FARMER ACTION GROUPS
A participatory, farmer-led approach to changing practices around antimicrobial use on UK farms

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Farmer Action Groups - A participatory, farmer-led approach to changing practices around antimicrobial use on UK farms

Morgans

A participatory, farmer-led approach is characterised by the sharing of different types of knowledge between farmers to solve farm-specific challenges. This study aimed to understand how such an approach supports changes in farm practice. The findings demonstrated how knowledge is generated and applied within a participatory framework to initiate and support change on farm with the help of a trained facilitator. Farms changed their antimicrobial use as part of the peer-to-peer learning and benchmarking encouraged by this approach. Farmer-led, participatory approaches that value different forms of knowledge and the mobilization of that knowledge by professionally trained facilitators are an effective way of empowering farmers to adapt and develop responsible farming practices.

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14 **A participatory, farmer-led approach to changing practices around antimicrobial use on UK**
15 **farms**

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ABSTRACT

Farmer-led, participatory approaches are being increasingly employed in agricultural research with promising results. This study aimed to understand how a participatory approach based on the Danish Stable Schools could help to achieve practical, farmer-led changes that reduced reliance on antimicrobials in the UK. Five facilitated Farmer Action Groups comprising 30 dairy farms across South West England met on farm at regular intervals between 2016 – 2018 and worked collaboratively within their groups to discuss how to reduce antimicrobial use. Qualitative data from group discussions and individual semi-structured interviews were collected and analysed using thematic analysis to explore how the approach helped farmers address and deal with changes to their on-farm practices. Facilitator-guided reviews of antimicrobial use and benchmarking were carried out on each farm to assess any change in usage and help farmers review their practices. The pattern of antimicrobial use changed over the 2 years of the study with 21 participating farms reducing their use of highest priority critically important antibiotics (6 farms were not using any of these critical medicines from the outset). Thirty practical action plans were co-developed by the groups with an average implementation rate of 54.3% within a year. All assessed farms implemented 1 recommendation, and many were still ongoing at the end of the study. Farmers particularly valued the peer-to-peer learning during farm walks. Farmers reported how facilitated discussions and action planning as a peer group had empowered them to change practices. Participants identified knowledge gaps during the project, particularly on highest priority critically important antibiotics where they were not getting information from their veterinarians. The study demonstrated that facilitation has a valuable role to play in participatory approaches beyond moderating discussion; facilitators encouraged knowledge mobilization within the groups and were participants in the research as well. Facilitated, farmer-led, participatory approaches that mobilize different forms of knowledge and encourage peer learning are a promising way of helping farmers to adapt and develop responsible practices.

INTRODUCTION

Reducing the overuse and misuse of antimicrobials is of the utmost importance in the fight to slow the development of antimicrobial resistance (WHO, 2015). 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 (AMR) in human health (Heuer, 2006; Knetsch, 2014; O'Neill, 2015). The sale of antimicrobials to UK farmers is strictly by veterinary prescription. Farmers can then treat their animals without the veterinarian being present, as stipulated in Schedule Three of the Veterinary Surgeons Act 1966. Therefore, UK farmers are making vital decisions on a regular basis when administering antimicrobials and treating animals on farm. For this reason, understanding the decision-making processes and practices around administering antimicrobials on UK farms is of key importance if farmers are to practice responsible antimicrobial use (AMU).

Government policy has often influenced farming practice in a top-down manner, for example, through regulation, legislation, penalties or advisor-led interventions. This has resulted in large-scale improvements to animal welfare (e.g. the outlawing of the battery cage for laying hens across the EU). However, regulatory governance can create perverse effects where compliance with policy becomes disconnected from good practice and exacerbates distrust (Escobar and Demeritt, 2016). Instead, farming policy challenges, such as water quality management, may be better addressed by a *"group-information sharing approach"* that shifts social norms, raises minimum standards and increases voluntary adoption amongst farmers (Barnes, 2013).

Farmer-led, participatory approaches are being increasingly employed in agricultural research with promising results (Conroy, 2005; Bodin, 2009; Šūmane, 2018) including on AMU. In Denmark, Vaarst (2007) demonstrated that using a bottom-up, participatory approach with dairy farmers helped improve animal health and reduce antimicrobial treatments. The approach was inspired by Farmer Field Schools, which are widely practiced across the world and are based on experiential learning and practical know-how (FAO, 2013). Stable Schools achieved a 50% reduction in mastitis treatments on participating farms with no detriment to herd health, welfare or production (Bennedsgaard, 2010). They were hailed as a success in Denmark and were consequently adopted into agricultural legislation as part of the Danish obligatory animal health service. Danish dairy farmers now have a choice as part of their animal health service of either having the veterinarian out more often or participating in a Stable School (Vaarst and Fisker, 2013).

As part of a pan-European initiative on organic farming called ANIPLAN, the UK national levy board – Agriculture and Horticulture Development Board for Dairy (AHDB Dairy) – began working with farmers using the Stable School approach (Ivemeyer, 2015). However, it is recognised that applying

similar approaches aiming to inspire change without attention to context - particularly social context - is futile and can result in poor outcomes (Peck and Theodore 2012). Dairy farms in Denmark are largely organised into co-operatives and the organic movement is large compared to the UK. Organic farming follows different rules on drug withdrawals and antimicrobial treatments compared to conventional farming. These differences are not irrelevant when seeking to change AMU practices. Therefore, we aimed to understand how the approach could work in the UK dairy farming context including conventional dairy farms and what lessons could be learned when using this approach on a wider scale to help farmers adapt their farming practices.

MATERIALS AND METHODS

This study is primarily a longitudinal qualitative case study involving an established methodology and using mixed methods i.e. qualitative and quantitative data collection and analysis. It uses a convenience sample of volunteers, has no control groups or randomisation and as such does not aim to generalise but to improve our understanding. Further detailed information on the methodology can be found in Morgans (2019).

Methodology

This study differed to Danish Stable Schools in 3 major ways. Firstly, this study focused on the presentation of AMU data for benchmarking rather than on the evaluation of key performance indicators as was the case in the Stable Schools (Bennedsgaard, 2010). Secondly, this study used qualitative data to introduce an additional focus on knowledge and antimicrobial stewardship. Thirdly, in contrast to the Stable Schools, where facilitators were limited to *"providing and pre-processing available farm data but not giving specific advice"* (Ivemeyer 2015), the facilitators in this project helped farmers understand and use the benchmarking data. They were participants in the process through adopting a more insider perspective to Participatory Action Research (PAR) (Kerstetter, 2012).

A PAR approach comes from a desire to empower disenfranchised communities, to relinquish control over the research process from academic institutions, to co-design and co-create research with local people and ultimately to improve the outcome from the research process (Chambers, 1985; Conroy, 2005, Macdonald, 2012). This research adopted a PAR methodology in order to conduct research while fostering a sense of collective action amongst farmers through a cycle of data collection and analysis, self-reflective inquiry and knowledge exchange (van Dijk, 2019). The Stable School model was adopted with the guiding principles of common experiential learning, peer-to-peer discussion and goal-orientated action, as defined by Vaarst (2007). The model was then adapted for application in the UK farming sector with the inclusion of AMU benchmarking and renamed Farmer Action Groups (FAG). Following a description of our methods in the FAG project, this paper presents the results from the

quantitative data on AMU, followed by the deeper analysis using qualitative data from farmers' experiences of reducing antimicrobials.

