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Author: Joanne R. Winter, Laura E. Green

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Cost-benefit analysis of management practices for ewes lame with footrot

Joanne R. Winter [1], Laura E. Green *

School of Life Sciences, University of Warwick, Gibbet Hill Road, Coventry CV4 7AL, United Kingdom

* Corresponding author. Tel.: +44 2476 523797.
E-mail address: laura.green@warwick.ac.uk (L.E. Green).

Highlights

- In flocks of sheep in England, the cost of lameness was greater in flocks with >10% lameness than flocks with <5% lameness.
- Treating lame ewes with antibiotics was associated with lower costs of lameness.
- Routine foot trimming and footbathing were associated with higher costs of lameness.
- Greater costs of lameness in high-prevalence flocks were due to production losses.
- Farmers satisfied with their management spent less time and money managing lameness.

Abstract

The aim of this study was to investigate the cost-benefit of different strategies to treat and control ovine footrot. In November 2006, 162 sheep farmers in England responded to a survey on prevalence and management of lameness. The costs of lameness per ewe per year (PEPY) were calculated for 116 flocks. Linear regression was used to model the overall cost of lameness PEPY by management method. Associations between farmer satisfaction and time and money spent managing lameness were investigated. The median prevalence of lameness was 5% (inter-quartile range, IQR, 4-10%). The overall cost of lameness PEPY in flocks with ≥10% lameness was UK£6.35 versus £3.90 for flocks with <5% lameness. Parenteral antibiotic treatment was associated with a significantly lower overall cost of lameness by £0.79 PEPY. Routine foot trimming and foot bathing were associated with significantly higher overall costs of lameness PEPY of £2.96 and £0.90, respectively. Farmers satisfied with time managing lameness spent significantly less time (1.46 h PEPY) than unsatisfied farmers (1.90 h PEPY). Farmers satisfied with money spent managing lameness had significantly lower treatment (£2.94 PEPY) and overall (£5.00 PEPY) costs than dissatisfied farmers (£5.50 and £7.60 PEPY, respectively). If the farmers in this study adopted best practice of parenteral antibiotic treatment with no routine foot trimming, and minimised foot bathing for treatment/prevention of interdigital dermatitis, the financial benefits would be approximately £4.65 PEPY. If these costs are similar on other farms the management changes would lead to significant economic benefits for the sheep industry.

Keywords: Sheep; Footrot; Lameness; Financial costs; Management practices

Introduction

Footrot is an infectious bacterial disease of sheep caused by *Dichelobacter nodosus*. The clinical presentation includes interdigital dermatitis (ID) alone or severe footrot (SFR), with various degrees of separation of hoof horn from the sensitive tissue; both conditions cause lameness. In England, the majority of ovine lameness is attributed to footrot (Kaler and Green, 2008; Winter et al., 2015). English farmers manage footrot using whole-flock strategies (quarantine, foot trimming, foot bathing, vaccination) and individual treatments, using one or more of foot trimming, topical disinfectant and systemic antibiotic injection (Winter et al., 2015).

Routine foot trimming can cause damage to sensitive tissue, resulting in lameness (Winter et al., 2015). Foot bathing generally is associated with a higher prevalence of lameness (Kaler and Green, 2009; Winter et al., 2015), except when used to prevent ID (Winter et al., 2015) or when handling facilities are excellent and sheep are turned onto pasture free from sheep for at least 2 weeks (Wassink et al., 2003, 2004). In past observational studies, vaccination was not significantly associated with prevalence of lameness (Wassink et al., 2004; Kaler and Green, 2009); however, in a 2013 study, vaccination was associated with a 20% reduction in the prevalence of lameness (Winter et al., 2015).

Footrot is one of the top five economically important diseases of sheep globally. In the United Kingdom (UK), footrot costs the sheep industry UK£24-80 million[1] per annum (Nieuwhof and Bishop, 2005; Wassink et al., 2010b). Economic losses from lameness occur in ewes left untreated for one week (Wassink et al., 2010b). Losses arise from ewe deaths and infertility, reduced numbers of lambs born and surviving, and reduced lamb growth rates (Stewart et al., 1984; Marshall et al., 1991; Nieuwhof et al., 2008; Wassink et al., 2010b).

[1] £1 GBP = approx. €1.268 and $1.433 USD on 21 April 2016.

