendar as well as extensive travelling times to meetings, which was intentionally kept under 30 minutes for most farms in anticipation of this issue (Chapter Three). However, variation in attendance can also be explained by the farm type of the hosting farm within each FAG and thus the relative benefit of learning from that type of farm for the rest of the FAG members. This suggests that having more heterogenous groups with variable farm systems acts as a limitation to participation, which will be explored more in the following section.

5. c. Rationales for Engagement in the FAGs

5. c. i. Drivers to engage and participate in the FAG project

The interviews with participant farmers sought to reveal the different rationales and expectations farmers expressed for their engagement and participation in the FAGs. From this data, a number of principal drivers to participation were constructed, summarised in the Table below and discussed in the section that follows the Table. The topic guide used for the interviews can be found in Appendix 6.

Table 8- Drivers to engage and participate in the FAG project

Driver to engage and participate	Example	Explanation
1) Prior experience in collective learning (e.g. farm walks, discussion groups)	*"We're in a couple of discussion groups like the XX one. So that's grazing orientated. We're also a member of the specific self-feeding group which is straights feeders or whatever they call themselves, which is predominantly autumn block-calving and self-fed silage. We attend quite a lot of dairy cow things or as much as we can; we pay a levy for a reason, get what we can out of it." FAGC2*	Many participants enjoyed discussion groups and described positive experiences of being members of other farmer groups. It was easier for them to see the benefits of this project, which from the outset appeared similar to other discussion groups. Interestingly, one participant described attending many AHDB Dairy events because they felt they were 'getting their money's worth' – they felt they indirectly funded the project through their levy. One participant stated how the project was the best use of levy payer's money he had known, and another described only attending meetings that the AHDB Dairy facilitator, in particular, organised!

	"We have a group of us, the same group all the time, we go to each other's farms and discuss whatever you want to discuss. Have a bit of a walk around." FAGC1 *"Whenever you go somewhere you always see something different don't you, even if you don't like what you see then you take that back and think, I'm not going to do that." FAGC1*	Many participants spoke positively about attending farm walks and discussion groups. Getting multiple opinions was perceived as beneficial. The inclusion of farm walks and the opportunity to learn from other farms in the FAGs was a persuasive factor for participating in the project. These aspects enhanced their collective learning experience.
	"The good thing about the group is it is a range, it's not the people that always go to these things necessarily." "We see people we wouldn't have seen normally at a meeting involved" "There's not many in the group that would go to other things, apart from XXX...[]... Everyone else is kind of, don't go to that many other so that's good, X occasionally. I've never met XX before." *All FAGDe2*	Some participants also commented on the mix of farms in their group, especially attendance of new farms that they did not know. This was highlighted as a positive experience in their collective learning and contributed to their participation in the project.
	"...would you have signed up for this sort of project, this farmer-led stuff, if it wasn't about antimicrobial use? *RES: Well what else would it have been about? Just any farmer -led project.* *INT: I don't know, tackling TB.* *RES: Yeah I think so, it's quite good to get off the farm, see other places, be nosey." FAGC2*	Those that joined based on previous collective learning experience maintained they would have also joined the project if it was on a different subject, as demonstrated in the adjacent quote. The focus on reducing AMU was not their main reason for joining the project, but rather to learn from their peers about improving the way they farmed. Participants found seeing other farms to be the most beneficial part of the project and saw the FAG project as primarily delivering on this aspect.

2) Specific benefit to farm operation i. Providing evidence of regulatory conformity	*"Yeah, I just thought it was interesting to sort of get involved and try and – whether it would make any bonus to me for farm assurance and bits and pieces in the future to say we've already, we're doing something about antibiotic use." FAGC4* *"...certainly, on our MILK BUYER inspection, it was really good - we got some evidence to back up what we're trying to do, with the report here." FAGDe2*	Some farmers saw the benefit of demonstrating responsible AMU through participation in the study for passing their Farm Assurance. As it turned out, the personalised Medicine Review done for each participant farm as part of the project was used by several farmers in their Red Tractor and milk contract audits, with great success. This is a good example of the participants taking ownership of the process and using it in ways to aid them and add value. The Medicine Reviews were not designed to be used for Farm Assurance and this was an unexpected outcome.
ii. Reducing costs	*"Well obviously from the human point of view you want to safeguard the ones that are important for that but from our point of view if we can get away with using less it saves us money, if it's unnecessary." FAGC5* *"What would be your main things to take away from it?... RES: This bill's dropped." FAGDe3*	Many participants commented on the relationship between saving money and the benefits reducing AMU would have for their business. They saw the project as a way of identifying where they were potentially using and therefore spending too much on antimicrobials. This was a perceived benefit before engaging in the project, which was evidenced later once farmers had participated for a year.

iii. Being benchmarked	*"It's interesting to see how we compare to other people and see what other people are doing." FAGC1* *"Basically, what it is, when you put your little pie charts up, we didn't want any red lines on it.... It's a bit like I said, when you turned it not into a game, but when you started giving us the bar charts and everything, I hope I come down today." FAGDe3* *"Yeah, they're getting away with it, why don't I give it a go sort of thing." FAGW1*	Other farmers described how they wanted to know where they stood in relation to their peers. They liked being compared and seeing their progress throughout the project. The Medicine Review and benchmarking part of the project appealed to them for this reason. Some farmers were driven to improve by their peers and had the attitude of 'If farmer X can do without the CIAs then why can't I?' as demonstrated in the last quote.
iv. Animal/Herd health	*"Because healthy cows are less likely to need antibiotics so it's a win-win situation in some respect, if you can do things so the cows are healthier, then you need less antibiotics, so you are hitting the target and you are creating less global problems with antibiotic resistance anyway and healthy cows are more profitable cows, you have got less antibiotic cost, you have got less labour cost, everything, less treatment, less culled cows." FAGDe6* *"INT: Were you personally worried about antimicrobial use or was it more for your cows?* *RES: More for the cows, I guess. It could be a good or a bad sign but the less antibiotics you're using the healthier your herd should be in theory." FAGC2*	Farmers described how reducing AMU for them was a 'win-win' situation and would mean healthier cows and therefore a more profitable farm business. Farmers were aware of the issue of AMR and the risks this posed to their animals and wider society. This influenced their decision to engage and participate. A prevalent idea was that a healthier herd was intrinsically linked to less antibiotics - farmers were looking at this issue in a very holistic '*prevention is better than cure*' way.

3) A collective responsibility	*"We don't initially join up to this to increase our profit or anything like that. We joined up because we're a little bit, I don't know how to put it, we supply the public don't we and that's what they wanted unfortunately, not what's in it for us. They want more transparency so..." FAGC2*	The reasons for participation extended beyond an immediate benefit for themselves to a wider appreciation of their role as farmers and supplying the public. They wanted to use antimicrobials responsibly because of being a public-facing industry.
	"I wanted to reduce it for the very reason we're being asked to reduce it. INT: So, for the health of humans and hospitals and things? RES: Yeah." FAGW2	Farmers recognised the importance of AMS for protecting human health and wanted to use medicines in a responsible manner.
	"We can see the benefit of it obviously but even before your project began we were looking at ways to reduce antibiotic use. Obviously, we didn't know a great deal about which ones we should be using and shouldn't be using." FAGC5	Several farmer participants explained they were already trying to reduce AMU and wanted to learn which products to avoid as a reason for participation in the project.
	"It worries me about public perception, I think people need to do more, because people still think about antibiotics...Various bits of bad press that were out there in the tabloids which it pretty shocking really." FAGDe2	They were aware of recent news stories depicting the dairy industry in a poor light and this concerned them. There was a worry about the public perception of dairy farming misusing antimicrobials and for some participants that was enough to interest them in the project.
	"'Because I could see that it was an issue that was only going to get highlighted more in the future I guess, which it has done since we started. All over the farming press and obviously on the TV last night." FAGC2	All these points indicate a wider concern that farmers had with reducing AMU and being responsible farmers. The pressure from the public and the worry they were making AMR worse by using antimicrobials irresponsibly was a driver in joining the FAG project.

4) Knowledge sharing	*"Well I wanted to put my point across….That I cannot do without dry cow therapy, so it's no good to say I'm not going to do it and then they ban it and I haven't had a voice." FAGC3*	The FAGs offered farmers the opportunity to share knowledge and experiences, to become empowered as sources, brokers and transmitters of knowledge and expertise. Some participants wanted to have more of a voice, particularly around Selective Dry Cow Therapy (SDCT). This particular farmer had difficulty implementing SDCT yet wanted to show that he was still using antimicrobials responsibly. If he did not participate and there was a ban on blanket DCT, he saw it as a missed opportunity to get his opinion out into the wider industry. He recognised the study as trying to empower farmers on this issue.
	"But who are you selling your milk to? And are they likely to in the future to impose a restriction [on blanket dry cow therapy]…" Group comments *"They will" They will have to". "They will have to, to keep up with everyone else."* Farmer replies *"Yeah that's why I am here. That's why I am here. Still, it is the one thing I get really nervous about stopping [blanket dry cow therapy]."* FAGS4	Likewise, a few farmers joined the project to directly gain assistance and support in moving away from blanket DCT. The farmer in the adjacent quote was the only one in his FAG not doing SDCT and he used the meetings and peer support to help him prepare to do it.

	"Well yeah they are generally 'cause every farmer is different and everybody has got different experiences of similar types of things so it's always better to get half a dozen people's opinions than just one, isn't it?" FAGC5 *"I'm always quite keen to listen to these different groups, because you just pick up a little bit from somebody. They could from you, or it could be somebody else in the room and so on, or somebody else says it. As you say, the trouble is, farming is how we do it here, we don't see any other way and you only hear from the rep who comes in and tells you. Alright, I've got a consultant and she is very good, but sometimes you might just want to question what they're saying." FAGW4* *"And also on that front, if I can bring something to a group and say we've been doing this for so many years it's worked really well for us, and someone goes away and it works for them then – it's worked hasn't it?" FAGC4*	The idea of sharing ideas and opinions was a strong rationale for participating in the study. There was a feeling 'the more brains the better' for solving farm challenges. There was also the recognition that the FAGs gave the participants space to discuss and question previously held knowledge, which supports the literature about farmers dealing with information from various sources and applying it based on their own knowledge and experience. The adjacent farmer was not only an advocate of farmer discussion groups but wanted to share the knowledge he had of managing cows without relying on antimicrobials. He was a low user of antimicrobials and in the past had been an organic producer.

5) Topic relevance	*"The reason I joined because it was a subject that I was interested in and you came along at the same time as I was interested. The two things happened at the same time: I had an interest in sorting out antibiotics, there is a meeting talking about how to deal with antibiotics at the same time. I wasn't sure about the format or anything but it sounded a good idea and I thought I would go along with one and see how I get on." FAGDe6* *"At that particular time I was thinking of a RETAILER contract. I had been approached for a RETAILER contract. It was more or less definite, but it wasn't definite and I knew with mastitis or critically important antibiotics, could well be a thing to be aware of and I just thought two things at the same time, I thought this [the project] might well help me…" FAGDe6* *"I just thought it was an interesting project, because obviously that – well even now, it is a sort of a buzz topic." FAGC4* *"Well because I wanted to reduce antibiotic use, I could see we were going to get forced into it…" FAGW2*	A final rationale for participation was to do with the relevance of reducing AMU and timing of the project starting. The farmer in the adjacent quote describes how the timing was crucial for him joining. The second quote describes how this farmer was under pressure from a new contract and had peripheral knowledge of imminent regulation on AMU in farming being introduced (pre-Red Tractor guidelines). The project came along at a time that was convenient for him and he saw it as an opportunity to help him adapt. Farmers described the subject of AMU being a "buzz topic", they had heard lots of things about it but wanted to find out more. They could see responsible AMU was something milk buyers and retailers were asking for and there was pressure to reduce use in the farming media and industry. They wanted to learn more about the topic and could see the relevance it had for their farm business.

Discussion

Farmers engaged and participated for many reasons, often a combination of two or more reasons. These drivers have been categorised into five main rationales:

- Prior experience of collective learning (to include positive experiences of the project funders)
- Specific benefit to farm operation
- Collective responsibility
- To share knowledge
- Topic relevance

A number of participants were already keen on attending discussion groups and had previously attended other AHDB events. Several farmers knew the AHDB Dairy facilitator, which not only helped raise awareness about the project but also helped convince farmers to sign-up.

> *"Your meetings [Facilitator's] are the ones I will make an effort to go to. If it comes through with your name on you know it is going to be quite good" FAGS1*

Such a group of experienced 'joiners' or 'learners' was well represented in the project. Their dominance reinforces the broader concern that participatory approaches in general might, in appealing to this subset of farmers, systematically exclude those that are considered 'non-joiners'. Nevertheless, the experienced 'learners' or 'joiners' were not the only subset of the farming community recruited here. Many farmers, irrespective of prior experience in other groups, described their rationale for participation in the FAGs as a positive and tangible benefit to their farm operation, such as assistance in passing an inspection or scheme certification. This is an important rationale and suggests that collaboration between FAGs (or similar voluntary farmer-led structures) and regulatory or certification procedures might be fruitful.

In Denmark, the adoption of the Stable Schools into legislation demonstrates how far this collaboration can extend. Danish farmers have a choice as part of their health service: they can participate in a Stable School or have the veterinarian out more often to create a plan to improve herd health and thus reduce AMU. By participating in a Stable School, farmers are able to meet legislative requirements without the necessity of more veterinarian visits. This was particularly welcomed by some organic dairy farmers who did not want to have their veterinarians visit more frequently and thus preferred working with their peers in a Stable School to reduce AMU on farm (24).

In the current study, participant farmers frequently saw the use of antimicrobials as a failure or an indicator of something amiss earlier in the system (i.e. failed preventative measures). The notion of an all-around functional and happy farm was championed on many occasions:

> *"Happy farmers, happy cows, happy bank balance." FAGDe3*

Farmers could see the benefit of focusing on improvements to herd health when trying to reduce AMU. They would not only have more profitable cows from improved management, but they would also meet industry targets for AMU and viewed themselves as contributing to the global fight against AMR. They saw wins on many fronts and were keen to engage with the project as a way of 'getting ahead of the curve' by implementing changes to AMU before they were forced to by regulation or legislation. They were positive about learning more on a topic that was popular in the industry at the time and were all too aware of the frequent publicity on reducing AMU (such as the introduction of the RUMA targets and new Red Tractor Farm Assurance guidelines on HPCIAs), which reinforced the necessity and relevance of the FAG project for participating farmers.

The 'buzz' around AMR in the farming industry at the time of the study was certainly a critical factor in driving participation and capturing the imagination of farmers. The literature clearly identifies that a degree of contemporary relevance to farming practice is necessary to successfully engage with farmers (11). Articulation with the broader policy and economic landscape becomes a key component when setting up projects such as this. Although the issues affecting researchers or advisors might not be the same as those affecting farmers and this can reduce the success of on-farm interventions (13, 99). Recognising and working within farmer priorities is a fundamental principle of PAR and to a large degree sets it aside from more traditional forms of knowledge exchange (Chapter Two). In this study, the interests of the researchers (reducing AMU in dairy farming) closely matched the interests of many farmers who also wanted to reduce their AMU. When goals are mutually aligned, the potential of initiatives to change practice is improved.

5.c. ii. Barriers to engagement and participation in the FAG project

Before going on to consider in detail the experiences of farmers in the FAG process, it is worth examining the views of those who chose not to participate in or dropped out of the FAGs. To recap, a selection of farmers who did not participate in the FAGs were interviewed to explore reasons for non-participation and their views on farmer-led projects. These interviewees offered up several reasons for leaving the study as well as offering criticisms of the farmer-led approach that are of relevance to this research. These are summarised in Table 9 below. Ten farmers were interviewed; six did not sign-up to the project from the start and four dropped out after either attending one meeting or not being able to make the first few meetings (Chapter Three). Due to the nature of following up drop-outs from studies, only a small number of respondents were interviewed and thus data saturation was not reached but relevant themes emerged that are pertinent to the research questions. The interview topic guides can be found in Appendix 7, 8.

Table 9- Barriers to engagement and participation in the FAG project

Barriers to participation	Examples	Explanation
1) Time constraints	*"Yeah well I recognised that it was going to be [a time commitment] and I would rather not, just not engage rather than say yes and then not be fully engaged."* DO2 *"Perhaps farmers' time. I think you'd struggle to get a lot of farmers onboard with something as intense as that. That's just what I thought. A lot of farms are pushed for labour and they'd struggle to or they wouldn't want to commit to it."* DO4 *"Because a lot of the people at the discussion groups … you do end up getting like the hobby farmer types because you have got time to go don't you?... Guy running like a thousand cows on his own, absolutely bossing it, hasn't got time to go to some like, you know, there is free cake, he's like no." NP2*	The most frequent reason given for withdrawing from the FAG project was time constraint. Some farmers preferred to engage fully in the project or not at all. Once they had missed the first few meetings, they felt as if they were not able to catch up, hence they withdrew from the project. Interestingly, one farmer had the idea that only hobby farmers came to meetings as they had the time to do so. He believed the larger units with large herds to manage would not find the time to attend, which suggests some farm systems may be under represented at meetings as perceived by farmers.
2) Imbalance between giving and receiving knowledge between farmers	*"I like going on farm walks, going to meetings. I came to your group meetings hoping I might be able to pick something up. I think the only thing I learnt is that the conventional dairy industry has got a long way to go." DO1*	The act of giving and receiving knowledge highlights how the learning process is two-way and if a participant felt they were doing more giving than receiving of knowledge then the benefit of participating was perceived to be less. This was a reason why several farmers dropped out near the beginning of the project or voiced as a reason to not sign-up. Two of

	" *… the fact that we are doing something different and we are getting a premium for it at the moment. It is giving the game away a bit." DO1*	these were organic farms who felt they were already ahead of the curve in the area of AMU. One further reason for dropping out of the FAG project that is related to an imbalance of knowledge was commercial sensitivity. One farmer described how being a zero antibiotic herd meant that the benefit of learning from farmers to reduce AMU when his use was already zero was minimal. He felt he was *"three steps in front"* and was being paid a premium for it; he did not want to necessarily lose that by sharing his 'secret'. Furthermore, the same farmer described his lack of knowledge on different antibiotics due to simply not using them. He found this an additional barrier to how much benefit could be gained from farmer discussions on reducing AMU. He felt he would not receive as much benefit from other farmers compared to what he would be able to offer in experience.
	"I can pretty much not guarantee you but before I went to any of those meetings, I would know who would be there before I even went." DO1 *"The trouble is with farmer groups and discussion groups, is you'll always get the same people. It's engaging the ones that don't ever turn up." NP6*	It was repeatedly said that always the same faces would be seen at farmer meetings. This was described in a negative light and non-participants and participants alike frequently mentioned engaging those that never attend meetings. Having the same faces and therefore farms at meetings was another perceived barrier to participation.

	"Lack of willingness to communicate and share and actually there should be nothing you should be ashamed to talk about." NP1	Many farmer discussion groups - particularly the FAGs - involve giving and receiving constructive criticism, which requires participants to be open-minded. This was highlighted as a barrier for participation by those that did not sign-up but were involved in other discussion groups.
	"I suppose the short answer is, I'm never terribly keen on discussion groups because I tend to find that in the main the more vociferous ones tend to sort of impose their will a little bit, and I don't play skittles (and you might think this is a bit of an odd thing) but I think a lot of farmers are so influenced by what they hear at skittles, and what they get told at skittles by other farmers that they go home and think 'Oh God, Fred and John are doing it ABC they must be right I must do the same' and I think that's probably not the right attitude." DO4	A general drawback of farmer groups was the presence of a *"vociferous"* member who dominated discussion. It was felt that certain prevalent ideas or people could persuade farmers to try things that might not be best for their farm, especially at informal events such as skittles! This further supports the idea that the movement of knowledge was perceived to be imbalanced by these interviewees and hence affected their participation.
3) Diversity of farm systems and farmer knowledge	*"I got a little bit concerned when we went to FARM X mainly because C takes things very literally and there was a lot of talk about wait and see with treatments and he was only using three tubes a year or treating three cows a year and we're way higher than that and C is like 'Oh perhaps we shouldn't be treating them', and I was like 'No we've got to treat them' so it raised some questions that I was uncomfortable with because it's a way different system to what we've got and our cows wouldn't survive for that " DO4*	Some farmers found this diversity a barrier to participating and learning. One farmer joined the project as he wanted his newly recruited herdsman to learn more about reducing antibiotic use after increasing pressure from their retailer. He was optimistic he could pick up new ideas from farmers. However, after two meetings, concern grew that the new herdsman was picking up conflicting advice from the FAG to what the he was trying to do on the farm. He felt that the varying farm

	"I'm generally sceptical you know talking about this I would always refer to a vet than a farmer's advice that's just generally the way I think they've got a high level of training and I'm going to probably check with them first and I think some farmers believe what they want to believe." DO4	systems in his group were too different to his own farm and that certain strategies they adopted were not suitable for his system. This farmer believed that AMS was the realm of the veterinarian and was sceptical that farmers had enough knowledge to help him. He doubted whether the other farmers would have enough sensible suggestions for the Action Plans and whether the 2nd visit in the project would be of any benefit considering the time commitment. Ultimately, he felt his veterinarian was the go-to person for advice on AMU. This mirrored concerns from veterinarians about the capacity of farmer-led groups to come up with best practice strategies (see later section in this chapter).

Discussion

There are many quite understandable reasons why farmers might have been reluctant to participate in FAGs; lack of time, which may be a factor of farmer age (190), lack of interest and unwillingness to either share information with peers or to learn from them. These are not necessarily surprising reasons to not participate but the different reasons reinforce the sense that FAGs, and other similar voluntary farmer-led initiatives, may have a selective appeal (this will be returned to later in the thesis). Nevertheless, FAGs - and other models of interactive, co-creative innovation and action, which are becoming increasingly adopted within agricultural knowledge systems - do critically depend on a significant degree of shared interaction and exchange between participants. Without this, such models are is likely to be ineffective. Notable imbalances in the perception of the value and movement of knowledge and experience were revealed in this research. Some non-participant farmers felt that if they were to share experience or 'commercial secrets' with others then they must get something in return, suggesting that there is a subtly protective nature within sections of the farming community. This contrasts markedly to the positive drivers amongst participants identified in the earlier section of this chapter, such as a sense of collective responsibility and mutual support. These contrasts need to be recognised when using farmer-led approaches that are based on common experiential learning. Consideration of the subtle subgroups within a seemingly homogenous target audience such as, in this case, dairy farmers, may help with recruitment strategies and preventing drop-outs. This is something that will be returned to later in the chapter.

Some have suggested that paying farmers to attend meetings (as happens in Ireland and New Zealand) is necessary to encourage and maintain participation. Others maintain that, on the contrary, payment can attract those that do not see any value in the participation. Yet payment, in itself does not guarantee reaching farmers who do not see any value in attending. In contrast, some veterinarians in the Netherlands and some veterinary practices in the UK charge farmers a small fee to attend veterinary meetings, arguing it adds value to the meetings and improves participation. No payment to farmers was made in this study.

A second reason to emerge from the examination of non-participation was a perceived lack of commonality between dairy farmers. Although the heterogeneity of the groups was something that was expressly encouraged in the study design (Chapter Three), the diversity of dairy farms within the UK and hence within the study sample was something some non-participant farmers found to be troublesome and a barrier to learning from each other. Yet the appreciation of the two-way flow of knowledge and a commonality that links farmers is important for farmer-led approaches because of the diversity of farming systems in the UK. Indeed, the diversity in experience between participating dairy farmers was frequently commented on in the FAG study, but in general, this was seen as a positive component of FAGs, not a barrier. Most participant farmers valued seeing other farm systems. Moreover, the commonality of using antimicrobials and managing dairy cows was enough for them to see a common purpose, as illustrated in the following quote:

> *"No shake it up a bit. Look outside the box. Otherwise we've all got 10,000-litre cows that we polish every day and we all say, 'Everything's fine.' But you'll get a totally different reaction to a 5000-litre spring-calving herd, wouldn't you?" FAGW1*

These findings suggest there are certain limitations to the wider applicability and scope of a farmer-led approach in the UK. If parts of the dairy farming community are unwilling to work together and perceive there to be barriers to common experiential learning, then this needs to be considered in future projects. Ensuring that the sharing of knowledge is encouraged and feels balanced between community members should be prioritised. Attempts to persuade those who see little value learning from their peers may be worthwhile. Work from the Hennovation project demonstrated that where there was an element of compulsion from certifiers for farmers to attend the innovation groups, these had enhanced outcomes ((Dijk, 2019 #6693) (*personal communications*). A compulsory element to commencing farmer-led initiatives may be necessary for optimising success.

The findings from these interviews suggest that some UK dairy farmers feel markedly distinct from one another and too dissimilar to work collaboratively, which can affect the community building arguably needed in PAR methodologies (162). The perceived barriers to participation in a FAG suggested farmers saw forming a learning community as detrimental; they deemed it better to focus on their own farm and own problems.

It is often said that within the UK farming industry, the 'bottom 20%' of farmers will simply 'fall off the bottom' if they do not change or adapt their practices. Those 'bottom 20%' are deemed to be farmers who do not engage with advisory services, are not seen as proactive, often have poor health and welfare outcomes and do not like to learn from others (73, 104). The results from this study demonstrate that non-participating farmers were not necessarily disengaged when it came to reducing AMU (indeed one was already running a zero-antibiotic herd) but had valid reasons for dropping out and issues with the collaborative nature of discussion groups.

5. d. Interaction between participants and with the project

This section examines in detail the experiences of farmers as participants in the FAG project. The data used for this section is from the meetings themselves along with semi-structured interviews with individual participants. From the analysis of these data sources (Chapter Three), three minor themes of the farmer experience participating in the FAGs were identified, which were related by the sense of solidarity they created, each of which will be addressed in turn:

1. Sharing knowledge and experience within the FAG meetings
2. Practical learning from farm walks
3. Benefitting from peer support

Building a sense of solidarity

Minor theme 1 - Sharing knowledge and experience within the FAG meetings

Farmer participants spoke highly of the meetings and feedback was generally very positive (Figure 18). The fact that 30 farmers remained in the project for the duration of the study is evidence of its value. The quotes below sum up the general sentiment about the meetings.

> *"I've definitely learnt quite a lot from doing this and it does make me think when I use stuff, 'Is it critically important?' " FAGC1*

> *"They're really good. It'll be a shame when it's all over...Can it be extended for another two years?"" FAGDe3*

This latter request for FAGs to continue was evidence of the value many participants saw in meeting with a group of likeminded farmers. The comradery and laughter that occurred at many meetings was unique to the project and created an enjoyable learning environment.

> *"There's never a dull moment." FAGDe2*

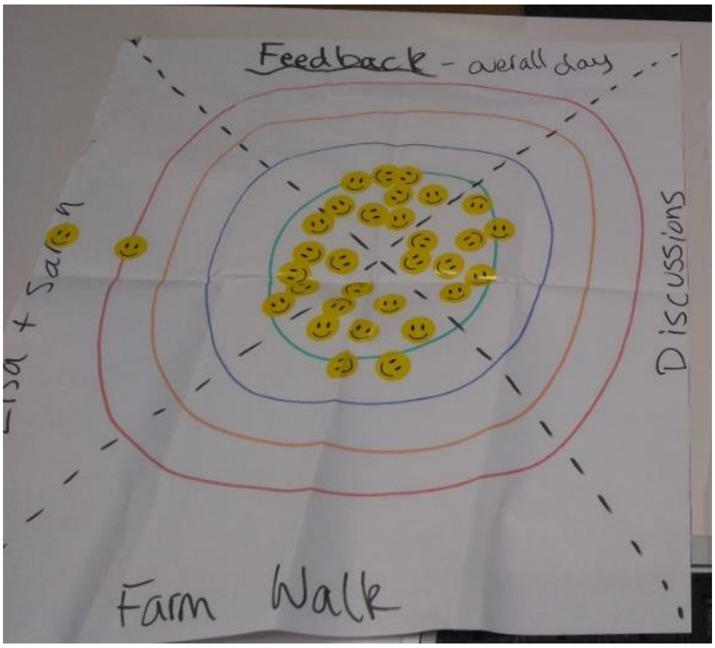


Figure 18- One form of feedback after a FAG meeting

Particular activities at the meetings helped to further this enjoyable learning environment. The use of mapping the farm walk to help the groups discuss areas for each farm's Action Plan was seen as a useful exercise (Chapter Three).

> *"I like the density of the circles, how big or small they are has given me an idea of what [FARMER] is thinking already, subconsciously, very good." FAGDe3*

This farmer commented on how the map that his FAG drew of his farm was helpful for him to see what people thought about the farm (Figure 19). The visual representation was a novel way to critically appraise a farm without being too pointed and judgemental, although, in places, the participatory process was quite critical and required farmers to be open to feedback, as demonstrated below:

> *"Well it's the ones with nothing to hide that are happy to show people round." FAGC3*

Figure 19- Mapping of a farm walk

The informal nature of the meetings was seen as a positive factor in the farmers' learning experience and generation of knowledge. Farmer learning is about exploration and involves discussion (192, 193), which the FAGs allowed farmers to do:

> *"the beauty about the project you've done allows a small group of farmers to talk…about different ways and having different practices represented is brilliant because there are different drugs and some I haven't even heard of!" FAGW3*

There was more to the FAG meetings than simply learning in the traditional pedagogical sense - knowledge was being shared back and forth and used to co-create new knowledge in a relaxed and non-judgemental atmosphere.

As the previous quote illustrates, the project enabled farmers to engage in an environment where they could talk freely and share knowledge with one another. This sharing environment contributed to their development and assisted them when deliberating changes to practice. This has noteworthy implications as it suggests that many farmers feel isolated and distinct from one another and being able to come together was a rare opportunity. Work by Mills and colleagues also describe the effect farmer networks on engagement with AES and how the least engaged were often the most social isolated (187). When these divisions are broken down, the response (particularly around knowledge sharing) can be very positive, especially for changing behaviour and practices.

Many of the farmers saw participating as a chance to learn and to share their experiences. This sharing of experiential knowledge through interactive meetings empowered them to make changes on their own farms, enhanced their position in their existing communities with new knowledge and enabled them to discuss the issues around AMU with their veterinarians, many of whom had not broached the subject of HPCIAs with them.

> *"I would say, The VETS, you have kicked our vets into not using – or actually looking [for HPCIAs]. They never mentioned, I would have said, the critical ones particularly, until we were starting to get into this group." FAGW4*

Empowerment through knowledge generation and mutual learning was a common benefit voiced by participants. This empowerment allowed farmers to engage with their veterinarians in a bottom-up manner. This is the essence of the PAR methodology - to foster the creation of new knowledge by prioritising and exchanging local knowledge, resulting in empowerment.

Minor theme 2 - Practical learning from farm walks

A key part of knowledge exchange in farming is the ubiquitous farm walk (24, 193). There are many farm walks organised in the farming sector in the UK, namely by AHDB dairy (194). The benefit of farm walks in providing social learning that combines multiple learning styles has been documented elsewhere in the literature (192) and is strongly echoed in the quote below from one of the participant farmers:

> *"I think it's just going round and seeing what other people do. Other people have got similar problems to you, sometimes worse problems than you and what people do to try and overcome them and you realise that you can do all sorts of things to try and overcome them and sometimes you can't. Sometimes you can, sometimes you can't and it's just accepting that you can do your best and sometimes you can get there and sometimes you can't." FAGDe6*

This aspect of seeing other farms and how their peers practically tackle similar problems was frequently stated as a benefit of the project. Despite living close to each other, many of the participants rarely, if ever, visited each other's farm in the normal course of events. In fact, as this research revealed, the input farmers had into each other's own practices and farm management whilst on the farm walk became a critical motivator for changing things on their own farm, a fact demonstrated in numerous conversations at meetings and illustrated below:

> *"I would have concerns over way the new calf sheds are going to face the way you have built them at moment… not easy to resolve. Need an awful lot of daylight getting in there with a lot of clear Perspex or something like that along the back. Timber up to calf height and then some clear Perspex above, conservatory panels from Wickes or something. Much brighter without losing the heat." FAGW1*

The above farmer commented how a half-finished calf shed had several issues, including size, location and ventilation. Another farmer at the same meeting shared how calf hutches were the best investment he had ever made.

> *"...horrendous year last year, we thought we aren't go down that same route again. We lost lots of calves with it [disease]… Terrible. We were Micotil-ing everything and cost over £1000 to treat everything. We have gone down the hutches route… I tell you what- amazing! 3 in a hutch… Amazing, breath of fresh air!" FAGW4*

As a result, the host farmer decided to go back to home-made calf hutches that focused on draught avoidance, taking on board the group's comments about location and light.

> *"It's a hair's breadth further forward, and we took it on board some of the issues that were raised on the day, particularly the fact that it wasn't going to be facing south, and we've got to try to come up with a way of letting sunlight in from the back basically, without letting the cold in." FAGW2*

The process of a farm walk and discussing problems with other farmers in the FAGs became an act of comradery, a shared source of ideas for solutions and a confidence booster when it came to changing practices. These factors are demonstrably important in facilitating changes in practice and in challenging risk aversion, such as in the reduction of medicine use (24, 172).

Some farmers valued the self-reflection that the act of describing their farm to a group of peers induced. Explaining their protocols and practices to a group of curious farmers on a farm walk made them question and appraise what they were doing:

> *"Trying to like giving the reasons why we do what we do. Because sometimes when you say it out loud it doesn't really sound like a valid reason....[]...Yeah. I can justify it to myself very easy but trying to justify it to someone else is a very difficult... just in the hour of telling them and saying well have a look round and see." FAGC3*

The practicalities of showing, explaining, observing and listening during a farm walk played a part in supporting the farmers' development as they participated in the FAG project.

Minor theme 3 - Benefitting from peer support

Two farmers independently likened the process of being a participant in the FAG project to Alcoholics Anonymous (AA).

> *"Antibiotics anonymous, except it isn't anonymous anymore!" FAGD4*

For them, the peer support they received in the group meetings, the sharing of experiences both of using antimicrobials and of how they were trying to wean themselves off the HPCIAs specifically, were comparable to AA. The participants would go through a 20 minute 'catch-up session' at the start of each meeting (Chapter Three) and inform the group whether they had used any HPCIAs since the last meeting. Those that had would share their shame in a disappointed manner and the group would console them, all in good humour.

> *"I am the same as you. Been on Cobactan for years, loved it, worked on everything. But I had to change. I use Ubrolexin and Duphatrim injectable. And so far touch wood, it works." FAGDe6*

The peer support was valued by participants and the resultant confidence from seeing and hearing others change practices was mentioned frequently as a positive experience, especially around using antimicrobials. This peer support, which in some cases was perceived as peer pressure, then encouraged changes in practice on farm.

> *"We were using Cobactan [HPCIA] way back down before we started, and that was, it was about the time we'd almost made the decision to change to something else anyway, and then this [FAGs] started and I think that pushed us." FAGDe2*

> *"You pick up little things of what people are doing and so on, and when you're just here on your own, then you just carry on doing what you're doing." FAGW4*

The latter quote refers to the motivation to change and adapt by being part of the group. Acting in isolation was seen a reason to carry on as normal and not adapt. The peer pressure also included affecting their normal buying habits when at the veterinarian's. The quote below relays a story from the receptionist at a veterinary practice sharing how one farmer participant decided against purchasing any HPCIA based on their participation in the project:

> *"I popped into VETS, last time I was down and one of the girls on reception said to me; 'Someone come in to collect some drugs recently, one of the farms [in the project]', and I was like, okay. She couldn't remember who, ' cos I put all these drugs out they'd requested and one of them was Advocin, which is a Fluoroquinolone, I put that up and he went to pick it up and then put it down', 'Oh, I can't take that, FACILITATOR'S going to be really annoyed with me'. [laugh]"* Facilitator relaying story to FAGC5

The influence of the facilitator affected farmer decision making as they were also perceived to be part of the peer group and contributed to knowledge mobilisation (i.e. were a participant). The peer support from each other and the facilitator had further effects in strengthening the farmers' voice when talking to other people in the industry.

> *"Well mine aren't. After the last meeting, I phoned up my vet and said I am using Cobactan tubes and I want to try something else… they sounded blank on the phone. They are not all signed up to it." FAGS4*

> *"I just ask them when I order anything, is it on the CIA list? It annoys me they don't ask, they don't tell you whether it is or not [on the CIA list]. You still got to ask them" FAGD4*

Veterinarians were often the target of this new empowerment and knowledge on HPCIAs as can be seen in the previous quotes. The effect of moving away from relying on antimicrobials as a peer group, meant there was an attitude of solidarity whilst making the change. Participants were not changing behaviours in isolation. They knew other farmers were also making the transition away from relying on antimicrobials and specifically HPCIAs and that some already had; this further encouraged them to persist with the change.

> *"I think it depends on the group. I think we have got quite a good group, we are all probably of a similar mentality. Where sometimes you get some groups, where somebody thinks they're up there and you can't get a word in edgeways and so on, and they don't really want to listen. I think as a group we're all pretty together, sort of thing." FAGW4*

> *"I think everybody is focused on selective dry cow therapy, it's a very hot topic and I think being a member of the Farmer Action Group, probably sort of concentrates your mind a bit more and you hear what other people are doing, which gives you a bit more confidence, despite the fact I am using Cepralock." FAGDe6*

Farmers felt more confident in their new knowledge and sharing that in a supportive peer environment. As the previous quote says, the FAGs helped 'concentrate the mind' as well as allowing comparison of one's practices with their peers. This was done informally in discussions and through the Medicine Review process (Chapter Six).

Additionally, a sense of competitiveness within the supportive environment of the FAGs was also a driver to improve and try new things.

> *"It's always good to find out what everyone else is doing." FAGW1*
>
> *"Yeah, they're getting away with it, why don't I give it a go sort of thing." FAGC4*
>
> *"I would say the biggest way in changing farmers habits is probably what I call looking over your neighbour's hedge. My neighbours doing it, why can't I do it or my neighbours, I want to beat my neighbour." FAGDe3*

The belief that if other farmers were doing without HPCIAs on the farm without the 'wheels falling off', then this was something that should be tried was a notion many participants shared. They used each other as inspiration to change. The farmers were encouraged to use antimicrobials more responsibly when in a collective peer environment where that responsible use was becoming normalized.

Recordings from the meetings demonstrated the extent to which participating farmers would actively share experiences (both positive and negative) and in doing so either encourage others to do the same or indeed to actively alter what they did and/or adopt new practices:

> *"Have you ever thought about weighing the calves?" …"If you can persuade him to pay for one I would…" FAGDe3*
>
> *"Yeah, he's more confident than I am with mine [SDCT thresholds], but it's whether I now have a little whizz at pushing it." FAGC4*
>
> *"After we came away from the first meeting where people were talking about SDCT. What benchmark could we put on ours… nothing would have it. Since we have been housed day and night we have not had a cow cell count above 50. So where do you set the benchmark on that? Technically we should not be doing dry cow therapy at all"* ***Host farmer FAGC3***
> *"Being low [SCC] is amazing but sometimes it can leave you open to like you said quite serious infections."* ***Another farmer FAGC4***

> *"...it seems it is high yielding cows we have problems with that bull really strongly and they don't let their milk out and then they come in the following milking and they are pissing milk out. Then it's the following milking after that is when they have got really bad mastitis. I don't know how you overcome that..."* **Host farmer FAGD4**
> *"Those cows, what would happen if, when you're spraying everyone, keep a cup full of barrier dip and just dip those cows [the bulling ones], just an idea..."* **Another farmer FAGDe3**

There were over 100 examples demonstrating knowledge exchange amongst participants in just the first 10 meetings. The informal meetings that fostered a peer-to-peer environment in combination with the practical learning on the farm walk, the sharing of knowledge between farmers as well as with the facilitator, resulted in a deluge of practical solutions to reducing AMU and improving herd health (Chapter Six). These elements of interaction and development, as described earlier in the chapter, are linked by the sense of solidarity that was created when going through a process of change.

Major theme – Building a sense of solidarity

This overarching theme of solidarity that emerged from the minor themes and thematic analysis developed during the project. Undoubtedly, the new knowledge generated and shared in the FAGs empowered farmers and, to a degree, set them apart from others who were not in the project.