Recruitment of farms

Ethical approval for the study was granted by the Ethical Review Committee of the Faculty of Health Sciences at the University of Bristol in April 2016. The recruitment target of at least four groups with at least five participants in each group was based on the Stable Schools i.e. minimum of 20 participating farms. The groups were established based on geographical location of farm participants to keep travelling time to a minimum, which was an important aspect to participation in the Stable Schools (Vaarst, 2007). Only dairy farms were targeted due to potentially excessive or unnecessary antimicrobial use e.g. blanket dry cow treatment (VMD, 2019b).

Individual farms were recruited to a FAG through one or more of the following methods between April 2016 – January 2017:

1. By local veterinary practices
2. Through the researcher (LM) speaking at retailer producer meetings
3. Online advertisements
4. Using existing veterinary contacts of the researcher (LM)
5. Advertising at agricultural shows and events
6. Running specific lunchtime recruitment meetings in collaboration with AHDB Dairy

Gatekeepers (local veterinarians and AHDB Dairy) were used to improve recruitment outcomes; this is an established method of recruitment in qualitative research (Morrill, 1999). The result was a pool of 63 farms that indicated an interest in participating. Participants were provided with an information pack, ensured anonymity and given at least 24 hours before signing up to ask questions. Participants were not paid to participate; the only material incentives were free lunches at meetings and agricultural show tickets awarded to 5 farmers at the close of the project for significant changes to AMU. Five regional groups were formed for the study with an average of 6 farms in each group (range 5-8). The 5 groups were established over a 6-month period in a staggered manner. Group numbers were based on the Stable Schools, which reported the optimum group size to be between 5-8 farms (Vaarst, 2007). A total of 44 farms attended the first meetings for each regional FAG, which stabilised to 30 farms by the 3rd meeting (i.e. 32% drop out rate). A total of 30 farms from South West England participated in the project for its entirety from July 2016 – June 2018.

Farmer Action Group process

Farmer Action Groups were the principal unit of investigation in this study and were created from the PAR process. The farm was the participant with a lead farmer as its representative, although all the farm team were encouraged to attend meetings by LM. Quantitative data in the form of AMU data was used by the participants throughout the PAR process but also demonstrated impact from this largely qualitative study. The qualitative data enhanced our knowledge and understanding of a participatory, farmer-led approach to changing on-farm practices.

In total, we held 58 group meetings on farms. Each group met approximately every 4 to 8 weeks with the first meeting occurring in August 2016 and the last group meeting in June 2018. They occurred in 2 cyclical phases commencing with a series of pre-visits by the first author, LM between July 2016 - March 2017 (Figure 1). In Phase 1, each participant in the group of farmers 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 (Figure 1). In Phase 2, each participant hosted their group again to evaluate any changes made and reflect on learning from the first phase.

LM visited each farm participant at the start of the study (before they hosted) so farmers could discuss the project, share their data and co-design the meeting agenda. Each meeting consisted of the following components: i) Introductory 'catch-up' session where everyone shared what had been happening on farm since last meeting with their group; ii) medicine use discussion, where LM presented the host farm's AMU results in a 'Medicine Review' with discussion and benchmarking; iii) farm walk led by the host farmer showcasing their farm and highlighting areas on which they wanted input from their group; iv) group discussions, where LM and SB facilitated the ideas and recommendations generated by the rest of the group using discussion tool activities and v) action planning, where the group discussion was distilled into a practical list of recommendations agreed by the host farm to reach the goal of reduced AMU (i.e. an Action Plan).

In Phase 1, an experienced facilitator (SB) was involved in the recruitment of the farm participants and the facilitation at the meetings. SB was familiar with the Stable School methodology as she had been using it in her work with UK dairy farmers as an AHDB Dairy knowledge exchange manager. SB held a Masters in Animal Behaviour and Welfare and had several years' experience in the dairy industry running farmer meetings. Meetings in the second phase of the project were facilitated by LM - a qualified veterinarian - who developed facilitation skills during the project. LM was present for all the meetings during the project and SB was only present for phase 1 meetings.

The facilitators ensured meetings kept to time and moderated discussions so that everyone got to speak and was heard. To facilitate the discussion and recommendations in step v), we used mapping activities, score charts and ranking exercises, which distilled the group discussions into Action Plans for host farmers. Mapping activities consisted of participants drawing a diagram in the form of a map depicting

the farm they had been around on the farm walk. Then as a group, they would highlight with stickers areas of strength and opportunities for change.

Quantitative data collection and analysis

Medicine Reviews

Thirty Medicine Reviews were conducted, one for each participant farm. Each review covered 2 consecutive 12-month periods over the course of the project (2015/2016 and 2016/2017) to assess any changes or reduction in AMU for each farm. The 12-month time periods were not the same for each farm participant because of the staggered start of each group (i.e. there was 6-months difference between the first farm meeting in the first and last groups and the Reviews covered the 12 months prior to hosting). Farm participants wanted as recent as possible data for their Medicine Review, which had to be weighed up against benchmarking each farm within their groups. Critically, the primary focus of the analysis in this study was on comparing each farm with themselves from year 1 to 2, rather than to other farms.

Veterinary prescription data was the basis for the Reviews, except for 3 farm participants where it was impossible to obtain veterinary prescription records; these 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 (Mills, 2018). Nevertheless, veterinary prescription data is a fair proxy of AMU (Firth, 2017) 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 to increase the level of detail of the Review, such as farm specific course lengths (Mills, 2018). These data were collected and interpreted in collaboration with the farmer participant at the pre-visit (Figure 1).

Veterinary prescription data was provided by 15 veterinary practices from across South West England. Data were provided in various formats such as Microsoft Excel spreadsheets, PDF documents and scanned images, and included expenditure on each product sold. Data were then processed and inputted into Microsoft Excel as a count of the number or volume of each antimicrobial sold to the farm. Medicines were grouped as antimicrobials (and further split into intra-mammary/injectable/oral/topical formulations), anti-inflammatories, vaccines, fertility drugs, anthelmintic, supportive drugs (e.g. oral fluid therapy) and miscellaneous, with the respective expenditure on each group of medicines recorded.

Costings were carried out on AMU data to aid discussion with farmers about medicine usage. These costings were presented in various ways but the metric chosen for discussion in this paper is pence per liter of milk (PPL) spent on antimicrobials, which is a common key performance indicator across the

UK dairy industry (AHDB Dairy, 2017). PPL was based on total liters of milk sold and did not factor in fluctuations in price.

AMU was then calculated using various metrics (Mills, 2018; Morgans, 2019), and data compiled into a report for discussion at the FAG meeting (i.e. with labelled and illustrated graphs to aid discussion). We chose milligrams per kilogram biomass (mg/kg) as the metric to present the AMU data in this paper due to its similarities to national reporting in the UK (VMD, 2019b). Mg/kg was calculated by either multiplying the volume of each injectable antimicrobial used per farm by the mg/ml given on the datasheet or by multiplying the number of tubes used per farm by the mg/tube. The total milligrams of each antimicrobial used was then divided by the biomass at risk of treatment by that medicine, which was either biomass of milking cows or calves < 12 months old. Weights used for these categories of stock were 600kg for milking cows and 100kg for calves as defined by Jansen (2004). Mg/Kg is different to the UK VARSS report mg/PCU, which instead follows the European Surveillance of Veterinary Antimicrobial Consumption guidelines on Population Corrected Units (VMD, 2019b). The FAG were consulted as to which metric they preferred and settled on mg/kg.

