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Original Article

Quantifying the beliefs of key players in the UK sheep industry on the efficacy of two treatments for footrot

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Highlights

- At the start of the study, all eight key players recommended parenteral antibiotic treatment for footrot
- Only four recommended avoiding foot trimming before hearing the evidence
- After hearing the evidence, seven of the eight would recommend avoiding foot trimming
- Some key players were resistant to changing beliefs despite hearing the evidence
- Key players continued to change their beliefs in the three months following the study

Abstract

Clinical trials have demonstrated that sheep with footrot treated with parenteral and topical antibiotic treatment without foot trimming (treatment A), have achieved cure faster than sheep treated with foot trimming and topical antibiotic (treatment B). We investigated how key players in the UK sheep industry recommended treating footrot, and tested whether reviewing the evidence surrounding treatment of footrot changed their beliefs. Eight key players attended a workshop to investigate current practice, and their perceived efficacy of treatments using probabilistic elicitation.

All participants recommended use of antibiotic injection but only four recommended not foot trimming feet with footrot. Initial beliefs in the difference in cure rate within five days of treatment ranged from 30-97% in favour of treatment A (true difference 60%); this heterogeneity reduced after reviewing the evidence. Participants who believed the cure rate differed by >60% over-estimated the cure rate of treatment A whilst participants who believed the difference was <60% over-estimated the efficacy of treatment B. During discussions, participants stated that parenteral antibiotics had always been recommended as a treatment for footrot but that the new research clarified when to use them. In contrast, it was highly novel to hear that foot trimming was detrimental to recovery, and key players and farmers are taking longer to accept this evidence. Three months after the workshop, three participants stated that they now placed greater emphasis on rapid individual antibiotic treatment of lame sheep and not foot trimming feet.

Keywords: Expert elicitation; Evidence base; Footrot treatment efficacy; Key players; Sheep

Introduction

There is robust evidence from a clinical trial that compared antibiotic injection and foot trimming in a factorial design, with a control of topical treatment, in that there is a difference of 60% in the cure rate of sheep with footrot five days after treatment with parenteral and topical antibiotic treatment with no foot trimming ('treatment A') versus foot trimming and topical antibiotics ('treatment B'). Cure rates five days after treatment are approximately 70% with treatment A and 11% with treatment B (Kaler, et al., 2010a). Treatment A also prevents loss in body condition and productivity; and is therefore economically beneficial (Wassink, et al., 2010).

The proportion of farmers using treatment A increased between 2004 (Kaler and Green, 2009) and 2013 (Winter, et al., 2015), but the majority of farmers were still not following the recommended treatment protocol; 24% of farmers 'always' treated lame ewes with antibiotic injections and only 3% of farmers 'never' trimmed the feet of ewes with footrot (Winter, et al., 2015). Increasing the proportion of farmers using treatment A would improve the health, welfare and productivity of sheep. Probabilistic elicitation enables an individual's knowledge and uncertainty regarding a topic to be captured as a probability distribution (Garthwaite, et al., 2005). Reviewing the evidence for the efficacy of treatments among veterinarians with and without expertise in sheep changed their beliefs nearer to the reported efficacy of treatment A (Higgins, et al., 2013). However, it is not known whether, and how, key players, such as consultants, influential farmers, political bodies, or knowledge exchange providers, involved in technology transfer in the UK sheep industry have incorporated the evidence from Kaler et al., (2010a) into their advice on managing footrot. The current study was designed to investigate how key players in the UK sheep industry currently recommend managing footrot, and to test whether a review of the evidence would change their beliefs.

Materials and methods

Ethical approval and data collection

A population of sixteen key players were identified based on having a relevant degree and more than ten years experience earning some or all of their income from consultancy within the English sheep industry. They were invited to participate in a 1-day workshop, held at the University of Warwick on 17–18th June 2014. The study was approved by the Biomedical and Scientific Research Ethics Committee at the University of Warwick on 13th June 2014 (study reference REGO-2014-795). All participants were provided with an information sheet detailing the purpose and methods of the study and that all data would be anonymised prior to publication. Informed signed consent was obtained from all participants. Travel expenses were reimbursed.

