Final grant report form: Norman Hayward Fund

PROJECT/STUDY TITLE:	DEVELOPMENT OF A VALIDATED LAMENESS CONTROL PLAN FOR SHEEP FLOCKS
PRINCIPAL APPLICANT(S)	Professor Laura Green
GRANT AWARDED (DATE):	July 2013

Lay summary of project outcomes, achievements and potential impact: Max 300 words

This project's aim was to create and test an adaptable lameness control plan that could be tailored to individual farm managements and reduce lameness prevalence. Study farmers were divided into 2 groups (tiers) and visited every 3 months for 18 months. Tier 1 farmers received their tailored lameness control plan after their first visit, and farmers in tier 2 received their plan after their third visit. Forty-six farmers were initially enrolled in the study, from which pre-plan data were collected from 44 farms and on-plan data from 41 farms.

There was a significant decrease in lameness prevalence and severity after farmers were given a lameness control from implementation to visit 5. The unseasonably warm, wet weather in Nov 2015-Apr 2016 (visits 6 and 7) led to significant increases in lameness prevalence on some of the study farms.

Housing sheep was associated with an increased prevalence of lameness for each week the flock was inside. Separating lame animals for treatment, culling animals lame more than twice a year, and only footbathing when animals are gathered or during outbreaks of interdigital dermatitis contribute to a reduced lameness prevalence. Maintaining accurate records and using these in an informed culling and replacement policy also helps to reduce the level of lameness in a flock. Several best practice recommendations, including not trimming diseased feet, not routinely foot trimming the flock, and treating within 3-7 days, were carried out by the majority of participants, so it was not possible to determine their impact but previous research indicates they are vital to controlling lameness.

Based on the results, we have developed a list of high- and medium-impact recommendations for combating sheep lameness that are grouped into six main categories: Housing, Biosecurity, Disease Transmission, Treatment, Culling and Breeding Selection, and Planning and Monitoring.

Word count: 295

Provide detailed expenditure breakdown of how your grant was spent against the budget headings in your original application. This can be submitted as a separate report page.

The total spend against the AWF funding is:

		Budget	Actual Spend
-	PI: L Green	£21,208	£21,108.00
-	Technician: J Gaudy	£60,854	£69,029.20
-	Travel	£20,000	£12,065.78
-	Consumables	£ 2,000	£ 1,759.02
		£103,962	£103,962.00

Detailed progress against original objectives: List outcomes against original objectives. Discuss what has been achieved, including any statistical analysis completed as part of the project.

Aim 1: Design a well-specified, practical, lameness control plan using all international peer reviewed and professional literature embedded in individual farm managements.

Identification of key managements for the lameness control plan

Published literature was reviewed and used together with discussions with experts and anecdotal comments from farmers to identify key managements for the lameness control plan. A total of 37 managements were identified (Table 1, Appendix). Tasks were rated as "high", "medium" or "low" likely impact on the prevalence of lameness based on the strength of supporting evidence. Managements were divided into 6 subgroups; "lesion identification and treatment", "vaccination", "biosecurity", "footbathing", "culling and breeding selection" and "housing and pasture management".

Preparation of a detailed booklet with information on lameness

The aim of the booklet was to provide farmers with detailed information on lesion recognition, recommended do's and don'ts of management with evidence for 'why' a management was recommended and issues farmers should consider when determining whether a management was feasible for their farm and system. In the subgroup 'lesion identification and treatment' there were colour images with descriptions of the six most common causes of lameness in sheep. For the remaining five subgroups the risks for lameness and explanations for the recommended managements to avoid the risks within each subgroup were presented. Each subgroup was colour coded to help farmers navigate around the booklet.

Aim 2: Assess whether the implementation of the lameness control plan delivers a reduced prevalence of lameness in sheep

Recruitment and enrolment of farmers

Farmers were recruited from a sub-sample of English sheep farmers who had participated in two surveys in 2013 and 2014 (Winter et al., 2015). The criteria for enrolment were that they were willing to participate in further research into lameness in sheep, had a flock size of 100-500 ewes, a farmer-estimated annual period/monthly peak prevalence of lameness in their flock of ≥5% and were willing to record treatments given for lameness throughout the study.

Invitation letters with prepaid return reply forms were sent to 73 farmers. Telephone calls were made to farmers who did not reply within four weeks. A second letter was sent to farmers who could not be contacted by telephone. Recruitment ended on October 31st, 2014. A total of 46 farmers agreed to participate in the study.

The study design was a stepped wedge trial (Brown and Lilford, 2006) with 23 farmers provided with recommendations after the first visit to their farm (tier 1) and the remaining 23 provided with information after the third visit to their farm (tier 2). Tier 2 farmers therefore provided control data on prevalence of lameness for visits 1-3. Participants were allocated to tier 1 and tier 2 using stratified random sampling. Flocks were paired by geographical location and flock size and a coin was tossed to allocate one of each pair to each tier. Flock size and farm locations by region are presented in Table 2.

