A comparison of the efficacy of three intervention trial types: postal, group, and one-to-one facilitation, prior management and the impact of message framing and repeat messages on the flock prevalence of lameness in sheep

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Abstract

The aim of this study was to evaluate the effectiveness of three knowledge-transfer intervention trial types (postal, group, one-to-one) to promote best practice to treat sheep with footrot. Further aims were to investigate whether farmer behaviour (i.e. management of lameness) before the trial was associated with uptake of best practice and whether the benefits of best practice framed positively or negatively influenced change in behaviour. The intervention was a message developed from evidence and expert opinion. It was entitled "Six steps to sound sheep" and promoted (1) catch sheep within three days of becoming lame, (2) inspect feet without foot trimming, (3) correctly diagnose the cause, (4) treat sheep lame with footrot or interdigital dermatitis with antibiotic injection and spray without foot trimming, (5) record the identity of treated sheep, (6) cull repeatedly lame sheep. In 2013, 4000 randomly-selected English sheep farmers were sent a questionnaire, those who responded were recruited to the postal (1081 farmers) or one-to-one intervention (32 farmers) trials. A random sample of 400 farmers were invited to join the group trial; 78 farmers participated. A follow-up questionnaire was sent to all participants in summer 2014. There were 72%, 65% and 91% useable responses for the postal, group and one-to-one trials respectively. Between 2013 and 2014, the reduction in geometric mean (95% CI) period prevalence of lameness, proportional between flock reduction in lameness and within flock reduction in lameness was greatest in the one-to-one (7.6% (7.1 – 8.2%) to 4.3% (3.6 – 5.0%), 35%, 72%) followed by the group (4.5% (3.9 – 5.0%) to 3.1% (2.4 – 3.7%), 27%, 55%) and then the postal trial (from 3.5% (3.3 – 3.7%) to 3.2% (3.1 – 3.4%), 21%, 43%). There was a marginally greater reduction in lameness in farmers using most of Six steps but slow to treat lame sheep pre-trial than those not using Six steps at all. There was no significant effect of message framing. The greatest behavioural change was a reduction in therapeutic and routine foot trimming and the greatest attitude change was an increase in negative attitudes towards foot trimming. We conclude that all three intervention trial approaches were effective to promote best practice to treat sheep with footrot with one-to-one facilitation more effective than group and postal intervention trials. Results suggest that farmers' behaviour change was greater among those practising aspects of the intervention message before the trial began than those not practising any aspect.

Keywords: sheep; footrot; intervention study types; message framing; farmer behaviour

1. Introduction

Sheep farmers consider lameness an important welfare problem (Goddard et al., 2006). Footrot causes the majority of lameness in sheep in England (Grogono-Thomas et al., 1997; Kaler and Green 2008; Winter et al., 2015). Treating sheep lame with footrot (both interdigital dermatitis (ID) and under-running severe footrot (SFR)) within 3 days of onset of lameness (Kaler and Green 2008) with antibacterials by injection and topical treatment and without trimming hoof horn, leads to recovery of >95% sheep within 2 – 10 days (Kaler et al., 2010). In a recent study, Winter et al. (2015) concluded that routine foot trimming was unnecessary. Avoiding trimming and rapid appropriate treatment can reduce the flock prevalence of lameness to <2% (Wassink et al., 2010a) and is current "best practice" for management of footrot.

In 2013, a postal questionnaire was sent to a random sample of 4000 sheep farmers in England in 2013. Farmers reported on management of footrot, the prevalence of lameness in their flock and their opinions, knowledge and attitudes towards footrot. There were three classes of farmer management of lameness identified by latent class (LC) analysis: 11% (LC1) used best practice, 57% (LC2) followed best practice but treated sheep within a week rather than 3 days and 32% (LC3) of farmers were more likely to use traditional managements. O'Kane et al. (2016) hypothesised that farmers in LC2 and LC3 might respond differently to intervention messages promoting best practice.