> *"I feel a bit self-righteous sometimes, talking to people who don't know, "What do you give that cow?" "Excenel." "Oh?"" FAGD2*

There was a feeling of 'being in the know' associated with having obtained new and relevant knowledge through the FAGs and acting on it before legislation or restrictions were put in place.

> *"I thought when I saw this, definitely, I thought we would learn something, and we have learnt a lot. When you start looking and see what we are using now and what we were using when you first came, it's all gone." FAGD3*

> *"It's just going to be one of those hot topics isn't it? You either get onboard and do it or you're going to be left behind and you're going to have to react to it at some point, so ...." FAGC1*

> *"I had been approached for a RETAILER contract. It was more or less definite, but it wasn't definite and I knew with mastitis or incredibly important antibiotics could well be a thing to be*

> *aware of and I just thought two things at the same time, I thought this might well help me..." FAGDe6*

Moreover, this 'knowledge edge' over other farmers was seen by some as a distinct benefit from participating in the FAG project. Farmers had learnt something that would help them adapt to future regulations in advance of many other farmers, which became evident by the end of the project, in fact in June 2018 with the introduction of Red Tractor Farm Assurance guidelines restricting use of HPCIAs on farm (6). The following quotes illustrate some conversations at the meetings on reducing HPCIA usage due to foreseeing upcoming regulation and using the FAGs as a tool to help them change before being forced:

> *"I think the milk buyer had highlighted it to a degree as well, with the selected dry cow therapy, he kind of alerted us to it. It didn't really alert us to the types of antibiotics we were using I don't think, more to the principles of targeting antibiotics better. But this is a step further certainly in the right direction." FAGDe2*

> *"I have got a horrible feeling our milk buyer is going to come in… [agreement] and they are going to look at what we bought and the next thing before our inspections we are going to have to pick out one of these like Draxxin and they will say where's it gone, as they will show us where the animal has gone. And half of people are not going to show, not going to have a clue." FAGDe3*

> *"Yes. Cobactan was working very well but the only reason I changed was it is a CIA and [RETAILER wanted it] yes. Theoretically I could still use it, but I had to prove that it was the only thing that would work and the bacteriology samples proved it wasn't the only thing that would work!" Laughter + "...So no I have not got any CIAs on the farm, I used up anything I had, it's all gone. I am not buying anymore." FAGDe6*

The second quote above refers to those not in the FAGs or acting on the pressure to reduce AMU as *"not going to have a clue".* The third quote demonstrates one participant sharing his knowledge on what retailers are already asking for in a supportive, 'raising awareness' manner. Being part of the FAG and sharing knowledge meant they felt supported in making these changes and were ahead of many in the farming community who did not have this knowledge support. The end result was a group of 'switched on' farmers with a good understanding of AMS.

> *"I think people have got their heads around what they should and shouldn't [use]- in our group." FAGDe2*

The continual interaction and knowledge sharing were essential in assisting farmers to make changes to how they used antimicrobials and to reduce the need for them. The sense of solidarity that the FAG project helped to foster through sharing knowledge at regular meetings, practical farm walks, peer support and the building of new friendships were critical elements in what the farmer participants enjoyed and valued in the FAG approach. They were not acting in isolation and had support along the way.

> *"... all I know is that I felt that I got a lot out of the group, looking at other people. Even to the stage of where you're doing something, you sort of think, 'Oh maybe I am doing it okay.' For arguments sake, compared to somebody else, sort of thing. The trouble with the industry is you are always being hit by everything and anything. A prime example is your bactoscan. You get a result, a high one and you think, it's like a major catastrophe. When you speak to other people, they all have them, but you don't speak to them." FAGW4*

The idea that one was 'going through this together' was critical in the giving, accepting and acting on suggestions from each other. At each subsequent FAG meeting, rapport and trust grew, so the advice and suggestions shared became more highly regarded as the project progressed.

> *"I was... honestly; I thought I don't know whether I really want to carry on, after the first meeting. There was too many people there running their mouth but not actually willing to back anything up... Then we went to the second meeting and they weren't there and I thought yeah maybe I'll carry it on." FAGC3*

This participant and several more like him did not know anyone in their group initially and were put off by certain members. Once they got to know their group, they became much more convinced of the value of the contributions from the other farmers. This was important in the subsequent development and successful implementation of the farm Action Plans (Chapter Six).

Although the FAGs established in this research relied heavily – at least at the start – on the role of facilitators, they became much more farmer-led in terms of knowledge support as they started trialling things on farm. This research has shown the participant farmers that they can mobilise and benefit from each other's shared knowledge to make real change, whether they carry on with the process has yet to be seen. Although farmer-led initiatives are criticised for a lack of longevity or integration, which has consequences for those communities that come to rely on them (152, 160), the nurturing of a sense of collective endeavour and the learning journey that these FAGs went on suggests that there is a real demand for such farmer-led structures, albeit with a finite lifespan:

> *"I am not sure that if this group was to continue whether it would have the same motivation perhaps, because everybody has been able to carry on and yes it might do but unless there is a particular reason for doing it, people will just drop by the wayside. It's not a criticism, it's just the way farmers are..." FAGDe6*

Some participants certainly did not see the groups continuing in the same vein. They felt they had come to an end and farmers would not maintain the initial enthusiasm. Vaarst and colleagues also believed that once the goal has been achieved then the groups should come to a natural conclusion (24). The goal for the farmers in this study was reducing the use of and need for antimicrobials on farm and this helped bring them together. This sense of a collective response to 'something bigger' further cemented the sense of solidarity amongst participants. The shared experience of reducing AMU together gave them further confidence to change practices and helped generate new knowledge.

5. e. Addressing specific knowledge gaps

The exchange and sharing of knowledge emerged as a key element in the FAG project and was something farmer participants all agreed they gained and valued from participation. PAR methodologies aim to empower people through collective knowledge generation and sharing (152, 172). The participatory mechanisms built into the study design and implementation (i.e. farm walks, facilitated group discussions, sharing of data through the Medicine Reviews) allowed the farmers' own experiential knowledge to be used to create farm-specific solutions to reducing AMU. In this sense, 'knowledge' was generated, shared and actively mobilised through the two-way flow of knowledge between participants. The term knowledge mobilisation was chosen in this study to cover the identified importance of the following processes: the two-way flow and sharing of knowledge between participants; between the author and the participants; the low attributed value of sharing knowledge amongst non-participating farmers and the lack of knowledge sharing on certain subjects by many veterinarians (see 5.f). Knowledge mobilisation is a key process in a farmer-led, bottom-up approach, even more so on a topic such as AMU where UK farmers are making decisions on AMU on a daily basis. As such, knowledge mobilisation is the second major theme to emerge from the analysis of the qualitative data.

An important component of the FAG research also included specific mechanisms to address identified and agreed knowledge gaps. These mechanisms were more directive and more science-led; they were essentially delivered by the author of the current research as the resident veterinarian at the FAG meetings. To a large degree, these mechanisms complemented the farmer-led sharing of knowledge and experience and were seen, by the participant farmers, as playing an important function within the FAGs. As one farmer said to the author during an early FAG:

> *"Antibiotics are a real minefield, aren't they? So, we have learnt the wrong and right antibiotics but there's still a lot more to learn. That's why you spent five years at the veterinary college to learn it." FAGW3*

All the farmer participants wanted to know how AMR could develop from what they were doing on their farms, what a HPCIA was and what categories of antimicrobials they were using on their farms. They saw this as essential knowledge they did not have or of which they had only a peripheral understanding (i.e. some had heard the term HPCIA from sources other than their veterinarian). Moreover, many FAG participants were in fact required to know and act on knowledge of HPCIAs by specific retailer contracts. Others saw the coming of legislation and restrictions on HPCIA use in the near future and wished to know more about the critical medicines.

This sought-after information on HPCIAs was first presented to farmers at the initial meetings. The term 'critically important antibiotic' (CIA) was introduced, and some example trade products were shown to demonstrate which antibiotics these were. At this point, the participants requested more formalised and detailed information in the form of information sheets. Posters were used to explain the drug classes and make the learning more visual. This was a decision taken by the primary researcher and the facilitator after reflecting on the first few meetings and the repeated request from the farmer participants to have the information in an easy-to-digest format.

> *"A crib sheet would be really good actually with all the drugs and what they are, definitely." FAGC1*

It was decided after the first few meetings to present this information in a variety of different ways over the course of the project to help farmers become confident in the newly acquired knowledge, as led by farmer feedback. At the second meeting for each group in Phase One, the 'MilkSure' videos on how AMR could develop were shown (195). The third meeting for each group involved using A3 posters to list examples of certain classes of antimicrobial and to highlight the HPCIAs. In Phase Two, there was a short informal quiz to test farmers' knowledge of the names of the HPCIAs and example products. Despite this, farmer participants were still keen to have this information written down somewhere and requested that the primary researcher should create a handout or poster. The primary researcher advised them to speak to their veterinarians about creating a poster specific to the products sold to their farms as this would vary between farms and veterinary practices. The primary researcher was concerned about providing a handout/poster that 1) would not get changed when guidelines were updated and 2) would potentially upset local practices if perceived as advising on trade name antimicrobial products to farmers. In response, the primary researcher conducted an online search for existing posters/handouts on HPCIAs specific to UK farming that could be shared with the group but there was a paucity of suitable material at the time (2017). Consequently, in the spirit of participatory research, the primary researcher spent a few minutes at one meeting for each FAG discussing what could go on a HPCIA poster with the farmers. One suggestion was to produce a 'traffic light' infographic, like many other cattle disease prevention information sheets that they were familiar with (e.g. National Milk Laboratory Johnes testing guidelines). This was a popular option and was used for the final poster. The primary researcher explained the difficulties in recommending trade names of antimicrobial products as part of the research project and after discussion with one FAG it was decided a space could be left for farmers to add in the specific product trade names for their farm in discussion with their veterinarian.

The result was the co-production of a laminated poster for each participant with a traffic light infographic listing the HPCIAs, CIAs and first-line products. It included a space for the farmer to write the trade name of what was used on their farm, in discussion with their veterinarian (Figure 20). Several farms were observed by the primary researcher to have the poster mounted on a wall close to the drugs cabinet on farm. Discussion with one FAG at a reunion meeting in June 2019 found the poster helpful but for some it was largely redundant as they were not using HPCIAs anymore. This was also compounded by Red Tractor guidelines coming into force in June 2018 .

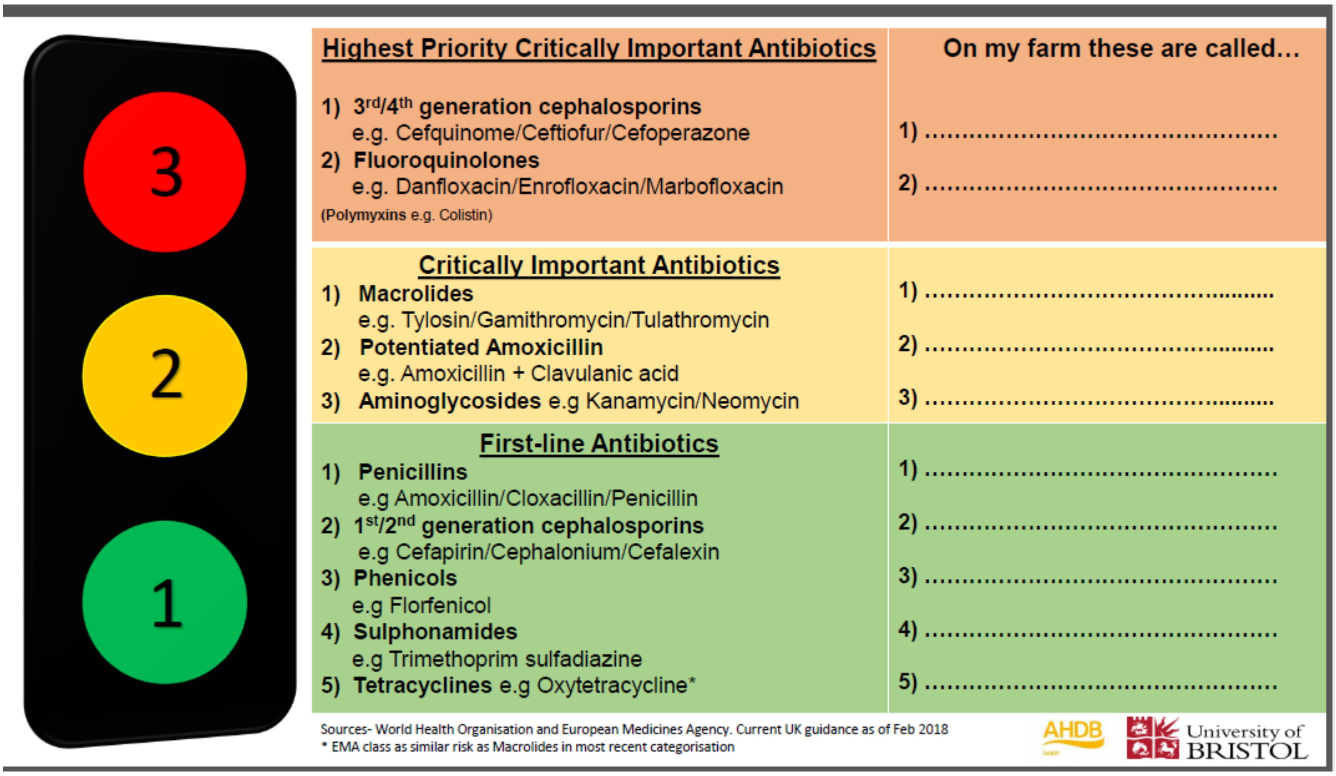


Figure 20- Poster co-created by author and farmers on types of antimicrobials used on farm

This farmer-identified knowledge gap around CIAs suggests that the veterinary profession was lagging behind in their responsibility to ensure antimicrobials were being used properly and with sufficient understanding by farmers. At the outset of this study, the O'Neill report had just been published, which called on the food-producing sector to reduce their use of antimicrobials (5). RUMA were also starting to produce sector-specific antimicrobial reduction targets (36). There were multiple stories in the press about extensive overuse of antibiotics in farming (196) and the farmers in the project were generally annoyed that they were getting a lot of the blame while it was the veterinarians who were prescribing them the medicines!

> *"I think we weren't knowledgeable enough to question them to start with. So they [vets] just carried on as normal and I think now that they're aware, particularly with us, that we're doing this study, then that's made them think a little bit more." FAGC2*

This farmer directly refers to the FAG project as a factor in encouraging his veterinarians to do more to ensure they were prescribing antimicrobials properly and that they were not being used irresponsibly by farmers. Many farmers in the project stated they had begun asking their veterinarians about what they were injecting their cows with and what classes of antimicrobials they were being sold. This behaviour was encouraged by the primary researcher and facilitator because it was seen as a good way to encourage more discussion about herd health between farmer and veterinarian. This tactic was popular with some veterinarians too, as this quote from email correspondence with the primary researcher shows:

> *"You have definitely got [FARMER] thinking. We have managed to discuss tube usage, respiratory [disease] treatments and colostrum management in the last three days!" V14 Email*

This particular veterinarian had a number of conversations about herd health issues as a result of their client participating in the FAG project. This is a positive result and, despite the concerns veterinarians were having about the approach (section 5.e), the project provided a benefit to veterinarians through increased discussions about preventative health measures.

Knowledge mobilisation between farmers, veterinarians and the facilitators was a major theme to emerge from the analysis and critical ingredient in the FAG recipe. The farmers identified a lack of knowledge on HPCIAs and AMR through their collective participation in the FAGs. One might argue that this knowledge could and should have been provided by their veterinarians. Notably, veterinarians reported improved engagement with some clients after discussions at FAG meetings and farmers felt the new knowledge helped them make more responsible AMU decisions and have better discussions with their veterinarians. Farmer-led approaches may therefore offer a novel way in which veterinarians could improve and expand their advisory role.

What is important here is that the mobilisation of knowledge that underpinned the FAG project was multiple, flexible and iterative. The demand for more specific information on antimicrobials came from the farmer participants as a result of the establishment of the FAGs and emerged out of meeting discussions. The mobilisation of external expertise is not contradictory to the principles and purposes of farmer-led interactive innovation models but can be, as the current example demonstrates, a critical and vital component and function of them. This is further supported by Lowe and colleagues when discussing rural development and the idea of vernacular expertise (20).

5.f. Contested knowledges

The final section of this empirical chapter takes a rather different perspective on FAGs and their role in addressing the issue of AMU on dairy farms. Its focus is veterinarians and their response to the participatory knowledge-sharing practices that have been examined in this chapter up to this point. The findings from the following section in this chapter support the work of the 'Farmer-First' movement that challenged the dominating paradigm in agricultural research and extension (13, 14) and is discussed in Chapter Two and the author's theoretical framework (Chapter Three). The Farmer First philosophy challenges the idea that positivist scientific knowledge is the best and only way to change and improve farming (21). Despite the mounting criticism of traditional knowledge transfer in agriculture, the pursuit to improve and develop agriculture worldwide currently lies in principally westernized, positivist, institutionalized reifications of knowledge (21, 78). Veterinarians alongside other agricultural advisors and research institutes largely maintain and perpetuate the notion that farmer knowledge is somehow inferior or flawed (186). The dismissal of certain types of knowledge and prioritisation of others arguably reflects relations of power and the domination of certain groups and interests. As examined extensively by social theorists (such as Michel Focault) and educationists (such as Paulo Freire) defining who decides which knowledge is relevant is largely an issue of power (21, 132). The following section in this empirical work highlights the tension between farmer and veterinary knowledge and differing epistemological approaches. This has relevance for a participatory, farmer-led approach in terms of lessons to be learnt in scaling up and wider adoption.

Evidence from past studies shows that veterinarians have a relatively low success rate in attracting farmers into participatory groups in order to change herd health practices and behaviours (164). How might veterinarians learn from the FAG experience and what perspective might they bring to the nature and method of knowledge sharing that the FAGs encourage?

In this research, veterinarians were used as Gatekeepers for recruiting farmers. The success of using veterinarians to access and recruit farmers was limited and revealed veterinarian concerns over the value of a farmer-led approach, particularly on medicine use. As a result, it was decided to interview a selection of veterinarians to understand the reasons for their hesitancy. Fourteen semi-structured interviews were conducted between October 2016 - October 2017 (after the main period of recruitment) with a variety of farm animal veterinarians from nine different practices in the South West of England. Specific details on the veterinarians interviewed are provided in Appendix 12 along with the topic guide used in Appendix 9.

Overall, the concerns of veterinarians about farmer-led approaches to reducing the use of and need for antimicrobials fell into three broad areas or minor themes, each one of which will be looked at in turn:

1) Concern about the propagation of possible mis-practice amongst farmer participants
2) Doubt over farmer knowledge and expertise on AMS
3) Concern over declining veterinary influence on farm

Concern about the propagation of possible mis-practice amongst farmer participants

Many of the veterinarians interviewed for this part of the research agreed that farmers liked to listen to other farmers. Moreover, they highlighted the positive influence this can have on everyday farming practices, often when compared to veterinary advice.

> *"So farmers definitely consider what other farmers are doing when deemed to be successful probably before they consider advice from vets on a lot of things." V7*

> *"If another farmer says something, they will listen to it before they listen to what I have to say, sometimes." V5*

> *"He [FARMER] does talk to a lot of farmers and a lot of them talk to a lot of farmers, on their day-to-day business, but to actually go to a farmer discussion group is a different thing in their mind. They value the advice of other farmers, but only on an informal basis. They don't see the value of it in a formalised context." V2*

Veterinarians were conscious about the frequent prioritisation of farmer knowledge and advice over their own. This was a cause of frustration as farmer advice was not always seen as being appropriate in all situations. Jansen and colleagues (2010) showed that farmers get information from a variety of sources and some will not value veterinarian advice (73). The farmers that these authors classified as 'reclusive traditionalists' or 'do-it-yourselfers' valued other sources of information over their veterinarians and remained generally distrustful of external sources of information. This was also a reason for the successful uptake of the Stable Schools in Denmark by organic dairy farmers, who had less positive relationships with the veterinary profession (22). Jansen and colleagues (2010) went on to say tailored communication strategies needed to be used to reach all 'types' of farmers (73). By recognising and maximising the benefits of farmers learning from each other, therefore, veterinarians could potentially reach out to more of their clients, even those reputedly called 'reclusive traditionalists'.

The veterinarians interviewed as part of the current research also noted the difference between farmers heeding advice in an informal setting with farmer friends and formally learning from other farmers in a farmer-led project or discussion group context. They veterinarians were not always convinced both routes of learning and information gathering were equal in quality, with the informal learning from farmer friends certainly causing more concern for some veterinarians.

> *"Take the example of BVD vaccines - a lot of people out there are using the BVD vaccine like annual boosters, so the licence one to six months but their mates are getting away with it so it's fine. Neighbour's getting away with it so it should be okay to do it." V12*
>
> *"And has that ever been to their detriment?... Yes, because somebody said to him, 'Oh, you do this,' and then they didn't listen to my advice and they took their neighbour's advice, which is not what I would recommend, perhaps – not based on science; maybe based on traditional and misconceptions." V5*

Informal sources of advice were often seen as inherently un-scientific. As the final quote above demonstrates, advice coming from neighbours was traditional and, as such, was considered misconceived. There was a concern amongst the veterinarians that farmers would pick-up bad habits and poor practices from each other, which were both contradictory to what the veterinarians were advising and detrimental to the health and welfare of the farm animals:

> *"My concern is if you take any industry and take 20 people that are doing something and you take them round to go and see one person and what they're doing there will always be three or four things they could pick up on to improve what they're doing, they just might not…they might pick up on the wrong things and pick up on things they shouldn't be doing……Okay and does that worry you?...... Yeah it does, it does worry me". V5*
>
> *"So that's my concern is that they don't necessarily pick up on the right things." V5*

Some veterinarians commented on the element of chance that farmers might pick-up bad ideas over good ideas and this 'pot luck' aspect made them nervous. This suggests veterinarians were not comfortable with the lack of control over the outcome. Some veterinarians saw a way of eliminating or reducing the 'pot luck' aspect of learning bad habits from other farmers by having a 'responsible' person present or within the group.

> *"Yeah, providing you've got a good person in that peer to peer, somebody that's doing it responsibly...[]...But that's the only thing with that approach, is that you need to have*

> *somebody there to say 'Hold on a minute, that's probably not the best thing to do. But if we haven't got the evidence behind it how can we say that?' " V14*

Certainly, the presence of an informed facilitator can act as a valuable knowledge broker as previously demonstrated (197). Nonetheless, for complex issues, such as AMU (where there is often a lack of specific evidence of best practice and the consequences of certain practices and high levels of uncertainty), the current study has supported the literature showing that farmer-led initiatives and knowledge sharing can also play a vital role in driving action and should be more widely acknowledged (79, 89).

Doubt over farmer knowledge and expertise on AMS

The veterinarians interviewed maintained that farmer knowledge about AMR and AMU was generally limited.

> *"...he didn't know whether Naxcel was an antibiotic or not, let alone whether it was a critically important antibiotic. So I enjoyed doing them; they enjoyed doing it. They enjoyed learning a little bit about the context of antibiotic resistance as well, because most farmers, in my experience, don't know what antibiotic resistance… I think I said that in the article. They think… 'cause they've never had to think about it before, really…" V6*

Veterinarians saw their role as informing and educating farmers (and others) on the issue of AMS. Veterinarians are prescribers of antimicrobials and have a duty to ensure farmers use them correctly. Nonetheless, they rarely mentioned listening to farmers' solutions or seeing them as equal knowledge partners who would be able to create solutions alongside veterinarians in this context (though there have been notable exceptions to this as the recent uptake of Motivational Interviewing techniques within certain veterinary practices demonstrates) (198). These next quotes illustrate the form of communication and advice-giving veterinarians often relied upon:

> *"The second thing we need to do is look at educating farmers." V8*

> *"...we've just gotta try and engage with them and just get them to realise that with farmers you just need to have – it needs to be black and white." V14*

> *"You've got to give them the knowledge, but they have to be keen to do it themselves. They have to see the problem and want to fix it themselves." V3*

Veterinarians are trained to give advice in a directive style (199). The co-creative style of FAGs seemed to sit uneasily with veterinarians' own experiences of formal knowledge acquisition[4]. Rather than assuming the advisor (i.e. the veterinarian) held all the answers and simply needed to pass this to a passive user of advice (i.e. a farmer), the current project demonstrated the value of more co-created understanding.

The interviewees were also asked their thoughts on farmer expertise. To what extent did they value farmer expertise in issues of animal health and welfare? Most interviewed veterinarians certainly had issues with the concept of farmer expertise.

> "*No, not at all. No, I think we've got to be the expert and we've got to lead that, but I think most farming change is going to come from within, isn't it?" V3*

Veterinarians saw themselves as the experts in animal health and medicine use. They did not see farmers as having the right training or skills to make treatment decisions like that of a veterinarian. This could pe perceived as a threat to the role of the veterinarian.

> *"but I don't think they're necessarily experts in animal health or in things like that." V9*

> *"I'm going to make a bold sweeping statement here: farmers don't really have the necessary education in the area of antimicrobial resistance to be making the appropriate decisions without the assistance of suitably educated consultants." V5*

> *"They're often very good at diagnosing what's wrong with their animals but they're not necessarily sort of pharmacologists really. They're definitely not and I don't think vets should back away from responsibility of being the expert and the authority in those sort of decision makings really." V1*

Veterinarians saw their training and education as what made them experts. The veterinarian of the final quote above acknowledges one aspect of farmer know-how (i.e. knowing their animals and recognising disease presentations). But overall, veterinarians emphatically did not think farmers had the capacity to do without the veterinarian and make treatment decisions. Veterinarians definitely

[4] This is understandable when one considers veterinary education and the directive communication style of delivering technical advice. The primary researcher conducting the interviews and analysis is also a veterinarian and took considerable time to adapt to the non-clinical role in the study. Allowing farmers to talk and guide the conversation, listening to them and refraining from telling farmers how to manage their herd took a substantial shift in mindset for the primary researcher.

saw their role as essential members of the farm advisory team and were quite protective of their place in educating farmers about AMR and protecting animal health and welfare.

Yet - and it is here that the experience of the FAGs becomes important - veterinarians would often express a desire for farmers to know more about medicine use in farming:

> *"RES: Very, very limited. Again, let's say, for 70% of the farming population, they know very little about what drugs they're using. INT: And do you feel they ought to know more or need to know more? RES: I would love for them to know more, yes." V12*

As was seen in the work with the FAG participants earlier in the chapter, many farmers wanted to know more about HPCIAs and expressed a certain frustration that their veterinarians were not providing this knowledge. This reveals a potential miscommunication: where veterinarians assume (possibly incorrectly) that farmers do not want to know the details of HPCIAs and farmers do not engage their veterinarians in discussions about HPCIAs. In this way, distinct and almost mutually exclusive pathways of knowledge acquisition are being identified:

> *"If it's a farmer that's got a good relationship with the vet and they value their vet, then the vet would rank high. Then you've got other farmers that can't stand their vets, and so they would rather go to a discussion group" V6*

Such a mutual exclusivity is problematic and suggests possible avenues for a more coherent approach to knowledge exchange and co-creation, which will be developed in the final chapter of this thesis.

The language around farmers' knowledge and skill often stemmed from frustration about uptake of veterinary advice and influence on farm. Despite all the dismissals of farmer expertise there were some veterinarians that, when pressed, did acknowledge farmers had expertise.

> *"I think that's more because, especially in this day and age, the dairy guys are so switched on, with everything that they have to do, and just the amount that dairy guys have to do with their businesses now and milk recording and all this kind of stuff.." V10*

> *I think they're experts in their things, so they are experts at how their farm works and how the logistical things and so much broader range of things than we are and then …" V9*

> *"I don't know like I'm not very good at nutrition for example and loads of our farmers would be way better than me at nutrition." V12*

> *"They know their stock better than we know them. That's probably the key thing to note. They'll know when something's not right. They generally will pick it up before we… they're on the ground, so they can tell you what is working or how things aren't. You can't underestimate what they know. We've got to respect them as the farmer in the same way they've got to respect what we think as vets." V11*

These quotes beautifully illustrate that there is a wealth of knowledge farmers hold that veterinarians have noticed and in which veterinarians see value in. Some veterinarians also identified differences to and gaps in their own knowledge and how the two could potentially complement each other. This bodes well for veterinary delivery of farmer-led approaches. The author believes veterinarians could be delivery partners in this approach, especially on topics like AMU.

Recognition of the value of experiential, context dependent knowledge amongst farmers offers a potential complement to the work of the veterinarian.

> *"Sometimes I think that they do, I do and calve cows and say, yeah, you can do this, you've calved cows for years longer than I have and leave her to it; and sometimes, especially because I'm not very tall and I don't have very long arms, in some calvings, actually the farmers end up helping me quite a lot and we kind of do it together." V4*

A practical service that farm veterinarians will frequently perform is delivering calves. That experience is used here as an example recognising that the combination of different scientific and experiential knowledges on the part of the veterinarian and the farmer, working together, can be highly beneficial. This is knowledge exchange and knowledge sharing in action. It is two-way and requires humility on the behalf of both partners to recognise the expertise in the other.

Frustration at lack of influence on farm

Most of the veterinary interviewees voiced frustration when trying to persuade farmers to adopt a new practice, using phrases such as an "*uphill struggle".*

> *"I see it as a challenge that I'm incredibly unsuccessful at and I don't like being unsuccessful. I get frustrated…that's how…it makes me sound like a dick, I get frustrated…I get frustrated by spending…by saying things over and over again and not even being able to engage in conversation on them. I also get…get frustrated when I'm seeing significant welfare issues and there are significant welfare issues." V5*

> *"I've managed to persuade that he doesn't need to use Marbocyl all the time, it's taken me six months to grind this guy down." V4*

> *"I go once a year, so what influence can I have?" V6*

> *"I'm desperate for him to listen and you have to hammer home the message so many times, but I feel like I'm battering him when I'm not even there." V9*

> *"No, I just get frustrated with the fact that they'll never see…a lot of them don't see the size of the problems they've got in front of them." V5*

> *"I've had big challenges with trying to convince people to change..." V3*

Many interviewees indicated they would much rather focus on working with people that heeded their advice. There was an element of constantly repeating advice and *"hammering home the message".* Some veterinarians accepted they could not help everyone, and some farmers were beyond help.

> *"I think, if somebody doesn't want to be helped, it's very difficult to help them." V12*

If a farmer would not listen and accept the help offered, then the veterinarian's role was limited. On the contrary, when farmers did heed their advice, veterinarians generally found the work much more satisfying, thus justifying their role in the wider supply chain and relative importance.

> *"They're the ones you, you know, you get most satisfaction working with 'cause you can see the result, but…" V14*

Veterinarians described having limited energy and resources to influence things on farm.

> *"And I suppose, people like XXX, we don't go there for routine, so we go to a sick cow, but you don't have time and it's not the right time to bring up that conversation." V10*

> *"Our energy is limited as well; we might as well spend it with the people who can be influenced." V12*

Veterinarians preferred to spend their energy and time working with farmers that engaged with them and heeded their advice, unsurprisingly. Adopting new strategies such as working with farmer-led approaches would assist veterinarians to engage with more farmers, especially those they may have had less success with. Sharing problems in a social group setting and working through them with support can help in instances where veterinarians feel they are having less of an impact. PAR and projects like FAGs are primed to help people work through the stages of change, assist knowledge mobilisation and implement new actions on farm (172). There was even a desire from veterinarians to be involved in this as seen here from one interviewee:

> *RES: "What you could do is fund another healthy livestock project for us to approach them and…….teach them what to use, that might encourage them to do. INT: What so like have vets as the deliverers? RES: Yeah." V14*

Nonetheless, most of the veterinarians believed the most effective method of changing farmer behaviour was when they were 'forced to' by circumstance, pressure or regulation.

> *"I think farmers do things when they have to." V12*

> *"Some came because it's something their milk buyer is getting into and they want to try and get ahead of the game and some of them basically because we bullied them" V10*

Veterinarians rarely saw themselves as the most effective way to influence or change anything on farm, which considering that they are the legal prescribers of these essential medicines, is a potential concern. Veterinarians recognised the power of large companies in the industry (such as milk buyers) the contracts producers were tied into and other top-down measures as being effective in driving behaviour change. Veterinarians felt their role had diminished in relation to these top-down behaviour change measures and that even they as veterinarians were at the mercy of doing what retailers dictated.

> *"Yeah, well, sort of they [milk buyers] did prompt us a little bit years ago, that they said we'd prefer it if you didn't use these products and we just switched everybody over straightaway." V14*

> *"Is that vet-led or is that retailer-led? Res: "That's retailer-led and delivered through the external vets, which I am one of, so I visit these farms as an external vet once a year and just do a bit of an audit or some training." V5*

> *" 'Look, if you don't do it, I'm gonna deduct 8p off your litre.' And that's the best incentive for a farmer. Farmers, even if they know hidden losses or obvious losses due to certain diseases, it's sometimes very difficult to get them to do something about it, for the reasons we've mentioned. Threatening them with a penalty is always a good idea – not coming from us – we*

> *want to be on their good side. We want to say, 'Right, the dairies are threatening to take some money away from you. Sit down with me and I'll help you get through it.'* " V12

Over the last few years, retailers have introduced rules for their producer groups restricting what antimicrobials can be used. This occurred before Red Tractor Farm Assurance guidelines on HPCIAs were enforced in 2018 and before veterinarians were widely advocating reducing HPCIA use. The retailers led on this issue and the veterinary profession followed, despite being the prescribers. Veterinarians commented on their lack of influence on farm at the same time as recognising their positionality in relation to the milk buyers/retailers. The establishment of the FAGs using veterinarians as Gatekeepers has revealed and supported arguments for re-addressing the imbalance in power structures within the food supply chain, such as who holds the relevant knowledge and how knowledge moves, particularly in the context of AMU (200).

Finally, the sense of despondency from veterinarians about their role as farm advisors and their position in the wider supply chain emerged as underlying rationale for some veterinarians' lack of enthusiasm for a farmer-led approach. One veterinarian describes how veterinarians have been cut out-of-the-loop somewhat.

> *"It used to be that the private vets…used to get paid to do a twice-yearly visit and do a bit of an audit of various bits and bobs. They knocked that on the head because it was perceived that some of the vets were just taking the piss and the routine visits… they were just not charging for a routine visit and putting it down to a SUPERMARKET'S visit, and so they weren't actually delivering anything different. Some vets were doing a good job, but I think they decided it was just not working, so now they just have the external vets, which is a shame, because it does mean that the private vet has been cut out of the loop a little bit more.." V6*

As prescribers of antimicrobials and trusted advisors to farmers (83, 127), this is a worrying sentiment coming from veterinarians. This supports the idea that veterinarians have become disempowered in the food supply chain and that they perceive a farmer-led approach as further evidence of their diminishing role as farm advisors, and potentially a threat to their role and professional identity (129). FAGs and other similar initiatives could be an ideal opportunity for the synergy of complementary knowledges on complex issues. Is there a cause for re-integrating veterinarians by transforming the mode of advice-giving?

5. g. Conclusion

Chapter Five has presented the results from participation in the FAG project (i.e. *engagement* with the participatory mechanisms of the study, the nature of the *interaction* between participants and how this started to *develop* the participants, personally and professionally, as they went on the participatory learning journey). The level of attendance at the FAG meetings and therefore engagement with the study demonstrated a high level of participation showing the project was valued by farmers. The goal of reducing AMU was timely and appealing to the majority of participants and there were many who had prior experience of collective learning that decided to participate. Some farmers felt a collective responsibility to do something on AMU in farming and others wanted help with either reducing costs, demonstrating responsible use or meeting milk contract requirements.

The barriers to participation from the perspective of other farmers revealed not only anxiety about pressure on their time but a deeper concern about the sharing of knowledge with other farmers, as well as a lack of commonality with others in their industry. This perceived lack of commonality within the dairy sector highlights the importance of fostering a sense of solidarity by using a participatory approach, which was identified as an important rationale for farmer participation and major theme from the qualitative analysis.

The interaction between participants and between the primary researcher, facilitator and participants revealed the importance of the mobilisation of knowledge. The two-way flow and sharing of experiences and knowledge on AMR and HPCIAs particularly, was highlighted as a key theme in the participatory learning journey. The practicalities of farm walks and the facilitated discussions helped farmers reflect on each other's practices. The peer support at the meetings inspired confidence to change practices and try things that were laden with risk. The participants went on a learning journey together which created a sense of solidarity. This empowerment through collective action enabled increased discussions with veterinarians and armed farmers with a knowledge-edge, which contributed to changes in practice.

The results from this research support the rationales for adopting a PAR methodology. PAR often stems from an inequality of power within a society or community (19). It could be argued that farmers are vulnerable to imbalances in the supply chain as end users that have to deal with risk on a daily basis (201). Farmers are used to dealing with uncertainty (201, 202) but does this inherently disempower them? Vulnerable or disempowered communities have been said to be weaker and find it more difficult to improve their situation (160). This thesis argues that many of the farmers in this study were not equipped with the necessary knowledge to make responsible treatment decisions when the project commenced. Farmers were not always in a strong negotiating position with their milk contract to challenge decisions that seriously affected their ability to improve herd health (i.e. receiving a record low price for their milk in 2014 - 2015 hindering farm investment). They were also in a weak position to question their veterinarians on treatment and prescribing choices because of a gap in their knowledge on antimicrobials. Consequently, farmers were at a disadvantage in terms of adapting farm practices, infrastructure or treatment protocols, which this project aimed to improve through a bottom-up approach. Until this inequality or imbalance is addressed, then it is arguably difficult to encourage change on farms (203).

For these reasons the PAR methodology aimed to and succeeded in empowering farmers with 1) knowledge and (59) confidence inspired by a sense of solidarity enabling responsible AMU to occur. Participation in this project tackled farmer isolation through peer support; isolation can be viewed as a mechanism of fragmenting power from certain parts of a community or supply chain (204). A key result from this study has been to highlight the importance of building solidarity in creating change on farm. The aspects of the FAG method that helped create a sense of solidarity with farmers were peer support, seeing other farms, forming friendships and, importantly, the generation of new knowledge.

Knowledge mobilisation was a further major theme to emerge from this project. Farmer participants identified gaps in their knowledge on HPCIAs and how AMR develops; information on these topics was not generally forthcoming from their veterinarians at the time of the study. The views of veterinarians revealed a frustration and despondency as to their influence on farms, despite many studies placing the responsibility of changing practices on farm with veterinarians (105, 177, 205).

These results in combination suggest that a farmer-led, bottom-up approach like the FAG project has a role to play in helping farmers change practices in the UK and there is an argument for including veterinarians in the adoption and delivery of such programmes. The approach has limitations in that it will not work for all farms on all topics – there is evidence to suggest there is a selectivity in those who tend to participate. Additionally, varying farm development pathways at different points in time will impact participation as discussed by Ingram and colleagues (188). Nonetheless, if a focus on fostering a sense of solidarity and knowledge mobilisation can be built into a farmer-led approach then there is every chance it could work more widely.

The next chapter presents the outcome on farm from the FAG project. Changes in practice from participation in the study were analysed through the Action Planning and the Medicine Review processes. The extent and scope of how the FAGs helped farmers achieve these changes on farm around AMU was explored. Development, the third phase in this research's conceptualisation of participation, was the focus of Chapter Six. Participant farmers developed their knowledge around AMU and developed each other by critical enquiry into each other's practices. Participant farms were developed based on the facilitated discussions, knowledge exchange and knowledge generation in the FAGs. This development was characterised by personal farmer development touched upon in this Chapter (through building confidence and capacity to make changes) but further expanded by development of farm practices and AMS strategies.

Chapter Six: Farmer Action! Results and discussion of the changes in practice around reducing AMU on UK dairy farms as part of the FAG project

6.a. Introduction

Chapter Six details the outcome from the FAGs in terms of changes to practice around reducing AMU. This chapter focuses on the 'Action' aspect of the PAR methodology, whereas the previous chapter focused on the concept and value of participation, particularly aspects of engagement and interaction. This chapter continues to address the third aspect of participation - development by examining what changes occurred on participating farms and how they were developed by farmers. Chapters Four and Five addressed the research question of 'What lessons can be learnt in order to scale-up the Farmer Action Groups?' Chapters Five and Six explore the research questions of 'What lessons can be learnt around how the approach helped support changes in practice on farm?' and more specifically 'What lessons can be learnt around supporting farmers to reduce the use of and need for antimicrobials?'.