After the first 12-month review, AMU for each farm participant was also benchmarked against the other farmers in the study, which was a service offered during recruitment and helped aid discussion with farmers. Once Phase 2 commenced, the second 12-month review was compiled and presented in a new report that compared Year 1 with Year 2. A Wilcoxon signed rank test (paired) was performed on the AMU data to check for statistical significance between the 2 years of the study as the data were not normally distributed. The level of statistical significance used in this study was $p<0.05$.

Qualitative data collection and analysis

FAG meetings

The overall purpose of the qualitative inquiry was to explore how and why this approach supported change on farm. The reporting in this study follows the COREQ guidelines for qualitative research (Tong, 2007). All data were collected and analysed by LM. An encrypted audio-recording device was used to capture the conversations and ideas shared at each FAG meeting. The entirety of each meeting was recorded and listened to by LM within 3 weeks of each meeting, comprising approximately 3 hours of audio per meeting. The audio data was used to compile summary meeting reports, which were circulated amongst each FAG. The total amount of audio data collected from the FAG meetings was approximately 174 hours.

LM transcribed a total of 30 hours from 10 FAG meetings and thematically analysed the data using the software package NVIVO version 11 (QSR International, Australia). LM chose this number of meetings for thematic analysis as it represented meetings on 10 different participating farms with

different hosts/attendees and from each of the 5 different FAG. There was a substantial wealth of information from 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 5 meeting transcripts (i.e. 15 hours of audio). These first 5 transcripts were analysed by LM at the time of the first meetings (2016 - 2017) but a further 5 meetings 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 presented later in the project, as described by Richards (2009).

The qualitative data were analysed thematically using a deductive approach, which allowed exploration of the data to investigate themes that helped answer the research questions as described by Braun and Clarke (2006). The research questions were 'How does a participatory, farmer-led approach initiate and support changes in practice, particularly around AMU and animal health on UK dairy farms? What lessons can we learn from such an approach to support change on a wider scale?' Coding of transcripts was performed in a 2-step process. Firstly, 'topic coding', where content from the transcripts answering the research questions was identified and organised into topics and sub-topics, referred to as 'nodes' in NVIVO. The overall research questions and the theoretical perspective of PAR formed the framework used for this first stage of coding and organising the data. Once all the transcripts had been coded and organised into the relevant topics/sub-topics', the second analytical step of 'coding on' occurred. This involved interrogating content organised into the topics/sub-topics looking for commonality, differences, links and divergences as described in Strauss and Corbin's seminal work (1990) and by Braun and Clarke (2006). From this, LM drew out minor themes that captured the essence of the content and selected quotes that reflected these minor themes. These multiple minor themes were then further interrogated in an integrative approach (Richards, 2009) with the other sources of data (so interview and discussion transcripts, AMU and Action Plans) to pull out the major overarching themes that answered the research questions and explained the social changes observed.

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 (Richards, 2009). Discussion on the analytical coding, grouping of minor themes and the commonalities within the sub-topics was carried out with the other authors at the end of the data analysis stage (November 2018).

Individual semi-structured interviews

In order to explore participants' views on the project from a more personal angle (i.e. not in a group context), LM conducted semi-structured interviews with 27 farmer participants during the project before they hosted in Phase 2 (the aim was to interview all 30 farmers but 3 were unable to make the

scheduled interview slot). LM also conducted interviews with 14 farm veterinarians when some expressed concerns about the project during recruitment and 10 farmers that expressed interest in joining but never participated/came to only one meeting. These were also thematically analysed, but the findings are not included here as it is beyond the scope of this paper.

Farmers had 8-12 months after first hosting to implement their Action Plans before being asked in the interview what and why they had implemented what they had and how implementation had gone. Interviews were also conducted to allow triangulation and to follow the evaluative approach taken in the Stable Schools (Vaarst, 2007). Interviews were audio-recorded and lasted between 30 minutes and 2 hours. Interviews were done on farm by LM and involved either the farm manager or 1-2 extra stock people or family members. The topic guide is provided (Appendix 1) and includes questions to explore why farmers took part in the study. This data is not presented here but is described by Morgans (2019).

Data saturation was reached by interview 16 and decided upon by LM in the same way as for the group discussions i.e. no further new information was presented. The remaining interviews were conducted to give every participant an opportunity to be heard and to collect data on Action Plan implementation. The first 16 were transcribed by an external company and the transcripts were analysed in the same way as the qualitative data from the FAG meetings. Quotes were selected by LM after conducting thematic analysis and defining the minor and major themes from both the interviews and group discussions; they were chosen as the most illustrative of the themes and to give a spread across participants. They are labelled in the text as FAG, which indicates farmer action group participant, A/B/C/D/E denoting group and then a number denoting different group members.

Action Plans

Action Plans were a direct outcome of Phase 1 meetings. Based on the discussions on the farm walk and using the discussion tools detailed above, the facilitator enabled each FAG to co-create a series of practical steps to help the host farmer reduce the need for and use of antimicrobials. Action Plans were co-created based on the farmers' knowledge and were farmer-led in implementation; the facilitators had minimal input and the recommendations came mostly from the farmers.

At each semi-structured interview, LM asked the farmer about their Action Plan and what they had actioned/implemented. On top of this, LM gave farmers a series of 'drop-down' answers to choose from on an Excel spreadsheet: 'fully completed', 'partially completed', 'not yet completed but hope to', 'not at all' and 'don't know'. Farmers were also asked if they perceived any benefits from implementing each specific recommendation and to choose from the following options: 'full benefit', 'partial benefit', hope to see some benefit', 'no benefit at all' and don't know'. They were asked to elaborate and LM recorded their responses in the spreadsheet.

Phase 2 meetings were focused on evaluating the host farm's Action Plan as a group and discussing how well it had been implemented. The period between each participant hosting in Phase 1 and Phase 2 varied between 8-12 months and was the time farmers had to implement the practical steps from the Action Plan.

RESULTS AND DISCUSSION

Farmer Action Groups

Average milking herd size across the 30 recruited farms was 212, slightly larger than the UK average of 148 in 2018 (AHDB, 2019). Twenty-one farms were all-year-round calving herds and 9 were block calving herds. The study included 2 organic herds, 3 robotic milking herds and 5 zero-grazing herds. Farm management structures on recruited farms ranged from family farms, single person operated units and multi-staffed teams.

The use of gatekeepers during recruitment allowed a variety of dairy farms with different systems to participate. However, gatekeepers can introduce an element of bias and selectivity to farm recruitment by prioritising the gatekeepers' own networks. Nevertheless, several gatekeepers were used to reduce selectivity, which is referred to as chains of referral in qualitative research (Penrod, 2003).