In 2006, 265 English farmers were asked whether they were satisfied with their management of lameness; 162 responded (Wassink et al., 2010a). Amongst 'very satisfied' farmers, the annual prevalence of lameness was ≤5%; these farmers were significantly more likely to catch and treat lame sheep within 3 days and to treat sheep with footrot with parenteral and topical antibacterial products, leading to rapid recovery (Kaler et al., 2010a; Kaler et al., 2012; Strobel et al., 2014). However, most farmers were also therapeutically trimming the foot, which reduces the rate of recovery (Kaler et al., 2010a). Farmers dissatisfied with their management of lameness had a median prevalence of lameness of 9.8%; dissatisfaction was associated with vaccination and routine foot bathing (Wassink et al., 2010a). Dissatisfied farmers indicated that they were interested in changing their management (Wassink et al., 2010a), but also reported foot bathing and vaccination as strategies they would like to use more. Additionally, it has been suggested anecdotally that individually treating lame sheep is costly in time to catch individual ewes and in medicines used, which may outweigh the benefits of treatment (King, 2013).

To date, the costs of ovine footrot associated with different management strategies have not been investigated. In this study, we used further data from the 162 farmers who responded to the 2006 questionnaire (Wassink et al., 2010a) and the University of Reading cost calculator model for footrot[2] to estimate treatment costs and production losses. The model's calculations are based on the best available evidence and expert opinion on costs and economic losses.[2] The overall costs per ewe per year (PEPY) by flock were used to investigate the relative cost-benefit of different methods for managing lameness.

[2] See: Farm Health Planning Models: Calculating the Costs and Benefits of Controlling Disease. http://www.fhpmodels.reading.ac.uk/index.htm (accessed 22 July 2013).

Materials and methods

Questionnaire

A questionnaire, described previously (Wassink et al., 2010a), was sent in 2006 to all 265 farmers who participated in the study by Kaler and Green (2008) and indicated willingness to participate in further research. Data were entered into Excel 2003 and analysed in Minitab 17 (Minitab Ltd, UK) and Stata 13.0 (StataCorp).

Management of lameness

Farmers were provided with a semi-closed list of whole-flock and individual methods for managing and treating lameness (Tables 2 and 3) and asked their frequency of doing each procedure and how long they took on each occasion.

Farmer satisfaction

Farmers were asked how satisfied they were with their overall management of lameness on a five-point Likert scale of 'very satisfied', 'satisfied', 'neither satisfied nor dissatisfied', 'unsatisfied' or 'very unsatisfied', with an option of 'don't know', and whether the methods they used to manage lameness made the best use of their time and money on a three-point scale of 'yes', 'to some extent' or 'no'. Kruskal-Wallis tests were used to investigate associations between time spent managing lameness, farmer satisfaction (overall, with use of time, with use of money) and prevalence of lameness. Box plots were visually assessed to establish that the distribution of the data met the assumptions of this test.

Production and treatment costs

The Farm Health Planning footrot calculator developed by Reading University[2] was used to calculate treatment and production costs of lameness PEPY. Forty-six of 162 flocks were excluded because of missing data. The following data for each flock were entered into the calculator: flock size, prevalence of lame ewes, time taken to treat individual sheep, and the frequency and time taken to vaccinate, foot trim and foot bath the entire flock. The recovery rate for interventions was set at 50% for flock foot bathing and isolation of lame sheep[2], 20% for therapeutic foot trimming and 98% for individual clinical treatment (Kaler et al., 2010a). All other values involved in the calculations were left as the programme default values, based on studies by Green et al. (2007), Wassink et al. (2003, 2010b) and expert opinion[2] where there was no scientific evidence available (Table 1). 'Prompt individual treatment' was defined as treatment within 1 week of observing a lame sheep and this option on the calculator was selected where appropriate. Farmer time was costed at the 2010 Craft grade rate[3] (£8.15). All cost variables in the model from 2011 were similar in 2016; drug prices vary considerably but the median was similar to 2011,[4] a cull ewe value was £79.48 on 9 April 2016[5] versus £80.00 in 2011 (Table 1), finished lamb values fluctuated around £60/head 2015-2016 and store lamb prices[5] and National Fallen Stock Company (NFSCo) charges (H. Davies, personal communication 2016) were also similar to 2011; therefore these were not adjusted.