This chapter analyses the results by focusing on the two principal on-farm actions to come out of the FAGs: first, the drawing-up and implementing of Action Plans and, second, the Medicine Reviews. Three quite different methods (i.e. Action Planning, Medicine Reviews and semi-structured interviews) and two differing epistemological approaches have been included in this chapter for two key reasons. Firstly, this chapter is interested in the outcomes from the participatory approach on farms. Were there changes to practice and what were they? The Action Plans, Medicine Reviews and interview data captured these changes in an empirical way. Through triangulation (as described in Chapter Three) the results have been interpreted in tandem to improve the reliability of the conclusions, which is more logically built into the structure of one chapter. Secondly, this is a policy relevant piece of research (see Chapter Seven) that aims to learn how the approach could be scaled-up. Policy-makers want to see evidence of the approach working in order to successfully adopt it (206). PAR methodologies have action and change at their core (as examined in depth in Chapter Three) therefore it is logical to capture and assess this change in a useful coherent way within one thesis chapter.

This chapter closely examines the Action Planning process and practical steps trialled and implemented by participating farmers. How the Action Plans related to reducing AMU and why some actions were implemented over others is discussed. The Action Planning process from the farmers' perspective and limitations with such a process are also described. The chapter then moves onto the results of the Medicine Review process - did farm participants reduce AMU whilst participating in the

FAG project? The role the Medicine Reviews played in changing practice is analysed and the active part farmers had in their evolution is discussed. The chapter concludes with a discussion of the limitations of the Medicine Reviews, how they could be improved and the parts the participatory Action Planning and benchmarking played in supporting a change in practice.

The impact of the FAG project has been captured through the following data: qualitative data from FAG meetings and individual semi-structured interviews, changes in practice from implementation of the Action Plans and changes in AMU from the Medicine Reviews. There were a multitude of changes on all the participating farms as reported by farmers. Many of these changes resulted from decisions taken through the formalised Action Plan process but many also resulted more indirectly from the peer learning, farm observation and discussions emerging from FAG participation.

The impact these changes had on the level of AMR on the participating farms was not assessed or investigated as it was beyond the scope of this study. No bacteriological samples were collected; only AMU was examined. The longevity of the changes on farm and the changes to practice was only evaluated for the two years of the project. Any assessment of the persistency of the changes beyond this time period was not evaluated.

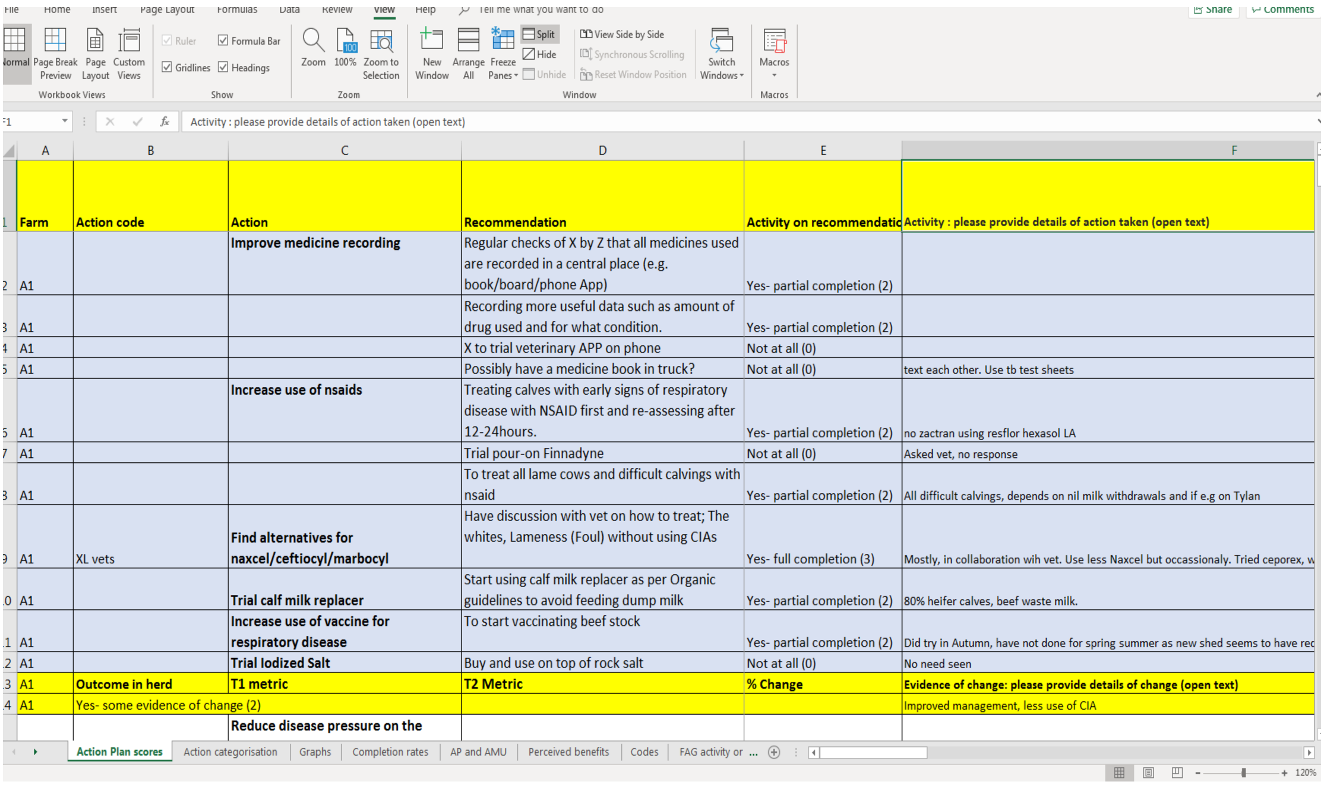
6.b. Action Planning

6. b. i. Materials and Methods

The full description of the approach taken for the FAGs and the Action Planning process is included in Chapter Three. Briefly summarised here is the purpose and analysis of the Action Plan outputs from the farmer meetings. The Action Plans were developed in order to 1) collaboratively facilitate recommendations for changes to practice based on farmer knowledge exchange occurring at the meetings - this was a technique taken directly from the Stable School model and 2) to measure and monitor the implementation of different recommendations from the Action Plans. The plans were co-created as lists of achievable, practical steps emerging directly from the FAG process that each host farmer accepted as a plan to work on to reduce the use of and need for antimicrobials. These plans were constructed from ideas developed out of the farm walk, from facilitated discussion using the Medicine Review data for the host farm and from group discussion activities. The basis of the Action Plan recommendations stemmed from farmers' own knowledge and experience, following PAR principles.

Each Action Plan was assessed both individually with the farmer participant in the semi-structured interviews and as a group at each FAG Phase Two meeting. The group assessment was in the spirit of a PAR methodology and also allowed the Action Plan to be improved and built upon. Some farms in Phase Two ended up with a 'Re-Action Plan' in response to the group's comments about how to build on existing changes (this was not evaluated in the same way as the Action Plans).

The principal foci for assessing implementation were the level of activity for each recommendation on the Action Plan and the perceived benefit of implementing the recommendation. The level of activity for each recommendation was categorised into 'fully completed', 'partially completed', 'not yet but hope to complete', 'not completed at all' and 'don't know'. The farmer selected an option from a drop-down box on a Microsoft Excel for Office 365 spreadsheet with the primary researcher at the end of the semi-structured interviews (Figure 21).



	A	B	C	D	E	F
1	**Farm**	**Action code**	**Action**	**Recommendation**	**Activity on recommendatio**	**Activity : please provide details of action taken (open text)**
2	A1		**Improve medicine recording**	Regular checks of X by Z that all medicines used are recorded in a central place (e.g. book/board/phone App)	Yes- partial completion (2)	
3	A1			Recording more useful data such as amount of drug used and for what condition.	Yes- partial completion (2)	
4	A1			X to trial veterinary APP on phone	Not at all (0)	
5	A1			Possibly have a medicine book in truck?	Not at all (0)	text each other. Use tb test sheets
6	A1		**Increase use of nsaids**	Treating calves with early signs of respiratory disease with NSAID first and re-assessing after 12-24hours.	Yes- partial completion (2)	no zactran using resflor hexasol LA
7	A1			Trial pour-on Finnadyne	Not at all (0)	Asked vet, no response
8	A1			To treat all lame cows and difficult calvings with nsaid	Yes- partial completion (2)	All difficult calvings, depends on nil milk withdrawals and if e.g on Tylan
9	A1	XL vets	**Find alternatives for naxcel/ceftiocyl/marbocyl**	Have discussion with vet on how to treat; The whites, Lameness (Foul) without using CIAs	Yes- full completion (3)	Mostly, in collaboration wih vet. Use less Naxcel but occassionaly. Tried ceporex, w
10	A1		**Trial calf milk replacer**	Start using calf milk replacer as per Organic guidelines to avoid feeding dump milk	Yes- partial completion (2)	80% heifer calves, beef waste milk.
11	A1		**Increase use of vaccine for respiratory disease**	To start vaccinating beef stock	Yes- partial completion (2)	Did try in Autumn, have not done for spring summer as new shed seems to have rec
12	A1		**Trial Iodized Salt**	Buy and use on top of rock salt	Not at all (0)	No need seen
13	A1	**Outcome in herd**	**T1 metric**	**T2 Metric**	**% Change**	**Evidence of change: please provide details of change (open text)**
14	A1	Yes- some evidence of change (2)				Improved management, less use of CIA
			Reduce disease pressure on the			

Figure 21 – Print screen of Microsoft Excel for Office 365 spreadsheet used to assess implementation of Action Plan

The same process with the same spreadsheet was used to assess the individually perceived benefit in completing or attempting the recommendations on the Action Plan. The degree of benefit was categorised as follows; 'full benefit', 'partial benefit', 'none yet but hope to see some benefit', 'no benefit at all' and 'don't know'. The group evaluation consisted of each recommendation being described on a card and the FAG sorting these into one of four categories. These were as follows:

Success, Ongoing, Disregarded or *Disaster* (see Chapter Three for a more detailed description). Two farms did not have their Action Plans fully evaluated with the primary researcher due to (1) not hosting a Phase Two meeting and (59) not being available (quantified in Table 11 as 8.1% 'not reported').

The purpose of the group evaluation was to reflect on the changes the group had recommended for the host farm's Action Plan in a participatory manner. What had worked well and why? What needed adapting? Which recommendations were inappropriate or even disastrous and why? The four categories were formed by the primary researcher after discussion with participants in the semi-structured interviews about how they perceived their Action Plans. There were suggestions from participants that they were still attempting many actions by Phase Two, and some had been dismissed after the first phase of meetings. This is explored more later in the chapter.

6.b.ii. Results and discussion

Reported here are the quantitative and qualitative results of the Action Planning process. The results are reported and discussed under the following themes: Action Plan content and implementation, perceived benefit from implementing the Action Plans, farmer reported changes in practice (broken down into topics), constraints to changing practice and general discussion. This mixed methods approach is valuable because 1) it follows the principles of triangulation whereby multiple sources of data and varying methods are compared to improve the validity of the findings and 2) the addition of qualitative data adds a richness to the quantitative data which helps explain and improve the findings. For instance, finding out why certain recommendations had been implemented over others required asking different questions that can be answered through a qualitative data approach using methods such as interviews.

Action Plan content and implementation

The outcome of this discursive and co-creative process was 30 Action Plans, one for each farm participant. There was a mean of 10 practical steps or recommendations on each Action Plan (range 5 - 19). In total, participants made 304 commitments to change something on their farm in order to reduce AMU. These commitments, as recommended by their FAG, included both changes to the use of antimicrobials and the adoption of preventative measures to avoid the use of these critical medicines in the first place.

There was a wide range of Action Plan topics covered; they were not limited to AMU in fact the farmers were encouraged to talk about any topic they saw as relevant. Figure 22 shows photos of example Action Plans co-created at various FAG meetings. Figure 23 illustrates the topics covered on the Action Plans, the relative number of recommendations in each topic and the proportion that were partially or fully implemented by Phase Two.

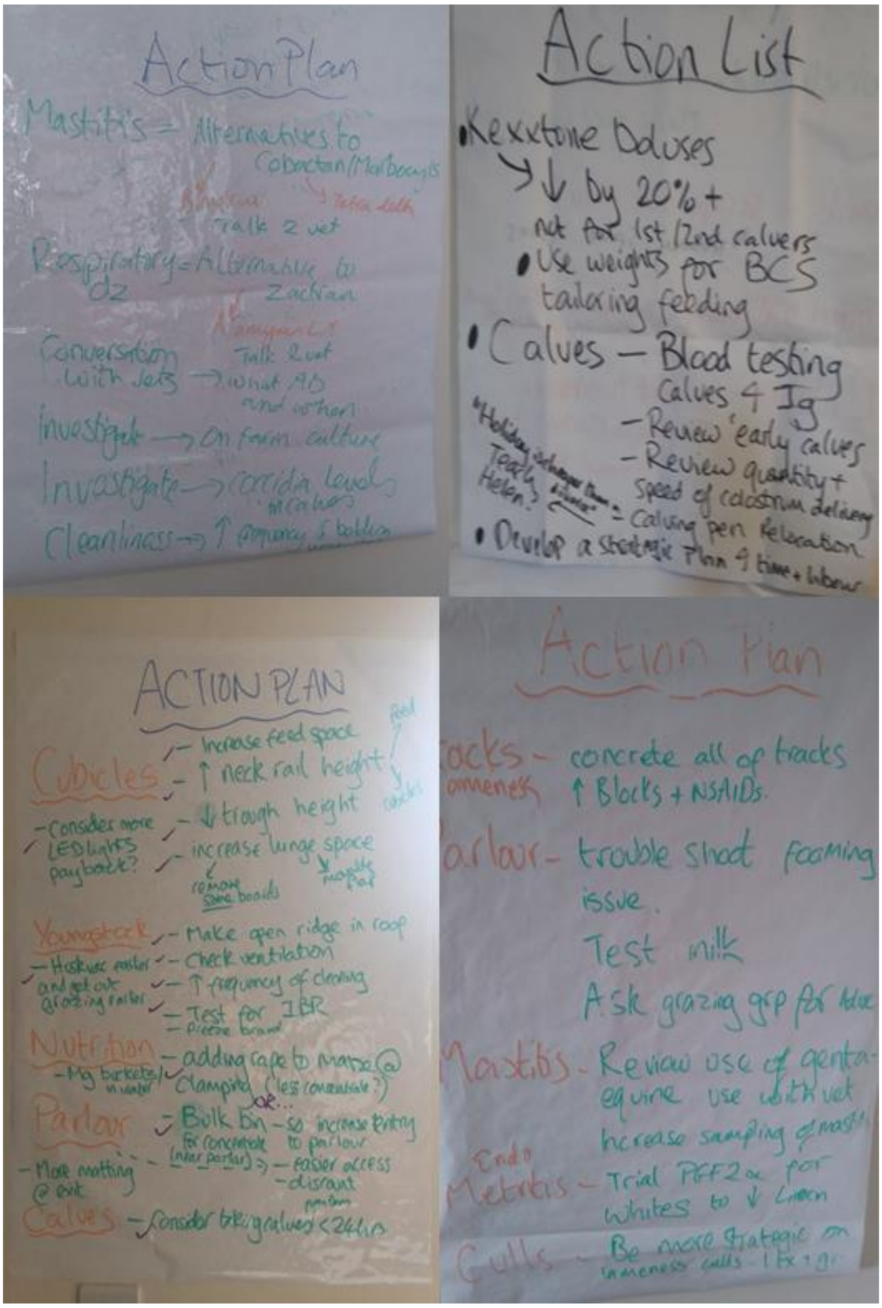


Figure 22 - Example Action Plans co-created at each Phase One FAG meeting

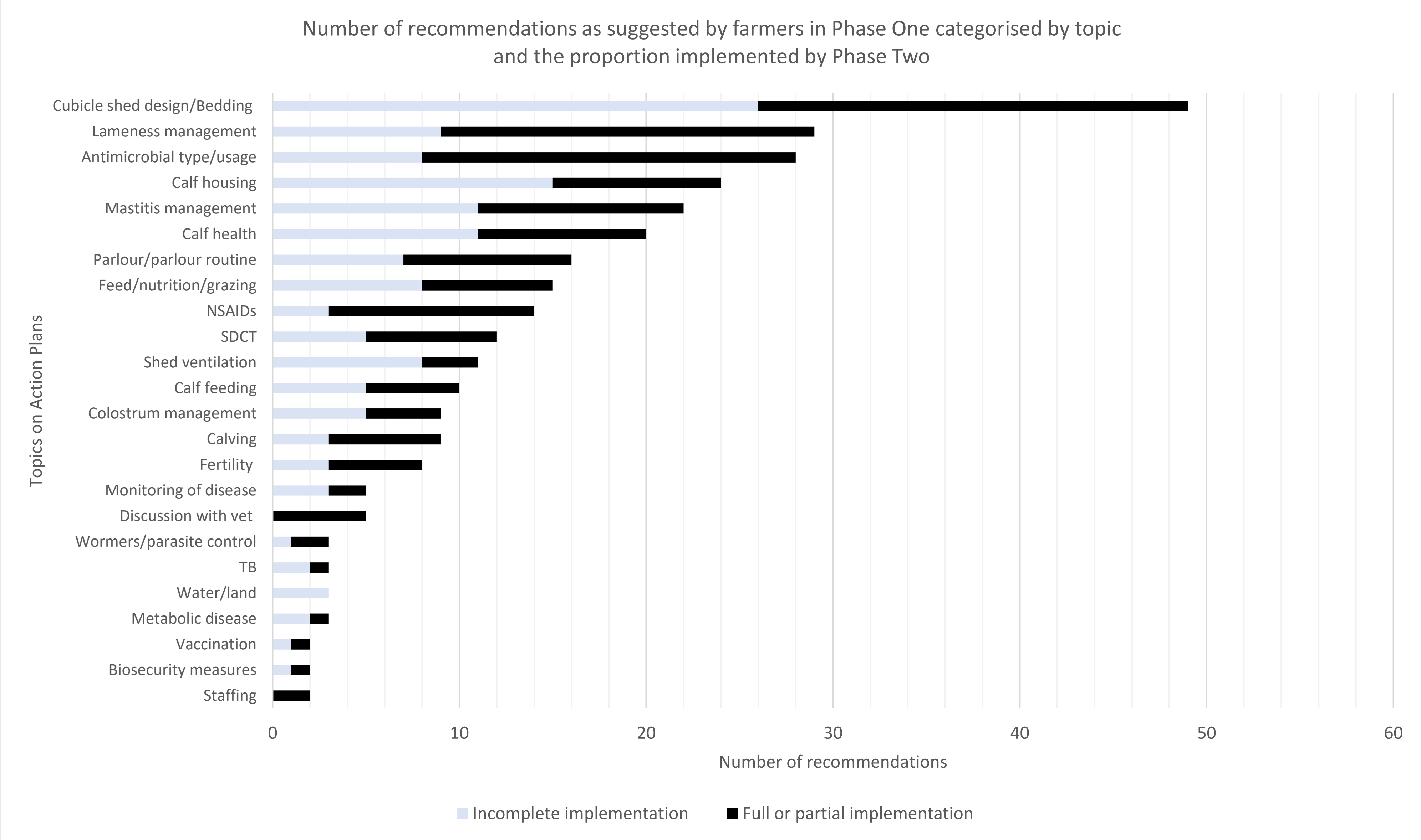


Figure 23 - Bar graph of number of recommendations in each topic from the Action Plans and proportion implemented by Phase Two

The most common topic to occur on the Action Plans was changes to the cubicle shed design and the bedding area for the cows. Recommendations in this topic occurred 49 times with examples such as increasing lunging space, increasing passageway space in planned new sheds, changing types of bedding, reviewing cleaning routines and focusing on shed lighting. This did not include measures on improving ventilation or air space, as these were counted in a separate topic (shed ventilation), which also featured fairly frequently (n=10). The second most common topic on the Action Plans was lameness management, which included doing more mobility scoring, swifter identification and treatment of lame cows and using more blocks and less antibiotics for treating individuals. Use of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) was counted as its own topic due its relative frequency (n=14). The third most common topic to feature on the Acton Plans was, unsurprisingly, antimicrobials. Recommendations in this topic pertained to moving away from HPCIAs and checking dosing regimens and withdrawals. Another common topic was calf housing. Recommendations in this topic were similar to the cubicle shed examples as they focused on the space in which the calves were kept and on improving cleanliness and dryness.

None of the participants had completed or implemented 100% of their Action Plan by the second phase of meetings. Phase Two meetings occurred between eight to 12 months after the first meeting for each participating farm (i.e. within a year of co-creating the Action Plan). However, all participants had attempted at least one recommendation from their Action Plan by their Phase Two meeting. The average proportion of recommendations that had been either fully or partially implemented by Phase Two was 54.3%; just over half of an average Action Plan was implemented within eight to 12 months.

Table 10- Participant reported completion of individual recommendations from their Action Plans (%)

No. of Recommendations	**Full completion**	**Partial completion**	**Yet to see**	**Not at all**	**Don’t know/No response**
304	101	63	52	77	11
%	33.2	20.7	17.1	25.3	3.6

As can be seen from Table 10, 101 recommendations were reported as fully completed and a further 63 were partially completed. This gives a total of 164 recommendations that were implemented partially or fully by Phase Two. ‘Don’t know/no response’ included one farm’s Action Plan that was not assessed for completion (i.e. ‘no response’) due to the participant not hosting a second time and thus not being evaluated (n=8) and three ‘don’t know’ responses.

Perceived benefit from implementing the Action Plans

The majority of recommendations on the Action Plans were perceived by farmers as beneficial to their business, herd or themselves, or hopefully would be when they came to fruition. The proportion of the farmer-led recommendations that were perceived to be of full benefit was 30.5%, as demonstrated in Table 11. When 'full benefit' and 'partial benefit' were combined, 54.5% of all farmer-led recommendations on the Action Plans were deemed to be beneficial to some degree. A substantial proportion (21.1%) of recommendations were deemed 'no benefit at all', which was mainly around recommendations that had been disregarded by the host farm as unsuitable or in favour of something else. 25 recommendations were not assessed for perceived benefit and were not included in the total actions assessed. This figure of 25 non-assessed recommendations consists of one farm's Action Plan that did not host in Phase Two and another that was unavailable for the full evaluation.

Table 11 – Participant perceived benefit from implementing individual recommendations from their Action Plans (%)

No. of actions assessed	**Full benefit**	**Partial benefit**	**Yet to see**	**No benefit**	**Don't know**	**Not reported**
279	85	67	48	59	20	25*
%	30.5	24	17.2	21.1	7.2	8.1

*= number of recommendations not assessed including two farm's Action Plans

The evidence presented on perceived benefit suggests farmers see some value in a participatory, farmer-led approach to Action Planning - the outcome on farm being perceived as more beneficial rather than risky, negative or unlikely to be implemented. Many of the recommendations that were deemed of no benefit or 'yet to see' had either been disregarded based on the host farmer's judgement or were in progress, respectively.

Figures 24 illustrates the relationship between the level of attendance across all meetings and the number of recommendations implemented from each farm's Action Plan.

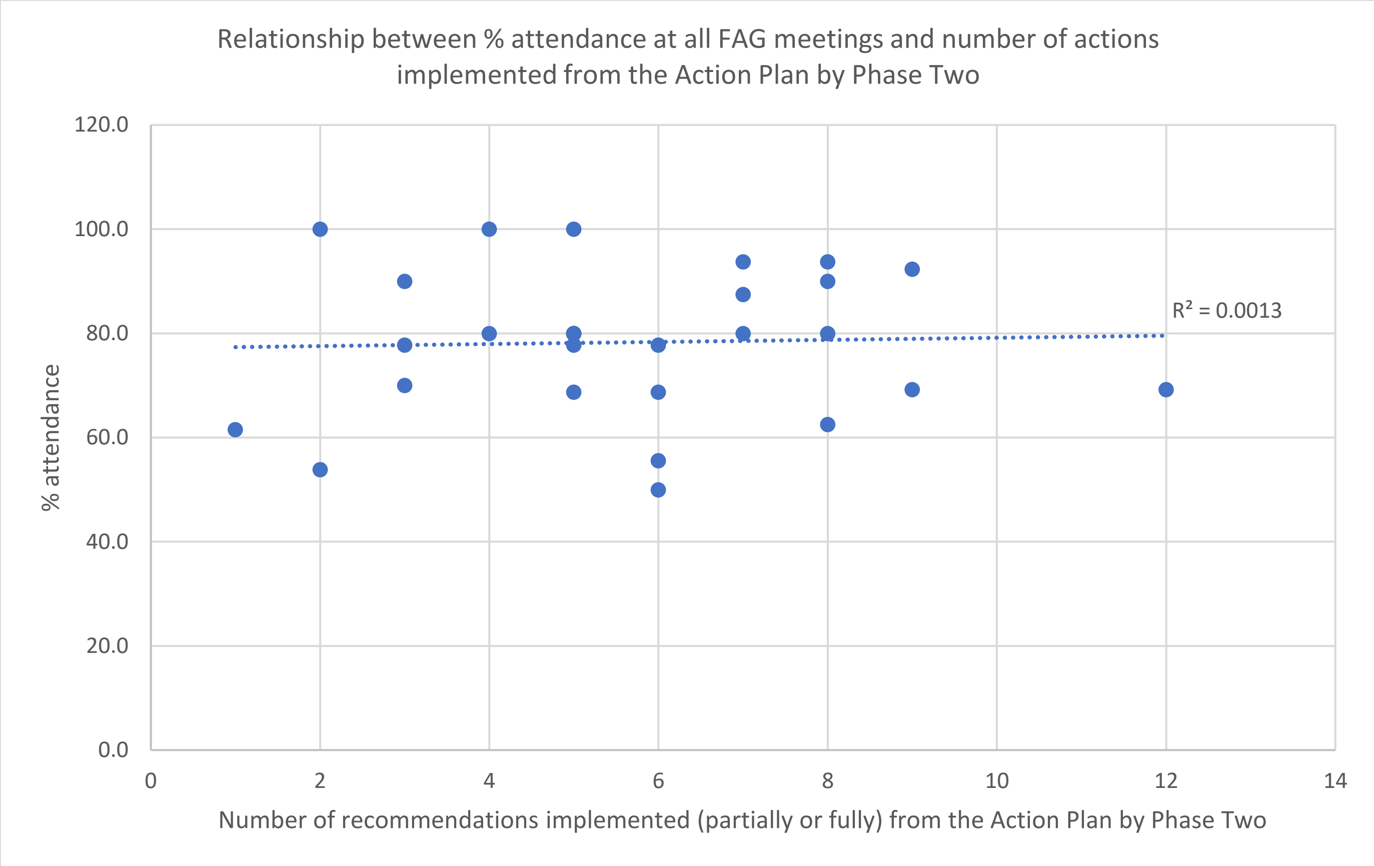


Figure 24 - Relationship between attendance (%) and number of recommendations implemented from the Action Plans by Phase Two (i.e. within a year)

Figure 24 shows there was no correlation between attendance at the FAG meetings and the implementation of the Action Plans, which would suggest there is not a clear link between attending the majority of meetings and implementing the majority of the Action Plan (R^2= 0.0013). It could be inferred from this therefore, that the FAG meetings were not performing a key role in helping farmers implement the recommendations on their Action Plans. However, the changes to practice were numerous and multi-factorial and cannot be simply determined by implementation of the Action Plan alone. As is discussed in this chapter, many changes were based on the Action Plan, but many were from the discussions with peers and seeing other farms (i.e. they were not formalised on the list of recommendations). Some of the greatest value farmers perceived in the project was the acquisition of knowledge and understanding more about AMU, which was not a specific measure on the Action Plan. In addition, 17.2% of the Action Plan implementation was reported as 'not yet but hope to complete' (see Table 11) suggesting more time was needed to observe further completion of the Action Plan recommendations. Finally, a solid conclusion cannot be drawn from this small a sample (n=29 assessed farm Action Plans) over such a short period of time.

Farmer-reported changes to practice on farm

The majority of recommendations, when discussed by participants during the FAG card sorting activity, were classified as either *Ongoing* or a *Success* (see Figure 25). Many had been *Disregarded* by the host farms but often after a period of consultation as a group or on farm trial. It was important that host farms could disregard suggestions as they saw fit. This was based on the understanding that the host farmer knows his/her farm best and some suggestions were perceived as inappropriate, especially when taking on board ideas from such a variety of dairy farming systems. For example, one farmer idea was to create 'high care cubicles' for freshly calved cows or lame cows so they did not have to move far from food or water. The host farmer decided the benefits of this were too low for the amount of work and space that it would require and hence was disregarded. Also, the option to disregard suggestions left the final say with the host and empowered them to decide what would happen on the farm. This is in line with the PAR philosophy of empowerment for those making a change (19), whether that be a community or an individual within the community. The ability to negotiate an outcome and have a say in what happens is a key element of a participatory approach (150). This following section details the farmer-reported changes on farm that participants perceived to be as a direct or indirect result of the FAG project based on the qualitative data from the FAG meetings and semi-structured interviews.

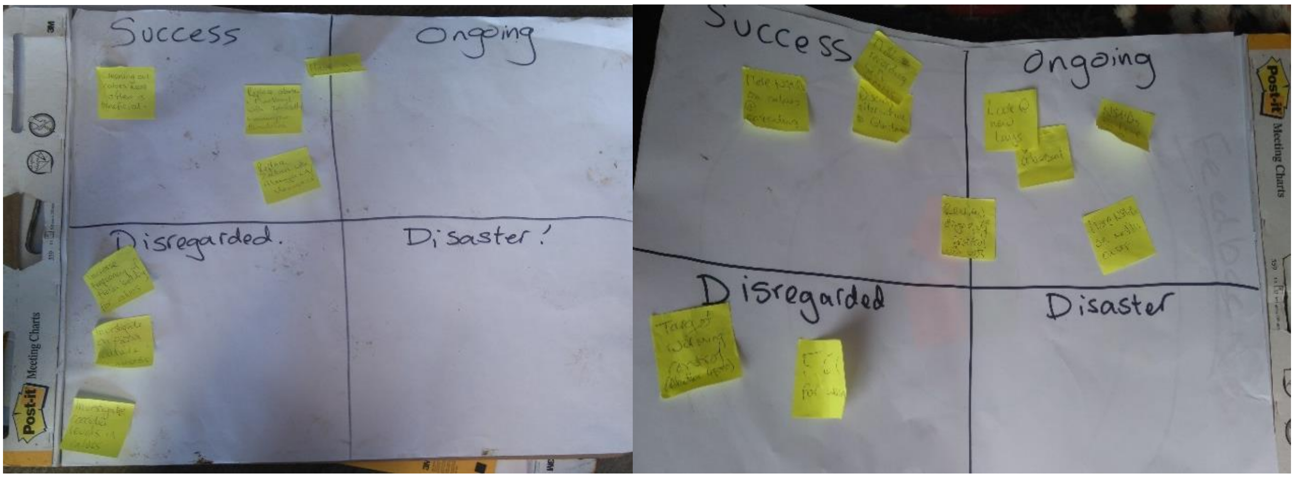


Figure 25- Examples of the outcomes from the card sorting activity to evaluate the Action Plans at Phase Two meetings

Cow environment – cubicle sheds and bedding areas

The most commonly featured topic on the Action Plans concerned cubicle shed design and bedding. Farmers were good at recommending and implementing changes to the cow environment, whether that was cubicle sheds or calf accommodation. Changes to the bedding areas, cow comfort, lighting and ventilation were all implemented.

> *"We gave them an outdoor loafing area which has worked very well. Got a bit wet at times but it just gave them somewhere to go out. We increased the lighting above our heifers feed silage bit, so put a new LED light in and stuff like that. Just above the silage so they could, we kept the lights on all the time in the shed." FAGC2*

These changes were practical and within the control of the farmer. They spent many hours in these environments and saw from visiting each other's farms the benefit it could have on cow welfare as well as observing changes to their health and behaviour.

> ***Host farmer*** *"Yield dropped by 3L a day when the lights were off for a day. The lights on timers, come on at 5am and off at 11pm. In feed yard, come on at 4 in afternoon and off at 2am, then on again at 5am.* ***Another Farmer*** *"Have you noticed much difference?".* ***Host*** *"They eat a lot more, you come out in the night and there will be cows out eating...Costs £1.20 a day to run the lights."* FAGC3

Participants also described cows being up and ready to be milked in the mornings, which made it much easier for staff doing morning milking. They noticed increases in their feed intake from increasing lux levels in the sheds in the day and providing eight hours of darkness at night. The sharing of the outcomes from making these changes encouraged others and re-enforced the practices, as is demonstrated later in this chapter.

Lameness management

The next most commonly mentioned topic on the Action Plan was around lameness management.

> *"We have not treated a cow with antibiotics for feet trouble this year, full stop… We're doing more foot trimming. We haven't used any antibiotics for feet whereas I used to use a bit of Excenel." FAGC1*

This farmer not only reported this change when interviewed about his Action Plan, but he phoned the primary researcher shortly after hosting to say what he had done! The rest of his group had explained that using antibiotics for claw lesions was rarely necessary and the Medicine Review had flagged up his Excenel use as excessive and a HPCIA. This culminated in him eliminating it from treatment of certain lameness aetiologies and finding a solution in using the foot trimmer more frequently, which he also reported saved him money. This was a common theme across more than one farm:

> *"I haven't treated a lame cow with antibiotics… maybe 1 in the winter with foul. We don't anymore but we used to, if we got a lame cow we used to routinely, I doubted whether they need antibiotics, I would jab them. Now I will block them, I am quite happy blocking them, blocks are a lot cheaper than antibiotics, I give them an anti-inflammatory if they are significantly lame." FAGDe4*

The above quote brings together multiple aspects of lameness management that were triggered by discussions at the FAG meetings. Rubber matting was used by several farmer participants and was recommended as a way of reducing lameness at sharp turnings and on hard concrete.

> *"Next one is flooring, improve flooring at parlour exit, use more matting." RES: "Yes….I have put some down, I had some that was supposed to have gone in the parlour that I hadn't used, so I have used that in the parlour exit, so I have done it." FAGDe6*

The discussion that precluded this recommendation focused the farmers mind on the benefits the limited matting would have at sharp corners where cows were turning, as opposed to in the milking area. The Action Plan helped him prioritise on limited resources and pushed him to act on something he had not got around to doing - *"was supposed to have gone in the parlour".*

The facilitator and primary researcher would ask farmers about their treatment protocols for a variety of conditions on the farm walks. One of these conditions was lameness and often revealed inappropriate use of antibiotics and rare use of anti-inflammatories. This sparked discussion from those already using blocks or thinking about giving pain-relief, and consequently appeared on the Action Plan and was implemented on farm.

> *"Yeah we'd used blocks just not the anti-inflammatory so much." FAGC2*

> *"We use more Recocam haven't we?" FAGW1*

> *"Actually, following on from what you said [farmer], with metacam use, I think we are going to have to re visit that again." FAGW3*

Generally, farmers were not against using pain-relief and this push to use more was heightened by the effect of social norms - they did not want to be seen as bad farmers by their immediate peers. The effect of social norms around treatment decisions has been documented elsewhere (207). The facilitators would point out that lame cows were painful and should receive anti-inflammatory - many in the FAGs agreed. This peer pressure explained at least partially why many reported using more anti-inflammatories over the course of the project.

Some of the actions around lameness were adapted and changed from the Action Plan, based on the host farmers' judgement and farm needs, as seen when considering rubber matting and then deciding a walk-through footbath was actually more helpful.

> *"We haven't installed the rubber matting, but we have put a walkthrough footbath." FAGW2*

This was evidence of the Action Planning process triggering further changes and ideas on farm, which the farmers took ownership of.

Antimicrobial usage

The third most common topic from the Action Plans was changes to the types of antimicrobials used on farms. These were often the 'easy wins' and was something farmers felt their veterinarians should be helping them with more.

> *"Well mine aren't. After the last meeting, I phoned up my vet and said I am using cobactan tubes and I want to try something else… they sounded blank on the phone. They are not all signed up to it." FAGS4*

The primary researcher encouraged all participants to discuss the Action Plan and specifically the drug changes with their veterinarians, which many did. Discussions with veterinarians was in fact the most implemented topic on the Action Plans (see Figure 21).

> *"We had a chat with her [vet] in the office a little while ago about it." FAGW1*

More detail on the changes to AMU particularly is covered in the next section of this chapter. Related to medicine use, a couple of farmers were open about their lack of medicine recording on farm and how they needed to improve.

> *"We are better now at scribbling down something in the diary but it still has to be written up still." FAGW1*

This was potentially more an effect of the primary researcher collecting their data and exposing significant gaps in their records, rather than the FAG holding each other to account as seen with HPCIA usage and pain-relief.

Calves

A further two topics from the Action Plan that farmers reported completing partially or fully were on calf health, housing and colostrum management. Farmer participants reported completing the design and building of new calf accommodation using feedback from their FAG. Some already had plans for new sheds but acted on the input from their peers or were pushed to act by having a group of farmers visit and then the ideas being put on the Action Plan.

> *"We've done that calf shed. We've done the first one." FAGDe3*

Another farmer describes having temperature checked calves that were seen coughing, which was a recommendation to check ill-thrifty calves for pyrexia and treat first with an anti-inflammatory. This recommendation was based on the knowledge antibiotics do not work on viruses and many early signs of respiratory disease in calves are caused by viral infection (208). This knowledge was initially provided by the primary researcher in the meetings but then repeatedly flagged by the participants in their group discussions.

> *"We did on our action list, we did action temperature check those calves that were coughing" FAGC2*

He goes on to elaborate that he was considering ear tag thermometers next, so he could pick up illness sooner. This is further evidence that some of the recommendations on the Action Plan sparked further ideas and changes.

Another area where farmer participants made changes was around calf feeding. There were many discussions around feeding regimes and protocols for calves beyond colostrum management.

> *"Yeah we've gone to a whey-based powder instead of the other one, skimmed. What does everyone else use? **Another farmer** "You cannot get enough detail anywhere to compare milk powders!" **Host farmer** "Whey based milk powder separates out and leave a sludge. Skimmed don't." Most of group admit using whey-based. **Another farmer** "I prefer waste milk..." **Same farmer describes frustration about instructions on milk powders**- "Someone ought to be fired there, they do not listen". **Facilitator interjects** "if you only feed 300g then that would be not even the maximum weight gain...The bottom line on milk powders is, it should be the mixing equivalent, should be minimum*

> *equivalent as whole milk. Otherwise why feed it? You wouldn't substitute whole milk with something less than whole milk." FAGDe3*

The recommendation to change calf feeding practices was encouraged by other farmers' experiences of using milk powders with occasional input from the facilitator due to her expertise in calf management. It is evidence of the capabilities of farmers to come up with practical solutions of relevance to their daily work whilst being guided by a credible facilitator - knowledge exchange in action.

Following on from this were recommendations on colostrum management. The following farmer made definitive steps to improve his neonatal calf care by focusing on feeding colostrum as quickly as possible after birth. His FAG had highlighted the importance of this not only when he hosted but also when visiting each other's farms.

> *"It's all sorted. Definitely the colostrum management, trying to get colostrum into calves, much more focused on that now than I was. In terms of taking cows away, I am taking them away earlier than I was, but still not by 24 hours." FAGDe6*

The above quote highlights that despite the influence other farmers can have on each other as previously discussed, they still have their own beliefs and points of view that will feed into their decision-making (i.e. the above farmer resisted snatch calving despite the recommendation to do this from his FAG). This farmer's FAG accepted that there were different strategies for calf-rearing and that there were benefits and drawbacks to each. The fact they did not judge each other and respected an individual's reasons for doing something, was further evidence for the peer support that the FAGs fostered.

Nevertheless, the peer pressure within the groups associated with ensuring colostrum management was following best practice guidelines was palpable.