Table 2. Summary of participants by region; GM=geometric mean

Region	No. of Farms*	Avg. Flock Size (Range)	GM % Lameness (Range)
East Midlands	10	299 (140-500)	6.63 (5.00-10.00)
West Midlands	12	304 (113-650)	6.56 (5.00-15.00)
Northeast	9	307 (180-430)	8.23 (5.00-15.00)
Northwest	1	360	13.00
Southwest	12	291 (130-400)	7.64 (5.00-15.00)

* 3 farms contributed control data only (2 West Midlands, 1 East Midlands)

Participants were visited at approximately 3-month intervals from enrolment to the end of the study. At each visit flock locomotion was scored (Kaler and Green, 2009) and treatment data forms were collected. Farmers were interviewed at alternate visits from the first visit to record the managements carried out over the previous 6 months. These visits also allowed for on-going discussion, assessment and adaptation of the lameness control plan. An annual review including treatment data, prevalence and severity of lameness was presented to farmers after the first year of the study. Full details of the interview and data collection schedule are presented in Table 3 and detailed below.

Table 3. Interview and data collection schedule; blue indicates activity during the listed period

Objectives	**Visit 1** Aug-14 to Oct-14	**Visit 2** Nov-14 to Jan-15	**Visit 3** Feb-15 to Apr-15	**Visit 4** May-15 to Jul-15	**Visit 5** Aug-15 to Oct-15	**Visit 6** Nov-15 to Jan-16	**Visit 7** Feb-16 to Apr-16
Confirm Survey Data	■						
Tier 1 First Interview	■						
Tier 1 Follow-up Interview			■		■		■
Tier 2 First Interview			■				
Tier 2 Follow-up Interview					■		■
Annual Review					■		
Lameness Prevelance Assessment	■	■	■	■	■	■	■
Locomotion Scoring		■	■	■	■	■	■

Data collection at the first visit to participants

The first visit was conducted as soon possible after a farmer was enrolled. At this visit farmers signed a consent form and we requested contact information for their veterinarian. All the participants were asked to confirm details that we held from the previous study, including flock size, average lameness prevalence, treatments used for footrot. In addition we recorded timelines in the annual sheep cycle for lambing, weaning and housing. Tier 1 participants were asked questions about other enterprises on the farm, work farmers did away from the farm, times of year when they considered they were too busy to treat individual lame sheep, and detailed information about their flock management and lameness control methods at this first visit. Tier 2 participants were asked these questions at the third visit.

Construction and delivery of the farm-specific lameness control plan

Based on the information collected at visit 1 (tier 1) and visits 1 and 3 (tier 2), a bespoke lameness control plan was constructed for each farm. This included managements we wished participants to continue. The plan was presented to tier 1 farmers 2-4 weeks after the first visit and to tier 2 farmers 2-4 weeks after the third visit. The plan was discussed to ensure that farmers understood the recommendations and to facilitate implementation. During this discussion, the researcher (JG) provided evidence to support the recommendations and facilitated thoughts on how adaptations might be made to current managements so that farmers adopted the recommended changes. For example, one farmer stated he could not catch and treat lame sheep within 3 days (which reduces transmission of disease to flock mates) because a mobile handling facility was needed each time they caught individual sheep and they had sheep in many different fields; however, they could take sheep that were lame to a separate field once caught and so reduce onward disease transmission using this management.

Follow-up interviews with participants

Farmers were re-interviewed at the 3rd, 5th and 7th visits. At all follow-up interviews participants were asked targeted questions about their management of lameness for the previous 6 months; e.g. information gathered at the interview during visit 3 was applicable to the period between visits 1 and 3. These questions were on a Likert scale of “Always”, “Usually”, “Sometimes”, “Occasionally”, or “Never” to establish the degree of compliance with each recommendation.