Changes in AMU

Presentation and analysis of AMU data was becoming more commonplace in the industry at the time of the study (Mills, 2018; Hyde, 2018). The Medicine Reviews took different aspects of AMU reporting from across Europe to measure progress. However, the participatory, farmer-led approach of the study turned the Medicine Reviews into more than a measure. It became apparent early in the study that the Medicine Reviews acted as a discussion tool that developed farmer knowledge on highest priority critically important antibiotic (HPCIA) and allowed farmers to input and take ownership of the metrics. This section presents the changes in AMU and shows how the Medicine Reviews helped farmers drive these changes.

The range in AMU across participant farms was considerable (e.g. 3.5 mg/kg – 93.4 mg/kg in Year 2) and reflected a similar range from studies on larger samples in the UK (Hyde, 2017). Figure 2a illustrates the range in total AMU across all participant farms over the course of the study and the difference in total AMU between Years 1 (2015/2016) and 2 (2016/2017) using mg/kg as a metric ($z = -0.360$). A small decrease was observed in the median total mg/kg between the years (Figure 2a).

Figure 2b demonstrates the reduction in PPL on antimicrobials from Year 1 to Year 2 of the study across the 30 participant farms ($z = -2.643$). Median PPL decreased from 0.23ppl to 0.21ppl over the study duration. Several cheaper, non-HPCIA alternatives were available for farmers to use in the UK

at the time of the study, therefore, the decrease in PPL may have been driven in part by a reduction in expenditure on HPCIA.

Most participant farms were using HPCIA at the start of the study in 2016 (n=24). HPCIA use reduced across most participant farms from Year 1 to 2 (n=21; 87.5%). Six farms were not using any HPCIA from the outset and 9 farms eliminated HPCIA usage completely after one year of the project. Figure 2c demonstrates the reduction in HPCIA as measured in mg/kg (z = -3.484). The reduction in HPCIA described in this study was more marked than national trends at a similar time point, where only a 28% decrease in HPCIA use was reported in the dairy sector between 2016 and 2017 (VMD, 2018) and a 68.4% decrease in HPCIA in 2017 compared to 2015 (VMD, 2018). The changes observed in this study were also before farm assurance regulation came into force (Red Tractor, 2018). Nevertheless, direct comparison is limited due to the difference in the metric used and period compared.

There are many limitations to measuring AMU and a detailed published account of the general limitations is well described by Mills and colleagues (2018). It is worth noting here though that the data collected for the Medicine Reviews covers only 2 consecutive years for each farm and was limited for assessing trends. Critically, it is important to note that the Medicine Reviews reflected a change in AMU on participating farms that was likely subject to multiple drivers (e.g. veterinary advice influencing farmer decision-making around treatments). FAG were not the sole cause of the observed changes and this was not a study to establish such a causative relationship. The other sources of data described alongside these results suggest the FAG had a supportive and critical role to play in helping farms change their practices around AMU.

In the UK, there has been an industry-wide push towards more responsible AMU and examples of reducing HPCIA with little detriment to herd health (Turner, 2018). Many participants perceived the FAG as instrumental in supporting them with that change. Farmers valued the holistic approach to farm and cow health that the project encouraged. They repeatedly focused on managing and improving herd health as a way of reducing AMU, covering topics such as feed, housing, immunity, treatment protocols, veterinarians and even the wider farm environment and infrastructure (Figure 3). This is in line with the results from the Stable Schools (Vaarst, 2007) and the principle that knowledge and action through the PAR approach are constructed within individual and varying social and professional contexts (Pretty 1995). Nevertheless, total AMU did not reduce for all participants and some reductions were only marginal. The project did not achieve the initial goal of total antimicrobial reduction over 2 years but instead helped farmers reduce HPCIA.

Highest Priority Critically Important Antibiotic

Reducing HPCIA use was regarded as an easy and quick change to make over the 2 years of the project, compared to longer and more involved changes on the farm that would have been needed to reduce the need for all antimicrobials. For this farmer, changing antibiotic was something they could do immediately:

> *"Ubro Red (framycetin, penethemate, penicillin) is what we went to [from a HPCIA], we did that straightaway." FAGA2*

Farmers saw these reductions and the shift away from reliance on HPCIA as a key benefit from participation. As this farmer told us, it was something they were probably about to do anyway, yet the project galvanised their decision:

> *"We were using Cobactan [4th generation cephalosporin] 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." FAGC2*

The FAG began to create a social stigma around using HPCIA and the farmers did not want to 'be in the red' for using them, as illustrated here with reference to being awarded 'smiley faces' for good practice during group discussion activities.

> *"[Host] has been using some no-no's [HPCIA] there, and you can't have a smiley face everywhere!" FAGE2*

Furthermore, 2 farmers coined the nickname "*Antibiotics Anonymous*" for their group. This was based on the fact the groups went through a collective process of 'weaning' themselves off certain antibiotics. They would share with one another when they had failed or 'relapsed' into using them again, a process that shares similarities with the organisation 'Alcoholics Anonymous'. This social pressure in the group was further enhanced by the Medicine Review process where all participants had their AMU measured and presented to the group; participants felt a collective responsibility to address any misuse or overuse. Using farm data and benchmarking progress has been used to encourage change in farming elsewhere with success (Sumner, 2018) and this was also the case in this study. Participants could see the changes that everyone was making and did not want to be the worst farm in the cohort.

Co-development of the Medicine Reviews

Developing the Medicine Review in partnership with the farmers offered them an opportunity to suggest how they would measure AMU, which helped bring farmers along the learning journey. The metric 'mg/1000 liters of milk' was suggested several times with mixed responses and a select group

of farmers that went to the Netherlands on a study tour in October 2016 came back convinced measuring AMU the Dutch way was best, which uses Animal Daily Doses (ADD) and quarterly reporting.

> *"They [Netherlands] have got that benchmark, 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." FAGD6*

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…? … It's a number we're just starting to get our head around." FAGC1*

Comparing AMU in adult cattle versus calves, (which differs to national reporting), using multiple metrics simultaneously and comparing to each other despite system differences were all farmer suggestions. Farmers were keen to be benchmarked and often revealed who they were on the anonymous graphs. Participants found the graphs of financial expenditure on different classes of medicines a useful starting point in the Medicine Review discussions, which led to further changes, such as increased non-steroidal anti-inflammatory drug (NSAID) use and enquiry into vaccinations with their veterinarians when they saw that most of their medicine expenditure was on antimicrobials not preventative medicine. Benchmarking such a diversity of dairy farms was added value and not perceived as a limitation to the Medicine Review process by farmers.

> *"Otherwise we've all got 10,000-liter cows that we polish every day and we all say, everything's fine but you'll get a totally different reaction to a 5000-liter spring calving herd wouldn't you?" FAGA1*

Benefits from participating in the Farmer Action Groups

Farmer participants spoke highly of the meetings and feedback was generally very positive. The fact that 30 farms remained in the project for the duration of the study suggests the approach was valued by participants. The following quote sums up the general sentiment about the meetings.

> *"They're really good. It'll be a shame when it's all over...Can it be extended for another 2 years?" FAGC3*

Farmers consistently mentioned 2 key benefits: the sharing of new and applied knowledge and feeling supported and empowered both by their peers and the facilitators. Both benefits were often interrelated. These benefits align with the major themes drawn from the qualitative data analysis, which were Knowledge Mobilization and a Sense of Solidarity.

Knowledge Mobilization (1) – generating new knowledge

Farmers often reported having gained new knowledge during participation (for instance on HPCIA) and while this new knowledge sometimes came from the facilitators, it most often came from the other participants and this was something farmers particularly valued. One example was learning how some farmers were managing mild mastitis cases with NSAID rather than antibiotics.