> *"Yeah, also now we're testing all the colostrum which we weren't before. You can see we've put a spectrometer in there." FAGDe3*

Colostrum management was one topic where there are some standardised evidence-based guidelines farmers can follow (209), compared to many issues discussed where it is not clear what is best practice i.e. milk powders, foot bathing protocols. During the project there was also a social media campaign called #ColostrumIsGold, which cemented some of these 'best practices' in farmers' minds. It was variable how participants managed colostrum, but all agreed that it should be fed as soon after birth as possible and should be stored clean. The volume given in the first feed was debated and dependent on the calf size; the industry agreed guideline of 10% of bodyweight was offered by the facilitator as one solution. The facilitator also offered information on the differences between the ways to measure colostrum e.g. using a refractometer or a colostrometer.

> ***Host farmer*** *"The colostrometer we use was a refractometer. The look through at the light one and read off. But is got really dirty and was confusing. No one ever cleaned it so we have gone back to *motions dropping something in milk* with red yellow green on it."* ***Facilitator asks*** *"but what temperature is the milk at when you use that?"* ***Host replies*** *"The temperature when it comes out of the cow."* ***Facilitator explains*** *"it will give you a false reading as it needs to be at room temperature to work". FAGS1*

A popular tactic to improve the health of calves were calf jackets. Several farmers in the project were already using calf jackets to some degree. Other farmers who were not using them often asked about their cost and how effective they were.

> *"We've got some calf jackets as a result of… RES 2: Of you being on holiday, wasn't it?...When you were away J bought them. J went crazy." FAGW1*

> *"Yeah, we've got a total of 40 I think, which when they're calving at their very quickest, still isn't quite enough. We did find that if we did need to take jackets off for new calves, and it coincided with some cold days, you could see it really hit them. I don't doubt we should buy more this time, once we get to the time of year when it really needs them. We found that a great success, yes." FAGW2*

> *"We're using more jackets, yeah we're using more of those…Yeah, you've got better use of feed. XX is a real convert." FAGW3*

Even those farmers that trialled jackets and were not initially convinced of the benefit, were converted after they saw how well the calves did on cold or wet days. They drew inspiration from seeing others try them and talk of the benefits, and then were completely sold once they saw the benefit on their own calves. The others in their group gave them the motivation to try jackets but their own experience of using them consolidated that behaviour. Some of the farmers would have been advised to trial calf jackets from other sources (their veterinarians) before the study. What was it about hearing from other farmers that really triggered them to try them? Part of it was the development of relationships with the rest of their FAG; the opinions offered had more relevance coming from their peers. These farmers were not strangers anymore but peers they could relate to. Also, they visited the farms of these peers and saw the results of the calf jackets - what they were recommending was not fabricated or from text books but had tangible, visible benefits. The suggestions were formalised and followed up through the Action Plan too, which acted as a final push to 'get around to buying some'.

Mastitis

Topics that directly related to AMU and appeared fairly frequently on the Action Plan were preventing and treating mastitis including milking routines. One farmer made a bold move and hired a relief-milker on recommendation from his FAG.

> *"We took on the relief milker, back in May. That is now permanent, at least two milking's a week." FAGC3*

This was direct advice from this farmer's FAG and was something he had already acknowledged he needed to consider. It demonstrates that much of the advice shared at the FAG meetings was not novel to the farmers - the group pressure and inclusion on a formal Action Plan that would be re-visited contributed to it actually happening rather than staying as an idea.

The same farmer also attempted SDCT for the first time, after a period of refusal and avoidance.

> *INT: "...did the people in the group and the project sort of push you to do it or was there other reasons why you thought right, now I'm just going to have to do this, I'm going to have to try Selective cow therapy? RES: "Well it was sort of part of the action plan really and I thought if I don't try it, what's the point in being in the group if you don't, you know." FAGC3*

He was encouraged to trial SDCT by the Action Plan and being part of the FAG. His view was that if he was going to be part of the study then he might as well engage and try the recommendations, particularly SDCT. The attitude of 'give it a go' is something to note and harness when helping farmers make a change. Changing habits and practices, particularly in farming is laden with risk (201) and will put some farmers off the general approach, but the supportive environment of a peer group i.e. other farmers can off-set some of this fear, as seen in the following quote:

> *"I suppose it's a habit, since 2009… it's part of our process. Once you have adapted a way of doing things it's very difficult, until someone comes along and questions things." FAGW3*

The questioning from their peers was a factor in changing practices. Furthermore, the inspiration participants drew from each other, demonstrated nicely in the next quote, also added to the push to change and adapt.

> *"Yeah, I think we might – antibiotic treated about thirty odd per cent last year for drying off….But they said they, like, tighten their parameters, spoken to B in the group and he has a smaller…[]…Yeah, he's more confident than I am with mine, but it's whether I now have a little whizz at pushing it." FAGC4*

This farmer drew confidence from seeing another farmer in the group pushing his SDCT limits. There is a lot of uncertainty in farming; the idea of drying-off more cows without antibiotic based on historical records of infection is fraught with uncertainty (207). Farmers need reassurance that if they go one step further it is not going to be a disaster. Farmers are used to dealing with risk and uncertainty and have been shown to be risk adverse (201). By allowing farmers to see how other people have made changes and discuss them in a supportive environment i.e. in a FAG, this risk aversive behaviour can be reduced.

Infectious Disease control

A topic that did not feature much on the Action Plan was around infectious disease control. This was slightly disappointing from a veterinarian perspective but reflects the interests and priorities of the groups of farmers. Nevertheless, there was one participant that implemented quite significant changes as a result of his FAG.

> *"The first thing was using individual cow sampling to begin to assess Johne's….Yeah, which we are doing now...[]...Well we have done two or three tests now, I think." ...[]... "Of which, possibly if I hadn't been involved – then to be fair I think it's probably been involved in this group kicked me off to do the vaccinating of everything." FAGW4*

This farmer appeared to be lagging behind the rest of his FAG when it came to infectious disease control and this pushed him to make the changes. The veterinarians were also promoting BVD and Johnes control at the time, which would have made it easier for him to initiate those conversations. In addition, this group had a lengthy discussion about Johnes control on the farm walk, which saw them share worries about the disease and the details of the Johnes testing regimes.

Despite the implementation of a series of changes to practice described above, some farmers did not perceive a practical benefit for their herd when asked. They did however, comment that the lessons they learnt from their group and the wider study were crucial to past and future changes on their farm.

> *"There hasn't been any evidence of any health improvements. I think we've learnt some lessons over the changes we made last year with the calves. Having made more than one change, which ones were the ones that were really [did anything]" FAGW2*

The only actions that were deemed *Disasters* by the farmer participants were:

1. Two attempts at SDCT (although crucially the two farms whom this affected were keen to attempt SDCT again in closer partnership with their veterinarians)
2. Targeted use of 'Kextone' (monensin) boluses as opposed to blanket treating every cow in the herd
3. Moving from feeding calves waste milk to powdered milk (this farm was on an organic contract, which meant powdered milk was much more expensive compared to conventional farms)

> *"I know when you tried to reduce your Kextone, that went a bit wrong. Am I remembering rightly?" RES: "Yeah we had one LDA. Since then we have selected which ones we've done, but I don't fancy they're milking as well as they should be, but it's hard to say because you can't... the same cow you can't give it or not give it and get a – " FAGC3*

> *"We tried some of the calves on powder. We have some of my heifer calves on powder. We did two batches and they looked awful.." FAGW1*

The unsatisfactory outcomes from the above changes initiated as a result of the Action Planning process can be partially explained by poor execution of the task (particularly for SDCT) or external factors and context not being accounted for. One of the two farms that attempted SDCT was drying cows off producing 25L of milk - him and his FAG admitted it was always going to be a risky strategy but did not see an easy solution. Intra-mammary tube insertion and infusion technique is often to blame for SDCT failing or resulting in a case of mastitis and was also something the FAGs highlighted as a focus point at the Phase Two meetings for these particular farms. In light of these relatively infrequent *Disasters*, the participants were offered the chance to focus on each other's SDCT technique at one of the meetings. They responded positively and one of the final meetings for each FAG involved a group activity where they had one minute to share their drying off procedure from start to finish with the group. The steps were discussed and compared but have not been evaluated for this study.

Constraints to changing practices

There were four main constraints cited by participants for not implementing more recommendations from the Action Plans. These were around the timing of the study and its evaluation, farm staff issues, risk aversion and farm structure challenges. These constraints or rationales for not reaching full implementation of the Action Plan by the close of the study are detailed in Table 12.

Table 12 - Farmer cited constraints to implementing changes on farm from the Action Plan

Identified constraint to Action Plan implementation	**Evidence**	**Explanation**
1) Timing	*"Yeah, if time wasn't an issue, yeah. Because you've had your Action Plan, you've had time to – almost a season then - to put it into place. Where if you were all year 'round calving you can have an Action Plan, and then that Action Plan can start within a month, can't it, whereas a lot of mine are on a yearly cycle." FAGC4* *"Yeah, it's a longer term. It's not something that I was going to do like in the next month. I need to get my head around it. You are changing quite a lot. Years and years of doing stuff a certain way." FAGC1* *"Well yeah really obviously we haven't done some of it because it's going to take more than 12 months, but it certainly gives you things to think about and things to find out things about, change what you're doing." FAGC5* *"My meeting would have been September and we were drying them off in December, so it didn't give me a huge amount of time to… if I wanted to put the amount of recording in place blah, blah, blah, it didn't give me a huge amount of time to do it…" FAGC1*	Many of the participants had herd management patterns that meant they had to wait a year before they could make any changes. They might have had only certain types of animals on farm at certain points in the year (i.e. block calving herds). As the Action Plans were evaluated less than 12 months later for many, not enough time had elapsed to attempt some actions, even if they had wanted to. Farmers needed enough time to *"get [their] head around"* significant changes. This is particularly pertinent to changes to habit, or lifestyle.

2) Risk aversion	*"The first time we dried off five. Five in one go, with just teat sealant and one lost a quarter; one cow went blind in four quarters." FAGC3* *"What I don't want to do is risk my lactation. I don't want huge amounts of mastitis in the lactation which will force me to use… I might end up using more [antibiotics] mightn't I, and then there's not milk in the tank either so I'd rather dry them all off and know. It's peace of mind isn't it? Surely that antibiotic is used up in the dry period, it's not still there." FAGC1* *"What I ought to do this year is try a few cows and do it and see how I get on. I have looked at some of the barrier teat dips which are quite… those really thick ones but they're quite expensive as well, that was the only thing that put me off." FAGC1*	There was a real fear amongst some farmers about putting into place changes that seemed to introduce risk. They worried about making changes that could result in higher disease rates, which would cause increased use of antibiotics overall. Some felt they were already managing disease processes well and were held back by fear and uncertainty of making changes. In some cases, attending the FAGs did not help farmers to overcome these feelings, but added further pressure to make changes that farmers knew they needed to do but were struggling to make the leap. Nonetheless, some farmers did eventually start to talk about 'making the leap' and using change language about how they were going to instigate changes. However, costs were also sometimes cited as a further major barrier.
3) Staffing	*"We've had a few staffing issues, so we haven't actually done as much as we would have liked on that...[]..."The trained one seems to be doing fine, but because there have been staff shortage issues, he hasn't been able to do as many as he should." FAGW2*	Many farmers commented on being short-staffed or struggling to find suitable staff throughout the project. One farm went out of business due to staff issues during the study. Staffing shortages had a direct impact on not only the running of farms, but also on the treatment of animals and AMU. Lack of staff meant some tasks were not completed well or at all (e.g. foot trimming). One farm found that poorly trained milking staff due to lack of time to instigate

		adequate training meant increased risk of mastitis from poor parlour routines.
4) Farm structure	*"I have done some, but I haven't done as many as some of the farmers would like me to have done, the main reason being that where they stand to feed is narrow, ideally you want 12 or 15 foot, I have got 9 foot now so it's a cow length and cow width and if I am not careful, I am going to end up with all those cubicle fronts there..." FAGD6* *"Yes, so we decided, it's all a bit dependent on TB. If we've got TB we'll get rid of the bull calves very early one way, and if they haven't got TB we'll get paid for them, basically." FAGW3*	The individual farm infrastructure was a further barrier to implementation; recommendations that focused on adapting sheds and yards were not always feasible with what the farmers had to work with. The adjacent quote summarises the decisions farmers are weighing up when looking to adapt the cow environment. They are often using old buildings, which are not always fit for purpose. This was one reason for encouraging host farms to disregard suggestions if necessary. Due to all participant farms being in the South West of England, TB was rife, and many farms were under movement restriction. The adjacent quote described how TB impacted whether they could move stock and therefore which sheds were available. Lack of space increases disease pressure due to overstocking, which can then lead to increased AMU. TB affected the implementation of the Action Plan as once 'down with TB', there was little the farmer felt they could do about moving stock/culling voluntarily to remove chronically infected cows.

Discussion

Participants were largely positive about the process of Action Planning and they perceived there to be more benefit than not from implementing Action Plan recommendations. There was no resistance to having a group of peers decide on a list of strategies to help the host farm achieve a reduction in AMU. Participants could see the value in having a group of farmers help them come up with a plan and for them to be involved from the start.

> *"I mean I've thought about and probably have a go at some of it, yeah...[]...Yeah, it was good to get everyone's views on – yeah, share information, have a separate or different pair of eyes on what you're doing every day isn't it. FAGC4*

This contrasted with the sense of bureaucracy and 'doing it because you have to' that characterised herd health planning, as can be seen below.

> *"It's [Action Plan] far more effective than a herd health plan; that's a joke. [laughter] That's an absolute joke because it's just tick box exercise." FAGW3*

Farmers felt the Action Plans were more collaborative than their herd health plan and made use of the farmers' shared knowledge at the FAG meetings. This contrasted with herd health planning, which was usually co-ordinated by their veterinarian and involved spending money, illustrated in the following quote.

> *"Actions plans from vets virtually always involve spending a lot of money! I'm not just talking about spending money on drugs, I'm talking about what you need to do is, and it will cost tens of thousands of pounds. Normally knock buildings down and put up new one, that sort of thing." FAGW2*

The comments made when comparing the Action Plans with the creation of a veterinary herd health plan (referred to as "Action Plans from vets" in the above quote) is interesting to note and supports the value farmers saw in a list of recommendations generated from the participatory mechanisms of the FAGs, as opposed to an advisor-led list of recommendations (i.e. the herd health plan). The Action Plan process follows the principles laid out by Vaarst and colleagues (2017) in the European project ANIPLAN, which states:

> *"...a health plan must be 2) farm specific, 3) based on farmer ownership, 4) involve external person(s) and 5) external knowledge, 6) based on organic principles framework and systems approach, 7) be written, 8) acknowledge good aspects of the herd and the farm, and finally 9) involve all" (142)*

Clearly, point 6) is more specific than the remit of the FAGs but the general principles are that it should be a farmer-led process with external input as required. This could explain why farmers perceive a low value in the veterinary-led herd health plan, which is usually not farmer-led in the same way seen in this study.

The farmer-farmer recommendations at the FAG meetings were perceived as practical and feasible; they had working knowledge of each other's situation, which farmers respected.

> *"I quite liked the cubicle shed. The lights are working very well in there. The cows look very healthy you know. You've done your best with an old shed, with what you can really. The only thing, I think from what I know of you now, you're probably not the sort of person who could sleep at night if you only scrapped out once a day."* ***Host replies*** *"In an ideal world it would be scrapped out 3-4 times a day in the cubicles. Their feet are walking through 12 hours of slurry." FAGC3 and FAGC6*

> *"Antibiotics is an obvious one. This is not a criticism at all, and I have been there and I know what you mean. Every farm has a different solution. You're going to have to make a solution to it at some stage. You will have to find a solution whether you want to or not and find a less critically important one [antibiotic tube]. I think the farm assurance are going to bring it in fairly soon... []... So it is something you are going to have to do at some stage, but I totally agree with what you are saying. It works, why change it? If it ain't broke don't fix it." FAGDe6*

The above examples demonstrate an understanding between farmers and acceptance that there were limitations to what could be practically achieved. The first quote acknowledges positive aspects to the cubicle shed, which supports Vaarst and colleagues (2017) point on *"acknowledge good aspects on the herd and farm"(142).* The process of co-creating an Action Plan at the regular FAG meetings helped build rapport, as discussed in Chapter Five. This allowed farmers to advise and recommend ideas to each other that were valuable and relevant to their farm situation, as demonstrated below.

> *"they look pretty good anyway but a bit of disinfectant powder can't hurt anyway… it's another person doing it but... we use 'Stella sand'." FAGS4*

> *"...it's a good idea because sometimes things come out there that people have thought about and talked about, but as a host, you haven't necessarily picked up." FAGD6*

Nonetheless, not all farmer participants perceived the Action Plan that highly, some farmers did not even look at it once created:

> *"Haven't looked at it!" FAGDe3*

The formalised Action Plan was valued to varying degrees but the participatory Action Planning process to get there – learning as a group, hearing from peers, seeing other farms – was regarded by all participants as influential in supporting changes to practice. On the one hand, writing down the list of recommendations and including it in the meeting summary report was formalising the discussions and reminded some farmers of the farmer-led ideas from when they hosted, as seen below.

> *"There's having it on paper as well to actually look at." FAGDe2*

On the other hand, some participants admitted they had not referred to their Action Plan by the Phase Two meeting, as illustrated in the quote before last. Many needed prompting as to what was on their Action Plan.

> *"Sounds like you know it better than I do!" FAGW1*

This farmer was referring to the primary researcher listing the recommendations from their Action Plan as a reminder at the semi-structured interview visit. In the semi-structured interviews, participants often commented on the Action Plan's role in helping them think about what they needed to do to reduce AMU. Some participants, however, felt the Action Plans were not the key component to implementing changes on their farms. These participants found the Action Plan useful but found the process of a farm walk, meeting other farmers and getting input through other informal means at the FAGs to be equally, if not more, useful.

> *"It is useful, because it is a reminder of things that have come out, some of the Action Plan things, even on the day you think, 'I am not doing it,' but there are also other things that came out from our walkabout, suggestions that came out of doing things that I have done, that didn't come out of the Action Plan. So it is useful, but it's not the be all and end all." FAGDe6*

> *"..but a lot of the things were things that were logical and things I have put at the back of my mind - 'Gotta sort that out,' - and the beef pens in particular were something that I needed to sort out and I just wasn't quite sure what to do and then that lot come along and they say, 'Oh yes you have gotta do this,' and they all sort of agreed about it. … I have done it and it works and it's fine." FAGDe6*

The formalised Action Plan acted as a reminder of all the recommendations and ideas that were exchanged at each meeting. The farmer could refer back to it by looking at their meeting report (see Appendix 11). The Action Plan also acted as a reflection tool for the group to use to evaluate what had changed on each farm and why, which was the focus of the Phase Two meetings. The Action Plan was not a rigid list they had to use; they could tweak and adapt their practices based on the Action Plan recommendations and from discussions with each other.

Essentially, some farmers would prioritise learning from the discussions at the actual meetings when co-creating the Action Plan over the formalised written 'list', whereas others used the formalised Action Plan as something tangible to aim for an refer back to.

> *"It gives me something to try and achieve." FAGC1*

This highlights the importance of the participatory process of Action Planning – it helped to bring a diverse group of farmers along the learning journey, rather than relying on individuals to implement a list of recommendations that they may not have been perceived as useful. Some individuals prefer to have written reminders to focus their attention, others preferred to exchange ideas informally at the meetings and on the farm walks. This reflects a diversity of learning styles (192) and in the spirit of participation the Action Planning process catered for both.

The majority of topics covered on the Action Plans were areas that were related directly or indirectly to reducing AMU. For instance, the maintenance of cubicles and bedding material are critical in managing and preventing mastitis. If cubicles are managed poorly and allowed to get dirty, bacteria can increase, and this, in turn, can lead to an increase in mastitis. Participants were quick to notice this and were keen on using the phrase *"prevention is better than cure"* when discussing changes to be made.

> *"I know that if they don't clear it up the first time, the chance of them getting it [mastitis] again is a lot higher. They either clear up the first time or they don't… So, I don't want it [mastitis] on my farm at all. That's the easiest way, if I don't have mastitis then I don't need to use antibiotics anyway." FAGC1*

Participants generally advocated the idea that if the cows did not get disease in the first place, then they wouldn't need to use antimicrobials. Considering mastitis is the biggest use of antibiotics on dairy farms nationally (36) as well as for the majority of participants in this study, it is no surprise that this topic occurred frequently on the Action Plans. Additionally, this also reflects where farmers saw their expertise in reducing AMU. They felt they had the capacity and knowledge to make changes in these areas without relying on external help.

The same principle can be argued for improvements to calf housing – the fourth most commonly recommended topic on the Action Plans. It was recognised by the primary researcher and facilitator that many farms in the project had less than adequate calf accommodation. The risk of calves getting too wet or too cold was high, which increased their chances of succumbing to disease and, hence needing antimicrobial treatment. There were many discussions based around lameness too, which involved the foot trimming crush, the cow tracks and concrete yards when on the farm walks, and thus focused minds on this topic. At least one farmer in each FAG tackled common claw lesions (such as white line disease and sole ulcers) without the use of antibiotics. This prompted those in the FAGs who were using antibiotics for these conditions to re-consider their actions. Some were even relying on ceftiofur (an HPCIA) to treat lame cows, which was highlighted by the primary researcher via their Medicine Review to the group.

> *"Naxcel, lame cows. One jab in the ear and you can walk away. No withdrawal." FAGW1*
>
> *"It's only because of this group [FAG], we would have carried on using Excenel or…"* **Farmer interrupts** *"No, you would have come along to VET's antibiotic meeting…" [Laughter]* **Other farmer resumes** *"We have been converted already…The practice - XX - have made that conscious decision to lower that price so it's more benefit for us to use Ceporex than Excenel." FAGD3*

The above farmer acknowledged that learning from his FAG had helped him move away from HPCIAs while at the same time his veterinary practice was also making it more expensive to use HPCIAs.

Another significant explanation of why these three topics (housing, mastitis and lameness) were commonly recommended as solutions to reduce AMU by farmers was to do with farmer knowledge. Farmers spend a lot of time on their farms in the same environment as the cows (i.e. the parlour, the sheds, the yards and fields). It can then be assumed that farmers have good working knowledge and experience of managing these environments - they know what the limitations are and have ideas about how they could be improved. Therefore, a group of farmers have a substantial amount of expertise to guide each other on how to improve the environment where cows are kept and thus move away from relying heavily on antimicrobials to maintain a healthy herd.

Participants gained confidence from their shared experiences of trialling new strategies as part of the FAGs and consequently, were more likely to share this experiential knowledge at subsequent meetings. This supports the reasons participants joined and engaged with the project – many of them liked to learn and share their knowledge, and this was reflected in the rich and varied content of the Action Plans. The project also helped farmers understand their role in tackling AMR. One of the knowledge gaps they identified was how AMR occurs and spreads and thus how using antimicrobials on farm contributes to this (Chapter Five). The participatory knowledge mobilisation within the FAGs, and in particular when recommending solutions on each other's Action Plans, helped farmers make the link between AMR and their actions on farm.

Conversely, topics that occurred least commonly on the Action Plans (but did still occur as opposed to not featuring at all) were changes to parasite control strategies, Bovine Tuberculosis (TB) control, environmental management, metabolic disease management, vaccination, biosecurity measures and staffing. The use of anthelmintic varied between farms and was not generally a huge part of their medicine expenditure (See example Medicine Review in Appendix 10). TB control measures only featured on two different Action Plans, but the topic was discussed frequently, especially when meetings were hosted on farms under TB restriction. This could be a result of farmer participants not knowing about or feeling capable of doing anything to mitigate TB on their farms (210). Enticott (2015) found that farmers felt powerless to instigate biosecurity measures to stop the entry or spread of TB onto their farms. Heffernan (2008) found that farmers were reluctant to introduce biosecurity measures when they deemed other farm visitors to add to the risk (211). In addition, some farmers did not see the relevance TB had to reducing AMU, especially if they were not under restriction. Host farmers and their FAG, therefore, did not prioritise TB on their Action Plan.

Many farmers, however, discussed TB as a cause of outbreaks of disease on their farms. The increased stocking density from not being able to move calves or groups of animals due to being shut down with TB was highlighted several times during discussions.

> *"Every calf will go through here. Get same issue every year - don't know whether [it's] disease build-up or stocking rate or what. So this year we decided we would start rearing them the other side of the village - heifers one side, bull calves the other side. Mainly issue with bull calves but started to see it in heifers. Lots of bull calves we'll get shot/slaughtered so [we] get some return- Don't like doing it, we try not to do it. Even if it is a cost to the business and there is a market… but if there is no market... Tried selling them but as TB restricted no one wanted them. Best thing we did, cleared that side out and haven't lost one since". FAGDe2*

The above quote illustrates the problem that many farmers experienced from not being able to move stock around because of TB. The added pressure on existing buildings from increased stocking density can clearly lead to increased disease and thus increased AMU.

Biosecurity was another area where farmers recommended very few actions for each other's Action Plans and seemed to lack practical solutions relative to other topics. In some cases, there was a defeatist attitude when it came to biosecurity.

> *"The field up there is just Cornish hedge and the field up there is just a barbed wire fence. There is quite a bit of contact. We have always tried to not graze animals in neighbouring fields but at some point, it will happen." FAGC2*

Biosecurity is viewed in many different ways in farming and there has been extensive work on the constraints to implementing adequate biosecurity measures on farm (205, 211, 212). Gunn and colleagues found that there was an attitude of 'why us' when it came to improving biosecurity, such as preventing disease entering the farm (205). This attitude still occurred in the face of disease outbreaks on farms. Farmers did not see it as solely their responsibility to do something to prevent disease entry on their farms. Moreover, veterinarians saw the added cost of implementing biosecurity measures, relative lack of results and lack of compliance from farmers as further major barriers (205). This impasse in co-operative working to improve biosecurity may be a factor in its relatively low occurrence on the Action Plan - farmers did not feel it was within their sphere of influence compared to changes to housing and lameness management.

The limited occurrence of some topics on the Action Plans has implications for the veterinary and dairy industries. In order to practice responsible AMU and improve how dairy farms prevent disease, vaccination and biosecurity need to be part of the solution (35). A limitation, therefore, of Action Planning in the participatory mechanisms of the FAGs is that they are good for mobilising certain types of knowledge but not others. External support and specific advice from veterinarians on disease prevention may be needed for change in the areas of biosecurity and vaccination. This support could be offered alongside a farmer-led approach and in a facilitatory manner in order to maximise uptake and implementation of new knowledge.

The veterinarian was mentioned on 17 different Action Plans and featured on 8.5% of the recommendations. Many of these were caveats encouraged by the primary researcher when farmers wanted to shift away from HPCIA usage and alternative products were suggested. Farmers in the project felt able to (and proved they could) make changes to their farms to reduce AMU and improve herd health without the assistance of their veterinarian. As veterinarians are the prescribers of antimicrobials, this could be viewed with concern by the veterinary profession (see Chapter Five for more on the knowledge gap) and is confirmed in the following quote.

> *"One comment – I would probably suggest that in your actions that you don't recommend specific brand-named antibiotics when proposing a change of antimicrobial? e.g. You mention Bimatrim – we have no trading relationship with the manufacturer of that product, but we do offer Duphatrim… It's not a problem with [FARMER], but a less enlightened client will demand the exact product that you have 'recommended'. You would be far safer suggesting an antibiotic group change (e.g. to a trimethoprim/sulphonamide based injectable) and allowing the practice to discuss the exact product with the client." Email from vet1*

The concerns of veterinarians about farmer-led action in the area of AMS poses challenges with regards to the adoptability of the approach on a wider scale. There is scope for veterinarians to be delivery partners and to be trained in facilitation, as described above when trying to achieve change in the areas of biosecurity and vaccination. However, if they fundamentally do not agree with the participatory philosophy and fail to recognise and appreciate farmer knowledge, then there will be barriers to its success.

There were many reasons given by participants for not implementing certain recommendations as discussed previously. One major constraint was the time taken to implement the changes. The evaluation of the Action Plans was within a year of their co-creation for most participants and some Action Plans consisted of quite major changes that needed research and planning e.g. initiating milk recording. For this reason, the average proportion of recommendations partially/fully implemented by Phase Two of 54.3% was potentially lower than it would have been if Phase Two meetings had been held after 12 months or more. On the contrary, if the meetings were too far apart and the Action Plans were followed up two or three years later, the impetus to act on the recommendations might have been lost. In order to overcome this obstacle, the Action Plans could be re-visited a year or more after their inception, or the Action Plan evaluation could be tailored to be dependent on the content of the Action Plan. If there were seasonally dependent or longer-term changes that needed further time to come to fruition, this could be factored in. Potentially, certain parts of the Action Plan could also be re-visited sooner, and the progress evaluated in a multi-step process.

Despite this, some participants focused on the quick wins over the longer-term changes and the Action Plan allowed them to do that in a focused way. Farmers could refer back to their Action Plan, decide what they could change overnight (e.g. eliminating HPCIAs from treatment protocols) and put measures in place to start the longer-term actions (i.e. starting milk recording).

6. b. iii. Conclusions from Action Planning

The vast majority of topics on the Action Plans can be related directly or indirectly to reducing the use of and need for antimicrobials. The general premise for this was that if one kept a healthy herd, then there would be less need for antimicrobials to be used on farm. The changes made to the housing environment of the herd reduced the risk of cows and calves getting infections and thus needing antimicrobials. The recommendations to reduce the risk of lameness, mastitis and to maximise the health of calves all subsequently lead to reduced need for antimicrobials.

In summary, the Action Planning process assisted farmers to varying degrees by identifying challenges and farmer-owned solutions, reminding farmers of discussions on farm walks and helping to prioritise tasks with goal orientated action. Most participants found the written formalised Action Plan helpful; a minority did not refer to it. The Action Planning process brought together the recommendations and practical solutions from each farmer in the group and allowed for objective and measurable progress to be made.

6. c. Measuring and benchmarking AMU

6.c.i. Materials and methods

The full description of the approach taken for the FAGs is included in Chapter Three. Briefly summarised here is the purpose and analysis of the Medicine Reviews from the farmer meetings. The Medicine Reviews were originally intended to monitor participant farm progress over time and provide a measure of AMU reduction but subsequently they evolved into a learning tool that farmers took ownership of and used to help them improve and understand the topic of AMU. The benchmarking of the results in particular was of great use to the farmers as a discussion tool at the meetings and allowed farmers to participate in their progress as a collective, which was novel considering most benchmarking in farming is advisor-led (55).

A detailed review of medicine usage allowed the researcher and participants to keep track of changes not only in total AMU but also in the types of antimicrobials used (i.e. moving away from HPCIAs to first-line antibiotics). Measuring AMU in the food-producing sector is not only important but has become an expectation to track and demonstrate reductions, as suggested by O'Neill in the Review on AMR (5) and commonly practiced across Europe (50). For the purposes of this study, two years' worth of veterinary medicine sales and usage data were collected from veterinary practices and participating farms and analysed. Once enough data had been collected and at the request of the participants, benchmarking of AMU was done to allow farmers to see how they compared with other farms in their group, as well as the rest of the farms in the project. No benchmarking was done with farms outside of the project. UK averages for AMU (based on the VARSS reports for each corresponding year) were included in the reports to give farmers a sense of where they stood nationally; this was at the request of the participants. The method of collecting, processing, calculating and analysing AMU and associated costings is described in detail in Chapter Three. A participant in regard to AMU is a farm.

6.c.ii. Results and discussion

As with the Action Planning section, the results reported here are a combination of quantitative and qualitative results. The results are reported and discussed under the following headings; changes in total AMU (to include benchmarking), reductions in HPCIA usage, limitations to measuring AMU and farmer perceived value and involvement in the Medicine Review process. This mixed methods approach is valuable because it (1) follows the principles of Triangulation whereby multiple sources of data are compared to improve the validity of the findings and (2) the addition of qualitative data adds a richness to the quantitative data which helps explain and improve the findings.

Changes in total AMU

As is always problematic when discussing AMU (173), representing AMU was dependent on the metric used to measure it. In this thesis, two different and well-accepted metrics were used to demonstrate the change in total AMU over the course of the project (these and additional metrics were used in the FAGs, see Appendix 10). The level of statistical significance used for this study is 0.05. P values less than this indicate that the probability of the result being down to chance was less than 5%.

The range in AMU across participant farms was vast (3.5 mg/kg – 93.4 mg/kg in Year two) and reflected a similar range from studies on larger samples in the UK (31). In general, approximately half of all participant farms reduced total AMU from Year one to Year two of the study (see Figure 26), although there was no statistical significance between the two years in any of the chosen metrics measuring total AMU, as can be seen in Figures 24 and 25.

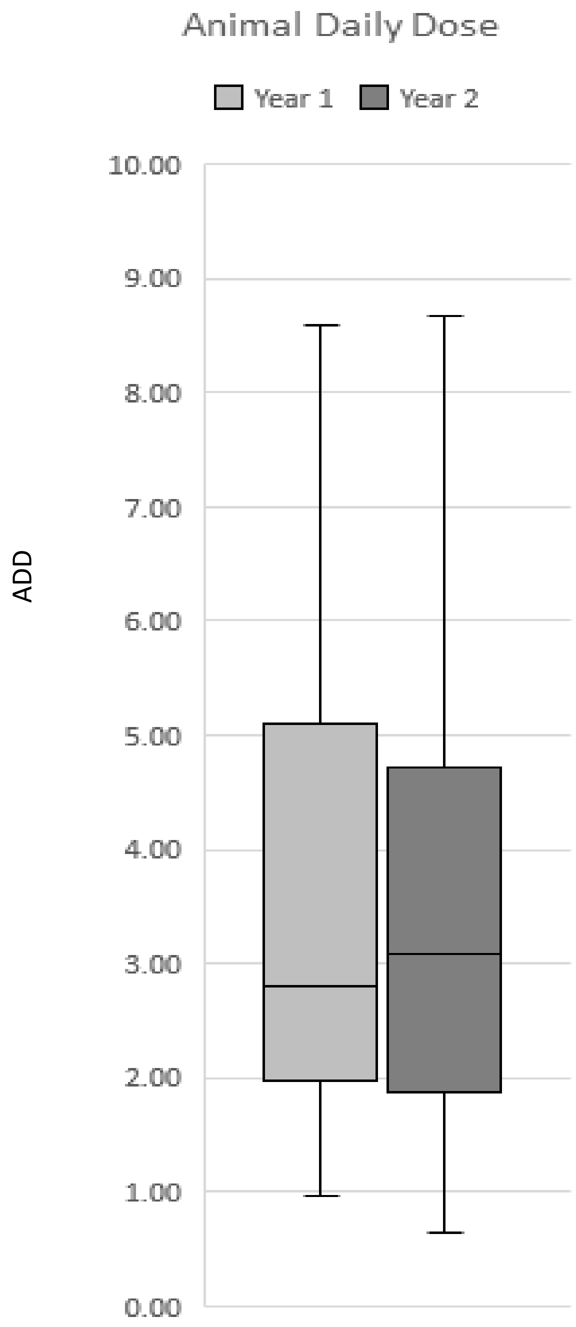


Figure 26 – A box and whiskers plot showing lower and upper quartiles, including interquartile range, of total AMU from 30 farms from Year one (light grey bar) compared to Year two (dark grey bar) measured in Animal Daily Dose (ADD). The ends of the bars (whiskers) show the lowest and highest observed values i.e. the range in ADD across all participant farms.

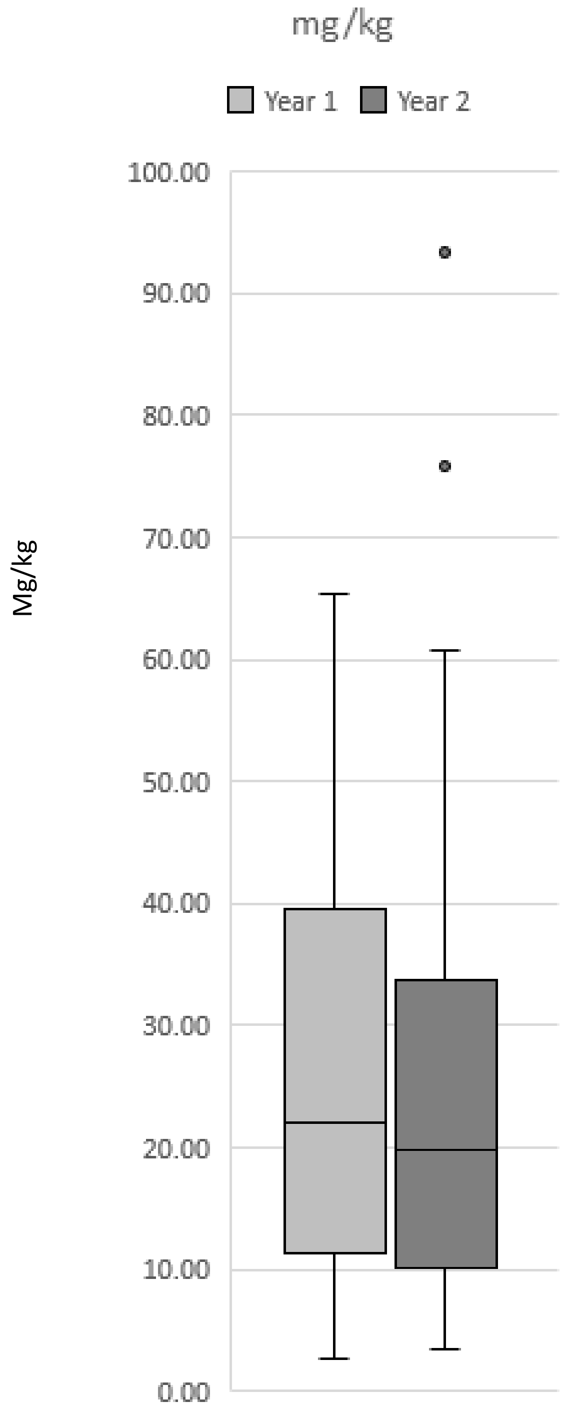


Figure 27 – A box and whiskers plot showing lower and upper quartiles, including interquartile range, of total AMU from 30 farms from Year one (light grey bar) compared to Year two (dark grey bar) measured in milligrams/kilograms (mg/kg). The ends of the bars (whiskers) show the lowest and highest observed values with outliers as dots i.e. the range in mg/kg across all participant farms.

Figures 26 and 27 illustrate the large range in total AMU across all participant farms over the course of the study using two different metrics. There was no statistically significant difference between total AMU in Year one and two using Animal Daily Dose ($p = 0.584$) or mg/kg ($p = 0.847$) as a metric i.e. there was no statistically significant difference in the mean total AMU from Year one to Year two. A small decrease was observed in the median total mg/kg from Year one to two (22.07 mg/kg to 19.81 mg/kg) as can be seen in Figure 27, but a small increase was observed in the median total ADD from Year one to two (2.80 ADD to 3.08 ADD) as can be seen in Figure 26. The mean and median values of the various metrics used in this thesis can be seen in Table 14.

Figure 28 shows the total AMU in mg/kg of each farm participant in the project as a benchmarking graph from Year one (orange bars) to Year two (grey bars). Fifteen farms in the study reduced their total AMU using this metric but 15 also increased their total AMU from Year one to two. Figure 29 shows the total AMU of each farm participant over two years measured in Animal Daily Doses (ADD). Using this metric, 18 farms reduced their total AMU from Year one to Year two.

Costings were also carried out on AMU data to aid discussion with farmers about their medicine usage (Chapter Three). This was measured and presented in various ways (see Appendix 10 for an example Medicine Review) but the metric chosen for discussion in this thesis is Pence Per Litre (PPL), which is a common Key Performance Indicator across the UK dairy industry (10).

Figure 30 shows the reduction in PPL on antimicrobials from Year one to Year two of the study across the 30 participant farms. PPL on antimicrobials across the 30 farms ranged from 0.11 to 0.46 in Year one of the study and increased in range in Year two from 0.07 to 0.51. Median PPL decreased from 0.23 to 0.21 over the study duration with the mean PPL decreasing from 0.25 to 0.22 from Year one to two (Table 14). The decrease in PPL on antimicrobials between Year one and two was statistically significant ($p = 0.004$).