Flocks were categorised by period prevalence of lameness into <5%, 5 to <10% and ≥10% (Wassink et al., 2010a), and costs of treatment and production losses attributed to footrot PEPY were calculated for each group. Overall cost, treatment cost and production cost of footrot PEPY and prevalence of lameness were calculated by farmer satisfaction with use of money and compared using Kruskal-Wallis tests.

A linear regression model (Dohoo et al., 2003) was used to estimate univariable and multivariable associations between the log overall cost of lameness PEPY from the Reading

[3] See: Agricultural Wages Order 2010. http://webarchive.nationalarchives.gov.uk/20130822084033/http://archive.defra.gov.uk/foodfarm/farmmanage/working/agwages/documents/awo10.pdf (accessed 22 July 2013).
[4] See: Farmacy. http://www.farmacy.co.uk (accessed 26 April 2016); VioVet. http://www.viovet.co.uk (accessed 26 April 2016); Wern Vets. http://www.wernvets.co.uk (accessed 26 April 2016).
[5] See: AHDB Beef & Lamb Market Reports. http://beefandlamb.ahdb.org.uk/markets/auction-market-reports/weekly-gb-regional-averages (accessed 26 April 2016).

calculator and management practices. Explanatory variables tested were isolating, moving, catching and foot trimming individual lame sheep, treatment with parenteral or topical antibiotics, a painkiller or vaccination, and, for the whole flock, foot bathing, foot trimming, vaccination and moving the flock.

A manual forward selection process (Dohoo et al., 2003) was used to test variables in a multivariable model and explanatory variables were considered to be significant when 95% confidence intervals did not include unity (Wald's test for significance) and were retained in the model (Cox and Wermuth, 1996). Where multi-collinearity was present, the most biologically plausible variable was included in the multivariable model. Model fit was assessed using plots of the standardised residuals against the predicted values.

Results

Response rate and descriptive statistics

There were 162/265 (61%) useable responses; not all farmers answered all questions. The median flock size was 275 ewes (inter-quartile range, IQR, 120-550) and the median period prevalence of lameness was 5% (IQR 4-10, range 0-60). The prevalence of lameness did not vary significantly by flock size (P = 0.3).

Management of lameness

The most common whole flock management procedures were foot bathing, routine foot trimming and moving sheep for treatment (Table 2). Foot trimming was the most time consuming activity (Table 2). The most common treatments for individual lame sheep were therapeutic foot trimming, topical antibiotic spray and antibiotic injection (Table 3).

As the frequency at which farmers checked their sheep for lameness decreased, the time spent inspecting each ewe per occasion increased, but the overall amount of time spent checking ewes decreased (Table 4). Prevalence of lameness was not significantly associated with time spent checking each ewe ($P = 0.7$), time spent checking the flock ($P = 0.4$) or the frequency of checks ($P = 0.1$).

Farmer satisfaction

Seventy-five of 116 (64%) farmers who answered questions on satisfaction with management of lameness were 'satisfied' or 'very satisfied' with overall management of lameness in ewes and 53/116 (46%) farmers considered that their methods for managing lameness made best use of their time (Table 5). The median prevalence of lameness was lower when farmers were satisfied with use of time managing lameness compared with farmers who were satisfied 'to some extent' or 'not satisfied'. Satisfied farmers spent significantly less time managing lameness than farmers who were not satisfied (Table 5).

Forty-eight of 116 (41%) farmers thought that their methods for managing lameness made best use of their money and 48/116 (41%) did 'to some extent'. Overall costs significantly increased with prevalence of lameness, but there was no significant difference in treatment costs with increased prevalence of lameness from <5% to ≥10% (Table 6). Farmers satisfied with use of money spent on lameness had significantly lower treatment and overall costs than farmers dissatisfied with use of money (Table 7).

Management strategies associated with the cost of lameness

In the multivariable model (Table 8), parenteral antibiotic treatment of individual lame sheep was associated with a £0.79 (95% CI £0.18-£1.29) reduction in overall cost of lameness

PEPY. Routine foot bathing (£0.90, 95% CI £0.08-£1.90), routine foot trimming (£2.96, 95% CI £1.77-£4.43) and vaccination (£1.19, 95% CI £0.05-£2.69) were associated with a significant increase in cost PEPY. Parenteral and topical antibiotic treatments and foot trimming individual lame sheep were positively correlated with each other, and with catching lame sheep for treatment (see Appendix: Supplementary Table 1). Vaccination of individual lame sheep was strongly positively correlated with vaccination of the whole flock. The model fit was good (Fig. 1).