> *"I learnt a lot from your meetings, and it has changed my treatments from antibiotics being first resort to second line of defence" FAGA5*

Knowledge Mobilization (2) – different types of knowledge

Aside from the intrinsic value of generating new knowledge, farmers also mentioned how much they valued the practical experiential nature of the knowledge; it was from peers and helped them improve their farming practices. Farmer FAGB1, for example, commented on how the new knowledge was important because it made them question their own practices:

> *"I've definitely learnt quite a lot from doing this and it does make me think when I use stuff, 'Is it critically important?'" FAGB1*

Knowledge Mobilization (3) – knowledge exchange

The FAG project enabled farmers to engage in an environment where they could talk freely and share knowledge with one another. Farmer learning is about exploration and involves discussion (Kilpatrick, 2003, 2007), which the FAG 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!" FAGA3*

Furthermore, the sharing of the cumulative knowledge assisted farmers with planning changes. Farmer FAGC6, for example, explained how the recommendations from the facilitated group discussions and

the farm walks, which were then distilled into an Action Plan, had helped him make decisions when feeling uncertain about making changes:

> *" 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." FAGC6*

Knowledge Mobilization (4) - knowledge gaps

Participants quickly identified gaps in their cumulative knowledge, such as how AMR occurs and spreads, and thus, how using antimicrobials (particularly HPCIA) on farm contributes to AMR; this was knowledge many of them deemed essential to have considering the requirements of some of the farms' milk supply contracts (i.e. they we discouraged from using HPCIA). The participatory knowledge mobilization within the FAG, with support from one another and the facilitator, helped farmers make the link between AMR, their actions on farm and coming regulation.

> *"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 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." FAGC6*

Sense of solidarity – peer support

The peer support at each meeting evidenced by the reference to 'Antibiotics Anonymous' and the numerous examples of peer-to-peer learning presented thus far were crucial factors in why farmers changed their practices. This peer-to-peer model galvanised participants to act, which was further heightened by the cyclical nature of the project.

> *"… 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." FAGC5*

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 2 meeting added an important element of follow-up.

Facilitation – building a Sense of Solidarity and encouraging Knowledge Mobilization

As much as the participatory nature of the project was mentioned consistently by farmers as crucial for their knowledge generation and for the peer support, participants also highlighted the input of the facilitator. The AHDB Dairy facilitator was a key player in this project, from recruitment to the running of Phase 1 meetings. She kept the meetings focused, engaged all farmers and helped develop tools farmers could use to reflect on their own practices. The facilitator helped farmers address problems and co-create a strategy. Facilitated group discussions using discussion tools, such as Mapping and benchmarking, were the foundation for the Action Plans and provided farmers with confidence to change and adapt practices, thereby building a sense of solidarity amongst the group. The role of LM was to provide knowledge on HPCIA and AMR at the request of the FAG. For farmer FAGA1, the fact that the facilitator was as knowledgeable of the subject as much as she was passionate about it was crucial to the Knowledge Mobilization:

> *"Your energy, enthusiasm and understanding of the subject has most definitely been pivotal in the success of the meetings." FAGA1*

The FAG project was more facilitator-led in the beginning and transitioned to being more farmer-led over its duration, which Cornwall and Jewkes (1995) describe occurring when a community is disempowered and initially lacks confidence to tackle certain challenges (i.e. reducing HPCIA). The literature describes the key role the facilitator has in supporting groups in their learning journey (Leeuwis, 2000; Koch, 2002; Sherson, 2002), meeting shared objectives, acting as a knowledge broker (Lowe, 2019) and inspiring confidence in participants, as well as initiating and managing project logistics (van Dijk, 2017a). The relationships developed between the facilitators and participants were not only an important part of the approach (Kerstetter, 2012) but helped create an equitable space as described by Koch and colleagues (2002) for Knowledge Mobilization. Chambers states in 'Beyond Farmer First' (1994) that knowledge is "…[]…*'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*". By embracing the different social practices and learning styles of farmers, facilitation can help a group to navigate and adapt to the challenges they face.

Nevertheless, there were drawbacks to the Knowledge Mobilization and peer support fostered by the FAG. A substantial number of farmer-led recommendations from the Action Planning were not implemented or were disregarded by farms as inappropriate (Table 1), which implies that existing farmer knowledge was not enough on its own to result in change. The need for the facilitator to fill the knowledge gaps identified by the group could be perceived as a limitation to this sort of approach i.e. would a group be able to function independently without a facilitator. This would be a further area to

explore but interestingly, Roche and colleagues show that the cost benefit for a farm increases when participating in a focus group program with facilitation rather than without (Roche, 2020).

The qualitative data analysis was based on a subset of the interviews and group transcripts due to the vast quantity of data available and evidence of data saturation, but this is a limitation of the analysis and findings and could result in omissions. Nonetheless, this study was conducted using a PAR approach, which emphasises the role of the researcher as an insider as well as an outsider in the process of change (Kerstetter, 2012). LM was present for all meetings, listened back to all audio recordings and lived the participatory experience for 3 years. As such, the facilitators were also participants, which is an important consideration when evaluating these approaches and highlights the advantages of having a facilitator rather than the limitations of one.

Technical content of the Action Plans

The outcome from the FAG meetings were 30 Action Plans, one for each farm participant. Each Action Plan amounted to, on average, 10 practical recommendations (range 5-19). In total, there were 304 recommendations on the Action Plans after the Phase 1 meetings that host farms agreed to, each addressing something that would help to reduce AMU. These recommendations - inspired and endorsed by each farmer's 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 (Figure 3), which shows discussion was not limited to AMU and reflects the areas that farmers saw as relevant. LM and SB encouraged the groups to co-create at least one recommendation but there was not a strict number.

Participants generally advocated the idea that if the cows did not get disease in the first place, then they would not need to use antimicrobials.

> *"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*

Cow environment

Figure 3 demonstrates that the most common topic was changing 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, changing types of bedding, reviewing cleaning routines and improving shed lighting. This did not include measures on improving ventilation as these were counted in a separate topic (i.e. shed ventilation), which also featured frequently (n=10).

The changes recommended were practical and within the control of the farmer. Farmers spent many hours in these environments and saw from visiting each other's farms the benefit such changes could have on cow welfare, health and behaviour.

> ***Host*** *"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."* FAGB3

Lameness

The second most common topic on the Action Plans was lameness management, which included more regular mobility scoring, swifter identification and treatment of lame cows and using more blocks, which farmers were pleased with as it meant fewer antimicrobial treatments.

> *"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 [ceftiofur]." FAGB1*

This farmer's group had explained that using antibiotics for claw lesions was rarely necessary and the Medicine Review had flagged up his use of ceftiofur as being excessive and a HPCIA. The discussion that followed culminated in this farmer eliminating ceftiofur from treatment of certain lameness aetiologies and finding a solution in using the foot trimmer more frequently, which he also reported saved him money.

Use of NSAID was counted as its own topic due its relative frequency (n=14). SB and LM would ask farmers about their treatment protocols for a variety of conditions on the farm walks. One of these conditions was lameness, which often revealed inappropriate use of antibiotics (e.g. for white line disease) and scarce use of NSAID. This sparked discussion and consequently appeared on the Action Plan, then was implemented on farms as shown in Figure 3.