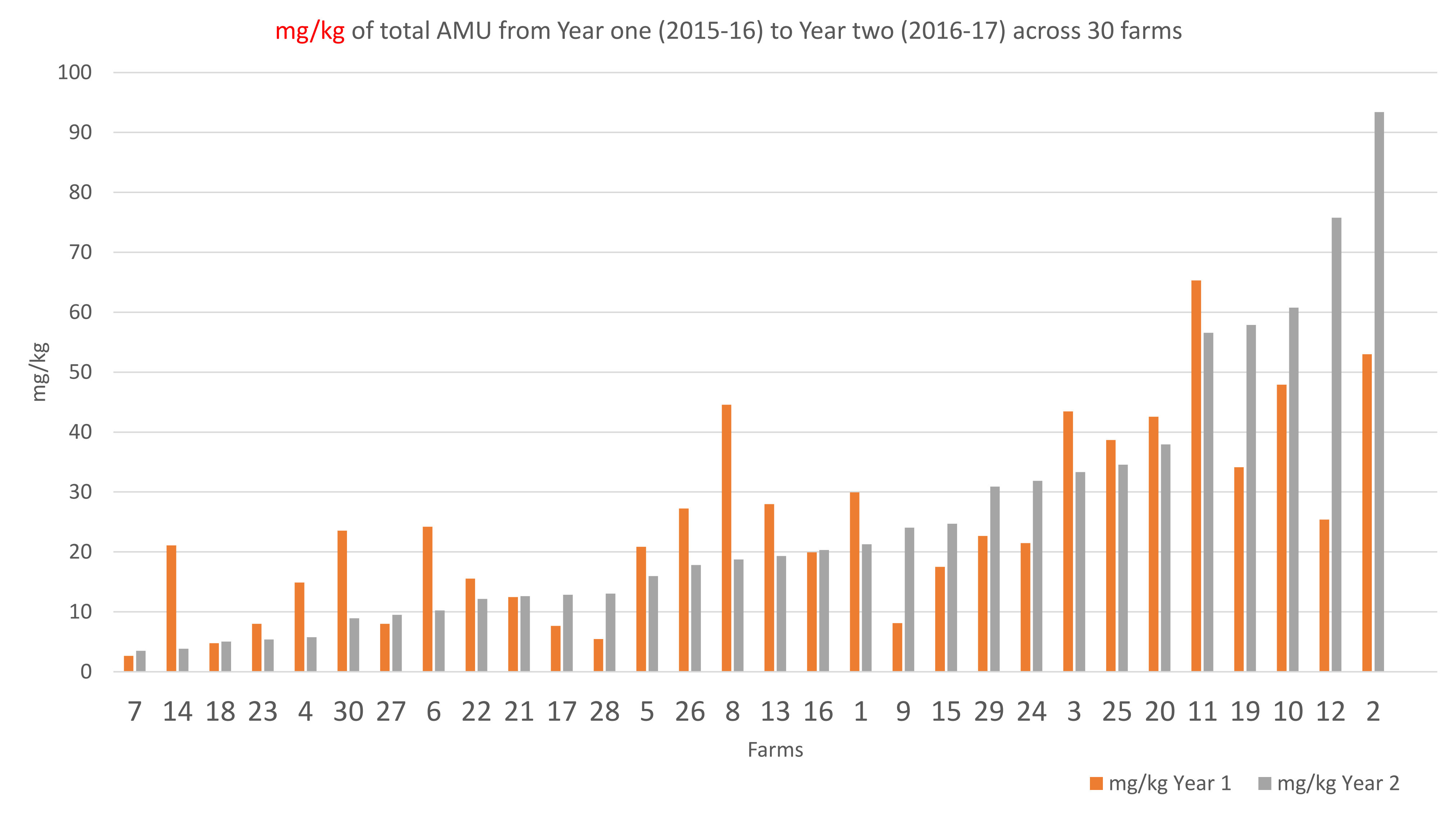


Figure 28 – Benchmarking bar graph of total AMU from Year one (orange bar) to Year two (grey bar) across all 30 farms, measured in milligrams/kilograms (mg/kg)

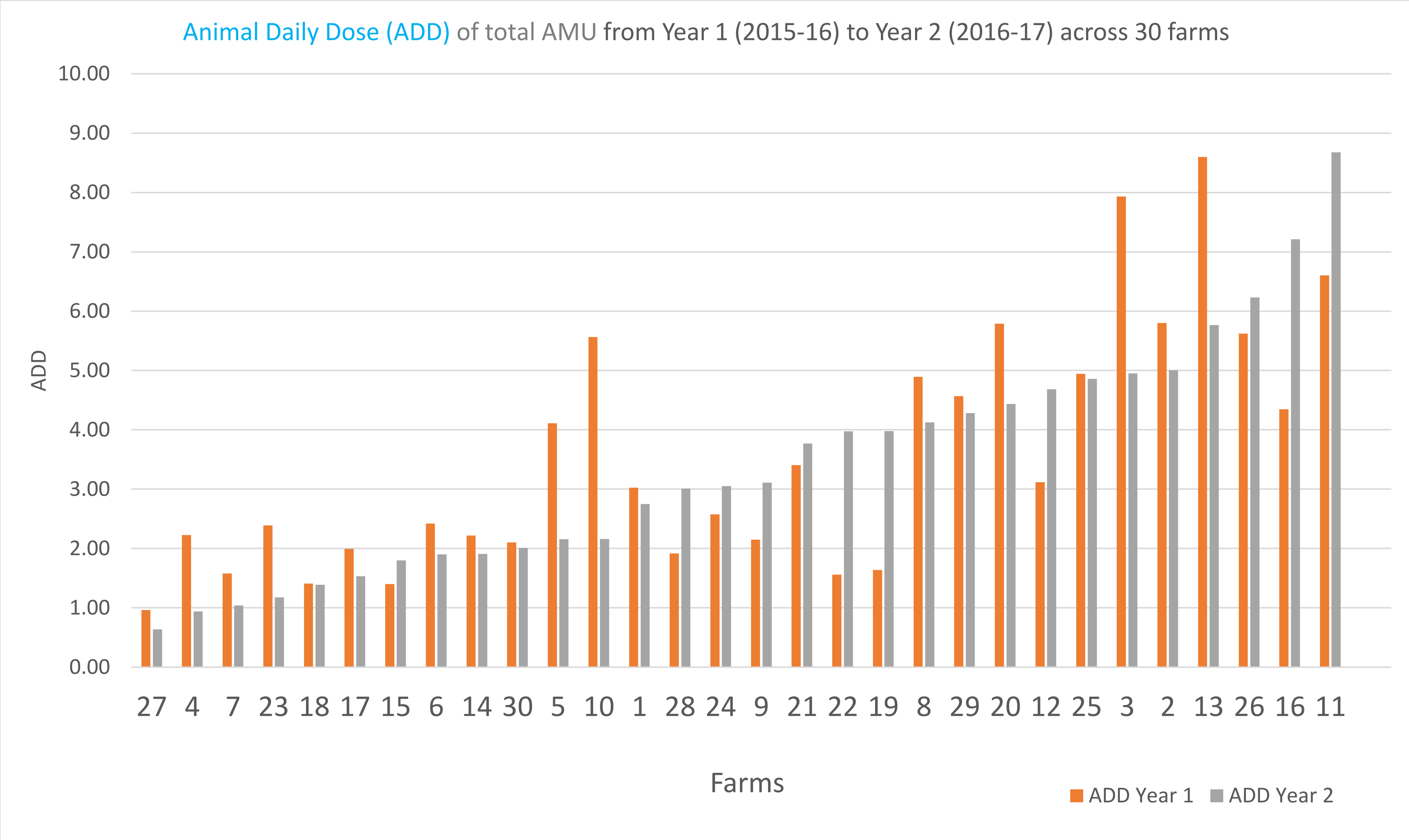


Figure 29 – Benchmarking bar graph of total AMU from Year one (orange bar) to Year two (grey bar) across all 30 farms, measured in Animal Daily Doses (ADD)

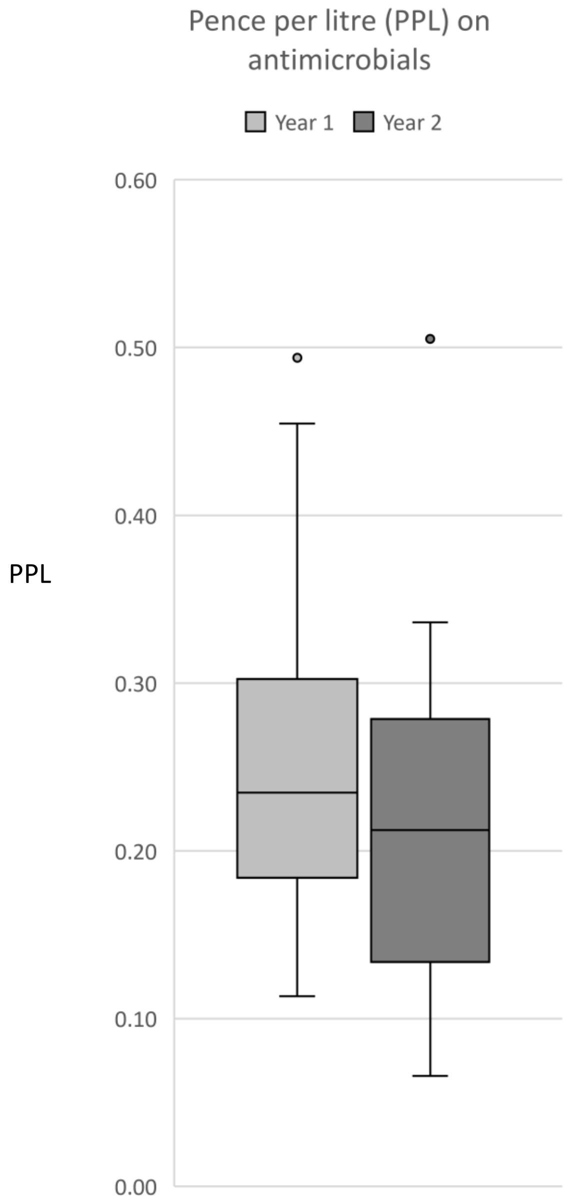


Figure 30 - A box and whiskers plot showing the lower and upper quartile, including the interquartile range of total AMU expenditure in Pence Per Litre (PPL) across 30 farms from Year one (light grey bar) to Year two (dark grey bar). The ends of the bars (whiskers) show the lowest and highest observed values with outliers as dots i.e. the range on PPL across all participant farms.

PPL was calculated by taking the total expenditure on all antimicrobials in 12 months from vet sales data and dividing this by the annual milk production as sold, as demonstrated in the following equation:

$$\frac{\text{Total antimicrobial expenditure in 12 months (£)}}{\text{Total annual milk sales as sold (L)}} \times 100 = \text{PPL}$$

It is also important to assess whether there was any relationship between the changes in AMU on participating farms and the implementation of the Action Plans, see Fig. 29. From this data set, there appeared to be an increase in AMU on farms that had a higher proportion of recommendations implemented from their Action Plan.

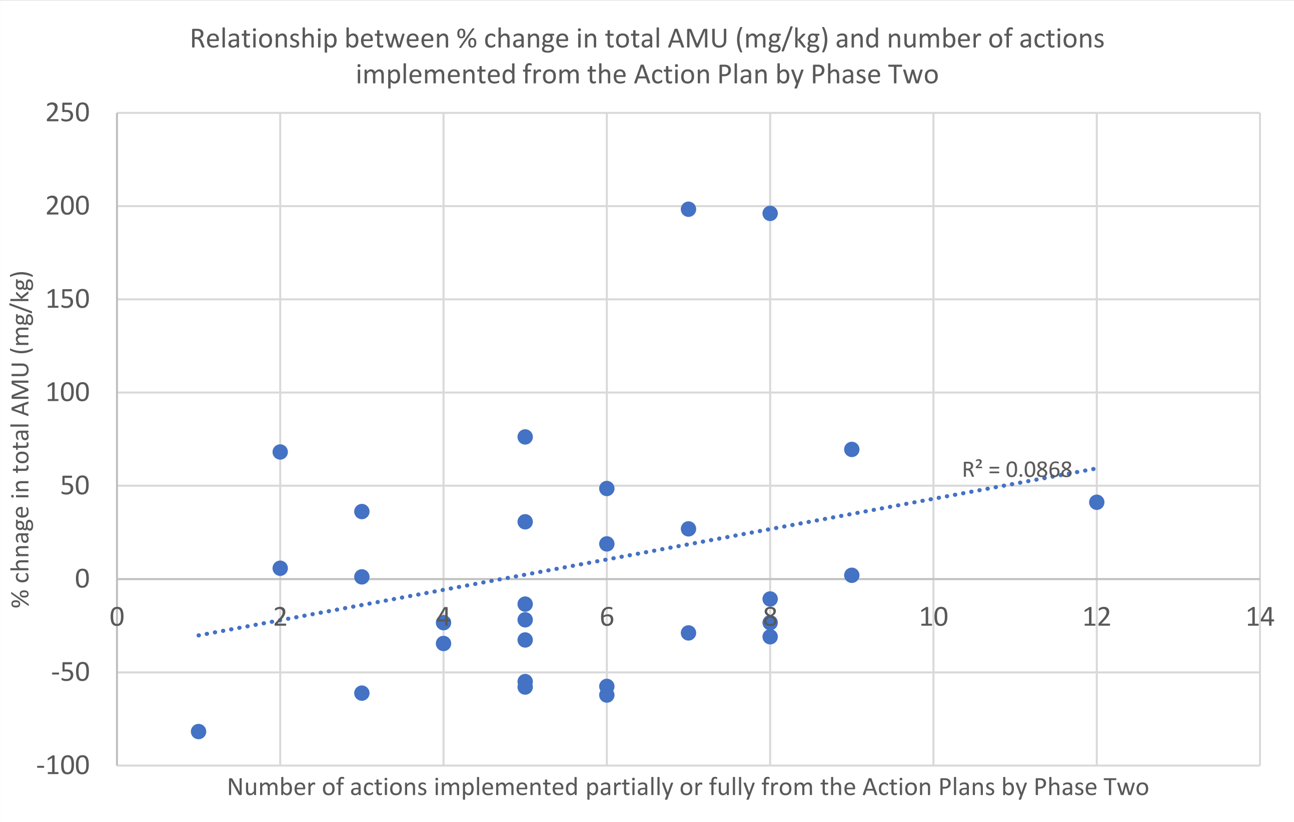


Figure 31 - Relationship between % change in total AMU (mg/kg) and number of recommendations implemented from Action Plan by Phase Two (i.e. within a year)

Figure 31 shows mild correlation between the two variables. The line of best fit suggests a weak positive correlation, with higher numbers of recommendations implemented from the Action Plan correlating with higher percentage change in AMU i.e. increased AMU. The R^2 is 0.0447, which indicates a weak or non-existent correlation, however. This data includes 2-3 outliers (~10% of all data points), and further analysis would benefit from more data points over a longer period of time to draw meaningful conclusions.

Table 13 illustrates the results of the paired sample t-test to check for statistical significance between the two years in each presented metric. A paired sample t-test was chosen due to testing the null hypothesis that there was no statistically significant difference between the means of the same parameter i.e. an AMU metric from one year to the next across all 30 farms.

Table 13 - Paired sample t-test values and statistical significance values

Paired sample t-test		**t**	**df**	**Sig. (2-tailed)**
Pair 1	Animal daily dose year 1 - Animal daily dose year 2	0.554	29	0.584
Pair 3	ADD HPCIA year 1 - ADD HPCIA year 2	2.588	29	0.015
Pair 4	mg/kg year1 - mg/kg year 2	-0.194	29	0.847
Pair 6	HPCIA mg/kg year 1 - HPCIA mg/kg year 2	1.460	29	0.155
Pair 16	Pence per litre on antimicrobials year 1 - Pence per litre on antimicrobials year 2	3.108	29	0.004

Table 14 - Mean and Median values in various AMU metrics from Year one to Year two of study across 30 participant farms

Metric	**Mean**	**Median**
Total AMU Animal Daily Dose (ADD) Year one	3.58	2.80
Total AMU Animal Daily Dose (ADD) Year two	3.43	3.08
Total AMU mg/kg Year one	25.57	22.07
Total AMU mg/kg Year two	26.76	19.81
HPCIA ADD Year one	0.54	0.34
HPCIA ADD Year two	0.14	0.01
HPCIA mg/kg Year one	1.13	0.30
HPCIA mg/kg Year two	0.16	0.03
Pence Per Litre (PPL) Year one	0.25	0.23
Pence Per Litre (PPL) Year two	0.22	0.21

Reductions in HPCIA usage

The majority of participant farms were using HPCIAs at the start of the study in 2016 (n=24). In contrast to the results on total AMU, HPCIA use reduced across the majority of participant farms from Year one to Year two (n=27). Six farms were not using any HPCIAs from the start and many eliminated HPCIA usage completely after one year of the project. Figures 32 and 33 demonstrate the reduction in HPCIA usage as measured in two different metrics. The difference in HPCIA usage from Year one to Year two using ADD was statistically significant (p = 0.015) whereas it was not statistically significant using mg/kg (p = 0.155).

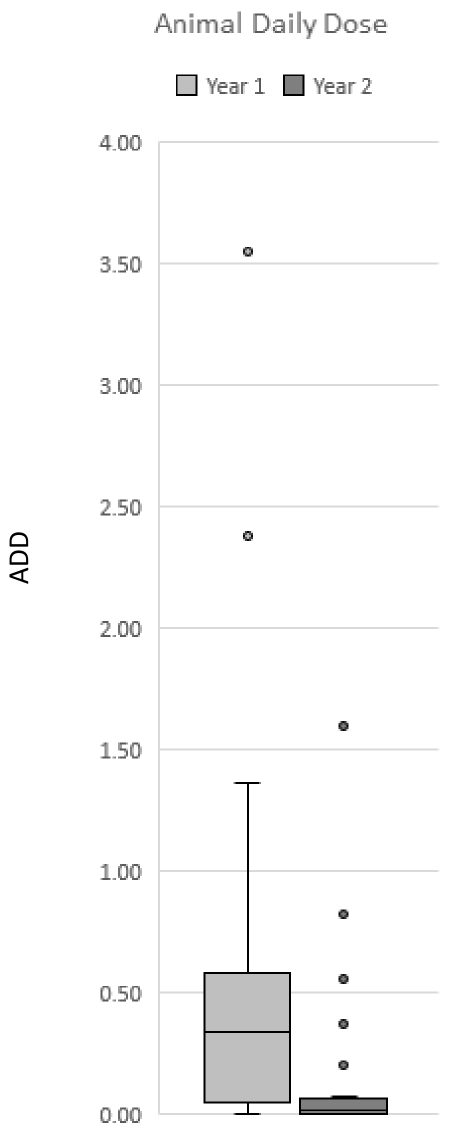


Figure 32 – A box and whiskers plot showing the lower and upper quartiles, including the interquartile range of HPCIA usage, measured in Animal Daily Doses (ADD), from Year one (light grey bar) to Year two (dark grey bar). The bars (whiskers) and outlier dots illustrate the lowest and highest observed values i.e. the range in ADD across all participant farms

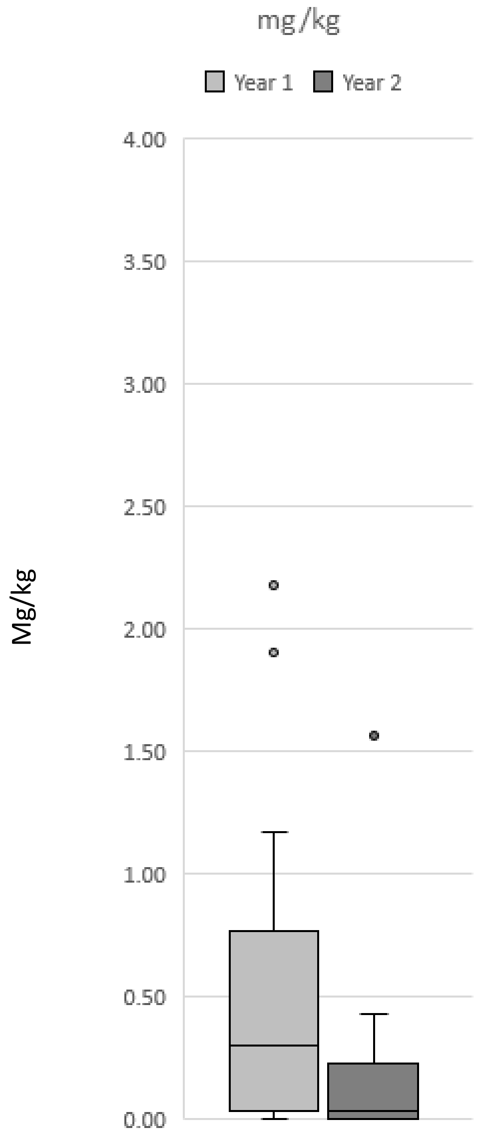


Figure 33 – A box and whiskers plot showing the lower and upper quartiles, including the interquartile range of HPCIA usage, measured in milligrams/kilograms (mg/kg), from Year one (light grey bar) to Year two (dark grey bar). The bars (whiskers) and outlier dots illustrate the lowest and highest observed values i.e. the range in mg/kg across all participant farms

HPCIA use was regarded as an easy and quick change to make over the two years of the project, compared to the longer and more involved changes needed to reduce the need for all antimicrobials. There were alternatives to many of the HPCIAs in use at the time of the study and the group learning and the facilitation from the primary researcher meant alternative products and experiences of using them were frequently shared. The reductions described above and shift away from reliance on HPCIAs was a key benefit voiced by farmers from participating in the FAG project and formed a key aspect to knowledge mobilisation described in earlier chapters.

Farmer perceived value and involvement in the Medicine Review process

As previously discussed, the farmer participants were generally unaware of the different classes of antimicrobials, which ones they were using on farm and which ones were HPCIAs at the start of the study. This was information they were encouraged to discuss with their veterinarians by the primary researcher and facilitator. The majority of participants (n=24) were using HPCIAs at the start of the project but many had the recommendation to stop using them completely on their Action Plan and were encouraged to do so by their FAG. As can be seen from Figure 30 and 31, the vast majority of participants reduced or eliminated HPCIA usage by the end of the study.

> *"We were using Cobactan go back down before we started, and that was- it was about the time we'd almost made the decision to change to something else anyway, and then this started and I think that pushed us." FAGDe2*

> *"Ubro Red is what we went to, we did that straightaway." FAGW2*

> *"Yeah. So as a result of that we haven't Naxcel an animal for a long time, which is good." FAGW1*

The above three quotes in addition to Figures 30 and 31 are just examples of the changes farmers made in addition to their Action Plan through discussing their Medicine Reviews as a peer group. The HPCIAs became the 'naughty drugs' that no one in the group wanted to use. This refers to the nickname the FAGs received from two farmer participants of "*Antibiotics Anonymous*". The FAGs began to create a social stigma around using HPCIAs and the farmers didn't want to 'be in the red' from using them.

> *"[Host] has been using some no-no's [HPCIA] there, and you can't have a smiley face everywhere!" FAGD2*

This social pressure from each other was enhanced by the Medicine Review process where their medicine expenditure and use of HPCIAs was measured, presented to the group and then used in the discussion group activities by the farmers. They all went through the process of having their AMU measured and presented to the group and felt a collective responsibility to address any misuse or overuse. They could see the changes that everyone was making and did not want to be the worst farm on the benchmarking graphs (Figures 26 and 27).

Farmers altered their practices and treatment protocols from using HPCIAs fairly routinely in some cases to actively avoiding them.

> *"The go to drug would have been Naxcel, but we try and avoid using that." FAGC2*

There were two farms, however, that increased their HPCIA usage over the course of the study. On enquiring with these particular farmers, they explained they had recently purchased intra-mammary tubes and been prescribed HPCIAs by their veterinarians, unbeknown to them at the time. Consequently, everyone in the project became increasingly knowledgeable about which products were in which class to allow more informed discussions with their veterinarians. This progressed to becoming more familiar with the class names. Eventually, many participants would use the antimicrobial class names (e.g. $3^{rd}/4^{th}$ generation cephalosporins) over trade names when asked which classes of antimicrobials were HPCIAs.

They demonstrated new knowledge acquisition, a knowledge-edge and knowledge empowerment, as discussed in the previous chapter. Farmers participants were keen to be benchmarked and often revealed who they were on the graphs. Participants found the graphs of financial expenditure on different classes of medicines a useful starting point in the Medicine Review discussions (see example Medicine Review in Appendix 10) and this led to changes, such as increased anti-inflammatory use and enquiry into vaccinations.

> ***In response to preferred part of medicine review*** *"Break down of everything I think [points at expenditure on all medicines]." ... "I think that one is important." Group agree.* ***Another farmer*** *"We vaccinate for four things, but salmonella is bloody expensive. It's about five pound a dose. We do BVD, IBR, Lepto and Salmonella."* ***Another farmer asks*** *"Now you have sorted out your water [problem] at what point do you stop… vaccinating… for salmonella?" FAGDe4*

By developing the Medicine Review in partnership with the farmers, they had an opportunity to suggest how they wanted to measure AMU. The metric mg/1000 Litres of milk was suggested several times in the first few meetings. A select group of farmers that went to the Netherlands on a study tour in October 2016 (see Appendix 14) came back convinced measuring AMU using ADD was the best way forward, as described to the rest of one participant's FAG in the below quote.

> *"It's even better than that! Effectively this program the vet uses to issue you your invoice, calculates the doses [ADD] you are giving on farm. So when your invoice is issued also has a graph of your usage over time, graph of your usage per kg of animals. It gives you a national peer group that you are benchmarked against, straight off. Then you have the colour, amber, green, red, to give you an indication of where you are. Dodgy area- we need to do something about it, what's the problem?"* FAGS5

Discussion around the metrics revealed different preferences for the different types. For instance, some farmers felt using mg/1000 Litres of milk made high yielding herds look better than low yielding herds and was perceived as unfair. One group found the use of mg/1000L of milk misleading to the public as it could suggest there were excessive or unsafe levels of antimicrobial in milk. Those that saw how the ADD metric was being used in the Netherlands (see Appendix 14) were persuaded of its relative merit compared to milligram metrics, which many participants noticed were affected by which types of antimicrobials were used on farm (173). Very few farmers liked the 'course' metrics as they perceived the differences between the data sheet recommendations and what was followed on farm as well as between each other's treatment regimens and antimicrobial course lengths difficult to compare.

The continual use of the Medicine Review at each meeting and the benefits of benchmarking not only improved the farmers understanding of the subject but allowed them to interrogate the data, see its limitations and ask for it to be improved. For example, many participants asked for the way the metrics were calculated to be explained or suggested improvements to their personalised reports:

> *"Why is it, could you not do ADD for each adults and youngstock… I don't know. It's a number we're just starting to get our head around." FAGDe1*
>
> *"We have the type of antibiotic one here [holds up bar chart of different classes]. I am not sure how important that one is. We have the red the blue and that already before, so whether you need to break it down into the different types of red and blue, I don't know whether we need that level, if you are trying to cut down on paper!" FAGDe2*

Developing the Medicine Reviews in partnership with the farmers resulted in illustrating AMU in adult cattle versus calves (see Appendix 14), using multiple metrics simultaneously, including some antimicrobials in the calculations and not others (e.g. Kextone boluses/Halocur) and comparing to each other despite system differences. Benchmarking such a diversity of dairy farms was seen as added value and not presented as a limitation to the Medicine Review process by farmers.

> *"Otherwise we've all got 10,000 litre cows that we polish every day and we all say, everything's fine but you'll get a totally different reaction to a 5000 litre spring calving herd wouldn't you?" FAGW1*

Discussion - Limitations to measuring AMU

There are many limitations to measuring AMU and a detailed published account of the general limitations can be found in(173). It is worth noting five main issues pertinent to the particulars of this study though. Firstly, the data collected for the Medicine Reviews presented in this chapter covers only two consecutive years - 2015/2016 and 2016/2017. The farmer participants were quick to point out the low value in this when switching antimicrobial products with differing dosages. They would have preferred to see several years of data or the continuation of the Medicine Review process. Many participants saw their total AMU increase in Year two using milligram metrics as they had reduced/eliminated HPCIAs. Many of them were changing away from products such as marbofloxacin or ceftiofur (HPCIAs), which tend to have lower dosages and concentrations. Thus, when measuring AMU using weight-based metrics such as milligrams, the outcome can be falsely lowered by using products that are higher risk to human health i.e. HPCIAs.

Secondly, the inclusion of antimicrobials in addition to just antibiotics in the Medicine Reviews differed to many other measures of AMU occurring in the industry at the time (36, 58). This study included products in AMU metrics such as 'Halocur' (halofuginone), 'Kexxtone boluses' (monensin) and topicals where relevant information existed. Halocur skewed dose metrics due to reflecting blanket treatments of calves with suspected Cryptosporidium infection but changed mg/kg metrics very little due to its low dosing. It did, however, lead to discussions within the FAGs on controlling cryptosporidium. It is the view of the author that all antimicrobials should be included in measuring AMU not just antibiotics.

Thirdly, collection of complete veterinary sales data for all 30 farms was not possible. Three farms had their total AMU based on their medicine book as recorded by themselves. This has been shown to be a poor source of medicine data (54) and thus could have resulted in falsely lower AMU on these three farms than if veterinary sales data had been used.

The Medicine Reviews for each farm were compiled using a combination of veterinary sales data, and on-farm medicine records supplemented with discussion with individual farmers. This meant that farm-specific course lengths and daily doses for many antimicrobials, particularly intra-mammary tubes could be ascertained instead of relying on data sheet recommendations. Farm-specific course lengths often differed substantially from the data sheet and affected the way the metrics were calculated. For example, if a farm dosed intra mammary tubes twice daily despite the data sheet recommending only once daily, the metrics based on dose and course length would account for this and consequently represented a more accurate depiction of that farm's AMU. Ultimately, improvements to medicine recording to stimulate improved practice would involve (1) a centralised database that permitted access by third parties to use veterinary sales data (59) an automated medicine recording system which negated the need for farmer data entry and/or well-kept on farm records to determine actual usage of antimicrobials at point of care and (3) more clarity on the AMU metric calculations and full inclusion of all antimicrobials.

The final limitation to note is that the Medicine Reviews reflected a change in AMU on participating farms that was subject to multiple factors and drivers e.g. veterinary advice, media pressure influencing farmer decision-making around treatments. The FAGs were not the sole cause of the observed changes and this was not a study to establish this relationship. The other sources of data described above alongside these results suggest the FAGs had a supportive and critical role to play in helping farms change their practices around AMU but were not solely responsible.

6.d. Conclusions

The FAGs helped farmers implement and develop a variety of changes to their farms and farming practices around reducing AMU. The participatory manner of the group meetings with facilitated Action Planning and the use of medicine data and benchmarking contributed to changes actioned on participating farms. The influence of the project varied in how much it directly led to the various changes (i.e. was it a direct result of seeing something on a FAG member's farm or was it from discussing it with their veterinarian?) and many things farmers reported implementing (or not) were dependent on external factors (i.e. finances and the price of milk). However, through the

Action Planning process, a multitude of farmer-led solutions, recommendations and ideas were prioritised to assist farmers going through the stages of change to reduce the need for and use of antimicrobials.

One of the most successful changes farmers implemented was moving away from HPCIAs to first-line antibiotics. This was the 'low hanging fruit' that felt quite easy for many of them to implement, especially where there were alternative products available. Many participants had this as a recommendation on their Action Plan (15/30 Action Plans); HPCIA use was highlighted on the Medicine Reviews and many experienced encouragements from participants who were already not using HPCIAs. The Medicine Reviews certainly began a process of learning about AMU, the different types of antimicrobials and which ones were HPCIAs, as well as learning about the data needed to measure AMU and the different metrics. This new knowledge was generated through the participatory mechanism of FAGs and helped inspire confidence in the farmers to change practices around AMU (Chapter Five). This new knowledge on HPCIAs was not forthcoming from many veterinarians at the time of the study and thus the project contributed to the farmers development as participants in the participatory learning journey.

The FAGs were a significant factor in encouraging participant farmers to change practices. When farmers made changes, they ascribed these to participating in the FAGs because they were 1) recommendations or ideas from their peers 2) had come from seeing others in their FAG managing their farms differently and/or 3) felt pressure to conform (e.g. SDCT, HPCIAs). It is also true that pressure to change sometimes came from outside the project (i.e. milk buyer pressure to do SDCT) and so some changes that farmers implemented were multi-factorial where the FAGs were one part of the stimulus to change. Although a myriad of pressures and pulls on farmer decision-making will have influenced their practices (91, 107), this study does not attempt to isolate the effect of FAGs but understand how it has contributed to changes in practice for individual farmer participants. The next section summaries the role of each aspect of the FAGs in supporting changes in practice on farm and aiding farmers personal and collective development.

Medicine Reviews and benchmarking

The Medicine Review process had two functions. Firstly, it was designed to be a measure of the progress the participants made reducing AMU and tracked their usage in a way they could see and participate in. It then became apparent early in the study that the Medicine Review acted as a discussion tool that developed farmer knowledge on HPCIAs and allowed farmers to input and take ownership of the metrics. The facilitated discussion around one another's Medicine Reviews aided knowledge mobilisation spoken about in Chapter Five and contributed to their development within the concept of participation. Using farm data and benchmarking progress has been used to encourage change in farming elsewhere with success (55). The unique aspect to benchmarking and the Medicine Reviews in a participatory, farmer-led project, however, was the emphasis on farmer knowledge and farmer-led interrogation of the data compared to advisor-led.

Action Planning

Action Planning provided a focus to the meetings through a process of goal setting as well as allowing for the targeted selection of changes to make on farm. Farmers also used the farm walk as a springboard for ideas for the Action Plans. Being in the shed where the calves had contracted respiratory disease, for instance, and seeing first-hand the issues the host had to grapple with gave them a sense of realism. This wasn't a case of recommending ideas from afar and without any prior knowledge of the host farmer's situation. The farm walks also helped the host farmer justify why they did things the way they did. Facing a shed full of other farmers forced participants to rethink and reflect on their actions.

Furthermore, the farm walks added an element of 'seeing is believing' to the co-creation of the Action Plan. Other participatory projects use farm walks as a useful tool for initiating self-reflective inquiry and challenging practices (140, 171). Farmers spend a lot of time on a farm; it's a familiar environment and they find the practice of walking around a farm with a with a group of peers to help find areas of improvement to be appealing.

The Action Plans were only part of the process of change witnessed in the FAG project. Alone they might be perceived as similar to herd health plans by some farmers, and consequently might not have been highly valued or utilised. Co-creation of the Action Plan using farmer know-how largely avoided this issue, as described by Duval and colleagues (110). A potential limitation to the farmer-led Action Plan is the influence that facilitation had on the outcomes. The primary researcher and the AHDB Dairy facilitator both had areas of expertise that could have enhanced some topics on the Action Plan more than others. Facilitation is discussed in more detail below.

Further considerations are 1) the timing of the evaluation of the Action Plan to allow enough time for implementation and (59) 2) how attendance at meetings can affect the number and quality of recommendations on the Action Plan. An emphasis on group contributions to each farm's Action Plan is necessary to ensure maximum benefit (22).

Facilitated group discussions

Farm walks and facilitated group discussions were reinforcing constructs in the process of change. Facilitated group discussion happened both on the farm walks and after, once everyone was seated and with time to reflect. Facilitation (also prioritised by Stable Schools) allowed for farmer recommendations and ideas to be formulated and shared and ultimately distilled into an Action Plan.

> *"Yeah. It was one of the things I know I needed to do but I didn't know how to do it or I wasn't sure what to do, I had lots of ideas but I wasn't sure which was the best way of going about it." FAGD6*

As the above quote demonstrates, there was often uncertainty around making changes, which the facilitator at the meetings helped farmers address, navigate and co-create a strategy. The facilitated group discussions were the foundation for the Action Plans and provided farmers with confidence to change and adapt practices. Many of the implemented actions were not new ideas but were things where there was uncertainty or confusion e.g. calf feeding. The support from the FAG helped farmers find a solution or work out what was the best way forward for them and their farm.

> *"Also it's a bit more because you are going to something on a regular basis, it tends to keep you a little bit more aware and a bit more motivated to sort things out, whereas otherwise you might think, 'I will sort that out' and you don't. Because you are going to a meeting, 'Must get that sorted out!' and some of the things that I have done because of the action list." FAGDe5*

This farmer acknowledged that the process of having the same group of farmers visit twice and seeing the same people on other farms, motivated and encouraged him to implement things that were on his Action Plan. The Phase Two meeting added an important element of follow-up.

It is well known in the industry that farming has a high rate of suicide and is subject to a number of occupational stressors, such as long work hours and financial constraints (213). This has serious implications for the FAG approach. If farmers are struggling to get basic jobs done due to pressures on their time, then surplus activities such as participating in a FAG and implementing actions from Action Plans are likely to drop down their agenda. On the other hand, participatory groups can help support farmers during difficult times (i.e. staff shortages) and therefore, could be seen as a way of reducing stress by sharing with other farmers in a similar situation and forming strategies to adapt (203).

Lessons to learn here about the applicability of farmer-led, participatory approaches are that external forces (such as Brexit and TB control) have an impact on changes to practice and building in an adaptive approach has been reported to policy makers before (157). Changing farm practices depends on multiple interacting factors and even with the most well-designed initiative or empowering process, external forces outside of the control of the participants can affect their outcome.

Facilitation

As much as the PAR principles and Stable Schools were about farmer-led change, the input of the facilitator cannot be under-estimated. It could be argued the project was more facilitator-led at the start and transitioned to being farmer-led over its duration, which Cornwall and Jewkes describe when a community is disempowered and lacks confidence (19). The AHDB Dairy facilitator was a key player in this project, from recruitment to the running of Phase One meetings. She kept the meetings focused, engaged all farmers and helped develop tools to help farmers reflect on their own practices (Chapter Three). The role of the primary researcher (who also served as the Phase Two facilitator) was to provide knowledge on HPCIAs and AMR at the request of the FAGs. A facilitator's role is to act as a knowledge broker (89, 197) and help the group achieve their shared goals. The facilitators in this study were cited as key actors in the farmer experience and even received presents of thanks from the participants.

> *"Your energy, enthusiasm and understanding of the subject has most definitely been pivotal in the success of the meetings." FAGW1*

Figure 34 - Thank you gift from one FAG at the close of the project

Due to the integral nature of a facilitator in a bottom-up, farmer-led approach, it is worth spending time acknowledging the input the facilitator had. As discussed in this chapter, facilitation had an influence on the co-creation of the Action Plans - the input from the primary researcher and the facilitator enhanced some topics more than others but also helped farmers prioritise and target their efforts. The AHDB Dairy facilitator in this study had expertise in calf health, behaviour and welfare, which meant she probed farmers' practices around calf health and welfare more so than someone without this expertise. Her facilitation style was often cited as a positive aspect of the project and many farmer participants spoke highly of her, as can be seen below:

> *"She's very engaging isn't she…She knows her stuff and I think you've definitely got a good resource." FAGDe2*
>
> *"From the farmers' point of view she's very good at control, and she's very good at channelling your energy into what you've got to go out of it. You know that having an objective and meeting your objective at the end, she's brilliant at that." FAGW3*
>
> *"I've once been to a talk and compared to her colleagues. She was much better at keeping us on track." FAGS1*

> *"Yeah, 'Calf to calving' person because he's doing another talk at M actually in December, I've signed up to go, B sent an email. He's very good, but he's not as good as FACILITATOR at putting it over." FAGW4*

Her reputation in the industry was influential in the recruitment phase of the study (Chapter Four) and due to the participatory nature of the FAGs meant she was not simply the facilitator, but also a key participant in the research (Chapter Three). She was keen to share her knowledge with the other participants but as an experienced facilitator with many years facilitating farmer groups, she avoided 'diving in' with expertise and knowledge unless the farmers requested her to. Her positive attitude to farmer knowledge and bottom-up projects, much like the primary researcher's described in Chapter Three, was essential in allowing farmers to innovate and learn (18, 19).

In summary, the integral role of the facilitators (both the AHDB Dairy facilitator and the primary researcher) in supporting the groups on their learning journey, co-ordinating the participatory activities and encouraging farmers to reflect on each other's practices was a consistent thread throughout all of the FAG components discussed thus far. The practical role of facilitation in this study is outlined in more detail in Chapter Three and further re-visited in the following chapter.