Discussion

The key findings of this study are that overall costs of lameness PEPY were significantly lower in flocks in the study that were following the evidence-based best managements for minimising the prevalence of lameness in sheep, including prompt treatment of ewes with parenteral and topical antibiotics, and avoiding whole-flock foot trimming and routine foot bathing (Wassink et al., 2003, 2010b; Kaler and Green, 2009; Kaler et al., 2010a; Winter et al., 2015). There was a net financial benefit (£0.79 PEPY) of managing lameness by treating individual lame ewes with parenteral antibiotics compared with not using this treatment, despite farmers' anecdotal concerns (King, 2013). Prompt parenteral antibiotic treatment therefore is not only the best method for reducing the prevalence of lameness (Wassink et al., 2010b); it was also the most cost-effective strategy for management of lameness across the 116 flocks in this analysis.

Routine foot trimming and foot bathing cost farmers an additional £3.86 PEPY, with no reduction in prevalence of lameness. Whilst this averaged cost must be interpreted with caution because of the variability in costs between farms, it highlights that significant savings could be made if farmers stopped using ineffective whole flock interventions. The farmers in this study would save £2.96 PEPY if they stopped routine foot and £0.90 PEPY if they stopped routine foot bathing and only foot bathed to prevent or treat ID, which is associated with a lower prevalence of lameness (Wassink et al., 2003; Kaler and Green, 2009; King, 2013; Winter et al., 2015).

Most farmers in this study using therapeutic antibiotic treatment were also foot trimming. Kaler et al. (2010a) reported that therapeutic foot trimming in conjunction with antibiotic treatment halves the rate of recovery. Foot trimming also leads to repeated episodes of footrot and poor foot conformation (Kaler et al., 2010b). Farmers in the current study who did not use therapeutic foot trimming saved 4 min per ewe treated (Table 3) and therefore saved money. If all the farmers stopped therapeutic foot trimming, they would have saved money and reduced the prevalence of lameness in their flock.

There was no association between vaccination and the prevalence of lameness in these flocks (Wassink et al., 2010a); there are costs to purchase and administer vaccines. The 13% of farmers who vaccinated their sheep were aware of this and did not consider vaccination to be effective or to make best use of money (Wassink et al., 2010a). In the study of Winter et al. (2015), vaccination against footrot was associated with an average 20% reduction in prevalence of lameness; therefore, it may be of use in some flocks, for example those with high prevalences of lameness.

The higher overall costs of lameness in flocks with ≥10% prevalence, compared with <5% lameness, were mainly attributable to increased production losses, although inefficient treatment may have contributed to costs on some farms. Production losses arise when ewes are lame for >6 days and therefore are lowest in flocks in which ewes are treated promptly (Wassink et al., 2010b).

This is the largest study of the economics of treatment of lameness to date. Despite this, 116 is a relatively small sample and therefore there is limited power to the study and a risk of failing to detect true differences. There was wide variation in treatment costs across all farms, which is probably a true reflection of the variability in treatment costs. Some flocks with a low prevalence of lameness have few sheep that become lame and therefore incur minimal treatment costs, whilst other flocks with a low prevalence of lameness will be controlling lameness by treating sheep promptly and therefore will incur higher costs. Similarly, flocks with high prevalences of lameness will have low treatment costs if farmers rarely treat lame sheep, while others will have high costs if they waste time and money using ineffective practices, such as routine foot trimming.

In the current study, the net benefit of prompt parenteral antibiotic treatment of lame ewes was £0.79 per ewe across 116 flocks with IQR 4-10% lameness, whilst in Wassink et al., (2010b) the benefit was £6 per ewe in a within-flock comparison of a group with 2% lameness versus a group with 6-8% lameness. The current study is less controlled than the within-flock comparison of Wassink et al. (2010b), which creates greater random error; however, it does compare 116 farms. The smaller difference in overall cost-benefit of using parenteral antibiotics in the current study might be attributable to a higher prevalence of lameness in the lowest category of lameness (up to 5%), hence greater treatment costs and less difference between the prevalence of lameness. In addition, most farmers in the current study practised therapeutic foot trimming, which delays recovery (Kaler et al., 2010a), and routine foot trimming and foot bathing, which cost time and might increase lameness. In the footrot calculator, these procedures are credited as benefitting sheep, but other studies suggest that this is not the case (Wassink et al., 2003, 2004; Kaler and Green, 2008; Winter et al., 2015); therefore, the cost-benefit of these interventions will have been overestimated in the current study. Routine and therapeutic foot trimming and foot bathing were not performed in the study by Wassink et al. (2010b) and so less time, and therefore money, was spent on these unnecessary activities. Wassink et al. (2010) also classed treatment as ‘prompt’ at <3 days, versus <1 week in the current study. The financial benefit of parenteral antibiotic treatment is probably higher if treatment is given sooner because of the reduction in onward transmission of disease.