> *"Actually, following on from what you said [farmer], with Metacam [meloxicam] use, I think we are going to have to re- visit that again." FAGA3*

Antimicrobials

The third most common topic to feature on the Action Plans was antimicrobials, for example changing treatment protocols, discussing dosing and course lengths, and moving away from HPCIA. Fortunately,

these were often the 'easy wins' to make due to alternative products being available. Changing from HPCIA to first-line products was often attributed to the learning occurring at the FAG meetings as discussed previously.

"The go-to drug would have been Naxcel, but we try and avoid using that." FAGB2

Mastitis

Considering mastitis is one of the greatest uses of antimicrobial on dairy farms in the UK (VMD, 2019b) as well as for the majority of participants in this study, it is no surprise that this topic occurred frequently on the Action Plans (Figure 3). Although all UK farmers need a prescription from a veterinarian to obtain antimicrobials, participant farmers felt it was within their expertise to discuss and recommend changes to the management of mastitis and lameness on one another's farms as evidenced here. They demonstrated they had working knowledge of managing these environments - they knew what the limitations were and had ideas about how they could be improved. Therefore, a group of farmers has a substantial amount of expertise to guide each other on how to improve.

Implementation of the Action Plans

The ability to negotiate a plan through discussion with a group of peers is a key principle in a participatory approach (Arnstein, 1969). LM deemed it important that host farmers could disregard any recommendations on their Action Plans after consideration as it 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 (Cornwall and Jewkes, 1995).

Twenty-nine participants had implemented at least one recommendation from their Action Plan by their Phase 2 meeting, which occurred within a year of co-creating the Action Plan (1 farm did not have their Action Plan assessed for implementation or benefit due to lack of time to participate in an interview and phase 2 meeting before the end of the project). The average proportion of recommendations that had been either fully or partially implemented by Phase 2 was 54.3% - just over half of an average Action Plan was implemented within 8- 12 months (Table 1). None of the participants had implemented all the specific recommendations by the second phase of meetings.

Farmers perceived most recommendations on their Action Plans as beneficial to themselves or their business (Table 2). The proportion of the recommendations that were perceived to be of full benefit was 30.5% (Table 2). A substantial proportion (21.1%) of recommendations were deemed to have 'no benefit at all', which was mainly around recommendations that the host farm tried and did not work or adapted to be more suitable after Phase 1. Twenty-five recommendations were not assessed for perceived benefit and were not included in the total actions assessed. This was due to the unavailability

of 3 farmers for interview to fully assess perceived benefit. Conducting the interviews before the phase 2 meetings may have influenced the findings on implementation and perceived benefit negatively by limiting the chance for farmers to discuss and review their Action Plans a second time as a peer group.

Process of Action Planning

The formalised, written 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.

> *"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 [Action Plan] is useful, but it's not the be all and end all." FAGC6*

> *"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. FAGB4*

This contrasted with the sense of bureaucracy and 'doing it because you have to' that characterised much veterinary-led herd health planning required as part of national UK farm assurance regulations. Asked to rank the project Action Plan against herd health plans, this farmer's opinion summed up what many farmers felt towards their herd health plans.

> *"Is [Action Plan] far more effective than a herd health plan; that's a joke. [laughter] That's an absolute joke because [a herd health plan]is just a tick box exercise." FAGA3*

Apart from the peer-to-peer nature of Action Plans, their perceived lower cost also boosted their implementation, as illustrated by 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." FAGA2*

Writing down the list of recommendations and including it in the meeting summary report was another element that aided Action Plan implementation:

"There's having it on paper as well to actually look at." FAGC2

The Action Plan was used in different ways; sometimes as a reflection tool for the group to evaluate what had changed on each farm and why, which was the focus of the Phase 2 meetings, and sometimes as a reminder of what was discussed at each meeting, as described by FAGC6 earlier. The Action Plan was not a rigid list participants had to use; they could tweak and adapt their practices based on the Action Plan recommendations and from discussions with each other. 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 had the chance to input into and do not value as highly. The effect of which was observed in the follow up to the UK national Mastitis Control Plan where several recommendations from advisor-led action plans were not implemented or adhered to (Down, 2016).

Non-implementation

Nevertheless, there were many reasons given by participants for not implementing certain recommendations. One major constraint was the time taken to implement changes.

"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." FAGB5

Evaluation of the Action Plans was within a year of their co-creation for most participants and some Action Plans consisted of major changes. Additionally, some recommendations were seasonally dependent (e.g. changing calf feeding protocols where block calving herds often had to wait 12 months before initiating these changes). For this reason, the average proportion of recommendations partially/fully implemented by Phase 2 (54.3%) was potentially lower than it would have been if Phase 2 meetings had been held after 12 months or more. Action Plans could be re-visited a year or more after their inception, or the 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.

Other factors cited as reasons for non-implementation were around risk aversion, farm infrastructure and staffing. Many of the recommendations involved changing treatment protocols from using antimicrobials as first-line treatment or commencing selective dry cow therapy, as described below.

"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

691 *[with antibiotics] and know. It's peace of mind isn't it? Surely that antibiotic is used up*
692 *in the dry period, it's not still there." FAGB1*

693 Changes such as selective dry cow therapy were laden with risk and worried many participants. Hearing
694 from other farmers that had made the change was pivotal in encouraging farmers to move away from
695 relying on antimicrobials for drying off cows. Nonetheless, 2 of the 4 documented 'disasters' from the
696 farmer-led recommendations were around implementing selective dry cow therapy. The other two
697 cases were pertaining to monesin ('Kexxtone') boluses and feeding calves milk powder as opposed to
698 waste milk. Interestingly, the 3 participant farms that reported these cases were keen to try them again
699 in a different way.

700 Certain farms were unable to implement specific housing changes simply because of space restrictions,
701 which was another reason to allow the host farmer to disregard parts of their Action Plan.

702 *"I have done some, but I haven't done as many as some of the farmers would like me to*
703 *have done, the main reason being that where they stand to feed is narrow…" FAGC6*

704 Farm staff issues were also cited as a reason for low implementation of the Action Plan. One farm went
705 out of business during the study because they were unable to find adequate staff. These wider
706 contextual factors are important aspects to consider when helping farmers navigate change, as
707 discussed by Peck and Theodore (2012).

708 The resources needed to coordinate and participate in such an approach are also significant. Farmers
709 spent approximately 50 hours travelling to, attending and hosting farm meetings over 2 years,
710 dependent on group size, which could explain initial drop out. Facilitators spent substantial time
711 planning meetings with farmers, coordinating logistics and data collection as well as facilitating 174
712 hours of farm meetings. This resulted in 30 farm Action Plans with an average of 10 recommendations
713 and an implementation rate of 54.3% after 1 year. When comparing the mean implementation rate of
714 54.3% in this study to other implementation rates, it is questionable how good a participatory approach
715 is at achieving change quickly. A study by Sjöström and colleagues (2019) that also used a participatory
716 process with organic farmers and their advisors across France, Sweden and Germany, found that the
717 proportion of animal health plans that had over 50% implementation was only 48.7%. This result is
718 slightly lower than in the FAG project where 53.3% of participant farms implemented over 50% of
719 their Action Plan within a year. Participatory processes require substantial resources and do not
720 guarantee 100% implementation of desired change. However, the time invested goes beyond
721 compliance with a list of recommendations and adds value in intangible ways, such as increased
722 confidence, enhanced knowledge and capacity to make changes, as demonstrated in this study.