"Be the change you want to see in the world" Mahatma Gandhi

Chapter Seven: Conclusions - The policy implications of a participatory, farmer-led approach to changing in practice on UK dairy farms

7. a. Introduction

This final chapter brings together the findings from this research on how a participatory, farmer-led approach supports changes to practice and how it might be adopted on a wider scale. Gaps in the existing literature have been described and used to develop the research questions and methods employed here. The role of a PAR-derived methodology in identifying and driving improvements in farming in the areas of AMS and animal health and welfare has been discussed in detail. The thesis has demonstrated and analysed the value farmers gained from the FAG project and the subsequent changes in practice around the use of antimicrobials in livestock farming that resulted. This final chapter aims to draw together the implications of the research findings and position them in the present agricultural context in the UK and Europe. The chapter will begin with a summary of the key findings including their limitations and areas for future work. A summary of the key elements of the FAGs is covered first followed by the findings from the recruitment and establishment of the FAGs. It is hoped that the lessons learnt will help others to design and implement successful farmer-led strategies in the future.

The second half of the chapter reflects on the relevant developments in agricultural policy in the UK and then across Europe, focusing on contemporary initiatives that prioritise a bottom-up approach. Part of the work for this thesis has included exchanging knowledge with others that have successfully implemented AMU reduction policies through a specific Thematic Network within EIP-AGRI. In addition, a policy workshop was held to understand the needs of policy makers as well as barriers to designing and implementing UK policy with a bottom-up ethos. A brief description of the outputs from these two events is included in Appendix 14 and will not be discussed further.

Following this, the chapter details 1) recommendations for designing and implementing future farmer-led strategies and 2) recommendations for policymakers and advisors that are in the process of building future agricultural policy. The chapter then concludes with the contributions this research has made to scientific knowledge. The author hopes this research will add to knowledge on participatory approaches and adopting a PAR methodology in practice, leading to more productive policy that enables an environment for practical changes in farming in the UK.

7.b. Summary of findings [1]: FAGs as a participatory, farmer-led approach to changing practice around AMU on UK dairy farms

The FAG project was a participatory study that aimed to change farm practices around using antimicrobials, preventing disease and general improvements to herd health and welfare to enable reductions in AMU to occur. The PAR-derived methodology helped to maximise the learning from adopting such an approach and has implications for others wishing to adopt a similar strategy, particularly in the positionality of the facilitator and primary researcher (Chapter Three). The facilitator and primary researcher were integral participants in the approach, alongside the farmers. Their roles and relationships with other participants had a major influence on the personal progress of individual farmers and the overall learning journey that the FAGs encapsulated. The primary researcher, as a veterinarian and advocate of farmer expertise, supported the farmers' learning and provided supplementary knowledge where gaps were identified by the participants. The facilitator, as an experienced AHDB Dairy employee and well-known in the target community, enabled the recruitment of farmers and provided creative and skilful facilitatory input, which farmers regarded highly and encouraged their engagement with the approach. The PAR methodology prioritised farmer knowledge to solve farmer-identified challenges; the facilitator and primary researcher built the philosophy of equitable, complementary knowledge types into the core of their participation in the project.

The FAGs helped farmers identify, commit to and achieve changes on their individual farms through the facilitated process of Action Planning and peer-to-peer support, as discussed in earlier chapters. The changes on farm, reductions in HPCIAs and experience of being participants has been documented, analysed and triangulated in order to evaluate the impact and adoptability of this approach in a wider context.

The evidence collected from this study has shown that for all participants there were positive changes made on their farms to reduce the need for antimicrobials, as well as direct changes to how antimicrobials were used. All participants changed at least one thing based on their Action Plans. Across all farms, the average proportion of recommendations that were partially/fully implemented was 54.3%. The majority of farms (27/30) reduced or eliminated HPCIAs and approximately half of participant farms (depending on the metric used) reduced total AMU from

Year One to Year Two of the study, although a direct causal effect of the FAG approach was not possible or desirable to establish due to the study design. Farmers changed their practices around using antimicrobials (e.g. dosing correctly, avoiding use of HPCIAs) and preventing disease (e.g. improvements to cow and calf housing); they also had more discussions with their veterinarians and the project empowered them to act as antibiotic stewards on their individual farms.

Participants learnt about HPCIAs, AMR, AMU and how to improve their farm from the participatory mechanisms of the FAGs. HPCIAs and AMR were areas where farmers identified knowledge gaps that they deemed essential areas to know about as administrators of antimicrobials on farm. This knowledge was not forthcoming from many veterinarians at the time of the study and arguably should have been. This knowledge was instead provided by the primary researcher in a facilitatory capacity at the request of the participants. The role of facilitation in co-ordinating and supporting the FAGs was key and was acknowledged by participants as a critical part of the knowledge mobilisation process. The input of external knowledge is not contradictory to a farmer-led approach but is part of the participants' knowledge acquisition and knowledge edge as well as part of developing their own vernacular expertise (20). The exchange of knowledge and experience between participants was a critical aspect of this farmer-led approach and was highly valued amongst all participants. Non-participants, however, revealed concerns with the sharing of their knowledge. This movement and balance of knowledge in a participatory environment was thereby termed 'knowledge mobilisation' in this study. It was a critical factor in empowering participating farmers and helping them to change certain practices.

The knowledge sharing and practicalities of seeing and hearing from other farmers gave participants confidence to trial new actions, some of which were laden with risk and uncertainty (e.g. delaying antibiotic treatments to allow for self-cures). The participants felt part of a peer group that was going through the same challenges at the same time (e.g. the groups earnt the nickname "*Antibiotics Anonymous*"). The repeated meetings added an important element of follow-up and allowed for trust to develop between participants. The sense of collective support, of solidarity, played a vital role in fostering change on farms, which has helped to reduce the use of and need for antimicrobials.

PAR methodologies and bottom-up initiatives often arise out of an imbalance in power or with the aim to empower communities and individuals acting collectively (19). The FAGs successfully empowered the participant farmers with new knowledge and improved their sense of capacity to make practical changes on their individual farms by increasing their confidence through peer support and collective action. Farmers' participation in this learning journey also gave them a feeling of empowerment in their wider social circles (to include their veterinarians) by arming them with a perceived 'AMS knowledge edge' compared to non-participating farmers. Empowering farmers through the FAG project, therefore, has shown the beneficial effect the approach can have when influencing change on farm. This is evidence of a PAR approach achieving what it set out to do – bringing about change.

The research also highlighted a power differential in the food supply chain, particularly around knowledge. Farmers at one end of the food supply chain are being asked to make quite significant changes to their businesses and herds and have a vital role to play in AMS. On the other hand, it can be argued that farmers have little negotiating power or control over the environment in which they can make these changes (21, 186, 214), hence why a PAR approach has been demonstrated to work well in agriculture worldwide (19, 21).

Returning to the Arnstein ladder of participation (introduced in Chapter Two), many examples of farmer involvement in the decisions that shape their markets, contracts and income barely meet the level of 'placation', which is defined as token participation (150). Using Arnstein's typology, one might argue that having regional farming representatives through which large companies gather feedback and opinions from their producers is not true participation but an attempt to 'placate' (or manipulate). The views of the farmers are not always heeded – they do not have a seat at the executive table making the decisions (214). PAR methodologies argue that for long-lasting change that people value and carry forward, a degree of participation and empowerment is necessary. Hockenhull and colleagues (2019) argue that large corporates in the supply chain have a role to play in AMS (183). Some large companies also have a very powerful role in the supply chain more generally due to controlling the price farmers receive for milk that has arguably hindered farmers ability to act autonomously. This research has suggested that empowering farmers encourages practical on farm change and that their disempowerment, (enshrined in references to farmers as 'end-users', 'laggards' or 'hard-to-reach'), is in part linked to the imbalance around the differential value placed on knowledge types, knowledge movement and the dismissal of farmer knowledge and capacity in the wider food supply chain. This has been highlighted previously in the literature, particularly within the Beyond Farmer First movement (21, 98). Embracing a participatory, farmer-led approach, particularly by large corporates with significant leverage (214), the restrictive imbalance of power to change one's own situation could be substantially re-addressed.

Limitations

Despite the strength in collective action and the benefits farmers experienced from participating in the FAGs, there are some issues to consider. Practices around using antimicrobials and managing the farms could have changed over the same time period as the study, even if the research had not happened. Farmers could have reduced their AMU or moved away from HPCIAs, despite being in the FAG project. Certainly, many farmers in the UK have been doing this due to milk contract stipulations or under the supervision of their veterinarians. The media coverage of AMU in farming (196), the pressure on the agriculture industry after the release of the O'Neill report in 2016 (5), the introduction of the RUMA AMU targets in 2017 (36) and the enforcement of Red Tractor guidelines on HPCIA use on farm in 2018 (6), have all played a part in affecting on-farm practices in this area (Figure 33). This participatory research was in addition to all these influences and was only part of the wider process of change. Therefore, the changes farmers have made and documented as part of this study might only be in part attributed to their participation. This research does not claim any simple and direct relationships between participating in a FAG and the evidenced reductions in AMU or changes to practice. It has not been the remit of this study to extract and quantify the individual influence of each factor on farmer behaviour, or to assign each change or reduction in AMU to the FAGs only.

It could be argued that one aspect missing from this research is a control group, which is crucial in establishing causal inference. This research, however, was not about comparing what participating farmers did to what non-participating farmers did with respect to AMU and attribute causal inferences to the FAG project; indeed, for this comparison to be made a control would have been needed. Rather, this study was about evaluating how the participatory process motivated and empowered farmers to identify and implement changes on their farms and why it resulted in doing so. The interest and emphasis was not on how participants compared to other farmers generally but instead was on how participants compared with themselves over time. What did participants change once they participated in the project? How many of the things they said they were going to adapt or change were altered and adapted since commencing the participatory journey? What were the influencing factors in helping farmers achieve these changes?

Finally, the findings from the FAGs and associated interviews reflect the views of the participants in this study and as such cannot be extrapolated to any wider population. Their perceptions and knowledge are situational and context-specific (79). The insights provided from this research have implications for the approach and further work on influencing change on farm, but the generalisability of the results is not the focus. The lessons learnt here are what is hoped will inform and shape future policy in this area.

Future work

As discussed in Chapter Two, the literature increasingly calls for more participatory methodologies and multi-pronged approaches to the complex challenges farming faces today. At a European level, EIP-AGRI has encouraged and championed a multi-actor approach using the Interactive Innovation Model to solve farm-level problems through Operational Groups (87). The FAGs share many similarities with this initiative and OGs. This research has shown that a farmer-led, participatory approach is well positioned to tackle the complexity of AMS. It embraces the holistic nature of farming and knowledge and gives a voice to farmers, which can bring valuable lessons and motivation to achieve solutions to complex problems (89). Chapters Five and Six have identified and detailed the intricacies of such an approach and the impact it has had on individual farms and farmers. Nevertheless, further involvement of all actors and industries aligned to the farming sectors would be potentially fruitful, and is an explicit aim of EIP-AGRI. The inclusion of the veterinary profession at farmer meetings (particularly on the topic of AMS) could be an area of further research. The role and effect of veterinarians or other advisors on the functioning of a farmer-led group should be investigated. The use of facilitated group work within veterinary practices could also yield some interesting results in terms of reducing AMU and encouraging responsible prescribing.

A further area of work that this research did not address was the longevity of the changes on farm. Although the Action Plans were followed up and there were two years of medicine data collected and presented, the persistency and commitment to the changes on farm was not evaluated beyond the project end (July 2018). A criticism of research within farming communities is there is often no plan for maintaining the initiative after support is withdrawn (154). Nonetheless, as demonstrated in Stable Schools, the purpose of farmer-led groups on tackling a specific issue, such as AMU is that they are finite and should not continue beyond a certain timeframe (24). The emphasis should be on upskilling farmers and enabling them to mobilise and address challenges on their own i.e. without research assistance. An area of further work could be to re-visit farmers that have participated in these types of initiatives and examine whether they have indeed been empowered with any lasting effect.

There are many ways to encourage farmers (and veterinarians) to reduce AMU and to use antimicrobials more responsibly (e.g. official training courses with Dairy UK or milk contract stipulations). The literature suggests that different people will need different approaches (11). A multitude of options are needed to enable, motivate, and support changes to practice on farm. This thesis argues that in order to establish practical changes to solve complex challenges that farmers really value and persist with, then a participatory approach can be one very productive option and should be built into future agriculture policy. Such additions to agriculture policy would allow farmers to meet legislative requirements or tackle future challenges in farming by accessing a facilitator who could help mobilise multi-actor groups within a participatory framework to realise a common goal. This ties in nicely with the goals set out by EIP-AGRI and is similar to the obligatory health advisory service using the Stable Schools approach in Denmark (24). Facilitation is and should be an integral part of a participatory, farmer-led approach being adopted more widely.

7.c. Summary of findings [2]: Recruiting and engaging farmers

As discussed in Chapters Four and Five, recruitment to farmer-led approaches like the FAGs can be difficult. The reliance on voluntary participation creates self-selecting samples and can exclude the so called ‘hard-to-reach’ farmers (73). From a veterinary perspective, these farmers may be those who could benefit most from such an approach (i.e. those who do not like veterinary advice and may prefer peer-to-peer support). One of the findings of this research is that from a farmer’s perspective the ‘hard-to-reach’ are not necessarily the same group of people as perceived by advisors. This is one reason why categorisation of farmers based on their relationship with advisory services is potentially short-sighted when engaging this community. The combination of relating the reduction of AMU to their own farm interests (e.g. passing farm assurance, retailer contract demands, cost benefits), of being concerned about AMR and farming's role in AMR (partly driven by negative news stories), combined with a desire to receive help with change practices before being forced to, all contributed to a wide range of dairy farmers joining this study. Some of these were not the 'usual suspects', often referred to as the 'proactives' but had their own valid reasons for participating. The labelling of farmers as hard-to-reach/proactives etc. was not helpful for recruiting to this study. If anything, the diversity of farms that participated demonstrated the fallacy of labelling groups of people based on their interaction with an advisory service.

Additionally, the range in AMU on participating farms was large (3.5mg/kg - 93mg/kg in Year Two); this project did not appeal to only those with low or high AMU. The variation in farming types in the study was also substantial (Chapter Four) and had implications for the continual engagement of farmers and for mutual learning. These findings suggest that the recruited sample reflected many types of dairy farm present in the UK and that attention to the drivers of participation will yield better recruitment results than categorisation of farmers *per se*. Perhaps the 'hard-to-reach' farmers are thus so because of the way in which one tries to reach them? This is partially supported by work by Jansen and colleagues (2010) with further categorisation of farmers dependent on their information sources (73). It is the view of the author that understanding farmers' interaction and engagement with the approach is more useful than categorising them based on their one-time choices.

Making use of pivotal community members (AHDB Dairy and an AHDB Dairy employed facilitator in this project) proved to be a successful way of reaching out to farmers. AHDB are well known in the industry and already had existing contacts that were used for promoting the study during recruitment. AHDB also provided a legitimacy to the project for those uncertain about signing up. Collaboration with an AHDB Dairy facilitator improved recruitment results further still, due to her extensive farmer network and pre-existing relationships with many in the target community - she was a trusted figure to many farmers. It is therefore a key strategy to liaise with these pivotal members or organisations if recruitment and engagement is to be maximised.

Recruiting farmers via veterinary practices, by contrast, was not a successful strategy for this study on reducing AMU. In theory, veterinarians are ideal Gatekeepers to access farmers for a researcher from an institute. However, veterinarians had concerns about farmer knowledge on AMS and were worried poor practice could spread between farmers within the FAGs (Chapter Five). Veterinarians were not fully incorporated into the approach either (i.e. they were not present at the meetings based on the Stable School model), which had an impact on recruitment outcomes. In addition, there were vested interests from the veterinary profession regarding reducing AMU and the potential impact on practice profits and their advisory role, which partly influenced their attitudes towards the study.

Further examination of the veterinarians' views on a farmer-led approach revealed a relative disregard for farmers as experts and a belief in the primacy of veterinary knowledge on farm, which does not bode well for acceptance of a farmer-led approach, especially on AMU. Alongside this, however, was the acknowledgement that farmers responded well to advice from their peers and that they did have a great deal of knowledge and experience in farming. This suggests there is an opportunity for veterinarians to accept the approach more widely, but more could be done to help veterinarians appreciate and harness farmer know-how in their advisory role (129). Veterinarians also described a sense of frustration and despondency at their lack of influence in the food supply chain and perceived their role as farm advisors to be limited with many 'types' of farmer. Veterinarians recognised that the biggest influence on farming practice was in fact large companies in the food supply chain, such as milk buyers, which has been described elsewhere regarding disease management (184). Veterinarians indicated that they would rather help farmers navigate the challenges of meeting the large companies' demands. These findings shed a different light on the veterinarian-farmer relationship. This finding in combination with the lack of support farmers felt they had from their veterinarians on AMU, suggests that the veterinarians' place as the esteemed farm expert is shifting. The findings from this research suggest that a farmer-led approach to changing practices on farm could be an opportunity for the veterinary profession to transform and evolve their advisory services. This would entail training for veterinarians as facilitators rather than farm advisors in the traditional, top-down knowledge transfer way. The farmer-led approach requires facilitatory input and this study has demonstrated there are gaps in farmer knowledge around AMS that veterinarians are well-positioned to support.

Limitations

The recruitment results should be interpreted in light of this being a research project. The majority of recruitment was done by the researcher herself (a veterinarian from an academic institution) and the process was largely carried forward in an iterative fashion rather than according to a rigorous and pre-defined protocol. The success of accessing participants is known to be heavily influenced by one's position in the community (163). Being a qualified veterinarian helped the author build rapport with farmers quickly but being in academia and unknown to many in the farming community made the process slow and meant many farmers did not even engage from the start. If AHDB had designed and executed the recruitment of farmers to this study from the start, the outcome may have been significantly different and the speed in which farmers were recruited could have been improved. Nevertheless, AHDB are not regarded by everyone in the farming community in a positive light due to the levy farmers have to pay them. Their involvement, therefore, could also affect future implementation and success of the approach.

The examination of non-participant farmers' views of the approach revealed an apparent protectionist mentality and a perceived lack of commonality between dairy farmers (Chapter Five). These subtle divisions in a community should be accounted for in future programmes and also mean not everyone in a target group will respond favourably to this sort of approach. Whichever organisation or group that carries out a recruitment strategy for a farmer-led approach, should be sensitive to their role and how they are perceived by the community they are trying to enrol. This is a reason why Gatekeepers and techniques such as Snowballing are often used in these situations where access to people can be challenging, but they are not without limitations, as discussed in Chapter Four. A combination of recruitment tactics, therefore, would be preferable. Above all, the encouragement of farmer-led groups to mobilise and form on their own using their own criteria would be the ideal solution as this would allow farmers to take ownership of the process early on and avoids issues with differences in knowledge and farm systems. Self-mobilisation could still be supported by a facilitator who assists the groups through communicating and liaising with the self-selected farmers in the initial stages. From a PAR perspective, allowing farmers to decide on their own challenges and goals and mobilising into groups themselves is preferable (150). How far up the Arnstein participatory ladder a farmer-led initiative needs to go is somewhat an academic question. From a pragmatic perspective, initiating farmer groups using an external body like a facilitator and taking account of the aforementioned points is, in the author's view, appropriate. Further work could examine the formation of groups dependent on farmer choice and how they perform and innovate compared to randomly or geographically formed groups.

The rationales for participation were drawn from qualitative semi-structured interview data and represent the views of a small subset of dairy farmers, which was further split into those who participated and those who dropped out/did not participate in the study. Generalisation of their views to the wider farming community cannot be made from this sample. There may also have been more barriers to participation than were elucidated in the interviews of non-participants as data saturation was not reached. Nonetheless, these results start to build on the understanding of participation in farmer-led initiatives and suggest ways to best engage with the farming community in the South West of England.

Finally, recruitment was begun in 2016 when the milk price was at an all-time low and below the cost of production. This may have had an impact on the uptake of the study and hence affected the results of recruiting dairy farmers to a participatory study.

Future work

Utilising existing community members as Gatekeepers and incorporating these community members into the strategy from the start will improve outcomes. If preliminary work suggests there are issues with the chosen Gatekeepers, then these should be rectified first to maximise recruitment success. For example, this research revealed veterinarians had concerns with farmer knowledge and challenges with their advisory role on farm, as well as other reservations to do with reducing AMU. These concerns were not accounted for when approaching veterinarians as Gatekeepers in this study and affected the success of this tactic. Using AHDB was very effective on the other hand, and a close partnership with an AHDB Dairy facilitator was integral to the establishment and running of the FAGs.

Compulsory recruitment to farmer-led projects is not recommended for a number of reasons (Chapter Five). However, an element of 'motivation' to join a participatory project would be potentially effective. If retailers or processors included these approaches in their requirements of farmers or as a way to achieve improved herd health and welfare, then improved uptake and outcomes could occur. This would be something to test and evaluate to determine if such approaches would affect the dynamics and participation of farmers. Vaarst and colleagues (2013) argue, however, that these types of approaches should always be voluntary and short-term (24).

The adoptability of these types of approaches hinges on successful recruitment and engagement of farmers and if insufficient attention is given to this, such approaches will only ever be expected to reach the few and not the many.

7. d. Situating the research in the UK and European agricultural context

DEFRA are responsible for the drafting of new agricultural legislation in the UK. This chapter explains the direct relevance this research has for future agricultural policy. For the first time since 1973, UK agriculture is moving away from the Basic Payments Scheme (BPS), delivered as part of the EU's Common Agricultural Policy (CAP). This is a significant change for UK agriculture and represents an opportunity to re-distribute how UK farming is funded and supported. In order to understand and examine options for the future of UK farming, DEFRA launched The Health and Harmony consultation, which ran for 10 weeks from 27th February – 8th May 2018. DEFRA wanted views on their proposals for future agricultural policy, particularly around phasing out BPS and protecting the environment. The consultation had an overwhelming reception from the public and varying farming sectors resulting in 43,356 responses. The Health and Harmony consultation marked an attempt by the UK government to involve multiple stakeholders in the creation of an important piece of legislation.

The consultation resulted in the formation of a new Agricultural Bill in September 2018. The Bill authorises new expenditure in agriculture and "*to make provision about direct payments during an agricultural transition period following the UK departure from the EU" (215).* It broadly sets out; new financial assistance powers by the Secretary of State - including assistance in exceptional market conditions and for the purposes of protecting and managing the environment - and covers plans for financial support after Brexit with the phasing out of the BPS. The Bill is largely enabling and much of the detail and practical applications are yet to be decided in future legislation post-Brexit. Nonetheless, it is the timing of the drafting of this agricultural legislation that is of interest in this thesis (Figure 35). At the time of writing, there exists an opportunity to influence draft legislation when it comes to changing on-farm practices. Influencing and supporting certain farm practices is arguably of the utmost importance with regards to the Agricultural Bill, whether that relates to animal health or environmental stewardship. In the view of the author, the wishes of the Secretary of State around animal and environmental health set out in the new Bill need to prioritise and include farmers and farmer decision-making.

Furthermore, this research has direct relevance to policy making as illustrated in DEFRA's policy paper in response to the consultation – Health and Harmony: the future for food, farming and the environment in a Green Brexit. Various statements within the paper directly match the aims and outcomes of this research. With regards to Environmental Land Management (ELM), the policy document states:

> *"The new system will respect the knowledge of the person who knows the land best, put them in control and inspire them to explore how best to improve the environment...[]...Plans will be adaptable and encourage local solutions, but they must be rooted in strong evidence and best practice, encouraging farmers and land managers to review and revise approaches throughout the year to deliver the best results." (216)*

The above statement acknowledges the principles of this type of research and of a PAR methodology. By putting farmers first and encouraging local solutions, DEFRA are effectively saying they are open and keen for farmer-led approaches in new policy.

The policy paper goes onto say that DEFRA want to work closely with industry and the veterinary profession to safeguard and deliver better animal health and welfare and thus improve farm productivity.

> *"Over the coming year, we will work with representatives of industry and the veterinary profession to determine how we can work more closely together to significantly reduce the impact of endemic disease and health conditions, as well* as *establish the range of tools required. We will pool our expertise to ensure that interventions are effective and industry-led."(216)*

These commitments fit in with a multi-actor approach and demonstrate DEFRA's keenness to adopt new interventions, such as participatory bottom-up initiatives. In relation to the goals of this research on reducing AMU, the policy document also states:

> *"Better use of data can improve farmers' performance on animal health, welfare and productivity. We want to expand the range and detail of animal health and traceability data, and, working with industry, maximise opportunities for using data responsibly. With greater access to data, we can support farmer learning, identify disease threats more quickly and improve the transparency of health standards from farm to fork. All of these have a direct impact on productivity, trade, and reduced reliance upon anti-microbial veterinary medicines." (216)*

DEFRA particularly mention "*farmer learning",* which this thesis has documented was crucial in helping support changes to practice around AMU. The policy paper describes the use of data systems having a role in improving animal health, which this project – through benchmarking AMU - has also shown were effective.

In terms of research and development, DEFRA specifically mentions funding groups of farmers in the second bullet point:

"We will focus on developing R&D funding to support high quality research, through:

- *targeted support for collaborative R&D in priority areas, including environmental outcomes and soil health*
- *industry-led research syndicates, with groups of farmers coming together to deliver practical solutions and commission research projects with academia that improve the translation of R&D onto farms*
- *encouraging short experimental projects, such as funding for trialling new ideas for different varieties and methods" (216)*

One of the key recommendations of this chapter is to propose an easily accessible fund to pay for the facilitation of future farmer groups, similar to Natural England's Facilitation Fund. The re-direction of resources and the notion of 'public money for public goods' (216) could underpin this recommendation.

At a recent meeting between various farmer-led innovation projects from across the UK - known as the Farmer-Led Innovation Network (FLIN) - significant interest was shown from a large UK research council in funding and supporting farmer-led approaches in future research. The funding council representative shared his enthusiasm and commitment to the approach. This is further evidence for the adoptability of the research by acceptance and inclusion of the methodology in funding frameworks.

EIP-AGRI - Paving the participatory path in Europe

Looking outside of the UK and to the rest of Europe, there is also growing demand for and momentum behind a farmer-led, bottom-up approach. The establishment of the European Innovation Partnerships (EIP) in 2010 (Figure 35), funded through the CAP Rural Development, is a prime example of policy-level support for the farmer-led approach. EIP aims to speed up innovation and improve the productivity and sustainability of agriculture across member states. The European Commission (EC) have a vision for rural development and agricultural innovation that focuses on working collaboratively and innovatively across multiple actors to reduce the gap between scientific research and practice. This has been based on the Interactive Innovation Model, mentioned in Chapter Two. In 2012, through two funding mechanisms, EIP-AGRI was borne (Figure 35) to realise the EC's vision. CAP funds the establishment and support of Operational Groups that co-design and implement innovation projects on various different topics. These have been running since 2014 and are due to continue until 2020; they consist of groups of farmers, advisors, researchers or Non-Governmental Organisations that work collaboratively to solve local issues of relevance to them. The second funding mechanism was through Horizon2020, which supports research projects investigating and developing the innovation process, in particular, the development and support of multi-actor projects and the so-called Thematic Networks. These are cross-border, multi-institute, multi-actor, cross-cutting networks that support and develop the OGs within them. Examples of Thematic Networks in EIP-AGRI are Hennovation, Eurodairy and Inno4grass (89). Further discussion on the involvement of this study with part of the Eurodairy Thematic Network is described in Appendix 14.

Around 3200 OGs have been planned for in the EIP-AGRI; these cover practical challenges on plant protection, preserving the environment, precision farming, renewable energy, supply chain co-operation and developing new products or practices. In October 2016, 231 OGs were operational. Initial independent evaluations have found the EIP-AGRI framework to be commendable and unique (87). The focus on bottom-up innovation covers real needs and opportunities in rural development in Europe. The flexibility of this programme allows it to be shaped to specific contexts (reflecting the variability between member states) and bridges the gap between research and practice. Recommendations for the programme were to keep the principles of interactive innovation central to its work, as well as to focus on practical measures such as reducing up-front costs and bureaucracy for establishing OGs. Further evaluations are ongoing as many OGs were still functional at the time of the evaluation. Future work within EIP-AGRI is focusing on the Agricultural Knowledge Innovation System (AKIS) and the key role of *"incentivising creativity and knowledge flows between key actors"* (87), such as rural networks, advisors and researchers. *"Its success depends on the combined performance of advisors, agricultural training and educational systems, researchers and farmer organisations often referred to as the Agricultural Knowledge and Innovation System (AKIS) which operates very differently from one Member States to another."* (87).

EIP-AGRI not only provides a practical, policy-level example of the relevance and importance of a farmer-led approach but also paves the way for further research into FAGs. The FAGs were in essence an OG. They were built around farmer knowledge and experience; they prioritised farmer issues and challenges on farm. Through a facilitator and peer-peer support, FAG participants worked to improve animal health and reduce AMU. Their interactive innovation was sharing knowledge, applying each other's knowledge and experiences on farm and co-creating practical solutions. The mechanisms of the FAGs mirror the aims and ethos of EIP-AGRI. The development of these approaches is working "*towards an agriculture of knowledge*" (87). AHDB Dairy, the funders of this research, have also had a major part to play in designing and implementing Eurodairy (an EIP-AGRI Thematic network) and, as such, these findings will have implications for their future policies as a Knowledge Exchange (KE) organisation in the UK. Some examples of this could be providing training and support of the KE staff to be able to deliver facilitation and innovation support, rather than maintaining their roles as technical agricultural extensionists. AHDB's role could include less emphasis on resources that promote the passive transfer of advice in the form of leaflets and talks and more engagement of farmers in small OGs.

In summary, the drafting of new UK agricultural legislation, an EU-wide appetite for participatory farmer-led approaches that support innovation and co-create solutions to farm-specific challenges and a growing shift away from top-down mechanisms to elicit change on farm, has resulted in a prime opportunity for this research to influence future policy. The promotion of further participatory, farmer-led approaches in farming that prioritise farmer know-how to solve societal challenges such as AMR, should have a place in new policy and should be funded accordingly.

7.e. Contribution to scientific knowledge

This thesis has contributed original and important scientific knowledge to the existing literature in the following ways:

- **By establishing and evaluating the key elements of a participatory approach - based on the Stable School model - that have helped participating dairy farmers adapt and change their practices around reducing AMU.** Mobilisation of knowledge and fostering solidarity were critical steps in supporting farmer innovation and action. This research has helped improve the understanding of participatory, farmer-led initiatives by identifying what works, what does not, what components need prioritising, particularly in the area of reducing AMU as well as the importance of the positionality of individuals and organisations involved in a PAR methodology.
- **By adding to the growing evidence base in the veterinary and agricultural literature that farmer knowledge can be of particular value when solving complex problems**. This research has shown that farmers want to be trained in responsible AMU and empowering them at a local level can help mobilise knowledge that helps reduce AMU on farm (Chapters Five and Six). The FAGs helped encourage the participants to take ownership of the solutions with the support of a facilitator, which can lead to better buy-in as a means to influence behaviours and practices on farm. This research has made significant steps to reduce the gap between research and practice by adopting a PAR methodology and putting farmers in the driving seat. This is one of the guiding principles championed by the EIP-AGRI as a way of supporting innovation and rural development across European agriculture.
- **By extending the case for a farmer-led approach in line with Stable Schools, Innovative Farmers, Pastoralists Field Schools, EIP-AGRI Operational Groups and Thematic Networks.** The FAGs have many similarities to other farmer-led, bottom-up approaches; this study builds on previous literature, in particular the body of work known as 'Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice', demonstrating the applicability and effectivity of the methodology to bring about practical change. This study has also proven the applicability of the methodology in communities and countries where the approach has historically not been widely practiced i.e. Europe.

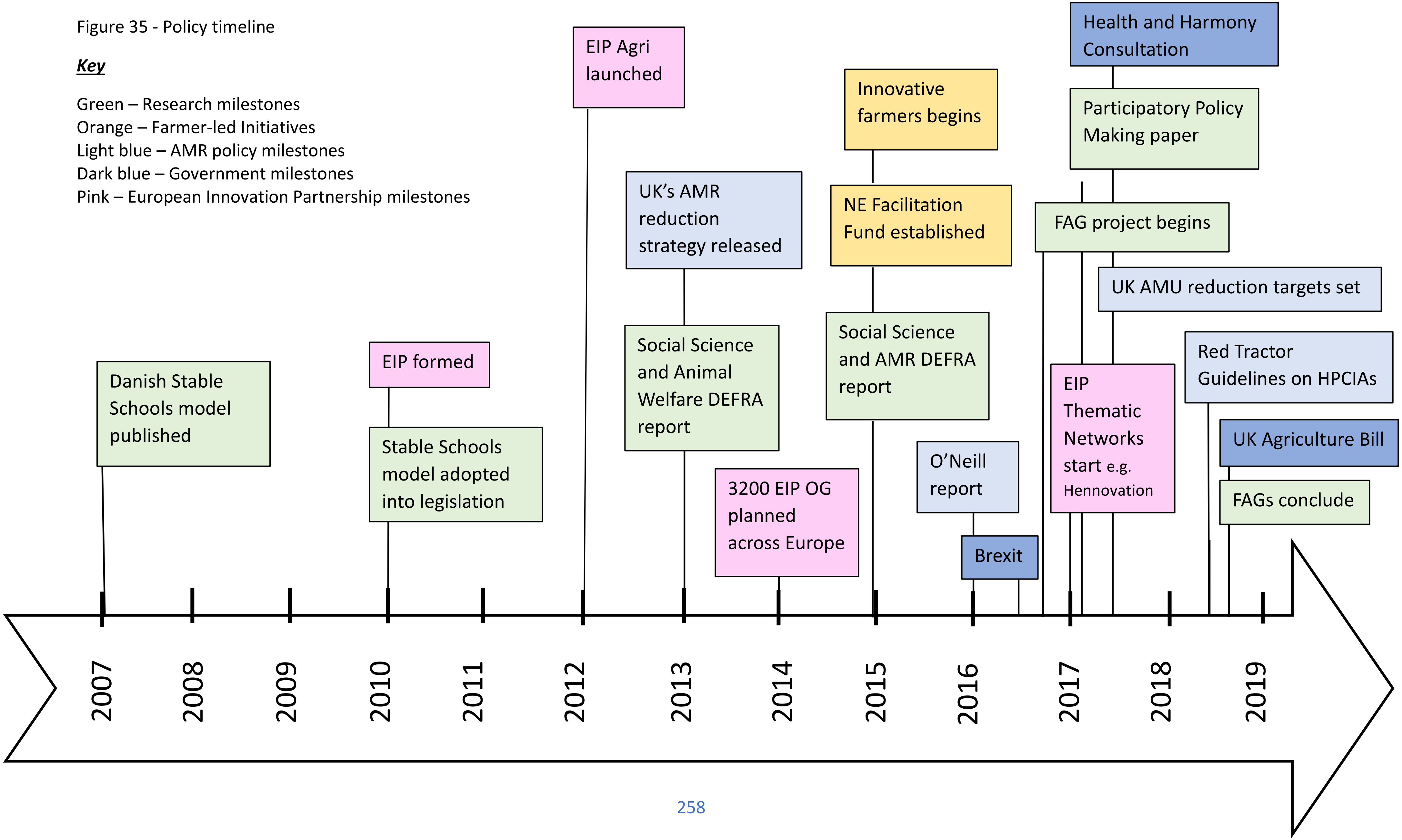
- **By highlighting best outcome strategies around recruitment and engagement of the farming community.** The results from recruiting farmers to this study will influence the implementation and success of future initiatives in the UK. The challenges that arose revealed issues with the applicability and adoptability of the approach on a wider scale and how pivotal community members, such as AHDB and facilitators, can improve outcomes.
- **By revealing issues around the veterinarian's role in influencing farmers.** These findings challenge the existing literature on aspects of the veterinarian-farmer relationship, such as challenging the dominant role veterinarians are reported to have in influencing farmer-decision making (83). The lack of support farmers felt they had from their veterinarians around AMU and the farmers' ability to innovate and change practices with little or no input from the veterinarians should be a humbling message to some veterinarians. Nevertheless, there was a desire from veterinarians to have more influence on certain farms and the results in Chapter Five suggested that the imbalance in power and knowledge within the food supply chain has affected the veterinary profession too. There is an opportunity, therefore, for veterinarians to adopt a more facilitatory communication style and implement a farmer-led approach within their advisory package that could readdress these issues. These are important findings for policy makers and other authorities in the industry to consider when looking to instigate changes on farm through the veterinary profession.
- **By promoting a stepwise shift in the way agricultural policy frames and attempts to change farming practice**. This research supports attempts to move Agricultural Knowledge Innovation Systems away from linear, top-down mechanisms and to a space where multiple knowledges are accepted and deemed relevant and where power in agriculture is distributed more equitably.

Farmers should and deserve to be at the forefront of changes to their situation. This thesis has argued for the validity of farmer know-how in solving complex challenges, such as reducing AMU within a participatory framework.

Figure 35 - Policy timeline

Key

Green – Research milestones
Orange – Farmer-led Initiatives
Light blue – AMR policy milestones
Dark blue – Government milestones
Pink – European Innovation Partnership milestones



7. f. Recommendations

This final section in this chapter lists some key recommendations for implementing future farmer-led projects and for designing policy around knowledge exchange and farmer-led approaches as a result of this research.

For future farmer-led projects

1) All the following recommendations can and should be co-ordinated by a facilitator - they should be trained in the approach and can have the following roles:
    a. a pivotal community member to help establish networks
    b. knowledge broker
    c. logistics manager
    d. group guide
    e. support figure
2) Identify and build relationships with pivotal community members and encourage them to act as Gatekeepers for recruiting farmers voluntarily
   And/or
   Motivate farmers to join an initiative by using certifiers/retailers/processors to stipulate participation as part of a higher tier contract or scheme
3) Ensure the benefits of participating are made explicit to all potential participants
4) Try to provide an added service to farmers as a return for their participation (e.g. passing farm assurance)
5) Aim to form farmer groups with participants that want to work with each other or see benefit from each other's experiences
6) Identify knowledge flows within groups and ensure all participants are giving and receiving knowledge or experience equally
7) Maintain engagement by using group activities, discussion tools or bonus trips/opportunities, bearing in mind that people learn differently
8) Use data and benchmarking throughout to allow participants to see their progress and participate in its presentation
9) Allow participants to feed into the evolution of the project/initiative - do not be too rigid with structure or format

10) Do not expect 100% attendance from all participants all the time
11) Keep farmer meetings on farms where possible and make use of farm walks for exchanging ideas between group members
12) Have a group goal (i.e. reducing AMU) and once achieved allow the groups to disband. The option to reform or re-invent with others or on another topic should be encouraged (see Stable Schools model).
13) Build in an evaluative framework (with a cost-benefit analysis if possible) to measure and evaluate impact of project on farms, farmers and wider community/environment.

For policymakers

1) Allocate money from the transition away from BPS to a nationwide facilitation fund that farmers or other industry bodies can easily access to be able to form and facilitate farmer groups without bureaucratic challenges
2) Accredit/recognise a professional board of facilitators
3) Work closely with industry partners to maximise recruitment of and engagement with the farming community, such as AHDB/retailers/processors
4) Do not make participation in schemes/initiatives compulsory or a legislative requirement unless part of a suite of options (e.g. as in Denmark with the adoption of Stable Schools into animal health policy)
5) Recognise farmer knowledge and expertise when making policy - seek farmer's views on the design of schemes and the development of policy
6) Encourage participation by working with existing schemes and farmer contracts (e.g. participation in X results in bonus Y or less bureaucratic requirements)
7) Reward positive changes to farm practice within schemes (e.g. Farm Clusters) but not only on financial incentives (e.g. opportunities to attend workshops and talks).