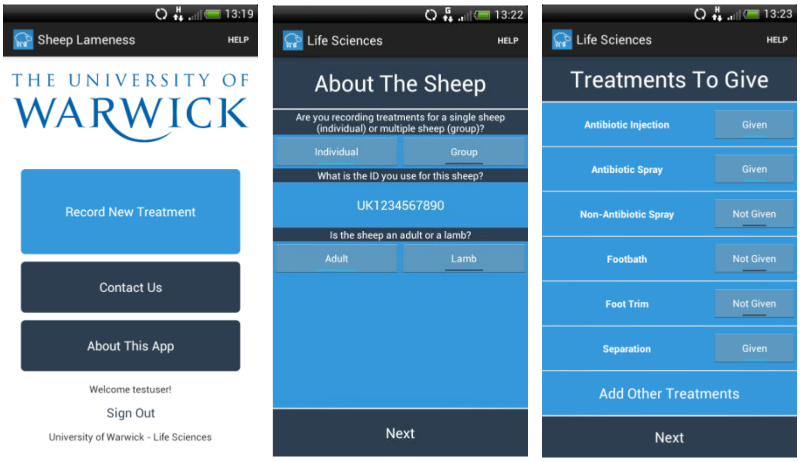
Locomotion scoring of sheep

An estimate of lameness prevalence was made at visit 1, and the locomotion of the whole flock or a representative group (at least 15% of the flock) was scored (Kaler and Green, 2009) at the remaining 6 visits. Scoring was recorded on a commercial smartphone app (Advanced Tally Counter Pro), using a customized tally recording system. Results were saved in a CSV file to a mobile phone and emailed with the date and time of scoring.

Recording treatment of lameness

Farmers were asked to record all treatments and preventions of lameness throughout the study. Some farmers already used paper or digital records, and so chose to submit these. Others were given the option of using a paper form designed for the study or a digital system created for the study with help from a student in the Department of Computer Sciences at the University of Warwick (Andrew Sula). The digital system included a smartphone app that was compatible with both iOS and Android operating systems, and made available for download through Google Play and the Apple App Store (Figure 1). An online portal was created for farmers with other operating systems. To access the system, farmers entered their Farm ID and a unique password.

Figure 1. Screen shots of the lameness treatment recording app



Data storage

Access databases were created to store the interview and treatment data. Treatment data from the smartphone app and online portal was stored in CSV format on a secure server at the University of Warwick. Locomotion score data were converted into an Excel spreadsheet to calculate the prevalence of lameness and the average severity score for each farm at each visit.

Compliance with the study

There was complete data from 21 tier 1 farms and 20 tier 2 farms; five farmers left the study after visit 3, two were from tier 1 and three from tier 2. All data from the tier 1 participants who left the study was removed because there was insufficient time to measure change in lameness as a result of the intervention. Data from the tier 2 participants who left the study was pre-plan control data for the analysis.

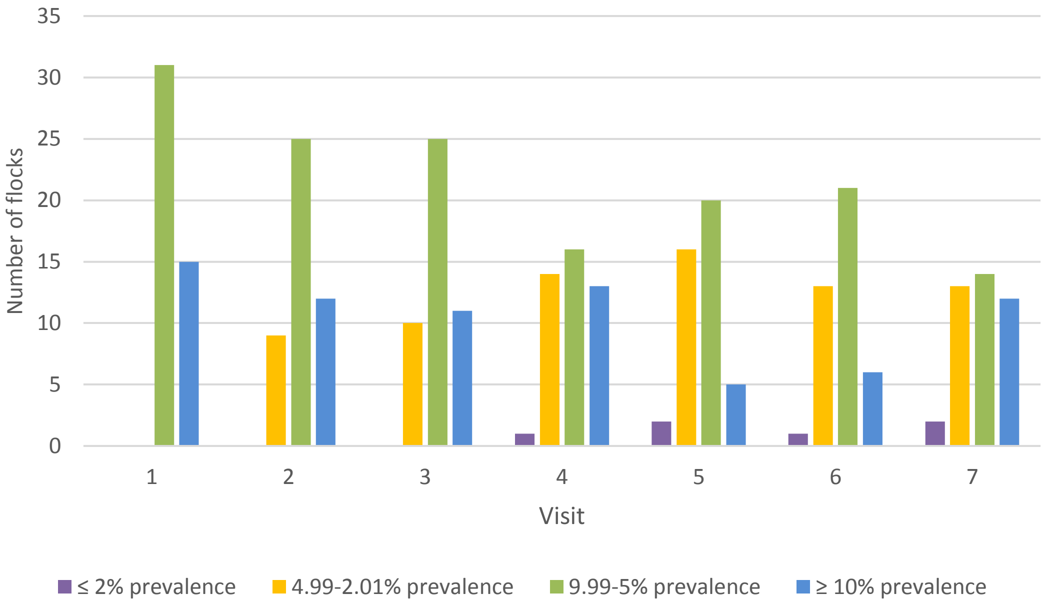
Assessment of prevalence of lameness (locomotion scores >1) on farms over time

The geometric mean lameness prevalence for each tier at each visit, calculated based on the number of animals within an assessed group that had a locomotion score >1, is presented in Table 4. By visit 3, within the first 6 months of tier 1 farmers receiving their control plan, the geometric mean prevalence of lameness was lower in tier 1 farms but not in tier 2 farms. When tier 2 farms were given treatment plans after visit 3 a decrease in average lameness prevalence was observed. Flocks were put into one of four categories of ≥10%, 9.99-5%, 4.99-2.01%, ≤2% prevalence of lameness at each visit. As the study progressed flocks moved to lower prevalence groups until visit 6 when whilst some farmers kept the prevalence of lameness low it rose dramatically in other flocks (Figure 2).