Furthermore, the FAG study resulted in a higher implementation rate compared to the UK Mastitis Control Plan, which is a top-down, advisor-led intervention, so a direct comparison has limitations. Green and colleagues (2007) reported that 17 of the 26 intervention farms (65.4%) implemented more than a third of their plans within a year. Compared to this study, 83.3% of participant farms in the FAG had implemented over a third of their Action Plans within a year. Therefore, the participatory, farmer-led approach presented here compares not only favourably with other published examples at initiating changes on farms but gives better results than some advisor-led interventions. To fully answer whether the ends of such an approach justify the means, a detailed cost-benefit analysis over a longer period would be recommended to evaluate the longevity and value of change from a participatory approach, attempts of which have been made by Roche and colleagues (2019).

The role of veterinarians

Farmers in the FAG project repeatedly stated that veterinarians were not helping them move away from HPCIA or supporting them with their knowledge gaps.

> *"After the last meeting, I phoned up my vet and said I am using [4th generation cephalosporin] tubes and I want to try something else… they sounded blank on the phone. They are not all signed up to it." FAGD4*

LM encouraged all participants to discuss their Action Plan and specifically the medicine changes with their veterinarians, which many did. Discussion with the veterinarian was in fact the most implemented topic on the Action Plans (Figure 3).

The veterinarian was mentioned on 17 different Action Plans and featured on 8.5% of the recommendations. Many of these were caveats encouraged by LM 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 was also demonstrated in the Stable Schools (Vaarst, 2007). As veterinarians are the prescribers of antimicrobials in the UK, this could be viewed with concern by the veterinary profession as demonstrated by the following quote from a veterinarian to LM.

> *"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." VETE2*

The concerns of veterinarians about farmer-led action around antimicrobial stewardship poses challenges with regards to the adoptability of the approach on a wider scale. These concerns are analysed in greater depth by Morgans (2019). There is scope for veterinarians to be delivery partners and to be trained in facilitation, as demonstrated by Roche and colleagues (2019) where farmer focus groups on Johnes management with veterinary facilitators had positive net gains for farms. Veterinarians could also use this approach alongside other communication methodologies, such as Motivational Interviewing (Bard, 2017). However, if veterinarians fundamentally do not agree with the participatory philosophy and fail to recognise and appreciate farmer knowledge, then there will still be barriers to the scope of farmer-led approaches to change.

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, biosecurity and controlling bovine tuberculosis (at least in the UK) need to be part of the solution (VMD, 2019a). A limitation, therefore, of Action Planning in the participatory mechanisms of the FAG is that it is 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, vaccination and some infectious diseases. Roche and colleagues demonstrated that farms with higher burdens of disease would do better from a cost perspective to participate in vet facilitated focus group programs than those with lower disease levels (Roche, 2019). Veterinary support could be offered alongside a farmer-led approach and in a facilitatory manner to generate and implement new knowledge, as has already been tried with success by van Dijk and colleagues (2017b). This is further supported by Lowe and colleagues when discussing rural development and the idea of vernacular expertise (Lowe, 2019). A key lesson learnt from this study when adopting this approach on a wider scale is the need for veterinarians to be trained in facilitation and to include facilitation in their advisory services. The mobilisation of external expertise is not contradictory to the principles and purposes of farmer-led interactive models but can be, as the current example demonstrates, a critical component and function of them.

Finally, a participatory, farmer-led approach is not suitable for all contexts and all farmers. Recruitment of farms and subsequent drop out showed it was appealing to only some and the sample was biased towards those that were either interested in the subject of AMU, were enthusiastic about discussion groups or felt they ought to do something on the issue of AMU as milk contract stipulations were forcing them to (Morgans, 2019). Reasons why farmers may not take part in such an approach are further explored by Morgans (2019). The small sample size and limitations to the quantitative outcome measurements make comparisons and generalisations limited in this sort of study. Nevertheless, a wide range of farms participated despite the level of commitment required over the 2 years. The approach

helped farmers navigate the changes that they knew were necessary and supported them to find practical solutions specific to their farm where there were many ways to optimise herd health and achieve a reduction in AMU.

CONCLUSION

Farmer Action Groups are a further example of a participatory, farmer-led approach to instigating and supporting changes to practice. This study is a novel application of the approach in the context of reducing AMU on UK dairy farms. This study supports the growing literature on the validity and applicability of bottom-up approaches in differing contexts. The FAG approach differs to traditional advisory services by prioritising and promoting farmer expertise in identifying and solving farm specific challenges. Participants demonstrated their ability to change practices on farm to reduce their reliance on antimicrobials through the co-creation of 30 Action Plans covering a wide range of topics with an average implementation rate of 54.3% after a year. Many participants found the project facilitation and participatory mechanisms helpful in prioritising tasks and learning from their peer group. A key outcome for farmers was the new knowledge they generated from participation rather than from their veterinarians, which contributed to farmers' efforts to shift away from HPCIA before UK farm assurance regulation came into force in 2018 (Red Tractor, 2018). A farmer-led, participatory approach that values different forms of knowledge and the mobilization of that knowledge by professionally trained facilitators is one way of helping farmers to adapt and develop their practices.

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Figure 1 – *The Phase 1 process for the Farmer Action Group method: co-creation of agenda, data collection and meeting sequence*