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Appendix 1

Table A1- Specific outcome for each veterinary practice contacted during recruitment

Vet practice	Communication via Email	Communication via Telephone	Communication Face-to-face	Response to project	Number of farmer participants recruited
VP1	x	x	X	+2	0 (2 initially)
VP2	x		X	-1	0 (1 initially)
VP3	x		X	+1	0
VP4	x	x	X	+1	0*
VP5	x	x	X	-1	0
VP6	x	x	X	+2^	2 (5 initially)
VP7	x			0	0
VP8	x		X	0	0
VP9	x	x	X	+1	0
VP10	x	x		0	0
VP11	x	x		+1	0 (1 initially)
VP12	x	x		0	0
VP13[1]	x		X	+2	4 (11 initially)
VP14	x		X	+2	1
VP15	x	x	X	+1	0
VP16	x		X	+1	0

0= No response; -1= negative response; +1= positive response; +2= positive response & actively recruited participants; *None recruited for the FAG project, but interviewees recruited; ^ overall positive response but shared concerns about project; [1] The primary researcher had pre-existing contacts at this practice due to working there as a veterinarian prior to starting study

Appendix 2

University of BRISTOL

FOR RESEARCHER USE ONLY
Study Number: 1
Location Number:
Respondent number:

CONSENT FORM

Title of Project: **Reducing antimicrobial use on UK dairy farms through farmer action groups**

Name of Researcher: **Lisa Morgans**

*Please **initial** all answers*

1. I confirm that I have read and understand the information sheet dated **May 2018** (version **[1]**) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason. ☐

3. I understand that relevant veterinary and farm data, as described in the information sheet, which is collected during the study may be made available, in anonymised form, to other researchers. I give permission for these individuals to have access to my records. ☐

4. I agree to the use of audio-recording equipment in this study and the possible use of anonymised quotes and photographs in future publications, upon request. ☐

5. I agree to the collection of and sharing of individual farm data and medicine use with my farmer action group and between the research group members. ☐

6. I agree to my veterinary surgeon being informed of my participation in the study. ☐

7. I agree to take part in the above study. ☐

______________________	______________________	______________________
Name of Participant	Date	Signature
______________________	______________________	______________________
Name of Person taking consent	Date	Signature

Appendix 2

University of BRISTOL

Date:
Version: 1

Participant Information Sheet

Research Title: Reducing antimicrobial use on UK dairy farms through farmer action groups.

We would like to invite you to participate in our research to reduce antimicrobial use on farms. For your information before embarking on this participatory project, we invite you to read the below information to advise you on what is involved. Feel free to discuss this with other people and please do contact me if there is anything you wish to ask or clarify.

What is the purpose of the research?

The aim is to test and use participatory group learning as a way to help UK dairy farmers reduce antibiotic use on farm. The method is centred on farmer led changes, on farm, for farmers and is unique to policy making in the UK. We want to inform policy from the bottom up, rather than top down. The intention is to create small groups of farmers called Stable Schools, which has been tried and tested in Denmark with success. You will be able to come together at regular intervals to see how each other have tackled similar problems and challenge each other to improve preventative health care and hence aim to reduce your antibiotic use on dairy cattle.

Why have I been invited?

You have been invited to participate in this research for one of the following reasons:

a) You have been suggested as a suitable participant for this research by your veterinary practice
b) You have been approached by the researchers directly because you fit the criteria for the research

There will be 20-30 other dairy farmers participating in similar groups across the UK.

Do I have to take part?

It is up to you to decide to participate in the research. We will describe the research and go through this information sheet with you. If you agree to take part, we will then ask you to sign a consent form. You are free to withdraw from the research at any time, without giving a reason.

What will happen to me if I take part and what will I have to do?

Involvement in the research will last approximately 18 months if you participate in the stable schools.

The stable schools will run from September 2016 until February 2018, depending on group size.

Each stable school will last 3 hours. The aim is to have a stable school every 6 weeks, but this may be extended to every 8-10 weeks depending on the group. You will be expected to host the stable school on your farm twice, several months apart. In between time you will be expected to attend the stable schools on the other group member's farms. If there are 6 farmers in a group, meeting every 6 weeks that is 12 meetings over the course of 18 months. It is a commitment and will take approximately 48 hours (2 days) over 18months i.e. 2 days spent meeting other farmers, seeing how other farm systems work and discussing ways in which you can reduce your antibiotic use on farm. This is time well spent in the view of the researcher.

Prior to and during participation in the stable schools, you will be expected to;

a) Sign a participation consent form allowing us to handle your farm data and to use farm data anonymously.
b) Fill in a questionnaire about your farming enterprise, which will include optional inclusion of personal data and will be kept secure and confidential.
c) Receive and read circulated herd reports on the farm hosting the subsequent stable school. This will be shared with your group members only.
d) Attend the stable school meetings, which will be a maximum of 30mins drive away.
e) Allow a facilitator to organise the meetings and liaise with you regarding the how, when and where to run them.
f) Actively contribute to discussion and questions at the stable school meetings.
g) Host 2 stable schools on your own farm over the project period.
h) Have your farm data accessed and analysed at the start and end of the process, so you can see how well the stable schools have been in helping you achieve the goal of reduced antibiotic use and where you stand compared to other farmers. This will be anonymised outside of each group and upon request.
i) Take part in audio recorded in-depth interviews upon request, about the process, your farm and antibiotic use.

What are the possible disadvantages and risks of taking part?

There are no foreseen risks of taking part in this research, physical or psychological. However suspected notifiable diseases, illegal practices or mistreatment of animals would require reporting to the relevant authority by the researcher, as they would by any other visitor to the farm.

A disadvantage may be the amount of time invested in the stable schools research if you feel like it was not worthwhile by the end. Also, it is acknowledged that there is a competitive risk in letting other farmers in your stable school see your farm data, and if this is a concern you do not have to share your herd data with the group.

What are the possible benefits of taking part?

We cannot promise that this study will provide any immediate benefits to you, however due to the nature of the stable school process, you will get to experience how other farms work and get advice from farmers and potentially external sources for free. Being able to achieve the goal of reducing antibiotic use on farm also has the implied benefit of cost saving and improved health and productivity of the cows. There will be a report after each meeting offered to each group member with a summary and plan for the next stable school.

The information we get from this research will help to inform the agricultural community, veterinarians, those in research development and policymakers about how to reduce antibiotics on farm and how stable schools can be used to inform policy.

Many people enjoy participation in research, particularly expressing their views during in-depth interviews.

Will my taking part in the research be kept confidential?

All information gathered about you and the farm will be handled in confidence by us. All data will be stored on encrypted computers or in locked cabinets at the University of Bristol. Video and audio-recordings of the stable school meeting and interviews will be made using an encrypted dicta-phone. These meetings and interviews will be transcribed, coded and the results anonymised. If using an external company to transcribe recordings, these will be subject to the same strict data handling rules as at the University of Bristol. Quotes from interviews may be used, but these will also be anonymous, any names or identifying features will be removed.

Data from this study will be available to suitable researchers, upon request and will be stored in line with University of Bristol rules in data depositories. All data will be anonymised.

Any data shared within your individual stable school will be completely confidential and optional.

What will happen if I don't want to carry on with the research?

You can withdraw from the research at any time without giving a reason.

Any video or audio-recordings with you or your voice on it that have been processed before withdrawing from the research, cannot be deleted but any other information given can be deleted at the time of withdrawing from the research. **What will happen to the results of the research study?**

It is intended that the results of this research will be published in the scientific literature and presented at national and international conferences. Results may also be publicised through the agricultural press. Your identity will be confidential in all public reports and publications. Regular summary reports will be made available to each member of a stable school group after each meeting. These will detail individual farmers at the discretion of the farmers in each stable school group and will be optional. A report giving an overview of the overall research results will be sent to you and all other participants once the research and analysis has been completed. You will also be invited to a meeting where the results will be presented. You can withdraw your information at any time.

Who is organising and funding the research?

The research is the basis of a PhD by Lisa Morgans, MRCVS at the University of Bristol. It is kindly sponsored by the Agricultural and Horticultural Development Board Dairy (AHDB- national dairy levy board) and The Langford Trust (charity promoting the practice, advancement and teaching of veterinary science).

Who has reviewed the research?

The Faculty of Health Sciences Research and Ethics Committee has reviewed and approved this research.

Further information and contact details

For any queries, concerns or further information please contact the lead researcher, details below.

Lisa Morgans MRCVS
University of Bristol Veterinary School
Dolberry Building
Langford
BS40 5DU
[redacted]
Lisa.morgans@bristol.ac.uk

For any complaints or problems, you can contact an independent source not linked to the research, details below. Please state project title.
Research-governance@bristol.ac.uk

Appendix 3

Farm recruitment leaflet (1)

What do I have to do?

Firstly, please either contact me (details at the end) or the person who you received this information from, saying you would like to participate or just to find out more.

The next step will be allocating interested farmers into groups based on geographical location. We aim to keep **travelling time to the stable school meetings to ~20mins**. Once groups are formed we will send out an information pack with all the necessary details about the project.

There will be basic data gathering done before the stable school process starts (using farm herd data and vet medicine data) and at the end, so that **participating farms can be benchmarked and reduced antibiotic usage actually measured**. This is only done with your consent and with financial data omitted.

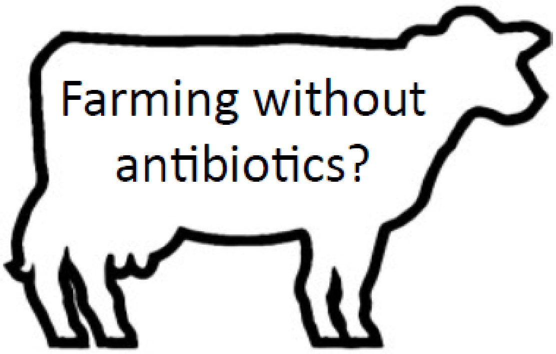
Who do I contact?

University of BRISTOL

Lisa Morgans
University of Bristol Veterinary School
Langford, BS40 5DU
Tel- [redacted] lisa.morgans@bristol.ac.uk

Facebook.com/groups/OurMilkOurMeds
Twitter: @OurMilkOurMeds

Sponsors: AHDB DAIRY Langford TRUST



Want to have your say on how antibiotics are utilised on farm?

University of BRISTOL

The University of Bristol are running a series of farmer groups to achieve the goal of reducing antibiotics on farm. We would like to invite you to participate in these groups, known as Stable Schools, as part of this project.

OUR MILK OUR MEDS

Appendix 3

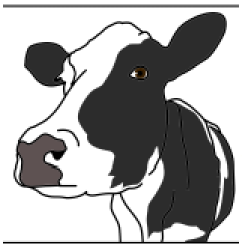
Recruitment leaflet (59)

What do I get out of it?

1) Chance to meet other farmers in a similar position. When looking for farm solutions, two brains are better than one.

Have you ever tried to calculate the accumulated years of farming experience in a room full of farmers?

Even 10 farmers who have farmed for an average of 20 years would hold 200 years of experience, experience that could be invaluable to you and your business.



2) Opportunity to see other management systems and what you could adopt from these on your farm.

3) Reduced antibiotic use and hence reduced on farm costs.

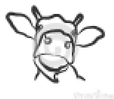
4) Improved cow health and welfare.

5) Free advice from related experts

What are stable schools?

A tried and tested way of **farmers coming together on each other's farms**. You get to see how each other manages their farm and deals with the challenges of rationalising and reducing their antibiotic use. Already adopted in Denmark and other European countries, the method allows you, the farmer, to **decide on farm strategies and lead policy** to reduce antibiotic use.

No one knows a farm better than a farmer!



How much time will it take?

We estimate that each stable school will last 2-3 hours and if meeting every 6weeks, a group of 6 will meet 12 times over 18 months.

How do they work?

Members of each group will host the stable school on their farm in sequence, simply providing a place to meet. All refreshments will be provided by us. The host will show-case their farm and highlight protocols they have to improve herd health and ways they rationalise antibiotic use. This will be followed by a discussion **facilitated by Sarah Bolt from AHDB** where other members of the group can share what they think worked well on the farm and then 1-2 points they would do differently. The host farmer will take these points on board and implement them in the time before they host again. Once every member has hosted once, everyone hosts a 2nd time to see how any on farm changes discussed and implemented from the first meetings have worked.
External advice to the group can be available at each group's discretion.

E.g.

One member always takes temperatures of young stock and if high and the only abnormality, treats with anti-inflammatories first, before considering antibiotics

↓

Host farmer sets action plan for on farm strategy using thermometers on youngstock

↓

9 months later, the group will see how effective the change on farm has been and will look at farm data and see a visible reduction in antibiotic use.

↓

Appendix 3

Example poster used to recruit farmers to study and to recruitment meetings

Appendix 4

Advert for farm recruitment given to Gatekeepers

The University of Bristol are running a series of **farmer action groups** to find out the most

Want to have your say on how antibiotics are utilised on farm?

effective way of reducing antibiotic use on farm, from the perspective of **UK dairy farmers.** The result of which will be used to inform policy. We would like to invite you to participate in these groups, known as Stable Schools, as part of this project.

What do I get out of it?

1. Chance to meet other farmers in a similar position. The combined farming experience in a room of farmers is an invaluable tool for your farm business.
2. Opportunity to see other management systems and what you could adopt from these
   on your farm.
3. Reduced antibiotic use and hence reduced on farm costs.
4. Improved cow health and welfare.
5. Free advice from related experts.

How do they work?
The agenda of each meeting is essentially down to you – no one knows a farm better than a farmer.
Members of each group will host the 'stable school' on their farm in sequence. The host will show-case their farm and highlight protocols they have to improve herd health and ways they rationalise antibiotic use. This will be followed by a discussion **facilitated by Sarah Bolt from AHDB** where other members of the group can share what they think worked well on the farm and then 1-2 points they would do differently. The host farmer will take these points on board and implement them in the time before they host again. Once every group member has hosted once, everyone hosts a second time to see how any on farm changes discussed and implemented from the first meetings have worked. External advice to the group can be available at each group's discretion.

Who is in a group?
There will be between 5-9 UK dairy farmers in a group and we aim to keep **travelling time to the 'stable schools' to ~20mins**. There will be a chance to meet each other before the 'stable schools' start in full and ultimately the decision who is in a group is decided by you. You may know each other, you may not. We aim to get a mix of farmers but acknowledge you will have to be able to relate to each other's systems.

How much time will it take?
We estimate that **each stable school will last 2-3 hours**. The aim will be to have a meeting every ~6 weeks, and if 6 people in a group with everyone hosting twice, the whole project will take 18months.

What do I have to do?

Please contact your vet if you would like to participate or just to find out more.
The next step will be allocating interested farmers into groups based on geographical location. Once groups are formed we will send out an information pack with all the necessary details about the project. There will be basic data gathering done before the 'stable school' process starts (using farm herd data and vet medicine data) and at the end, so that **participating farms can be benchmarked and reduced antibiotic usage actually measured**. This is only done with your consent and with financial data omitted.

Sponsors;

Appendix 5

Farmer Questionnaire completed at Pre-visit

University of BRISTOL

Date:
Version:

Farmer Questionnaire

The following information will be used as part of the research in **'Reducing antimicrobial use on UK dairy farms through farmer action groups.'**

Please fill out as much or as little as you can.

Farmer details

Name………

Address……

……

Post code………

Name of Veterinary Practice……………………………………………………………………………………………….

Name of Veterinary Surgeon……………………………………………………………………………………………….

Age:

(18-30) (31-40) (41-50) (51-60) (61-70) (71-80) (81+)

Gender:

Do any family members help out on the farm? Who and how much?

Dairy unit details (please fill out as much or as little as you can)

Size of farm	
Number of units	
Land available to grow forage (hectares) Silage Maize Wholecrop Wheat Other	
Grazing land available	
Type of dairy farming system (e.g. block calving, in-all-year, organic)	
Total number of stock	
How many farm workers/herdsmen? Nationalities?	
Type of housing	
Type of parlour	
Frequency of milking	
Breed of milking cow	
Do you **milk record** and with who?	
Do you use any dairy herd software on farm? Which one?	

Production (please fill out as much or as little as you can)

Main saleable product	
Total annual milk sales	
Milk price (ppl) (average for last 12 month)	
Annual yield/cow (L)	

Average 305 day milk yield (L)	
Average Somatic Cell Count	
Average Bactoscan	
Average milk fat %	
Average protein %	
AI or Natural service?	
Calving index (d)	
Calving to conception interval (d)	
Conception rate (%)	
100 day in-calf rate (%)	
200 day in calf rate (%)	
Frequency of fertility visits by vet?	
Milking cow nutrition: e.g. silage/TMR/grass/ concentrate in-parlour	
Dry cow nutrition:	

Health (please fill out as much or as little as you can)

Youngstock

Where are youngstock kept throughout year?	
How many replacement heifer calves <8 weeks?	
How many replacement heifer calves 8weeks – 12 months?	
How many heifers >12months?	
How many in calf heifers?	

How many beef cross or male calves?	
Calf mortality (% or numbers) <24hrs old 24hrs-1 week old >1 week old	
Respiratory disease in youngstock (cases/100 cattle/year)	
Digestive disease in youngstock (cases/100 cattle/year)	
Vaccinations (Y/N) What?	
Age at first calving?	

Milking cows

Number of milking cows	
Cull rate	
Death rate	
Heat detection method	
Vaccination (Y/N) What?	
Mastitis How many cases/100 cows/year? Early lactation Mid lactation Late lactation Dry cows How do you manage mastitis?	
Lameness How many cases/100 cows/year? Digital dermatitis White Line Disease Sole ulcers Other How do you manage lameness?	

Do you buy in? (Y/N) If yes, where from and how often?	
Do you have isolation facilities?	
Do you have a Herd Health Plan? (Y/N) How often is it reviewed with the vet? How often do you refer to it?	
Are you a member of a certification/assurance scheme? (Y/N) If yes, which one?	
What is your herd health status for the following? BVD Johne's IBR Leptospirosis Tuberculosis	
How many cases of metabolic disease do you see per 100 cows/year? (milk fever etc.)	
What are the three most common calls to have the vet out for?	

Dry cows

Length of dry period?	
Numbers/groupings (Transition group etc.)	
Describe dry cow management (DCT)	
Vaccinations (Y/N) What?	
Other management tasks done in dry period	

Other animals

How many other beef cattle not mentioned already?	
Sheep	

Goats	
Llamas/alpacas etc	
Other	

Please use the following space to describe what you *like* most about your farm? (Words, pictures, anything goes!)

Please use the following space to describe what you *dislike* the most about your farm? (Words, pictures, anything goes!)

Please use the following space to describe what you *value* most about farming? (Words, pictures, anything goes!)

Appendix 6

Interview topic guide

Farmers (FAG participants)

- How have you been getting on?
- Have you made any changes on farm since you hosted, tell me about them?
- How did you hear about the project?
- What made you sign up?
- How did you feel the first meeting went?
- What did you like/not like about hosting?
- How did you find the medicine review?
- What involvement has your vet had?
- Did you find making an action plan and having an action plan worthwhile?
- Was there anything you thought could have been done better?
- How have you found consequent meetings?
- What would you like to see discussed or covered at subsequent meetings or when you host next?
- What other groups do you belong to? Tell me about them?
- How beneficial do you find them/how do they compare?
- What do you value most about working with other farmers?
- What thoughts or comments do you have for any policy makers looking at these groups as a way of causing change?

Appendix 7

Interview topic guide

Farmers (Withdrawals/drop outs)

- Tell me about your farm.
- What do you like best about farming/your farm?
- What made you join the project in the first place?
- What concerns you most about AMR?
- What do you think the industry should be doing to reduce AM use on farm?
- Where did you hear about the project?
- What did you think of the first meeting?
- Was there anything you didn't like?
- Is there anything myself or the facilitator could do differently?
- Why did you withdraw from the research?
- What other groups do you belong to/meetings do you attend? Tell me about them.
- How beneficial do you find them? How do they compare?
- What do you value most about working with farmers?
- What issues could there be getting farmers to work together if any?
- What thoughts or comments do you have for any policy makers looking at these groups as a way of causing change?

Appendix 8

Interview topic guide

Farmers (non-participants)

- Tell me about your farm.
- What do you think is the best part of your farm?
- What do you like most about farming?
- What do you think about all the talk around antimicrobial usage on farm?
- Have you made any changes on farm regarding antimicrobial use, tell me about them?
- If so what made you make these changes? The vet? The media? Other farmers?
- How responsible do you feel about AMR? Scale 1-10
- Do you belong to any discussion groups? If so what ones?
- How useful do you find them? What benefits have come from them?
- What makes you join a farm group?
- How do you think we can encourage more farmers to join groups? Make changes on farm?
- Who would be best placed to encourage/force farmers to change practices? Milk buyers? Pharmaceutical? Vets? Farm assurance?
- How do you feel about being told to do something on farm because that's what e.g the milk buyers want? Compared to thinking up an idea yourself and trialling it? Which category do you fall in?
- Do you have any thoughts/ideas how the industry should/could tackle antimicrobial stewardship?

Appendix 9

Interview topic guide

Veterinarians

Best bits about being a farm animal vet

- Find out what they like best about their job
- What do you love most about your job/being a vet?
- How comes you chose to be a farm animal vet?

Antimicrobial Resistance (AMR)

- What does the practice already do on this issue?
- What worries you the most about AMR?
- What do you think would happen to your practice, your job if certain AB were banned?

Motivation to change

- What do you think motivates farmers?
- What do you find hard about getting farmers to listen to veterinary advice?
- How do you feel when a farmer doesn't listen to your advice?

Benchmarking/Awards

- What techniques have you used to motivate farmers?
- How do you feel about benchmarking farms?
- **LIST OTHER TECHNIQUES NOT MENTIONNED, EXPLAIN AWARDS CEREMONY IDEA ETC**
- Do you have any other ideas on how to motivate farmers?

Role of farmers

- What do you think farmers could do to reduce risk of AMR>>livestock>>humans
- **How do you think farmers take veterinary advice?**
- **What is the best way in your opinion to work with farmers?**
- **What do you think of farmers expertise?**

Role of vets

- How can vets reduce the risks of AMR?
- What do you think of vets prescribing habits?
- Where can you see the practice in 5-10 years' time? The profession?
- **What do you think you could do to help dairy farmers on the issue of AMR?**

Working together

- How did you find your training in preparing you to engage farmers?
- Who do you prefer to work with and why? Vets? Farmers? Friends? On own?
- **What farmer groups do you already take part in?**
- **What do you think of working in a stable school to tackle issue of reducing antibiotic use on farm?**

Appendix 10

Anonymous Medicine Review comparing Year one and Two AMU data

Medicine Review 2 (2016 v 2017)

Anon Farm

Below is a summary of how much antibiotic has been sold to (and assumed used on) ANON Farm in the period from 01/01/17 – 31/12/17 incl. compared with 2016. Included is;

- Cost breakdown
- Total antibiotic used in Animal Daily Dose, mg/kg, mg/1000L of milk and Cow Calculated Course
- Distinction between Critically Important Antibiotics and the first line antibiotics (See key)

This is by no means comprehensive and is simply a starting point to monitor the use of antibiotics and to see how you are progressing. There will be benchmarking reports once all other participant details have been collated.

Limitations to the metrics are acknowledged and disparity between recorded data and vet sale data is significant. It is assumed vet sales data represents actual usage data for the purposes of this project. Where possible, actual course lengths and dosages, particularly of IM tubes, have been collected from farm medicine data.

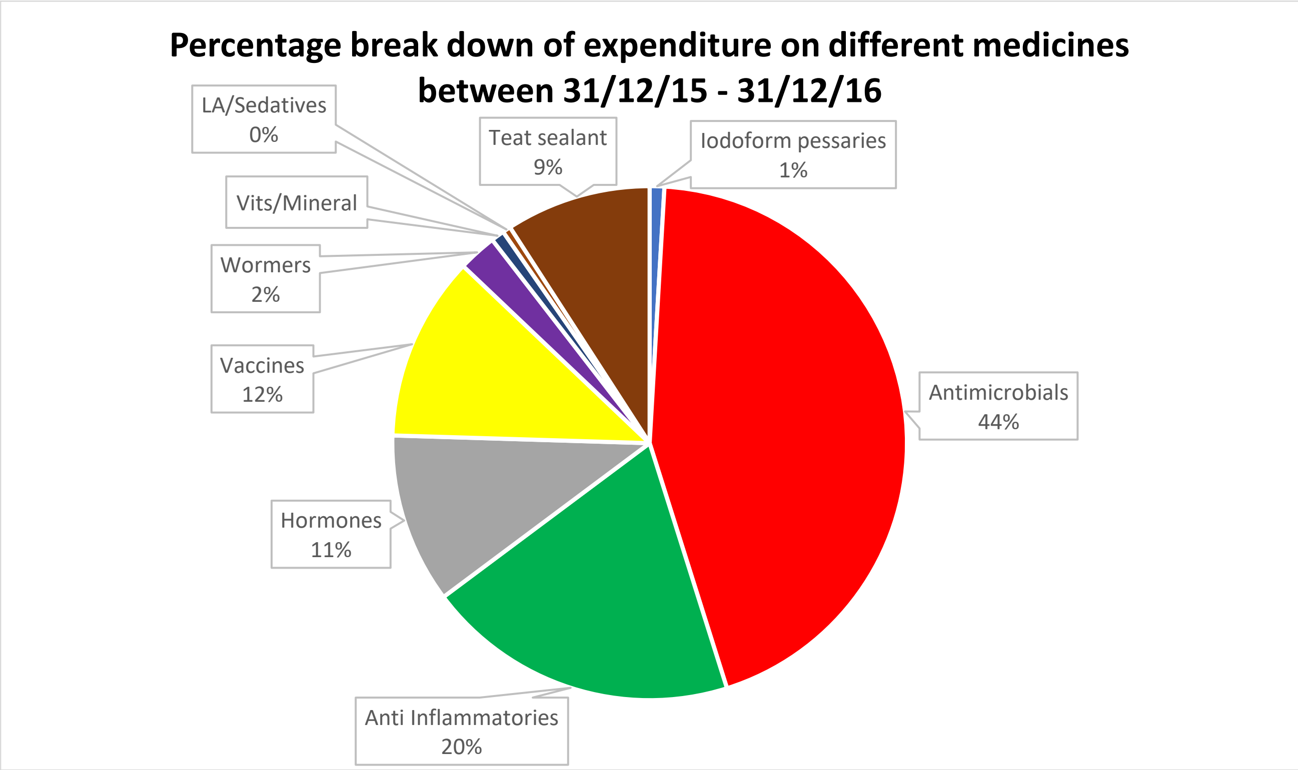
Key

Critically Important Antibiotics (CIA)= Types of antibiotics that the World Health Organisation regard as essential for treating humans and that need to be protected in order to preserve their efficacy for the future. These are the 3/4th generation cephalosporins, Fluroquinolones and Macrolides for this project. **Highest Priority Critically Important Antibiotics** = ¾ gen. cephalosporins and Fluroquinolones (European Medicines Agency 2014).
First Line antibiotics= Types of antibiotics which should be used first to treat disease.
AB= Antibiotic AM= Antimicrobial
IM= Intra-mammary tubes **DC**= Dry cow **LC**= Lactating cow
Mg = milligrams, unit of mass measurement for antibiotics
FQ= Fluroquinolones, a group of antibiotics on the HP-CIA list e.g. Marbocyl
3CF/4CF= 3rd and 4th generation cephalosporins, a group of antibiotics on the HP-CIA list e.g. Cobactan
ML= Macrolides, a group of antibiotics on the CIA list and regarded as HP-CIA by W.H.O e.g. Zactran
BL= Betalactams, a group of antibiotics not *fully* on the CIA list e.g penicillin, 1st/2nd generation cephalosporin (Metricure) aren't, but Potentiated Amoxicillin (Synulox/Combiclav) is.
AG=Aminoglycosides, a group of antibiotics also on the CIA list e.g Streptomycin
SP=Sulphonamides, a group of antibiotics not on the CIA list but regarded as essential for human use e.g. TMPS
TE= Tetracyclines, a group of antibiotics not on the CIA list but regarded as essential for human health e.g. Alamycin
FF= Florenfenicols, a group of antibiotics not on the CIA list e.g. Resflor

CCC= Cow calculated courses, worked out by seeing how may courses of a certain drug has been used in 12 months and dividing it by number of cows in treatable group
NSAID= Non-steroidal anti-inflammatory drugs e.g. pain relief like Recocam/Metacam
ADD/DDDa= Animal Daily Dose. If an average animal existed, this figure equates to how many daily doses of antibiotic that animal would receive in a year.

Costs

Year 1 (2016)



Year 2 2017

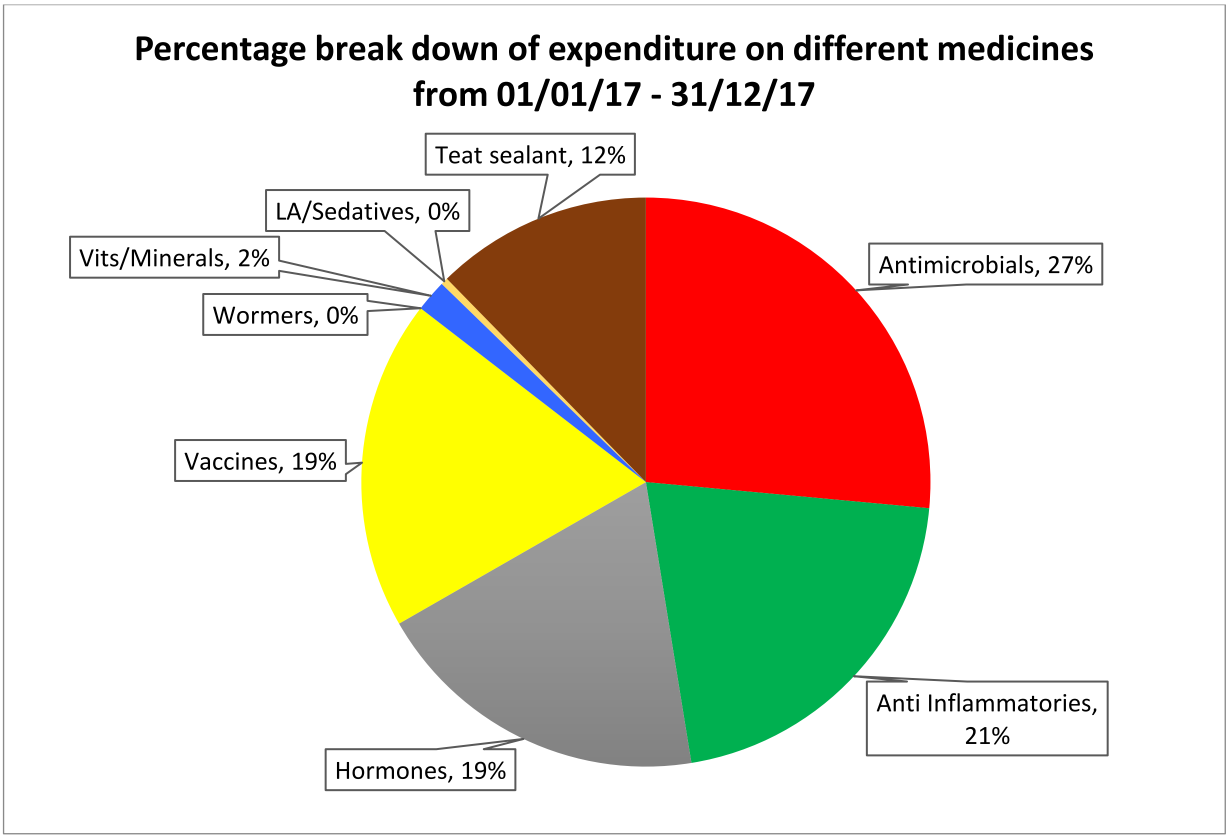
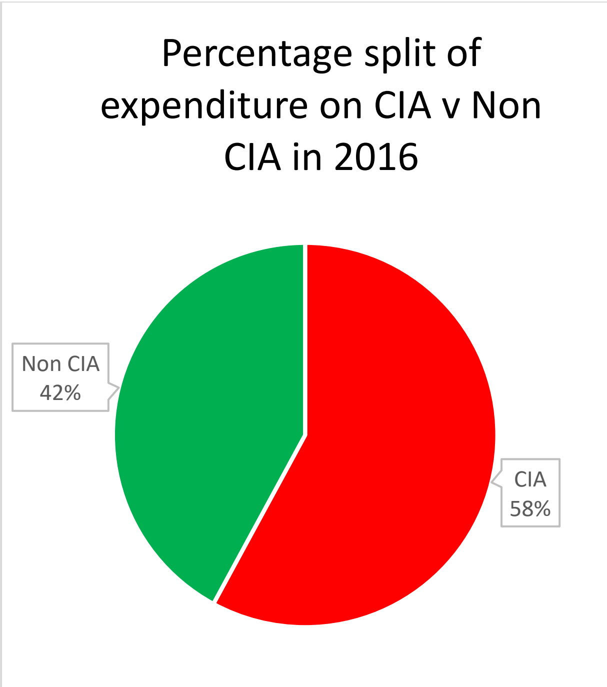


Table of costs

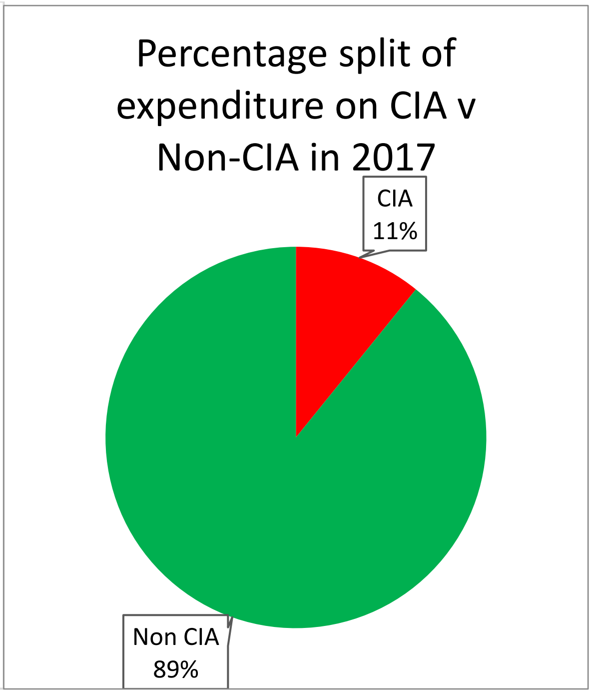
Parameter	Year 1 (2016)	Year 2 (2017)
12 month total medicine cost (£)	**XXX**	**XXXX**
Total AM cost incl Kexxtone (£)	XXX	XXX
Total Anti-inflammatory cost (£)	XXX	XXX
Total Vaccine cost (£)	XXX	XXX
Total IM AB cost (£)	XXX	XXX
Total CIA AB cost (£)	XXX	XX

Split between CIA and Non CIA

Year 1 (2016)

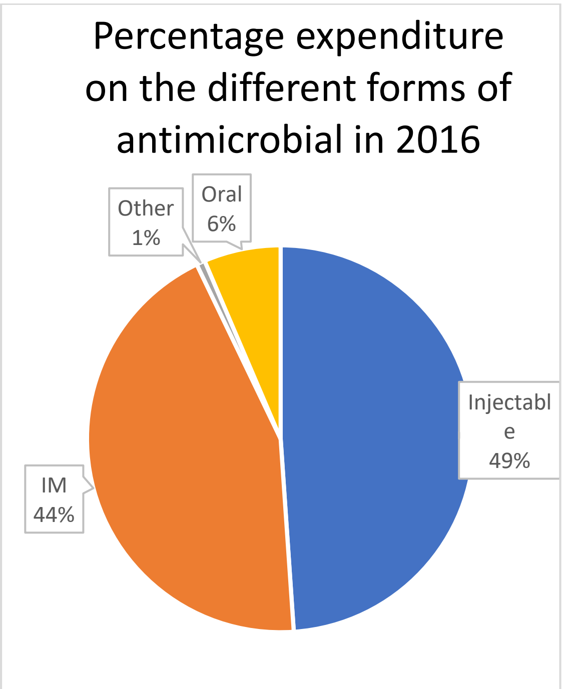


Year 2 (2017)

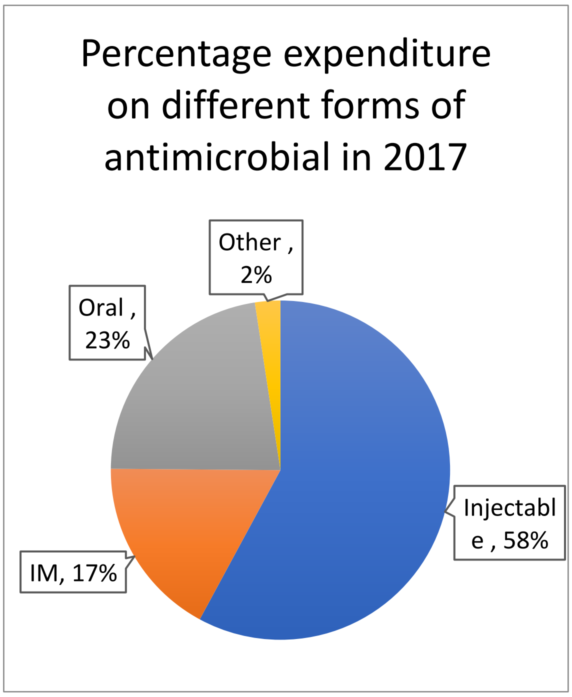


Different forms of antimicrobials

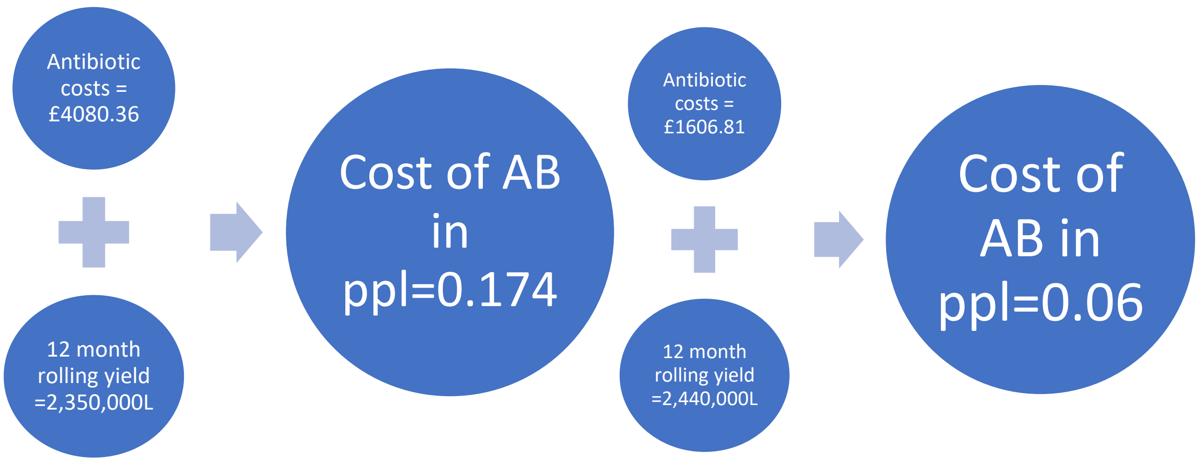
Year 1 (2016)



Year 2 (2017)



Year 1 (2016) **Year 2 (2017)**

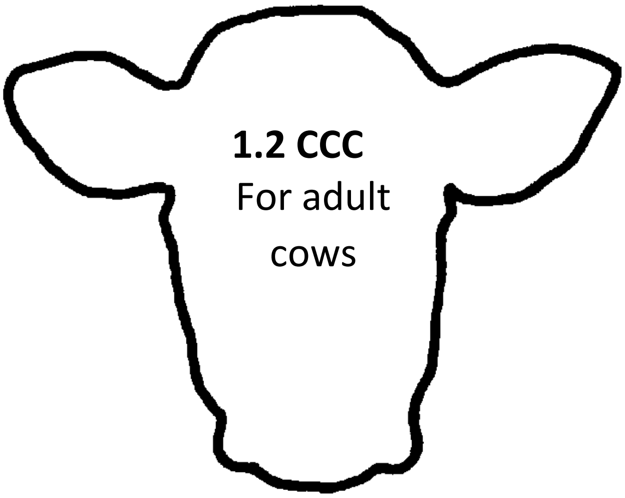


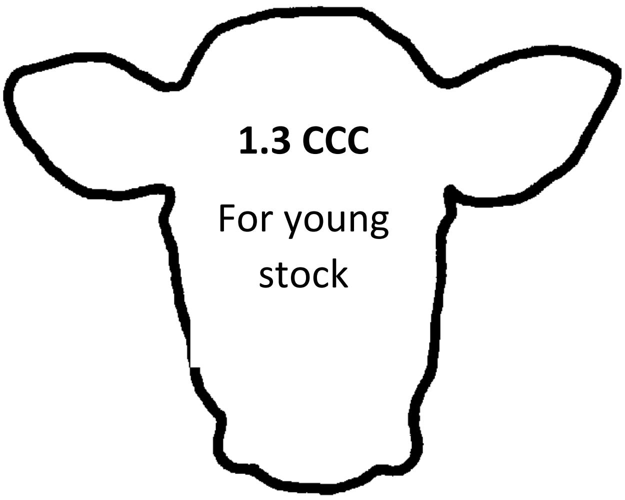
NB- Antibiotic costs without Kexxtone included

Total Antibiotic usage

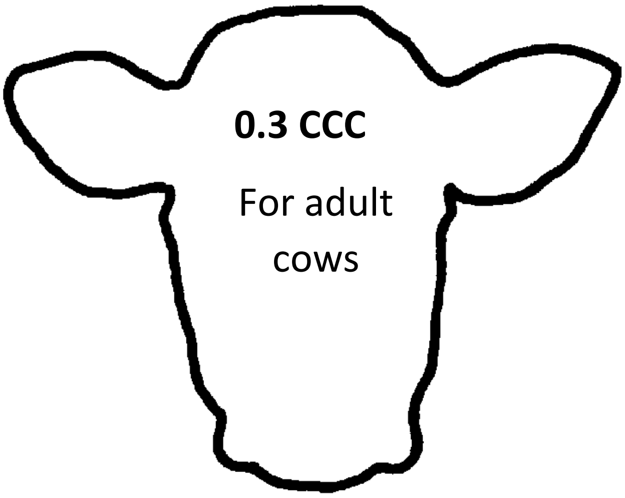
Cow Calculated Courses *(NB without Kexxtone boluses)*

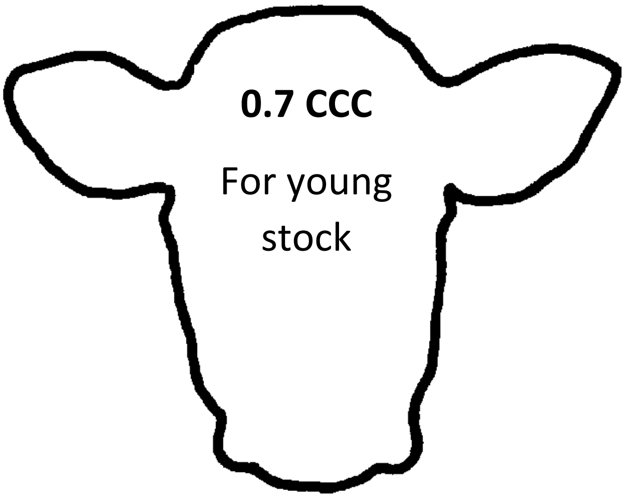
Year 1 (2016)





Year 2 (2017)





Other producer groups have averaged around 2.1 CCC for adult cows and 0.7 CCC for young stock.