Traditionally, intervention messages have consisted of generic, mass-produced printed material distributed to the population by mail (Kreuter et al., 1999). These reach many people at little expense but might not be effective (McCaul and Wold, 2002). One method of improving the persuasiveness of an intervention message is through message framing (Kahneman and Tversky, 1979), in the current example of footrot, focusing on losses incurred by not adopting best practice (e.g. 10% of sheep will be lame) or the gains that would be received by doing so (e.g. 98% of sheep will be sound). In human health, loss framed messages are more effective at promoting increased levels of detection behaviours especially when the procedural risk and uncertainty about the outcome of the behaviour is high (e.g. screening for HIV: Apanovitch et al., 2003). Conversely, gain framed messages encourage increased levels of prevention behaviour (e.g. sunscreen use: Detweiler et al., 1999) and are more effective when the procedural risk and uncertainty about the outcome is low. For footrot, farmers open to new ideas or already using some or all of best practice to treat sheep lame with footrot (i.e. LC2) might consider the risk and uncertainty about the outcome of adopting best practice as low and thus respond to gain framed messages whilst farmers resistant to change, using traditional techniques to manage lameness (i.e. LC3) might consider the risk and uncertainty high and thus respond better to loss framed messages (Ferguson et al., 2005; Ferguson et al., 2007; Rothman and Salovey, 1997, Rothman et al., 1999).

Group meetings, where farmers are addressed by a credible and trustworthy (Blackstock et al., 2010; Henriksen et al., 2015) "expert", are often used in agricultural knowledge exchange. They are considered to be more effective than mass produced literature. The ultimate tailoring of messages is one-to-one communication because it is personal and interactive, but due to cost and time constraints its use is limited (Kreuter et al., 1999).

In the current study, we tested the efficacy of three intervention trial types (postal, group and one-to-one) on farmer uptake of an intervention message for best practice to treat lame sheep.

It was predicted that the one-to-one trial would be more effective than the group trial (Figueiras et al., 2001), with the postal trial the least effective (Hawkins et al., 2008; Noar et al., 2007). In the postal intervention trial we also investigated the impact of message framing and the number of repeat or seasonally framed messages by farmer LC.

2. Materials and Methods

Consent for the study was obtained from University of Warwick ethical committees for studies on humans and animals and Defra survey control liaison unit. All trials assessed change in the flock prevalence of lameness between 2013 and 2014. The intervention trials were three within flock trials comparing one-to-one, group and postal routes to provide a message on best practice to manage lameness in sheep. In addition, the postal trial was used as a between flock trial to compare framing the intervention message as a gain or a loss and to compare repeated and seasonally targeted messages and farmer management of lame sheep before the start of the trial.

2.1 Development and testing of the intervention message and documents

The intervention was a message to encourage farmers to adopt best practice to minimise lameness in sheep. In 2012, data from one-to-one interviews with 15 experts, 7 focus groups with 46 English and Welsh sheep farmers and a telephone survey of 46 randomly selected English sheep farmers were used to identify barriers and motivators to treat lame sheep. The research team facilitated by two clinical psychologists created the intervention message ‘Six steps to sound sheep’, which was summarised in six key words: catch, inspect, diagnose, treat, mark and cull (Table 1). Leaflets and posters were developed. One version emphasised the gains of adopting best practice, while the other emphasised the losses of not adopting best practice. There was a frequently asked questions section and an email address for farmer queries. Quotes, with a photograph, from a specialist sheep veterinarian and a sheep farmer were included in the leaflet (Supplementary material). Two seasonally focused leaflets were also written for weaning – mating and pregnancy – lambing (Supplementary material). Design options were discussed with 38 farmers at Welsh Sheep 2013 and then with 30 farmers at North Sheep 2013. The finalised documents were pilot tested on 20 farmers involved in previous stages of the study, and were received positively.