Table 4. Geometric mean (GM) and 95% confidence intervals (CI) of lameness prevalence by visit and tier

Visit	Tier	GM % lame	Lower 95% CI	Higher 95% CI
1	1	7.67	7.03	8.31
	2	6.96	6.34	7.58
2	1	7.63	6.96	8.30
	2	7.43	6.75	8.11
3	1	6.81	6.10	7.52
	2	7.35	6.73	7.97
4	1	6.12	5.38	6.86
	2	6.46	5.65	7.27
5	1	4.67	3.95	5.39
	2	5.56	4.76	6.36
6	1	5.33	4.65	6.01
	2	6.79	6.12	7.46
7	1	7.12	6.28	7.96
	2	6.73	5.86	7.60

Figure 2. Bar chart of the number of flocks by lameness prevalence category by visit



To assess the change in lameness prevalence within farm we used the reliable change index (RCI), which provides an indication of whether an observed change between measurements within a farm is significant and the direction of the change (Jacobson and Truax, 1991). The baseline for comparison was the visit before the lameness control plan was implemented. There was a significant reduction in lameness prevalence in majority of tier 1 and tier 2 after implementation of the plan (Figure 3a and 3b). This continued up until visits 6 and 7 when there was an increase in mean lameness prevalence. Visits 6 and 7 made were in an unseasonably warm, wet winter when many flocks were housed.

Figure 3a. Geometric mean (GM) and reliable change index for tier 1 farms

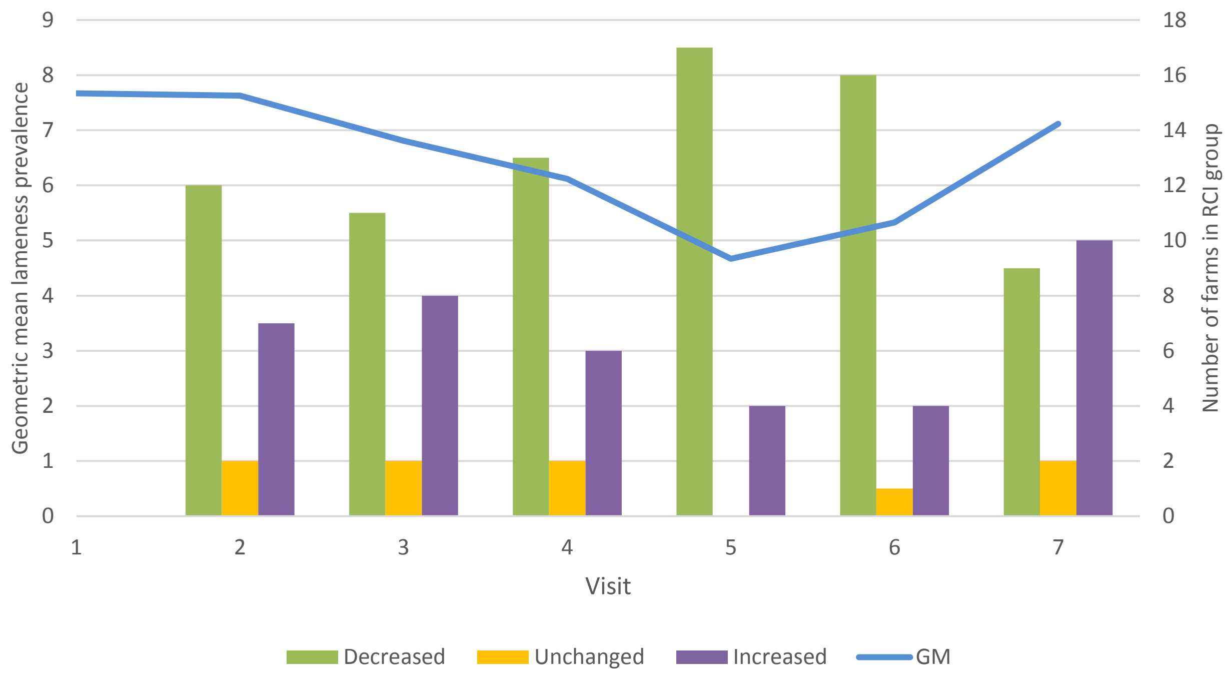
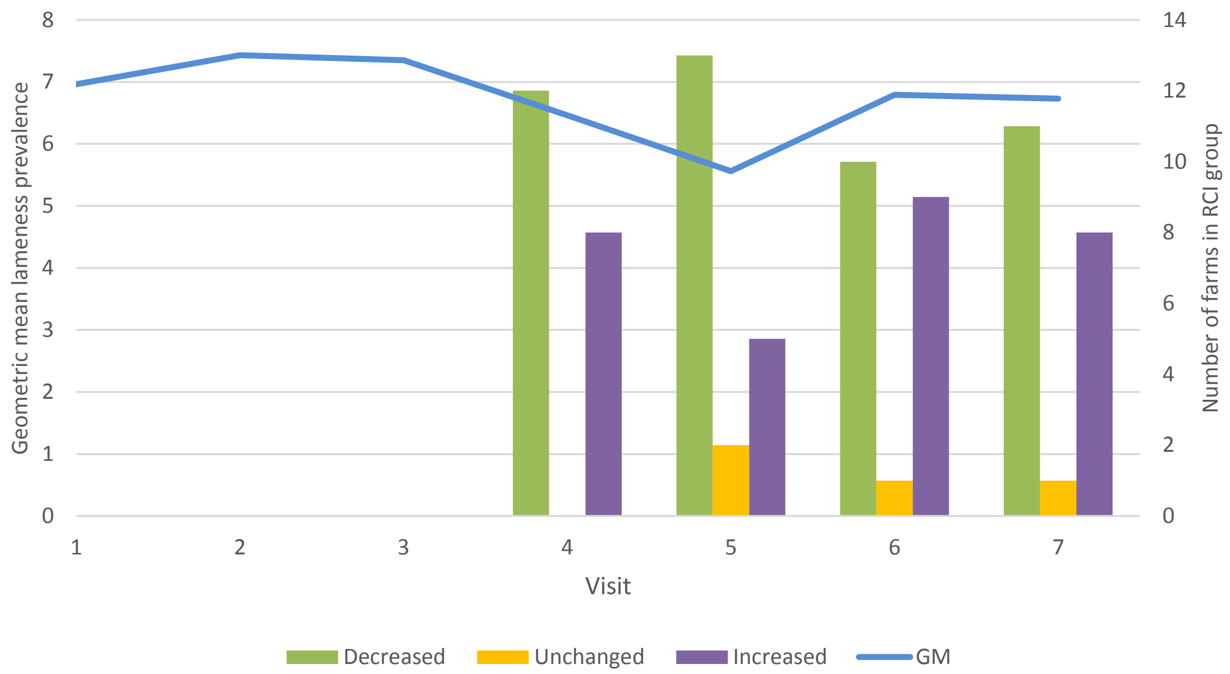