The data for the current study were collected in 2007 and it is unlikely that the time taken for a management practice has changed substantially since that time. Medicines and management costs are still at similar prices to 2011, when the cost calculator was developed. Finished and cull ewe prices fluctuate widely, but 2016 prices are similar to those in 2011, i.e. £79.48 versus £80.00 for a cull ewe. Farmer time is difficult to cost, but the cost used was that determined by the 2010 Craft grade rate. As a general rule, if the market price of lamb increases above £60/head, the cost calculator estimate for production losses from incorrect treatment increase.

This study is the largest investigation of costs and benefits for management of lameness in English flocks to date. Previous analyses were based on a single flock (Wassink et al., 2010b) and a simulation model (Nieuwhof and Bishop, 2005). One question that arises is whether the results are generalisable to all English lowland flocks. The original selection of farmers came from a random selection of farmers in the Agriculture and Horticulture Development Board (AHDB) Beef and Lamb Better Returns programme. This consists of 18,000 English sheep farmers and is the most comprehensive list of sheep farmers that can be accessed. This is the same list as used for 50% of participants in the 2013 questionnaire (Winter et al., 2015); the remaining 50% were from a complete list of sheep farmers held by the Department for Environment, Food and Rural Affairs (DEFRA). There was no measurable difference in sheep farmers sourced from DEFRA or AHDB by prevalence of lameness, response rate or managements investigated (unpublished data). When considering the respondents, the response rate was 61%, similar to other studies involving second questionnaires to compliant farmers (Wassink et al., 2003; Kaler and Green, 2008). The median prevalence of lameness was 5%, similar to estimates in 2004 and 2011 (Kaler and Green, 2008; King, 2013). The flock size in this study (median 275, IQR 120-550) was similar to the average flock size in 2006 of 327 ewes (Fogerty and Robbins, 2007) and there was considerable overlap with flock size IQRs from other random studies (Kaler and Green, 2008; King, 2013; Winter et al., 2015). Management practices, i.e. using ‘best practice’ (O’Kane et al., 2016), of prompt parenteral and topical antibiotic are also similar to those in a recent study of a random sample of farmers (Winter et al., 2015). The number of farmers using foot bathing as treatment for footrot has fallen to 36% since 2006 (Winter et al., 2015), possibly a result of promotion of alternative effective management practices. Therefore, as far as it is possible to ascertain, the farmers in the current study are largely similar to other farmers who have contributed to research on ovine lameness in England. It is not possible to know if the farmers in this study, or any of the other studies listed, are representative of all sheep flocks. However, over the past 10 years, the prevalence of lameness has halved (Winter et al., 2015), possibly because results from these studies have bene used to inform farmers of the best management strategies. The main comparison in the current study is the relative difference in costs by different management strategies between flocks; this calculation does not require a population based sample. Consequently, even if the flocks in the study are not representative of all sheep flocks, the estimated differences in costs by management strategy are expected to be similar for other lowland farms in England.

Conclusions

A net financial benefit of £0.79 PEPY resulted from using prompt antibiotic treatment, predominantly because of lower production losses. If these farmers also stopped therapeutic foot trimming, the financial benefit would be higher. Routine foot trimming and foot bathing, previously associated with higher prevalence of lameness, were associated with increased costs of lameness (£2.96 and £0.90, respectively). If farmers stopped these practices they would save a further average of £3.86 PEPY. If the costs in the current study are similar for other sheep flocks in England, these results indicate that adopting best practice to treat and control footrot would benefit the health of sheep and the economics of sheep farming.

Conflict of interest statement

None of the authors of this paper have a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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Appendix: Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi: ...

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Figure legend

Fig. 1. Plot of the predicted values against the standardised residuals, for the linear regression model of management practices associated with log cost of lameness.

Table 1 Assumptions used in the University of Reading footrot calculator.