Mg/1000L milk

Year 1 (2016)

771.7 mg of AB/

1000L of milk

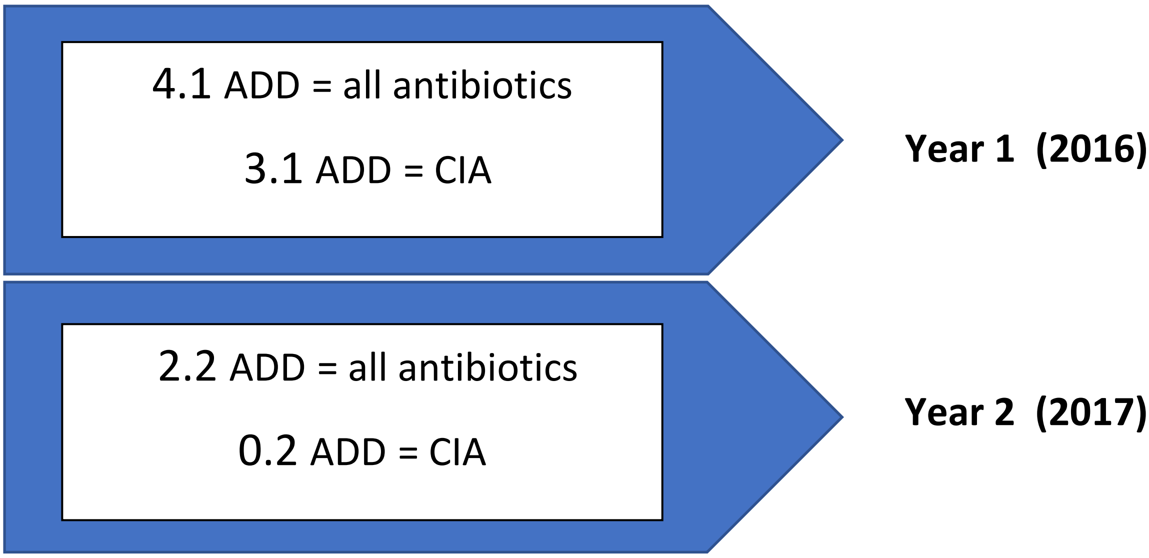
Year 2 (2017)

268.4 mg of AB/

1000L of milk

NB- Without Kexxtone included

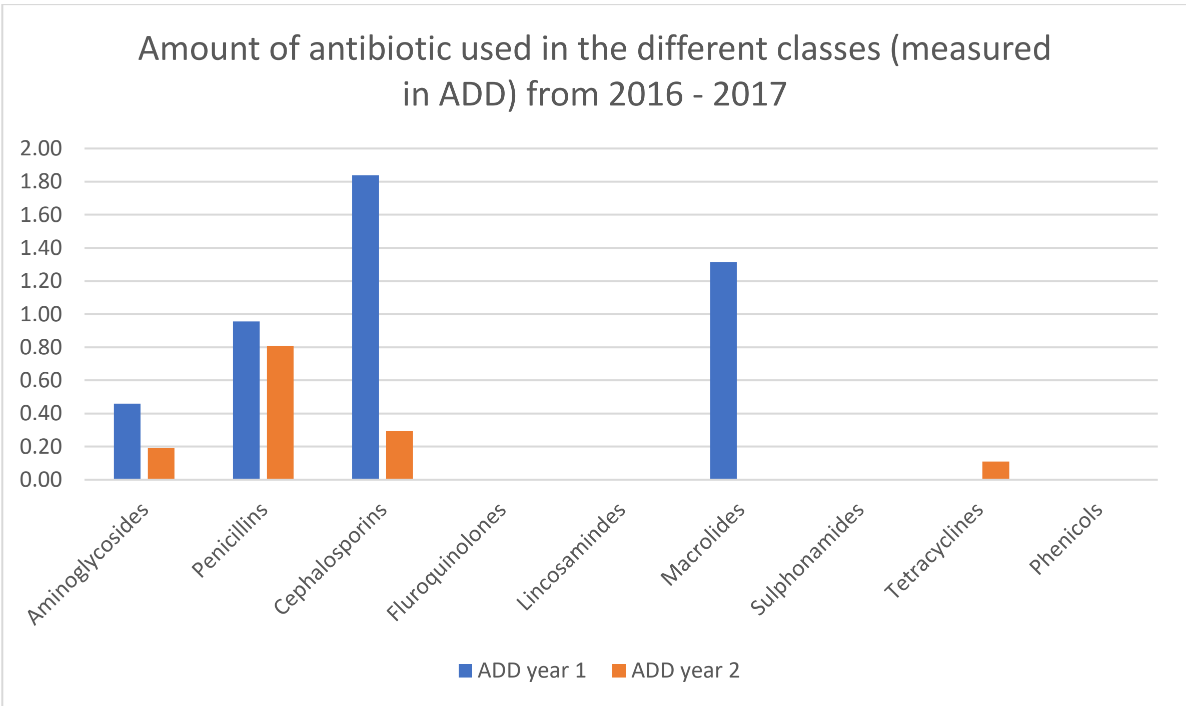
Animal Daily Dose (ADD)



Approximate national average is between 2- 5 A.D.D. for all antimicrobials. Farmers in the Netherlands aim for <4, ideally <2.

CCC and ADD do not include AB sprays/powders/topical treatments

NB- Without Kexxtone included



Mg/Kg

Total AB = **26.7 mg/kg**

CIA only = **8.7 mg/kg**

Year 1

(2016)

Adults= **18.8 mg/kg** Young stock = **7.9 mg/kg**

Total AB = **18.4 mg/kg**

CIA only = **0.1 mg/kg**

Year 2

(2017)

Adults= **6.7 mg/kg** Young stock = **11.6 mg/kg**

*Total annual antibiotic use, measured in mg/PCU, for all food producing animals in the UK in 2016 = **45mg/PCU***
*In the dairy sector only, estimates have averaged use at **26mg/PCU***
(NB- mg/PCU uses a different standardized cattle weight of 425kg, compared to 600kg in this project)

NB- Without Kexxtone included

Year 1 (2016)

ANTIMICROBIALS USED TO TREAT CALVES	ANTIBIOTICS USED FOR SICK COWS	ANTIBIOTICS USED FOR UTERINE DISORDERS	ANTIBIOTICS USED FOR LAMENESS
ULTRAPEN LA	CEVAXEL	CEVAXEL	PENSTREP
ZACTRAN	CEPOREX	CEPOREX	CEVAXEL
	COBACTAN	COBACTAN	READYCEF
	READYCEF	READYCEF	
	SYNULOX	SYNULOX	

Year 2 (2017)

ANTIMICROBIALS USED TO TREAT CALVES	ANTIBIOTICS USED FOR SICK COWS	ANTIBIOTICS USED FOR UTERINE DISORDERS	ANTIBIOTICS USED FOR LAMENESS
ULTRAPEN LA	PENSTREP	METRICURE	PENSTREP
HALOCUR	SYNULOX	PENSTREP	
		ALAMYCIN	

Mastitis

Drugs used 2016

Cepravin DC

Ubro Red DC

Cobactan MC

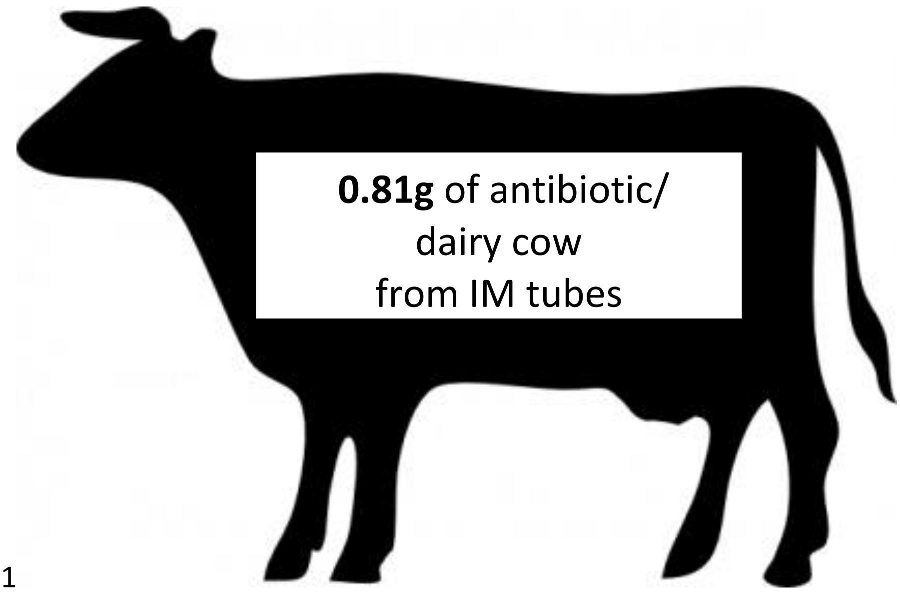
Drugs used 2017

Cepravin DC

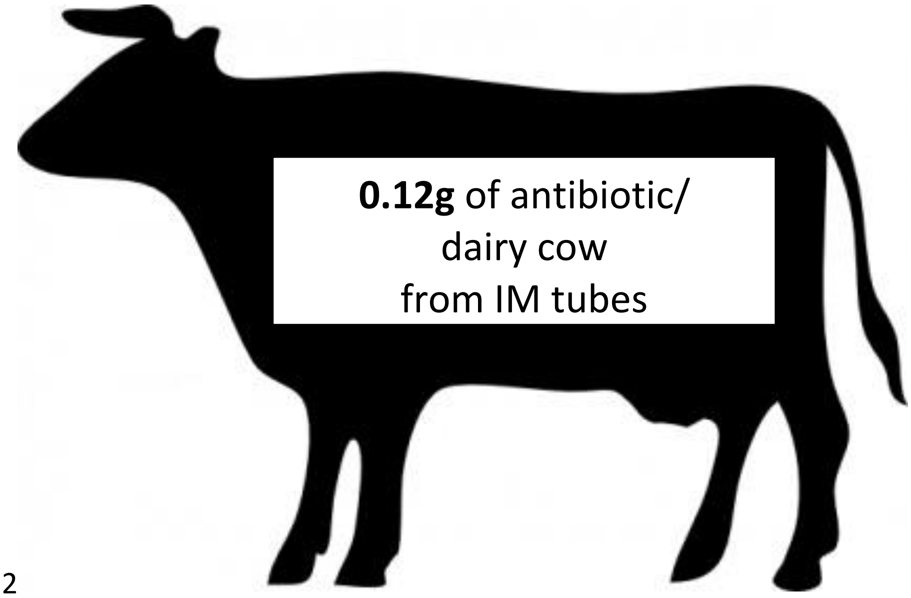
Ubro Red DC

Cobactan MC

Mamyzin injectable



YEAR 1



YEAR 2

National average for 2015/16 = 1.94g antibiotic/dairy cow based on national herd

Appendix 11

Anonymous meeting summary report, including example Action Plan

Farmer Action Group on reducing antibiotic use- Meeting one report

XXX

Date	XXX
Host	XXX
Location	XXX
People present	XXX
Unable to attend	XXX
Duration	3hours (11.10am-2.00pm)
Course of day	➢ Introduction to project, host farm and each other ➢ Explanation of medicine review for XXX ➢ Farm walk ➢ Lunch ➢ Further discussion on medicine review and types of AB used on farm ➢ Culmination in production of a farmer led Action List

Key-
P= participant F= facilitator R= researcher AB= Antibiotics C.I.A= critically important antibiotics

C.I.A- Antibiotics that are regarded as essential for treating humans, where there are no effective alternatives and as such their use in agriculture should be stopped or restricted, due to the risk that using these AB in farming leads to resistance to them in human medicine.

e.g. 3rd/4th Generation cephalosporins, Fluroquinolones, Macrolides

Topics discussed

- ✓ Medicine Review
    - Total cost and usage of AB on host farm in various metrics from Aug 2015-Aug 2016
    - NSAID usage- relatively low amount of money spent here
    - Biggest use of AB is blanket use of dry cow tubes, followed by respiratory disease treatment in calves
    - Total mg/kg, courses of AB/cow/yr and mg/1000L of drugs used and how that compares nationally- **well below average usage at XXX**
    - Cost of AB in PPL = XXX
- ✓ Udder health
    - Low rate of mastitis in herd (~3 cases per 100 cows last year)
    - Uses 'Tetra delta' and sometimes 'Tylan' for poor cure cases
    - Blanket treats all dry cows with 'UbroRed'
- ✓ Farm walk

    Milking cows- extremely friendly!

    - Aiming to breed a small, robust Friesian cow, getting away from the Holstein breed. Happy with BCS of cows. Some people weighing cows using scales others using cull weight. Few using BCS.
    - Rotates herd every 12 hours on pasture, extensive grass based system. Clip tails to help keep cows clean.
    - Low levels of lameness and mastitis. Has a regular foot trimmer and has an even spread of claw conditions (foul, white line disease, ulcers).
    - Tracks wet but superficial mud with little gravel/rocks
    - 'Excenel' ($3^{rd}/4^{th}$ generation cephalosporin- Critically Important Antibiotic) used for lame cows- only C.I.A AB used on farm at present.
    - Very low level of disease-*"naïve herd"*. Host reports negative for BVD, IBR, Lepto and very low level of Johnes.
    - Blanket dry cow v selective dry cow discussion.
    - **KEY FACT**- the Netherlands banned the use of blanket dry cow therapy in the dairy industry in 2013.
    - Discussion on how best to dry off cows. Using forage based diet and reducing frequency of milking. Agreement of drying off at 15L or less. Suggestion to keep dry cows away from parlour to reduce milk let down stimulus. Suggestions to assist in selective dry cow treatment to milk record 3x a year- *"as little as necessary"* and now one farmer only treating 15% of dry cows with AB. *"When we first started using [SDCT at drying off], our vet said if you want to start saving money at drying off you can stop using antibiotics but don't stop using teat sealant, always stuck in my mind and we done that and use less and less [AB] each year".*
    - Differing experiences of teat sealant, agreement cleanliness is key. Training to use teat sealant by vet/milk buyer seems to be common.

- **KEY FACT**- Treating low SCC cows with AB has been shown to increase risk of toxic mastitis.
- Covered use of pain relief like 'Metacam/Flunixin' and how it improves cure rates for mastitis. One farmer shares that using these drugs has improved their mastitis cure rates significantly.
- **NEW PRODUCT**- Transdermal Finadyne. Anti-inflammatory for calves. See - http://www.noahcompendium.co.uk/?id=-454763

Youngstock

- Fed pooled, unpasteurised colostrum with added hot water on a 20 teat feeder. 0 calf mortality this season and a very simple system. Calves kept on cow for ~2 days to suckle and then kept indoors as young calves and on milk and solids from day 1. Out on pasture over winter. Has had outbreaks of respiratory disease in past. Treated with Oxytetracycline (AB) like 'Alamycin LA' and anti-inflammatories.
- Discussion on when to treat with anti-inflammatories for respiratory disease in calves and when to use AB; maybe using thermometers more was brought up as a suggestion and being tuned into calf clinical signs. Talk about growth rates and measuring these. Host does not weigh. Others in group do weigh or measure at birth and weaning.
- Wormed with a pour on few weeks ago.
- Parlour- Host has a simple herringbone parlour- scrupulously clean. Pre wipes teats and post dips. No ACR and this has been a barrier to milk recording.
- Differing views on who pre strips and who does not. Can contribute to spreading infection in parlour but also shown to allow earlier detection of mastitis cases. One farmer shares that it helps with detection of mastitis and improving milk let down.
- Acknowledgement that building design and location is important in reducing disease and stress on cows.

✓ Types of AB used on farm and what for
  - Discussion on critically important antibiotics- what are they?
  - **C.I.A- Antibiotics that are regarded as essential for treating humans, where there are no effective alternatives and as such their use in agriculture should be stopped or restricted, due to the risk that using these AB in farming leads to resistance to them in human medicine.**
  - Examples of AB used on farm and which groups they fall in- **desire to have technical information on AB on documents for all of farm team to refer to.**
  - No mention from the group of the use of the class of AB called 'Fluoroquinolones' (e.g Baytril, Marbocyl), which was good to hear. Awareness that these should not be used on farm unless *absolutely* necessary.
  - Why do we use the AB we do? Is the fact they are convenient to use a reason to use C.I.A AB? Must have a discussion with YOUR vet about this.

✓ Action List for host farm (see overleaf)

Action Plan for XXX

ACTION	HOW TO ACHIEVE	HOW WILL THIS BE MEASURED?	WHO TO CONSULT
USE LESS ANTIBIOTICS AT DRYING OFF I.E. SELECTIVE DRY COW THERAPY	"I NEED TO MILK RECORD TO FIND OUT THE STATUS OF EACH COW" "I NEED TO SET A THRESHOLD AND SELECTIVELY DRY COW TUBE" E.G. >100,000 SCC RECEIVE AB. <100,000 SCC AND NO CASE OF MASTITIS IN LAST LACTATION, DO NOT RECEIVE AB "I WILL TRY 'ORBESEAL' [A TEAT SEALANT]"	SET UP INDIVIDUAL MILK RECORDING 2-3 TIMES A YEAR. IN COLLABORATION WITH YOUR VET WITH THE RESULTS OF YOUR BULK SCC/COW SCC, SET A THRESHOLD. RECEIVE TRAINING ON HOW TO USE TEAT SEALANT. TRY IN COMBINATION WITH AB TUBES.	VET, MILK RECORDER VET VET, MILK BUYER
MILK SAMPLE FOR BACTERIOLOGY	STERILE COLLECTION OF QUARTER MILK SAMPLES OF EACH CASE OF MASTITIS BEFORE TREATMENT. CAN FREEZE SAMPLES FOR TESTING LATER.	BY KNOWING BACTERIA CAUSING MASTITIS ON FARM SO CAN TARGET TREATMENT	VET
STOP USING 'EXCENEL'	USE FOOT TRIMMER MORE OFTEN TO THERAPUTICALLY TRIM COWS FEET AND PICK UP CASES OF LAMENESS EARLIER TO REMOVE NEED FOR TREATMENT WITH EXCENEL	NO EXCENEL ON MEDICINE AUDIT AT SECOND REVIEW	VET FOOT TRIMMER
MEASURING GROWTH RATES OF CALVES	CONSIDER WEIGHING WITH SCALES/WEIGHT BANDS AT BIRTH AND WEANING	BY COLLECTING DATA ON GROWTH RATES	VET

Key Points from the discussions

"Once you have put those tubes in [dry cow tubes] you kill everything. In theory they [cows' immune system] should fight that in that 6 weeks dry period". Comment on increasing the risk of more damage to the cow by giving AB at drying off and not allowing the immune system to do some of the work antibiotics are expected to do.

"I am quite happy blanket dry cow treating as it is my safety blanket". Voicing concerns about trialling selective dry cow therapy and what could happen.

"How do you know if it's viral? How long do you wait? It's a fine line". The worry about knowing when to use just anti-inflammatories in youngstock and when to use antibiotics.

"Consistent routine and trying to keep things clean. Low stress cows probably helps. Not pushing for yields". Response to how to achieve a low mastitis rate. Cleanliness.

"Convenience…I would like to keep hold of it for as long as possible if we can". Talking about using 'Excenel/Naxel' which are on the C.I.A list of AB.

"If we can do selective dry cow therapy we are a step in the right direction". Acknowledgement that SDCT is achievable and the right thing to do in terms of reducing AB usage on farm and reducing antibiotic resistance overall.

"I know that if they don't clear it up the first time, the chance of them getting it [mastitis] again is a lot higher. They either clear up the first time or they don't… So, I don't want it [mastitis] on my farm at all. That's the easiest way, if I don't have mastitis then I don't need to use antibiotics anyway". Comment that prevention is better than cure when it comes to mastitis and reducing your antibiotic use.

Feedback so far

- XXX is very tidy and the cows were super friendly- sign of good herdsmen!
- Desire for more information on classes of antibiotics, which ones should be used less on farm and how they work. How this is presented could be in technical information sheets to refer back to. **Any more suggestions how this information should be presented are gladly welcome. E.g. Handouts, separate speaker event, discussion with own vet.**
- Question from one farmer- ARE ALL THE LARGE ANIMAL VETS IN THE LOCAL AREA ON BOARD WITH THIS [Antibiotic reduction on farm to reduce antibiotic resistance]? Check back with your vet.
- Encourage all participants to speak and keep up the large group size.

Plan for next time

1. Set date and venue to host next time. Options below.

2. Allow access to farm medicine data by researcher to compile medicine review.
3. Talk to own vets about meeting and summary report.

Do check out the facebook page and share your ideas and thoughts on there.

www.facebook.com/groups/OurMilkOurMeds

Appendix 12

Table A7 - Veterinarian interviewee attributes

Interviewee code	Gender	Years in practice	Speciality	Successfully recruited farmers (Y/N)
V1	M	15	Farm	N
V2	F	10	Farm	N
V3	M	7	Farm	N
V4	F	5	Farm	N
V5	M	15+	Farm/cattle	N
V6	M	15	Dairy	N
V7	F	2.5	Mixed	N
V8	M	<1	Farm	N
V9	F	1.5	Farm	N
V10	F	4	Farm/cattle	N^
V11	M	25+	Farm/cattle	N
V12	M	20+	Farm	N
V13	M	30+	Mixed	Y
V14	M	10	Farm	N*

*= helped with recruitment meeting but no farmers recruited for project; ^= recruited farmers for interview

The veterinarians interviewed specialised in farm work only with three working solely in cattle practice and one working mainly as a veterinary consultant. Two veterinarians were in mixed practice. The interviewees had a range of experience - two veterinarians had been qualified for less than two years and three had been in practice for over 20 years. Nine male and five female veterinarians were interviewed. The gender split and range of experience in the interviewees ensured enough of a variety of viewpoints were captured to allow data saturation to be reached. Six of the veterinarians were interviewed whilst at a national conference and the rest were interviewed at their respective practices. This variation in the source of interviewee enabled a wider practicing geographical area to be covered.

Non participant farmer interview attributes

Interviewee number	Non-participant (NP)/ Drop-out (DO) / Withdrawal (WD)	Farm worker (FW)/ Farm owner (FO)	Approximate location of farm
1	DO	FO	Devon
2	DO	FO	Somerset
3	WD	FO	Wiltshire
4	WD	FO	Somerset
5*	NP	FW	Somerset
6*	NP	FW	Somerset
7	NP	FO	Northern Ireland
8	NP	FO	Northern Ireland
9	NP	FO	Northern Ireland
10	NP	FW	Dorset

*= pilot interviewees

Appendix 13

Statistical test results on AMU data (Paired T test)

t-Test: Paired Two Sample for Means

	ADD 1	ADD 2
Mean	3.583045486	3.428343471
Variance	4.320703926	3.946586048
Observations	30	30
Pearson Correlation	0.717276826	
Hypothesized Mean Difference	0	
df	29	
t Stat	0.553516627	
P(T<=t) one-tail	0.292076223	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	0.584152445	
t Critical two-tail	2.045229642	

t-Test: Paired Two Sample for Means

	HP CIA ADD 1	HPCIA ADD 2
Mean	0.537849441	0.135441673
Variance	0.593688399	0.11037833
Observations	30	30
Pearson Correlation	-0.041510205	
Hypothesized Mean Difference	0	
df	29	
t Stat	2.587989116	
P(T<=t) one-tail	0.007464935	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	0.01492987	
t Critical two-tail	2.045229642	

t-Test: Paired Two Sample for Means

	mg/kg 1	mg/kg 2
Mean	25.56953	26.16814
Variance	279.8776	502.2094
Observations	30	30
Pearson Correlation	0.663544	
Hypothesized Mean Difference	0	
df	29	

t Stat	-0.19437
P(T<=t) one-tail	0.423621
t Critical one-tail	1.699127
P(T<=t) two-tail	0.847241
t Critical two-tail	2.04523

t-Test: Paired Two Sample for Means

	HP CIA mg/kg 1	*HP CIA mg/kg 2*
Mean	1.128393403	0.157893274
Variance	13.05768477	0.090311437
Observations	30	30
Pearson Correlation	-0.048014609	
Hypothesized Mean Difference	0	
df	29	
t Stat	1.460195342	
P(T<=t) one-tail	0.077493024	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	0.154986047	
t Critical two-tail	2.045229642	

t-Test: Paired Two Sample for Means

	PPL 1	*PPL 2*
Mean	0.247764	0.215153
Variance	0.008578	0.009343
Observations	30	30
Pearson Correlation	0.81646	
Hypothesized Mean Difference	0	
df	29	
t Stat	3.108177	
P(T<=t) one-tail	0.002095	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.004191	
t Critical two-tail	2.04523	

Appendix 14

Policy Knowledge Exchange

The following section describes the outputs from a Knowledge Exchange study tour to the Netherlands with several farmers from this study as part of the EIP AGRI EuroDairy Thematic Network. The aim of which was to learn more about the Dutch AMU reduction policy in farming and what aspects the UK farming industry could implement here. Following this a brief overview of a UK-based policy workshop held in February 2018 will be described. This was an opportunity to present preliminary results from this study to an array of industry bodies and policy makers, as well as to learn what is needed for government policy in this area.

Eurodairy Knowledge Exchange study tour to the Netherlands

Six farmers from the FAG project took part in a three-day Knowledge Exchange study tour to the Netherlands (see chapter three). The study tour was part of a wider programme called Eurodairy (https://eurodairy.eu/), which was one of the EIP AGRI Thematic Networks within animal production systems. EuroDairy aimed to "support the development and communication of practice-based innovation in dairy farming." There were four main areas that twenty different partners worked on covering socio-economic resilience, resource efficiency, animal care, and the integration of milk production with biodiversity objectives. 120 pilot farmers were involved in the network which spanned several countries from the UK to Poland and from Sweden to Italy. The Knowledge Exchange trip was part of the EuroDairy ethos of sharing solutions and implementing best practice across the network in the area of AMR.

The trip began with a day of talks at the Dutch Agriculture and Horticulture Organisation (LTO) headquarters and was an opportunity for the farmers to learn about the Dutch AMU reduction policy. The Dutch farming sector had recently reduced their total AMU by 56% from 2013 levels but had done so under duress from their government (REF). The second day included three farm visits to varied dairy farm systems. The farmers were able to swap ideas and find out how farming without HPCIAs and with increased collaboration with the veterinarian actually worked in practice i.e. only veterinarians are able to administer HPCIAs in the Netherlands and total usage is tracked on a quarterly basis. The trip concluded with a visit to Dairy Campus (https://www.dairycampus.nl/en/Home.htm) and a facilitated group activity reflecting on the Dutch AMU reduction policy, how it worked in practice and what aspects of it could be applied to the UK farming sector.

The results of this reflection were described by the three groups of farmers as follows;

Group 1

Step 1- Farmer knowledge

- Help farmers learn about AMR- What the problem is, what solutions are there and how it is going to work in practice- the exchange of knowledge.
- Engage vets and drug companies with cross industry support on the challenge of AMR.

Step 2- Farmer engagement

- How to reach all farmers- carrot and stick
- Government approval
- Black market issues sorted

Step 3- Measuring AMU

- Standard measuring system (farmers liked the ADD metric)
- Get farm assurance and processors on board
- Use a carrot v stick method. So proactive farmers get rewards and the bottom 10% have the stick!

Step 4- Implementation

- Agreed protocols like the treatment plans in the Netherlands
- Drug accreditation schemes *“Some acronym on the drugs saying use or not use”*

Group 2

Step 1

- *"Making people aware...Needs to be a very simple mail shot, not a great big booklet because people will not read it. So people know what's happening and to encourage them to participate in meetings. If they want to have an input then fair enough. Making them aware, farmers."*
- *"One year voluntary, next year compulsory sign up and 3rd year looking at action taken...penalties. Otherwise it will roll on and on."*

Step 2

- Find out where we are using data
- "*Why re-invent the wheel? Why not just encourage these bodies to see this system over here [Netherlands] and adopt something similar."*

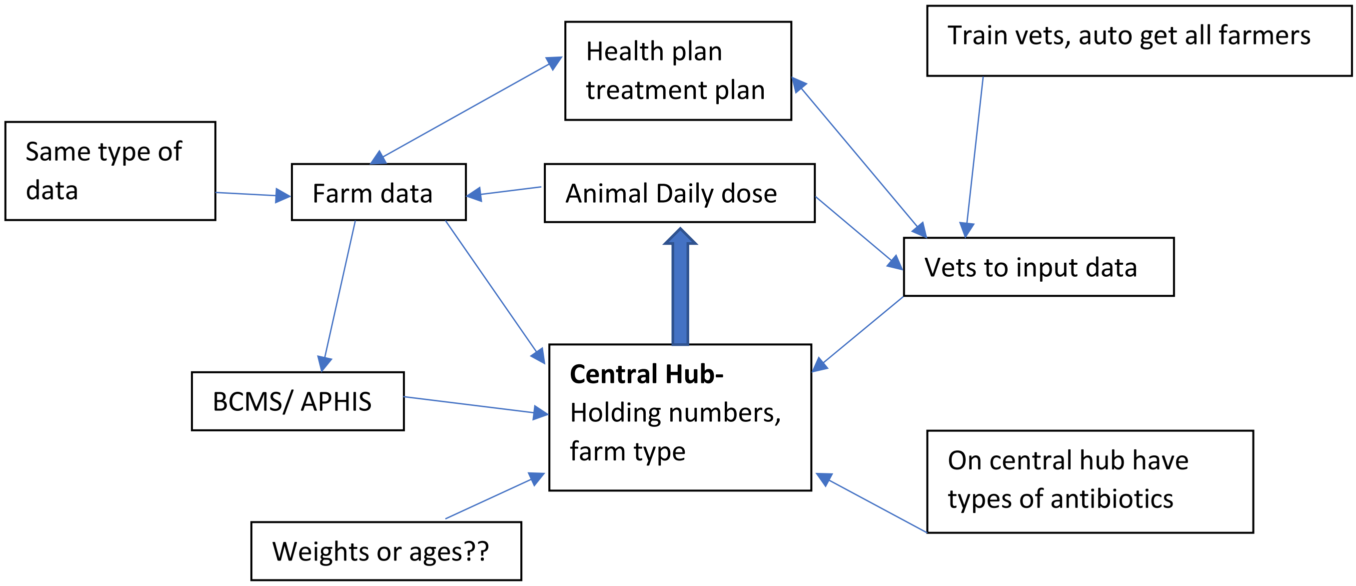
Step 3

- Benchmark- Use BCMS and vets (vet sale data) to benchmark farms.

Step 4

- Processor involvement

Group 3



The attending farmers identified three key areas that the UK could implement from learning about the Netherlands' AMU reduction policies. The first area was adopting the Dutch way of measuring AMU with benchmarking of farms and veterinarians. This involved quarterly reporting and all reports were based on data inputted by veterinarians to a centralised database – 'Medirund'.

Measuring AMU

> *"Get a central database and go from there."*
>
> *"Traffic light system like they have over here [Netherlands]"*
>
> *"They have got that benchmark [Netherlands], they know where they are and it's every quarter as well, it's not like you see that figure once a year when the vet comes in, every quarter you are getting seen and you get points."*
>
> *"Biggest efficiency driver is, I think personally, is being competitive. You want to be as good or if not better than your neighbour. So if that data is already out there, if they can do this for 0.2 ppl and ours is 0.4 then what are they doing?"*
>
> *"No farmer should input data. Vets input it".*

There was also a desire to see veterinarians take more responsibility for their prescribing and to be in charge of data entry. These points were made pre-Red Tractor guidelines coming into force in the UK.

Veterinary involvement

> *"What about Vet bodies, push down onto vets. As a rule you cannot serve 3rd and 4th drugs [3rd and 4th generation cephalosporins] without C+S [Culture and Sensitivity]. Straight away, vets stop. It's not the farmer's choice even."*
>
> *"No vet can prescribe stuff without being allowed to put the data up."*

The third and final area they identified was how to motivate and engage all the industry on reducing AMU. They recognised that the Dutch had been made to change the way they used antimicrobials. There was a feeling of wanting it to be farmer-led in the UK, but some form of 'stick' (e.g. pressure from milk processors) would be needed, similar to in the Netherlands.

Motivating and engaging the industry

> *"No we want it farmer led, we're the ones on the ground doing it!"*
>
> *"Pre-empting a stick from the government and we can actually come forward with a plan, I am sure this is a far better way of doing things."*
>
> *"Processors say, because they're the ones with the power on the farmers, a lot of farmers will sign up but…processors can go back to the farmers, look you have got to sign this as part of your commitments."*

The Knowledge Exchange trip inspired the participating farmers to make changes to their own practices. For instance, one farmer changed the type of neck rails on his cubicles after seeing the Dutch farms and the absence of neck lesions on their cows, and another two farmers decided to implement shorter dry periods based on research presented on the study tour. All visiting farmers came away with a greater understanding of the challenges of measuring farm AMU in the UK and how they could help by collaborating with their veterinarians more and improving on-farm medicine records.

Policy workshop, Royal Agricultural University

As a result of Brexit and the subsequent opportunity to influence future agricultural policy, a policy workshop was held in collaboration with the Royal Agricultural University. This was a chance to present findings to industry from not only the FAG study but also other farmer-led, bottom-up initiatives happening in the UK (e.g. Innovative farmers, Hennovation). It was also a chance for policy-makers, advisors and other industry bodies to contribute their expertise and advice about how these sorts of approaches could be used in future policy, or not. The outcome of which is hoped can be used to make the adoption of these methodologies more successful.

A wide range of organisations attended from AHDB, DEFRA, the Food Standards Agency (FSA), Red Tractor, Soil Association, the VMD, Royal Society for the Protection of Animals (RSPCA), the National Farmers Union (180) as well as four farmers from the FAG project. The workshop was structured around discussing how to enable, motivate and implement such approaches in future policy.

Enabling future farmer-led initiatives

In order to enable farmer-led, bottom-up projects, it was agreed that facilitators were critical to the process. A readily available fund to fund facilitation that farmers or other industry bodies could access was stated as necessary and important. Those present from government organisations were understandably quiet on this issue of funding.

Motivating future farmer-led initiatives

To motivate uptake of these approaches, top-down mechanisms such as making them compulsory or using penalties was generally unpopular. It was however, recognised that encouragement by retailers or certifiers, possibly financially, could be an option.

Implementing future farmer-led initiatives

Finally, implementing such initiatives nationally was a popular idea and it was agreed it would need a network of trained facilitators. Organisations such as AHDB could be delivery partners but there was some disagreement as to who could be trained in the facilitatory role. Taking account of the varying farming sectors and differing needs/challenges was also highlighted. The benefit of participatory bottom-up approaches is they are versatile and can work to local requirements i.e. pig farming compared to dairy farming. An important barrier that was highlighted was a lack of joined-up working between the different projects, not to mention a paucity on evaluating the outcomes from implementing or taking part in a participatory intervention. The lack of a cost-benefit analysis was a particular concern of government organisations.

In light of this workshop, the importance of facilitators in the success of a farmer-led approach was confirmed. This along with the facilitator's key role in recruitment and engagement in this study has led to the recommendation later in this chapter for (1) funding for facilitators and (59) recognition of their role in the form of a professional accredited body. It also emphasized the appetite for these ways of working to bring about positive changes on farms, regardless of the specific goal. Finally, the need for more structured evaluative frameworks, including cost-benefit analyses from running/participating in these types of approaches is necessary for government adoption.

Appendix 15

Example Agenda

Time	Activity	Who to run	Questions
10.45-11am	Welcome, coffee/tea		Ensure register signed
11am-11.10am	Catch up on each farm		Check for new comers Outline agenda
11.10-11.20am	Host introduction		Brief outline of farm
11.20-11.30am	Medicine review summary		The good, the bad and the ugly.
11.30- 12.45pm	Farm walk Host's areas of concern for AB use- • Mastitis- started using on farm culture and a TSDG producer • Sick downer cows post calving- use a lot of drugs/cost • Youngstock- high incidence of BRD blamed on poor calf housing.		**Youngstock (20mins)** Talk us through your protocols from birth to weaning? What problems have you had with your calves recently? **Milking cows (MS them) (15mins) (Fresh calvers> Lows> Highs)** How do you manage a dirty cow/fresh calver? How do you manage a lame cow? What's your method of heat detection? Fertility like? *Host uses Genus services for fertility/lameness*. What do you vaccinate for, why? Johne's control? *(8 +ve in herd at present)* **Dry cows (BCS them) (10mins)** Talk us through DCT protocol? What else do you do with the dry cows? Nutrition and Ketosis? **Nutrition (10mins)** What is in your TMR? How do you manage your land? Analyse ration/grass? **Parlour (10mins)** Talk us through your treatment for mastitis? What's your parlour routine?
12.45-12.55pm	Lunch		SB/LM get ready for activities
12.55-1pm	Explain **mapping exercise**		
1pm-1.15pm	**Mapping exercise**- farmers to draw map of farm. Host farmer to correct/comment.		Does host agree with representation? What do they think?
1.15-1.20pm	**Mapping exercise**- add stickers for areas of excellence/opportunities for change		
1.20-1.35pm	**Mapping exercise**- Explain stickers		Why is this sticker here? How can this be achieved?
1.35-1.50pm	Summarise into Action List		Check host agrees
1.50-1.55pm	Set next host and date		
1.55-2pm	Feedback forms		