Figure 3b. Geometric mean (GM) and reliable change index (RCI) prevalence results for tier 2 farms



*Decreased (unchanged / increased) = significant decrease (unchanged/increased) in prevalence of lameness from prevalence at last control visit

Based on these results, the lameness control plan had a significant impact on reducing the lameness prevalence on most farms. At visits 6 and 7, some farms maintained the prevalence of lameness from the previous visit, or even saw a reduction, while others had a sudden increase above the highest initial reported prevalence of lameness of 15%, with two farms exceeding 20% prevalence. We attributed this to a combination of heavy, flooding rain and warmer than usual temperatures, along with a decrease in farmer compliance with the control plan in the face of these extreme weather conditions.

Assessment of severity of lameness on farms over time

Locomotion score severity data were recorded on every farm from visit 2, from which we calculated the number and percentage of ewes by score tier and visit (Table 5). As with the prevalence data, there was a decrease in the number of animals with higher locomotion scores (score 2-6) and an increase in clinically sound sheep over time until visits 6 and 7 (score 0-1). Farmers in tier 1 reached and maintained a higher percentage of clinically sound sheep than tier 2 farmers, probably because of the longer time spent on the lameness control plans.

Table 5. Number and percentage of sheep across all flocks by locomotion severity score by visit by tier

Visit	Tier	Score 0-1 No. (%)	Score 2 No. (%)	Score 3 No. (%)	Score 4 No. (%)	Score 5 No. (%)
2	1	5454 (92.16)	204 (3.45)	185 (3.13)	30 (0.51)	45 (0.76)
	2	4829 (91.96)	187 (3.56)	169 (3.22)	30 (0.57)	36 (0.69)
3	1	3001 (92.91)	110 (3.41)	90 (2.79)	13 (0.40)	16 (0.50)
	2	3396 (92.53)	125 (3.41)	113 (3.08)	18 (0.49)	18 (0.49)
4	1	3842 (93.82)	141 (3.44)	86 (2.10)	13 (0.32)	13 (0.32)
	2	2788 (93.71)	113 (3.80)	55 (1.85)	8 (0.27)	11 (0.37)
5	1	4947 (95.25)	130 (2.50)	96 (1.85)	12 (0.23)	10 (0.19)
	2	3117 (93.60)	101 (3.03)	85 (2.55)	10 (0.30)	17 (0.51)
6	1	4507 (94.72)	134 (2.82)	93 (1.95)	9 (0.19)	15 (0.32)
	2	2485 (92.97)	93 (3.48)	74 (2.77)	8 (0.30)	13 (0.49)
7	1	3096 (91.81)	123 (3.65)	116 (3.44)	21 (0.62)	16 (0.47)
	2	2377 (91.66)	87 (3.36)	100 (3.86)	16 (0.62)	13 (0.50)