Flock and footrot details	Assumed value
Expected lambing percentage (at scanning)	150%
Percentage lambs sold as finished	25%
Percentage of ewes with footrot culled	3%
Average finished lamb value	£60/head
Average store lamb value	£40/head
Average cull ewe value	£80/head
National Fallen Stock Company (NFSCo) charges	£20/head
Treatment	Cost per ewe
Individual clinical treatment (parenteral antibiotic)	£1.30
Isolation of clinical case	£1.00
Chemical cost of flock foot bathing	£0.10
Vaccination product cost (per dose, per ewe)	£0.80
Cost of routine flock foot trim	£1.30
Response to treatment	Response rate
Prompt individual clinical treatment (parenteral antibiotic)	98%
Isolation of clinical case	50%
Flock foot bathing	50%
Routine foot trimming of all sheep	20%
Effects of disease on ewes	Percentage reduction
Dry ewe conception rate	15%
Dry ewe condition	15%
Dry ewe survival	2%
Pregnant ewe condition	15%
Pregnant ewe survival	5%
Lactating ewe condition	15%
Lactating ewe survival	5%
Lambing percentage	15%
Lamb survival	12%
Number of finished lambs	15%

Table 1 Whole-flock management practices used by 162 English farmers in 2006.

Flock management	Minutes per ewe		Frequency of management, per year		Hours per 100 ewes per year		Number (%) farmers using management
	Median	IQR [a]	Median	IQR	Median	IQR	
Routine foot trim	4.2	2.5-7.5	2.0	1.0-2.0	11.2	5.7-24.7	80 (49)
Foot bath	1.0	0.6-1.8	4.0	2.0-9.0	6.2	3.3-17.9	92 (57)
Vaccine	1.1	0.6-2.0	1.0	1.0-1.0	1.8	1.0-4.7	21 (13)
Move to treatment area	0.5	0.2-1.3	3.5	2.0-9.5	3.4	1.0-8.1	71 (44)

[a] IQR, interquartile range.

421 **Table 2** Number and percentage of 162 English sheep farmers using different methods to treat footrot in individual
422 lame ewes and the median time per activity in 2006.
423

Management practice	Minutes per activity per ewe		Number (%) farmers using this management
	Median	IQR [a]	
Move to treatment area	10	2-15	51 (31)
Isolate ewe	5	2-10	5 (3)
Therapeutic foot trim	4	2-5	136 (84)
Catch ewe	2	1-5	128 (79)
Foot bath	1	1-5	89 (55)
Vaccinate	1	1-3	20 (12)
Antibiotic spray	1	1-2	131 (81)
Antibiotic injection	1	1-2	101 (62)

424
425 [a] IQR, interquartile range.

Table 3 Frequency of, and time spent, checking sheep for lameness by 162 English farmers.

Frequency of inspections	Number (%) farmers	Minutes spent per ewe, per inspection		Minutes spent per ewe, per week	
		Median	IQR [a]	Median	IQR
Every day	87 (53.7)	0.28	0.15-0.50	1.93	1.05-3.50
Twice a week	19 (11.7)	0.33	0.18-1.17	0.66	0.35-1.50
Once a week	26 (16.0)	0.48	0.31-1.38	0.48	0.31-1.38
< Once a week	27 (16.7)	0.29	0.00-0.60	0.09	0.00-0.18
Kruskal Wallis test		$P = 0.02$		$P < 0.01$	

[a] IQR, interquartile range.

Table 4 Median management time per ewe per year (PEPY) and prevalence of lameness for flocks grouped by farmer ratings of overall satisfaction and satisfaction with use of time.

Satisfaction	Number (%) farmers	Management hours PEPY		Prevalence of lameness	
		Median	IQR [a]	Median	IQR
Overall satisfaction					
Very Satisfied	11 (9)	2.36	0.42-3.91	3.0	2.0-10.0
Satisfied	64 (55)	1.84	0.97-3.96	5.0	3.0-7.75
Neither	25 (22)	1.90	0.94-5.22	10.0	5.0-10.0
Unsatisfied/Very Unsatisfied	16 (14)	1.20	0.58-1.81	8.5	5.0-15.0
Kruskal-Wallis test			$P = 0.35$		$P = 0.01$
Satisfaction with use of time					
Satisfied	53 (46)	1.46	0.72-3.18	5.0	3.0-10.0
Satisfied to some extent/Unsatisfied	59 (51)	1.90	1.02-4.59	7.0	5.0-10.0
Kruskal-Wallis test			$P = 0.04$		$P < 0.01$

[a] IQR, interquartile range.