2.2 Roll-out of intervention messages

2.2.1 One-to-one intervention trial

Sample size calculations indicated that a 3% change in within flock mean prevalence of lameness could be detected in 18 flocks with a variance of 10 with 80% power and 95% confidence and a two-tailed test. Thirty-two farmers (Table 2) were convenience selected into the one-to-one intervention trial from respondents to the 2013 postal questionnaire. The criteria for selection were willingness to participate, flocks with >300 sheep, with ≥5% flock lameness, with <3% lameness due to contagious ovine digital dermatitis (CODD), and farmers who either did not treat individual sheep within three days of becoming lame or did not treat individual sheep until >5 were lame in a group. Two – four farmers were visited per day between June and September 2013. Laura Green (LG) interviewed all 32 farmers, Jasmeet Kaler was present at the first 18 visits to ensure between observer agreement on the causes of lameness. At the visit, the farmer discussed their current management of footrot. Following this, the researcher(s) and farmer examined some lame sheep that the farmer had gathered. Throughout, LG and the farmer discussed best practice and whether a strategy could be identified so that the farmer could adopt the Six steps. The visits lasted 1 - 2.5 hours.

The farmer was sent a letter summarising the discussion and detailing flock specific advice within two weeks of the visit. All farmers in the one-to-one trial received the gain framed intervention message. In 2014, follow-up visits were used to discuss changes in the management of footrot on these farms. Holly O'Kane, who was blind to the discussions at the first visits, conducted follow-up visits following a semi structured interview script.

2.2.2 Group intervention trial

Sample size calculations indicated that a 2% change in within flock mean prevalence of lameness could be detected in 40 flocks with a variance of 10 with 80% power and 95% confidence and a two-tailed test. A population of 400 members of the National Sheep Association in Wales, South-West England and the English Marches regions were invited to attend one of six group meetings. The meetings were held, two per region, in August and September 2013. One meeting per region was randomly allocated to the gain framed intervention message and the other as the loss framed message by tossing a coin. A total of 78 farmers attended the meetings (Table 2). On arrival, farmers were asked to complete the 2013 questionnaire. They were then given a gain / loss framed twenty-minute presentation (by Laura Green, LEG) on the "Six steps to sound sheep". Discussion and questions from the floor were encouraged at the end of the presentation for approximately one hour. At the end of the meeting farmers were given the relevant framed intervention message documents.

2.2.3 Postal intervention trial

Sample size calculations indicated that a 2% change in between flock mean prevalence of lameness could be detected in 40 flocks with a variance of 10 with 80% power and 95% confidence and a two-tailed test. Participants in the postal trial were 1081 respondents from the questionnaire sent to 4000 randomly selected sheep farmers in 2013 (Winter et al., 2015), and excluding the 32 selected for the one-to-one trial. Participants were assigned to one of seven trial arms (TA) by random number allocation using stratified random allocation by geographical region (North, Midlands and South of England) and ≥5% or <5% flock prevalence of lameness. TA1 was a control arm that received intervention messages after the end of the study. TA2 – 7 received loss or gain framed messages, once or three times, or seasonal messages (Table 3). Messages were sent out in August and October 2013 and January 2014. Participants were blind to their TA.

2.3 Follow-up 2014 postal questionnaire design and administration

A second questionnaire (available on request) was sent to postal and group trial participants in June 2014 and to one-to-one participants immediately after their follow-up visit. The questions were identical to the 2013 questionnaire (O'Kane et al., 2016; Winter et al., 2015) but questions where responses were stable over time or redundant were removed. The questionnaire was nine pages long and captured information from August 2013 – June 2014. There were 33 questions. One question was open text, all the others were closed or semi-closed with an 'other, please state' option. In 2013 and 2014 the prevalence of lameness was estimated from the question 'Between (start month) and (end month) what was the average level of lameness in ewes in your flock?'. This question has been tested and is reliable and repeatable (King and Green 2011).

2.4 Data storage, preparation and analysis

Data entry and cleaning of the 2014 questionnaire was as for 2013 (Winter et al., 2015). The 2013 and 2014 datasets were merged in Microsoft Access 2010 (Microsoft Corp., Redmond, WA). Flocks were excluded from analysis if flock size or prevalence of lameness was not reported.

2.4.1 Change in prevalence of lameness and participants' behaviour between 2013 and 2014

The number pf flocks with a mean period prevalence of lameness between 5% and 15% in 2013, indicating that these sheep were not being managed using best practice (lameness ≥5%) and also that there was not an epidemic of lameness in the flocks (lameness ≤15%) was calculated.