Aim 3: Identify and understand the key risk factors influencing the success or failure of the lameness control plan

Interview data were exported to an Excel spreadsheet and combined with locomotion score data to assess the level of compliance at different times of year and the effect this had on prevalence of lameness. Interview data was then given a numeric compliance score based on the recorded response ("Always"=4, "Usually"=3, "Sometimes"=2, "Occasionally"=1, "Never"=0). For individual recommendations, a score of 4 was categorised as compliant while all other scores were categorised as non-compliant.

Data analysis was carried out in MLWiN version 2.35 (Rasbash et al., 2015) using a two-level continuous outcome model. This model took the form of:

$$y_{ij} = \beta_0 + \beta x_j + \beta x_{ij} + u_j + e_{ij}$$

Within this model, y (lameness prevalence) is the continuous outcome variable, β_0 is the intercept, βx is a series of vectors of fixed effects that vary at j (farm) and i (visit), with residual variance estimates u_j and e_{ij}. Forward manual stepwise model building was used to analyse individual variables for significant association ($P<0.05$) with the outcome variable. Where 2 significant variables were highly correlated, we selected the most biologically plausible variable to remain in the model.

Univariate analysis results

In total 46 variables were assessed in the univariate analysis. These variables included the 37 recommendations, as well as whether the flock was housed and for how long, whether the farm had a history of CODD, regional temperature and rainfall for the month prior to the visit, percent compliance with recommendations, how long the farm was in the study and how long they had been on the lameness control plan. There were 9 variables significant at P<0.05 in the univariate analysis. Four variables were protective when farmers were compliant; these were not foot trimming diseased feet, culling animals with 2 or more cases of lameness within a year, having a separate pen or paddock for separation of lame animals, separation of lame animals throughout the year. Five variables were associated with higher prevalence of lameness, these were housing and number of weeks housed, initial prevalence of lameness, compliance with treatment recommendations for CODD and having double-fencing paddocks that were adjacent to neighbouring farms livestock.

In light of the univariate results, we created 2 additional variables for testing in the final model. A footbath variable was coded as the average score of "Footbath animals if there is an outbreak of interdigital dermatitis" and "Footbath animals only when gathered or during an outbreak"; a score of ≥3.5/4 was categorised as compliant. A separation variable was coded as "Separate lame animals all year round as soon as seen lame" classified as being fully compliant and "Separate lame animals at key times of year (housing / weaning)" as being partially compliant.

Final model and outcomes

The final model (Table 6) consisted of 6 variables including correct treatment of white line abscesses, culling sheep lame twice or more per year, separating lame sheep throughout the year and compliance with both of our footbath recommendations were associated with reduced prevalence of lameness. Conversely, initial prevalence of lameness, number of weeks spent in housing, and separating animals at key times of year were associated with an increased prevalence of lameness. Another interesting outcome was that those that were footbathing, but not compliant with our recommendations, had no significant decrease in lameness prevalence compared with farmers that did not own a footbath.

Table 6. Multi-level model of 44 flocks adjusted for repeated measures of the same flock

Variable	Average change in lameness (%)	Lower 95% CI	Upper 95% CI
Cull after 2 or more cases	-2.06	-3.78	-0.34
Treat white line abscesses with injectable long-acting antibiotics and topical spray	-1.64	-3.27	-0.01
No separation of lame sheep	0.00		
Separate lame sheep throughout the year	-3.13	-5.54	-0.72
Separate lame sheep at key times of year	2.44	0.38	4.50
Routinely gathering the flock for the sole purpose of footbathing	0.00		
Only footbath when animals are gathered and during outbreaks of interdigital dermatitis	-1.33	-2.29	-0.37
Do not own a footbath	0.09	-1.22	1.40
Weeks housed (average change per week)	0.14	0.06	0.22
Initial lameness prevalence	0.38	0.24	0.52

Impact of regular farm visits by the research assistant

In this study the research assistant's 3-monthly visit was viewed by participating farmers as very positive; farmers said that regular input from a trusted outside source is highly valuable and provided motivation for compliance. There is evidence that using vets and other consultants to help plan flock health on a regular basis is rare. Sheep farmers view vets more as problem solvers in a disease outbreak situation and are not clear how consultancy could be of value (Kaler and Green, 2013). Recent moves to set up sheep health clubs, where several farmers meet with one vet (Lovatt, 2015), are one possible solution. We propose that farmers and an external adviser (vet/consultant) meet regularly to plan ahead for challenges in the coming 3 month period, such as management of lame sheep at housing, or demands on the farmer's time (i.e. harvest).