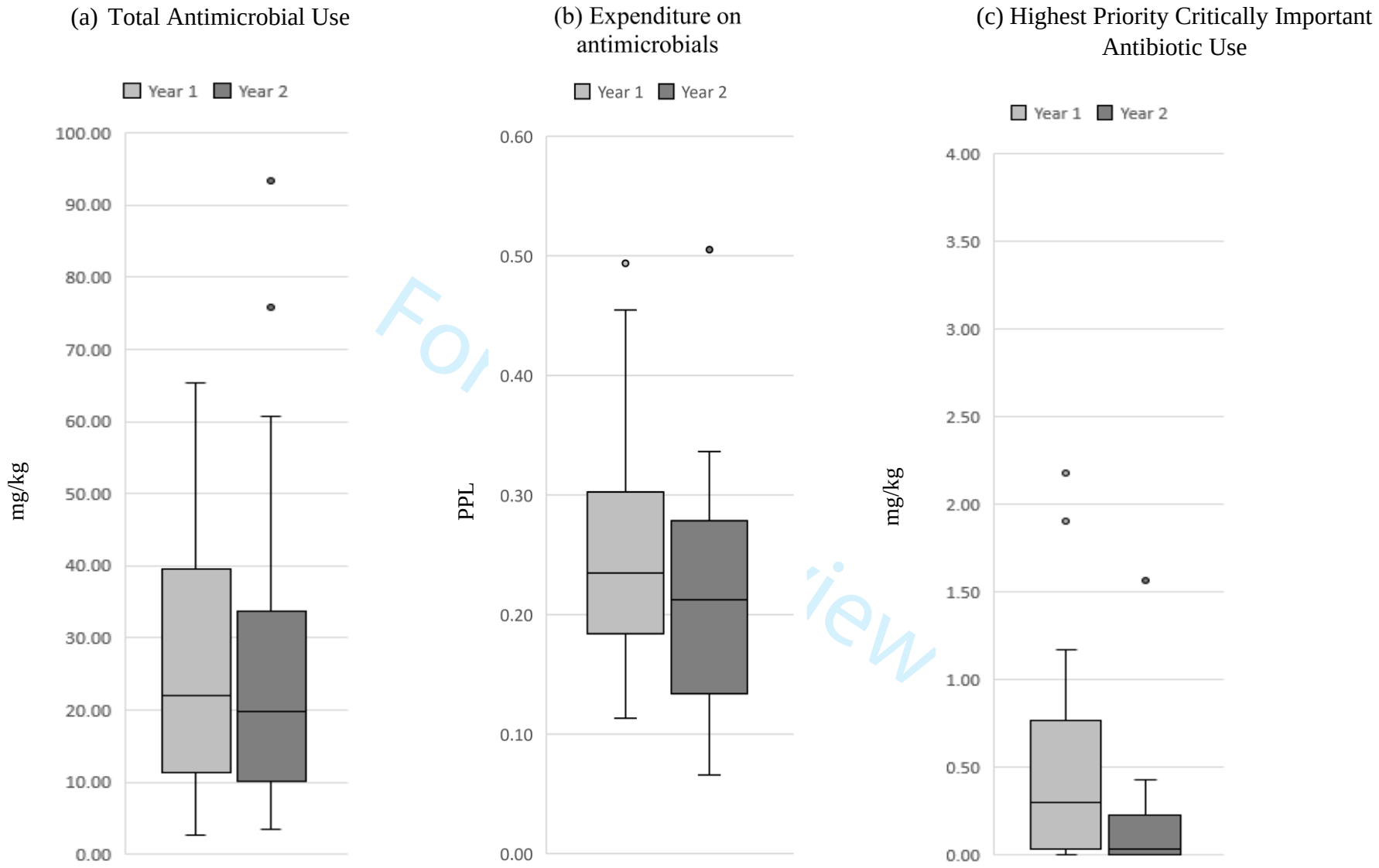

Figure 2 *- The Interquartile ranges (shaded boxes), Medians (middle solid line in shaded box), range of observed data (whiskers) and outliers (dots) of (a) Total antimicrobial use from year 1 to year 2 in mg/kg[1] (**p** = 0.719), (b) Expenditure on antimicrobials from year 1 to year 2 in PPL[2] (**p**=0.008), and (c) HPCIA[3] use from year 1 to year 2 in mg/kg (**p** < 0.001) across n=30 farms.* *[1] mg/kg = Milligram per kilogram; [2] PPL = pence per liter of milk; [3]HPCIA = Highest Priority Critically Important Antibiotic*

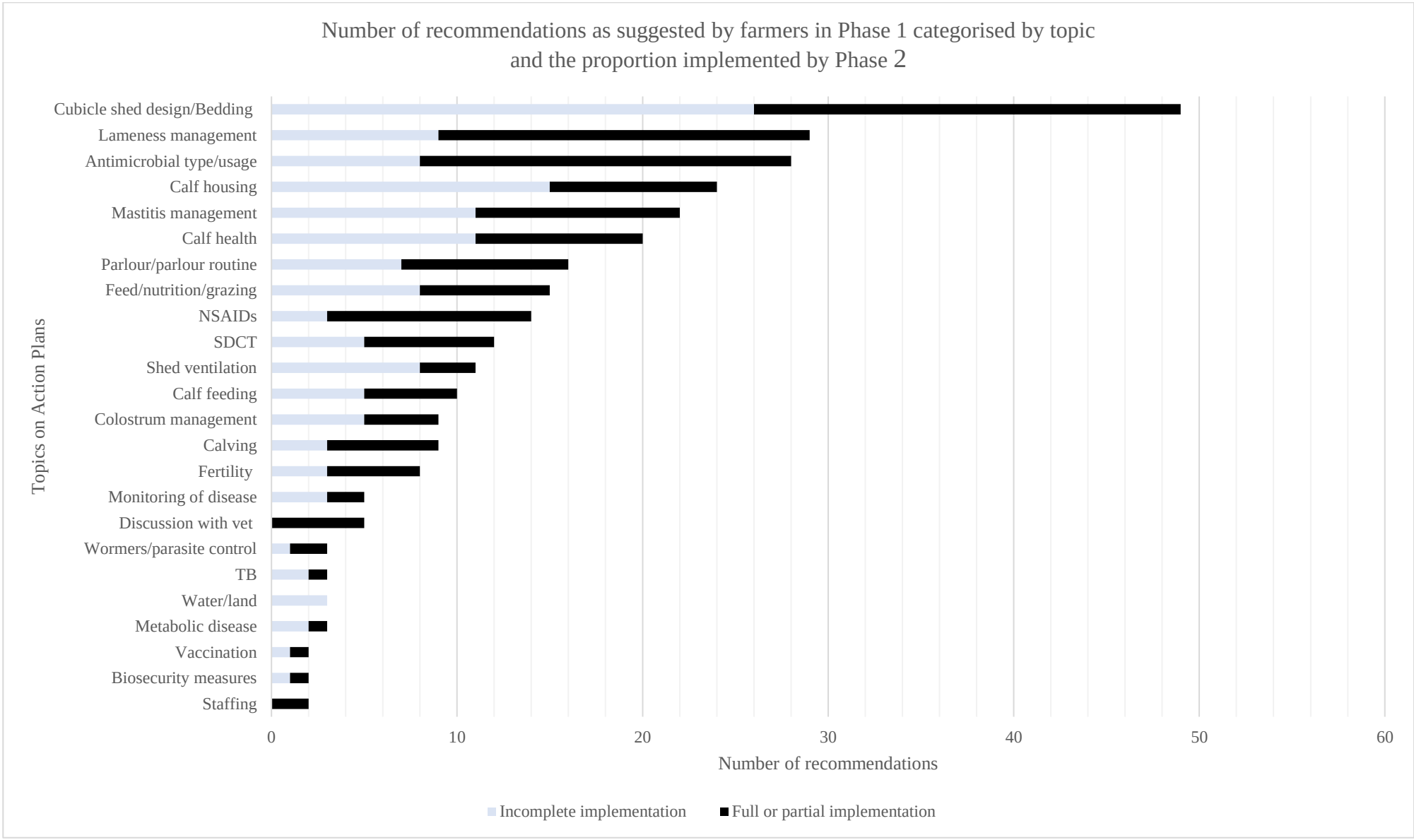

Figure 3 *- Bar graph of number of recommendations in each topic from the 30 Action Plans and proportion implemented by Phase 2. NSAID = Non-Steroidal Anti-Inflammatories; SDCT = Selective Dry Cow Therapy; TB = Bovine Tuberculosis*

Table 1. Participant reported completion of individual recommendations from the 30 Action Plans (%)

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

Table 2. Participant perceived benefit from implementing individual recommendations from the 30 Action Plans (%)

No. of recommendations assessed	Full benefit	Partial benefit	Yet to see	No benefit	Do not 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 2 farms' Action Plans

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APPENDIX 1

Semi-structured interview topic guide - FAG participants

- How have you been getting on since we last met?
- 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?