For all respondents, respondents with 5 – 15% prevalence of lameness, one to one, group and postal trials and postal by LC, TA and gain and loss the following were calculated for 2013 and 2014

(1) Global mean prevalence of lameness = Σ (all lame sheep) / Σ (flock size)*100

(2) Log10 geometric mean (GM) and 95% confidence interval (95%CI) of the prevalence of lameness within a subset

Then the mean reduction and proportional reduction within flock prevalence of lameness in 2014 was calculated by

(3) Σ(2014-2013 within flock prevalence of lameness)/number in subset

and from this the mean within flock proportional reduction in percentage lameness was calculated by

(4) (mean reduction in prevalence of lameness in 2014)/(prevalence of lameness in 2013)

Finally, the reliable change index (RCI) (Jacobson and Truax, 1991) was calculated using the formula:

(5) RCI = (2014 lameness prevalence – 2013 lameness prevalence)/(SE_{diff})

Where $S_{diff} = \sqrt{2}\,(S_E)^2$ and S_E = standard deviation of the lameness prevalence ($\sqrt{1}$- test-retest reliability of the scale) (Zahra, 2010). A test-retest reliability value of 0.999 was assumed for 2013 and 2014 because it has been demonstrated that sheep farmers accurately estimate the prevalence of lameness in their flocks (King and Green, 2011). A chi-square test was then used to investigate whether frequencies of decrease / increase / no change in RCI were statistically different from chance.

2.4.2 Investigation of changes in managements and opinions about lameness between 2013 and 2014

For all flocks and subsets, related-samples Wilcoxon signed rank tests (Petrie and Watson, 2013) were used to investigate differences between 2013 and 2014 questionnaire responses to managements and opinions (IBM SPSS Statistics version 22, 2013).

2.4.3 Over dispersed Poisson regression model of the postal trial

An over dispersed Poisson regression model was used to investigate the impact of postal trial arm on the between flock period prevalence of lameness in 2014 which had had a period prevalence of lameness between 5 and 15% in 2013. The model took the form:

$$y_i \sim \alpha + \text{offset} + \beta_i X_i + e_i$$

where y_i = number of lame ewes in the flock, ~ is a log link function, α is the intercept, offset is the natural logarithm of the number of expected lame ewes in the flock, β_i are the coefficients for a vector of X_i explanatory variables which were, GM period prevalence of lameness in 2013, trial arm and latent class, which varied by farm *i* and e_i is the residual random error.

The models were developed using a manual forward stepwise approach in MLwiN version 2.35 (Rasbash et al., 2015). Variables were considered significant when the 95% confidence intervals did not include one (Wald's test). Log10 flock size was forced into models. The model fits were assessed using the Hosmer - Lemeshow test.

2.4.3 Attributable fraction and population attributable fraction of risks for lameness

The attributable fraction in exposed (i.e. those farmers practising a management) farms (AF_e) and the population attributable fraction (AF_p) for the risks for lameness were calculated from the 2013 (Winter et al., 2015) and 2014 questionnaire respondents across all trials using the formulas:

$$AF_e = (RR - 1)/RR$$

and

$$AF_p = AF_e\ (a_1/m_1)$$

where RR is the risk ratio, a_1 is the total number of farmers using the management practice and m_1 is the total number of flocks (Dohoo et al., 2003).

3. Results

3.1 Response proportions by trial and summary statistics

In total 30 (94%), 53 (68%) and 801 (74%) in the one-to-one, group and postal trials respectively responded to the 2014 questionnaire with 29 (91%), 51 (65%) and 779 (72%) usable responses respectively (Table 2). There was no difference in response proportions for LC1, 2 and 3 farmers to the postal questionnaire with 73%, 73% and 76% responses respectively. The median (IQR) flock size was 650 (440 – 898), 120 (55 – 325) and 330 (225 – 510) in the one-to-one, group and postal trial respectively. Not all farmers answered all questions.