Aim 4: Revise and finalise the lameness control plan in light of the project results and to present a clear 'route map' for sheep vets, advisers and producers

We used results from current and previous research to revise the list of recommendations for the lameness control plan (Table 7, Appendix). This list is grouped into 6 major headings (Housing, Biosecurity, Disease Transmission, Treatment, Culling and Replacement Selection, and Planning and Monitoring) with recommendations to address each area. This list, together with knowledge of the farm, time, labour and facilities available, can be used to facilitate compliance and increase farmer satisfaction.

Discussion of individual headings

- **Housing** - Housing was a risk time for many farmers in the study, on average there was a significant increase in prevalence of lameness with each sheep were housed (Table 7). Many farmers house their flocks in winter. The high stocking density and warm, damp underfoot conditions create a highly favourable environment for the spread of footrot and CODD. Farmers should aim to reduce these effects as much as possible by only housing as long as is absolutely necessary, separating lame animals, topping up bedding frequently before it becomes damp, and spreading disinfectant or lime when topping up bedding.
- **Culling and Replacement Selection** – This is the first study to identify culling of repeatedly lame animals as a beneficial practice for the control of lameness. Sheep that are persistently lame, e.g. with granulomas or repeated bouts of footrot, add to the overall lameness prevalence as well as spreading disease within the flock. At the start of a control programme, the faster these sheep are culled the faster the fall in lameness prevalence and the more immediate the improvement in the health of the flock. If lame sheep are then treated correctly and over trimming of hoof horn is avoided few sheep become persistently or repeatedly lame and the requirement to cull reduces to a very low level. Removing highly susceptible sheep through culling can be complemented by actively avoiding selecting replacements from repeatedly lame ewes which also reduces the prevalence of lameness (Winter et al 2015) by increasing resistance in the flock. Sheep should be culled if they have 2 or more bouts of lameness within a year. Farms with exceptionally high levels of chronically lame sheep could start by culling after 3 or more bouts of lameness, but it is essentially that they move to culling more severely in order to see a reduction in their overall prevalence of lameness.
- **Biosecurity** - There are 10 different serogroups of *Dichelobacter nodosus*, the organism responsible for footrot and interdigital dermatitis, so whilst the vast majority of sheep farms have footrot present, new strains can be introduced if biosecurity is poor. There are also infectious diseases, such as CODD, that can have devastating effects if introduced to a naïve flock. Purchasing replacements from a known private source allows farmers to be more selective and gather more information about the animals before arrival, while quarantine for at least 4 weeks gives farmers the chance to observe new and returning animals for developing lameness, as well

as to inspect all four feet for signs of disease. It is also essential to maintain stock-proof boundaries to limit contact with other livestock, particularly in fields that are adjacent to a neighbor with sheep; such fields should ideally be double-fenced.

- **Disease Transmission** - Sheep with interdigital dermatitis and footrot are infectious. Rapid correct treatment, separation of lame sheep for treatment, and footbathing healthy feet after gathering the flock contribute to reducing the spread of footrot. It is also recommended to walk animals through a footbath as they go into and out of quarantine, as these areas are at risk of building up high levels of bacteria.
- **Treatment** - Prompt treatment with appropriate therapy will not only reduce recovery times for lame animals, but will also help reduce the spread of disease as well as ultimately reducing the number of antibiotic treatments required within a flock. While ideally sheep would be treated the day they are seen lame for that individual's welfare, this is not always in the best interest of the group. Decreased disease transmission is seen when sheep are treated within 3 days and the benefits persist, although they are less, if sheep are treated in 4-7 days. Waiting longer than a week to treat does not prevent the spread of footrot. Veterinarians can advise on the most appropriate antibiotic to suit the farm and the conditions present, but ensure farmers are made aware of the recommended dose as under-dosing is ineffective for recovery from footrot.
- **Planning and Monitoring** - Lameness management decisions are made based on knowledge of individual animals, the flock and the farm, so having as much information as possible means those decisions are more likely to be both efficient and effective. Whether it is written on paper, saved on a computer, or carried on a personal device, having the information available when needed is essential.

Revision of booklet and other materials

In light of the results of this study and the changes we recommend to the original plan, we are updating the booklet and will make it available as a PDF document from our research group webpage. Results from the project will also be passed to the veterinary and farming communities at events and conferences, as well as in published works that are currently being written.

Were there any challenges or barriers/modifications to the project? Explain the nature of and reasons for any changes in project focus, scope, delivery, schedule or evaluation.