Table 5 Overall costs, treatment costs, and production losses per ewe per year (PEPY) by prevalence of lameness for 116 English sheep flocks.

Prevalence of lameness	Number (%) farmers	Overall cost PEPY (£)		Treatment cost PEPY (£)		Production losses PEPY year (£)	
		Median	IQR [a]	Median	IQR	Median	IQR
<5	34 (29.3)	3.90	2.15-5.75	2.67	1.22-4.86	0.80	0.56-1.05
5 - <10	44 (37.9)	5.15	2.85-7.75	3.47	1.08-6.41	1.51	1.45-1.61
≥ 10	38 (32.8)	6.35	4.95-8.38	3.68	2.04-5.30	2.40	2.23-2.87
Kruskal-Wallis test			*P* <0.01		*P* = 0.43		*P* <0.01

[a] IQR, interquartile range.

Table 6 Prevalence of lameness, overall and treatment costs of footrot per ewe per year (PEPY) by farmer satisfaction with use of money.

Farmer satisfaction with use of money	*n*	% Lame		Overall cost PEPY (£)		Treatment cost PEPY (£)	
		Median	IQR [a]	Median	IQR	Median	IQR
All farmers	116	5.0	4.0-10.0	5.45	3.30-7.60	3.47	1.41-5.43
Satisfied	48	5.0	3.0-10.0	5.00	2.70-7.10	2.94	0.84-5.03
Satisfied to some extent	48	6.0	4.5-10.0	4.95	3.33-6.70	2.95	1.29-4.59
Unsatisfied	6	6.0	4.25-15.0	7.60	5.48-8.78	5.50	3.00-7.83
Don't know	14	8.0	4.5-12.8	6.60	4.70-12.63	4.07	3.40-8.46
Kruskal-Wallis test			$P = 0.17$		$P = 0.02$		$P = 0.03$

[a] IQR, interquartile range.

Table 7 Univariable and multivariable linear regression model of management practices associated with changes in overall cost of lameness per ewe per year (PEPY) in 116 English sheep flocks.

Management		*n*	%	Univariable Change in cost	95% CI [a]		*P* value	Multivariable Change in cost	95% CI		*P* value
Individual treatments											
Parenteral antibiotic	N [b]	39	33.6%								
	Y	77	66.4%	-£0.82	-£1.41	-£0.06	0.039	-£0.79	-£1.29	-£0.18	0.015
Topical antibiotic	N	15	12.9%								
	Y	101	87.1%	-£0.86	-£1.64	+£0.26	0.123				
Foot trim	N	14	12.1%								
	Y	102	87.9%	-£0.97	-£1.74	+£0.14	0.082				
Isolate	N	95	81.9%								
	Y	21	18.1%	-£0.04	-£0.96	+£1.23	0.947				
Move	N	80	69.0%								
	Y	36	31.0%	+£0.54	-£0.38	+£1.73	0.277				
Catch	N	19	16.4%								
	Y	97	83.6%	-£0.19	-£1.10	+£1.07	0.734				
Painkiller	N	111	95.7%								
	Y	5	4.3%	-£0.24	-£1.69	+£2.39	0.817				
Vaccination	N	104	89.7%								
	Y	12	10.3%	+£2.42	+£0.54	+£5.19	0.008				
Flock management strategies											
Foot bath	N	46	39.7%								
	Y	70	60.3%	+£1.70	+£0.61	+£3.07	0.001	+£0.90	+£0.08	+£1.90	0.031
Foot trim	N	46	39.7%								
	Y	70	60.3%	+£3.68	+£2.33	+£5.33	<0.001	+£2.96	+£1.77	+£4.43	<0.001
Move	N	59	50.9%								
	Y	57	49.1%	+£0.64	-£0.24	+£1.75	0.172				
Vaccination	N	98	84.5%								
	Y	18	15.5%	+£2.38	+£0.78	+£4.59	0.002	+£1.19	+£0.05	+£2.69	0.041
Lameness											
For each percentage increase				+£0.14	+£0.08	+£0.20	<0.001				

The intercept of the model was £3.47 (95% CI: £2.76-4.35, *P* <0.001). Associations significant at *P* ≤0.05 (Wald's statistic) are shown in bold.

[a] CI, confidence interval.

[b] N, no; Y, yes.