3.2 Change in prevalence of lameness and participants' behaviours

The global mean prevalence of lameness across all flocks in all trials was 4.3% (compared with 4.9% in 2013, Winter et al., 2015), with a geometric mean flock prevalence of 3.3% (95% CI: 3.1% - 3.4%), compared with 3.5% (95% CI: 3.3% - 3.7%) in 2013). Between 2013 and 2014, the reduction in geometric mean period prevalence of lameness, proportional reduction in lameness and within flock reduction in lameness was greatest in the one-to-one intervention trial (7.6% (7.1 – 8.2%) to 4.3% (3.6 – 5.0%), 35%, 72%) followed by the group trial (4.5% (3.9 – 5.0%) to 3.1% (2.4-3.7%), 27%, 55%) and then the postal trial (from 3.5% (3.3 – 3.7%) to 3.2% (3.1 – 3.4%), 21%, 43%). Flocks in the one-to-one trial had the greatest absolute and relative reduction in prevalence of lameness, followed by the group, and then the postal intervention trials (Tables 3 and 4).

3.3 Participants management and opinions in the 2014 questionnaire, all trials

Only 24% of farmers in the control TA1 reported that they had had no written information from elsewhere during the trial. Overall, participants had received written information on lameness from their veterinarian (28% of farmers), AHDB (55%) and other sources (8%), and 17.6% also reported receiving a visit with advice on lameness from someone not part of the current study.

Significant changes in management and attitudes occurred across the trials between 2013 and 2014 (Table 5). Overall, farmers caught sheep more promptly and when fewer in a group were lame than in 2013 and, possibly as a consequence, they were more likely to report that catching lame sheep was difficult. The proportion of farmers who practised therapeutic and routine foot trimming decreased significantly between 2013 and 2014 and opinions reflecting that foot trimming was a negative behaviour increased significantly. Significantly more farmers used parenteral antibiotics to treat footrot. A greater proportion of farmers were angry / miserable about having footrot in their flock.

3.4 Over dispersed Poisson regression model of flocks in the postal trial with lameness prevalence of 5% – 15% in 2013

After adjusting for each flock's prevalence of lameness in 2013, TAs 2 - 7 had a lower mean period prevalence of lameness in 2014 than the control TA1 (Table 6). For all but TA7 the confidence intervals (CI) did not include unity (Table 6). Both loss and gain framed messages were associated with a reduction in the prevalence of lameness and 95% CI excluded unity. When flocks were grouped by loss (TA 2-4) and gain (TA5-7) framed messages compared with the control group TA1 but there was no difference in prevalence of lameness by framing of messages (data not shown). There was a marginally greater reduction in prevalence of lameness in flocks of LC2 farmers compared with LC3 with a lower coefficient but confidence intervals were that they included unity. The model fit was good (Figure S1). There was insufficient power in the group trial to investigate loss and gain framed messages.

3.5 Attributable fractions of risks for lameness between 2013 and 2014

The attributable fraction and the population attributable fraction of the risks for lameness from all respondents in 2013 and 2014 are presented in Table 7. Using the PAF from 2013, if farmers followed the 'Six steps to sound sheep' and stopped routine foot trimming, the expected reduction in lameness from 2013 to 2014 would be 33.6%. The actual proportional reduction in prevalence of lameness was 22% across all flocks and 30% in flocks with 5 – 5% lameness in 2013 (Table 3).

4. Discussion

This is the first study to compare the efficacy of postal, group and one-to-one intervention trial types on one behaviour, treatment of sheep lame with footrot. There was a difference in behavioural change by route of intervention message. This behaviour was selected because there is robust evidence from several studies (Kaler and Green, 2008; Kaler et al., 2010; Wassink et al., 2010a) that 'best practice' could be defined and recommended. In addition, whilst there have been several studies hypothesising that attitude and personality influence the likelihood of changing behaviour, this had not been evaluated in an intervention trial.