The project was delayed on 2 occasions. First, recruitment for the technician position caused a delay to the start of the project from October 2013 to January 2014. Second, we elected to delay recruitment until the completion of a survey study being undertaken within the Green Research Group. This delay allowed us target recruitment for the study to farms with a persistently high lameness prevalence, but resulted in a delay in the roll out of the lameness control plans. Overall, there was a 6 month delay which meant that instead of 2 full years of data collection we had 18 months. We therefore took the decision to reduce the first year of pre-plan data collection of tier 2 farms to accommodate this, and requested a 1 month extension to the completion date of the study without the need for additional funding. With these changes, we were able to collect 6-8 months of control data instead of 12 months, which generated substantial baseline control data as well as the expected intervention data, and we complete the project to time.

Provide details of knowledge transfer activities to date and any future plans/actions.

Professor Green and Ms. Gaudy attended the Livestock Event 2014, a major annual farm show in Birmingham, to deliver talks to sheep farmers on lameness treatment. Ms. Gaudy also travelled with AHDB to the National Sheep Association's South Sheep 2014 event and provided information on lameness treatment to farmers visiting their stall.

In January 2016, the Green Research Group from the University of Warwick hosted a farmer information day for individuals that had participated in any of our various sheep research projects. 65 farmers attended, including 5 from the current study. This day included presentations and guided discussions on control of sheep lameness based on our latest results.

Ms. Gaudy presented a project poster at the annual conference of the Society for Veterinary Epidemiology and Preventative Medicine in 2015 and 2016, as well as a conference on recent advances in animal welfare science hosted by the Universities Federation for Animal Welfare in 2016.

Three case reports based on results from farmers in this study were included in a special bulletin produced by AHDB Beef and Lamb in June 2016. This bulletin focused on sheep lameness control and was circulated to all members of their Better Returns program.

Based on the results of this study, we will amend the booklet that was provided to participants and make it available as PDF file on the University of Warwick website dedicated to farmer and veterinary outreach within our research group. (http://www2.warwick.ac.uk/fac/sci/lifesci/research/greengroup/farmersandvets)

The results will also be used to update our group website dedicated to the control of footrot and interdigital dermatitis. (http://www2.warwick.ac.uk/fac/sci/lifesci/research/greengroup/farmersandvets/footrotinsheep/)

We also plan to bring the results to the wider farming community through attending sheep and agriculture shows through 2017.

Provide details of any original peer-reviewed research papers, book chapters and books/monographs that have resulted directly from your work supported by this grant.

A paper is in preparation for Preventive Veterinary Medicine with the anticipation that it will be published in 2017.

Have any other funding bodies been involved in supporting the development of the work supported by this grant?

AHDB Beef and Lamb contributed £12,000 in kind for knowledge transfer. This has been used to update their “Reducing lameness for better returns” manual, as well as produce a lameness bulletin in July 2016, and to produce new updated information videos.

Has any intellectual property activity has resulted directly from the research funded through this grant to date?

The work on this project yielded several bespoke creations, all of which remain the intellectual property of the University of Warwick. First, software code was written for a smartphone app for use by study participants. Along with this, code was written for 2 websites; one for use by farmers in the study and the other for use by the researchers. A Norman Hayward Fund grant (reference number: NHF_2016_06_LG) has recently been approved to expand these creations and promote the use of these systems to the wider farming community, but the copyright for these will remain with the University of Warwick. Second, we created a printed booklet for our study participants. We plan to amend the booklet in light of the study results and make it available as a PDF file accessed via our University of Warwick website (http://www2.warwick.ac.uk/fac/sci/lifesci/research/greengroup/farmersandvets). Finally, the study has resulted in the generation of knowledge which is protected as “Know How”. Throughout the project we have sought advice on Intellectual Property related to this project from Warwick Ventures Ltd., a wholly-owned subsidiary of the University of Warwick that promotes technology transfer and commercialisation of innovations from research undertaken at the university.

Briefly tell us about the staff who received a salary or stipend from this grant (including yourself) - Name, job title, full or part time

Professor Laura Green – Primary Investigator

Ms. Jessica Gaudy – Senior Research Technician, Full-time

How has the grant contributed to the professional development of the staff named above (including yourself)? Max 250 words

Ms. Gaudy has won a competitive BBSRC funded PhD at Warwick to study the role of climate in persistence of footrot. She gained training in study design and implementation and statistical software through in-house training on MLwiN and an external workshop on R. She also attended the Society for Veterinary Epidemiology and Preventive Medicine's annual conferences in 2015 and 2016 to present a project poster to colleagues, as well as attending training workshops on Bayesian statistical analysis and use of veterinary data handling packages in R. She also made use of the University of Warwick IT training courses to enhance her knowledge on Excel, Access, and EndNote software programs.

Prof. Green continued to develop experience from interchange with farmers, including 4 meetings with study participants after the first year. She also provided valuable advice during an outbreak of contagious ovine digital dermatitis on a participant farm.

Both scientists have gained knowledge in IT and app development, as well as the related Intellectual Property considerations.