All three intervention trial types led to a significant reduction in prevalence of lameness. The increased reduction in prevalence of lameness followed a "dose-response" effect, with farmers who received greatest exposure to the intervention message in the one-to-one trial having the greatest change in prevalence of lameness, followed by the group, and then the postal trial. Hjort et al. (2003) also reported that personal dialogue and close contact with an advisor was more motivating to farmers than printed information in a study that promoted farm health and safety in Denmark. Such trials are expensive and typically with only a small sample of farms, consequently where the rate of disease is already low a significant effect might not be observed e.g. Tschopp et al. (2015). In the current study, flocks were recruited for the one-to-one intervention trial with a high prevalence of lameness and not managed using best practice so that there was sufficient power to investigate change in prevalence of lameness. This does mean that the greater reduction in prevalence of lameness in the one-to-one intervention trial could be an artefact. However, this group also had the greatest proportional reduction in lameness and largest percentage of flocks with a reduction in the prevalence of lameness (Table 4), indicating that the larger reduction in lameness was probably a real effect. Change in behaviour is most likely because farmers had the opportunity to discuss the recommendations with a veterinarian with expert research and practical knowledge of sheep lameness who used facilitation to help farmers find solutions to adopt the recommendations in their systems. English sheep farmers have reported that specialist veterinarians are a preferred source of new information on treating lameness (Kaler and Green, 2013; Wassink et al., 2010b). Farmers also received a letter that summarised the discussion and advice given and they knew they would receive a follow-up visit in 2014; all of these personal links might have made farmers feel a responsibility to follow at least some of the advice. This is consistent with health literature, which attributes the effectiveness of one-to-one intervention messages to greater focus, effort and emotional investment by participants, helped by the bond formed with the researcher (Figueiras et al., 2001; Hawkins et al., 2008).

Resources were greatest for the one-to-one trial and the benefits were greatest. This intervention might be best replicated in farmer-vet one-to-one facilitation. Farmers have stated that it is expensive to use veterinarians and recently ‘health clubs’, where small groups of farmers work with a vet, have been proposed (Kaler and Green, 2013; Lovett, 2015). If our results are transferrable then one might hypothesise that ‘health clubs’ might be less effective than one-to-one facilitation, at least initially, because they are more like the group trial, but the benefit might accrue with repeated meetings.

The success of the group trial adds weight to the popularity of this approach for knowledge transfer in agriculture. Led by (LEG) and with each meeting including approximately one hour of discussion where farmers shared experiences, uptake of best practice might have occurred because of a trusted lead and because farmers trust other farmers as reliable sources of information (Blackstock et al., 2010; Dodunski, 2014; Garforth and Usher, 1997; Thompson et al., 1999; Wood et al., 2014; Wassink et al., 2010b). To avoid selecting farmers enrolled in the postal trial, farmers in the group trial were sourced from membership of the NSA, a political organisation with about 10% of sheep farmers as members. Whilst flock sizes were smaller than flocks in the other intervention trial types, there was no significant difference in the prevalence of lameness or managements in 2013 between group and postal trial farmers and so we believe the samples are comparable. However, the small sample size meant that gain and loss framed messages could not be investigated.

All TAs in the postal trial had lower mean prevalence of lameness in 2014 than 2013, including TA1, the control arm (Table 3). There are several explanations for this. The climate in the period targeted by the 2014 questionnaire was colder and dryer and so less conducive to the occurrence of footrot than the period for the 2013 questionnaire and so the national prevalence of footrot was likely to be lower. Additionally, for TA1, a questionnaire-behaviour effect (Wilding et al., 2016) may have been operating, where the act of completing a questionnaire and agreeing to participate in a trial might have stimulated TA1 farmers to act more to treat lame sheep. Finally, the range of information in circulation on the treatment of lame sheep might have influenced all sheep farmers, including TA1. Whatever the reason for the decrease in lameness in TA1, these results highlight the importance of control groups in intervention studies.

To test the impact of postal trial arm allocation (Table 6) we excluded flocks with prevalence <5% because these farmers were likely to be in LC1 and already follow best practice (O'Kane et al., 2016) and so the interventions could not lead to further change in behaviour or reduction in prevalence of lameness. Flocks with prevalence of lameness >15% in 2013 were also excluded because such a high prevalence of lameness is indicative of an outbreak of infectious lameness which would not be resolved by adopting the intervention message e.g. an outbreak of CODD (Dickins et al., 2016). Flock size was forced into models because it is negatively associated with prevalence of lameness (Winter et al., 2013).

Overall there was a 20-29% reduction in prevalence of lameness in the postal trial (Table 3). Gain and loss framed intervention messages had similar influence. Possibly because individual farmers varied in their perception of the procedural risk and uncertainty of adopting the Six steps. Where message framing has been important it has often consisted of a one-dimensional message, promoting disease prevention behaviour (Detweiler et al., 1999; Ferguson and Gallagher, 2007) or disease detection behaviour (Apanovitch et al., 2003). The Six steps message is not characterisable as promoting a single detection or prevention behaviour. As our results do not favour either gain or loss framed messages very strongly, they suggest that message framing was not important. There was also no further reduction in lameness in groups receiving repeated or seasonal messages. Possibly because farmers were receiving messages from other sources diluting this effect or because there is fatigue in receiving repeated messages.

LC2 had a marginally lower prevalence of lameness (Table 6) than LC3. LC3 farmers had the greatest scope for improvement, but it was hypothesised that they might be difficult to influence because of negative attitudes and may need specially designed intervention messages (O'Kane et al., 2016). The results from the current study indicate that this was the case, after adjusting for 2013 prevalence of lameness, LC2 farmers, who maybe needed nudging to treat sheep more promptly, changed their behaviour more than LC3 farmers. According to the theory of planned behaviour one could argue that LC2 farmers were more ready to change than LC3.

Farmers were selected from the whole population of English sheep farmers, however, those who participated had indicated that they were interested in taking part in research into lameness in sheep. This might mean that the farmers in all trials were more receptive to the intervention message and not representative of the population as a whole. The reduction in prevalence of lameness across all trials and flocks was 22% and 30% in flocks with 5-15% lameness (Table 3). This was lower than the maximum predicted (Table 7) because there was not complete uptake of the recommendations. This reduction is still considerable; if these flocks are generalizable and the intervention was as effective across all flocks with lameness prevalence 5 – 15%, this would be a reduction in global mean prevalence of lameness from the 2014 value of 5% to 3.5%.

The biggest behavioural change was in relation to foot trimming (Table 5). In 2006, farmers ranked foot trimming as their top current and ideal method for treating footrot (Wassink et al., 2010b) but they also reported that they would like to stop routine foot trimming. Research suggests that if new recommendations appear to go against current beliefs or knowledge, farmers are resistant to change and intensive knowledge transfer is required, whereas if they consider them easy to implement, appropriate and beneficial they will adopt them readily with little or no evidence (Garforth and Usher, 1997; Garforth et al., 2013; Harvey and Kitson, 2015). The change in behaviour regarding foot trimming over time maps this, with an initial reluctance to stop foot trimming and a demand for more evidence that this was correct advice (Abbott et al., 2003), to the situation in the last few years where there has been a rapid reduction in the percentage of farmers practising routine and therapeutic foot trimming.

Uptake of antibiotic treatment was low. Antibiotic resistance is a concern in human and animal health and so farmers might have been less keen to treat all sheep with footrot with antibiotic injection, despite antibiotics being an appropriate treatment for this bacterial disease. In addition, many farmers consider antibiotics an expensive treatment (LEG, personal communication).

5. Conclusions

All three intervention trials, one-to-one, group and postal, significantly reduced the prevalence of lameness in sheep. There was a dose-response effect with an increasing reduction in prevalence of lameness measured as an absolute, proportional or percentage of flocks with significantly lower prevalence of lameness. Farmer behavioural change was greatest for activities that led to stopping the practice of foot trimming and less great for uptake of use of antimicrobial therapy. There is evidence that farmers' management of lameness in 2013 influenced likelihood of adopting the new recommendations in 2014, indicating that some farmer types received intervention messages differently from others.

Conflict of interest

The authors have no conflicts of interest to declare.

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