Participants completed a questionnaire on their role in the sheep industry, how they currently advised farmers to treat footrot and whether this was different from their perceived 'reference standard' care, the number of farmers they advised per year and the media used in knowledge exchange.

A probabilistic elicitation exercise was then used to capture their beliefs regarding the difference in cure rates between two treatments for footrot (A and B) as a probability distribution. The method used was the same as that in Higgins, et al. (Garthwaite, et al., 2005; Higgins, et al., 2013; Johnson, et al., 2010). The elicitation was explained using a standard script (available on request) that included the clinical context and the question of interest. The clinical context was a ewe lame in a single foot with footrot, separation of the hoof horn that started at the interdigital skin and grey oozing pus with a distinctive foul smell, caused by *Dichelobacter nodosus* (Beveridge, 1941); no other foot conditions were complicating the clinical presentation. The outcome was cure from footrot defined as 'ewes had no observable limp and were not head-flicking', within five days of treatment (Kaler, et al., 2010a). The question was: 'Which treatment is more effective at curing footrot within five days?' Treatment A was an intramuscular injection of long-acting oxytetracycline, correctly dosed for the sheep's weight, combined with topical oxytetracycline spray and no trimming of hoof horn. Treatment B was foot trimming by someone experienced and proficient at trimming, and application of oxytetracycline spray to the foot. Any other factors which might influence cure rates were consistent across treatments.

Probabilistic elicitation was done using the roulette ('chip and bins') method, (Johnson, et al., 2010). Participants were given six example distributions (Supplementary Figs. 1-6), demonstrating how they could make a distribution of their different beliefs and certainty in their beliefs. The central tendency of the probability distributions is the participant's 'best guess' and the range of the distribution is a measure of 'certainty'. Participants were given 20, 5 pence coins, each representing a probability of 0.05, total probability = 1, which they used to create a probability distribution indicating the weight of their belief for θ_d (the difference in cure rate between treatments) by placing the coins on a blank laminated sheet laid out as in Supplementary Fig. 1. The interpretation of the probability distribution was described to the participant by a trained assistant and the participant could revise their distribution if they felt it was inaccurate. Participants were also asked their estimate of the actual cure rate for each treatment, and the upper and lower boundaries they believed for these values.

Evidence presentation and follow up

Participants then listened to a 30-minute presentation delivered by LEG summarising the current peer-reviewed evidence regarding treatment of footrot, now published in Green and Clifton (2018). Information sheets were then provided to each participant. After the presentation, participants were asked to consider their initial distribution, and to make a second distribution, whether or not their opinions had changed and to complete a second questionnaire. This was followed by a group discussion on how the evidence produced from recent research into footrot had changed the recommendations they gave to farmers. Three months after the study, participants were asked whether the workshop had changed their beliefs regarding how best to treat footrot, or the advice they gave farmers.

Data analysis

Data were entered into Microsoft Excel (2010) and data analysis was done using R (RDevelopmentCoreTeam, 2008). There were two unknown parameters, θ_1 the probability of cure within five days when treated with Treatment A ($\theta_1 \in [0,1]$), and θ_2 the probability of cure within five days when treated with Treatment B ($\theta_2 \in [0,1]$). Participants' beliefs were quantified by eliciting a probability distribution for the difference in cure rates,

$\theta_d = \theta_1 - \theta_2$, where $\theta_d \in [-1,+1]$

because this was a clinically intuitive scale for the participants to use.

Normal distributions were fitted to the elicited data. The best fitting hyperparameters (mean and standard deviation) were selected using numerical optimisation (Nelder and Mead, 1965) to minimise the sum of the squared differences between the distributions of the observed cumulative probabilities and the fitted cumulative probabilities.

Participants' change in belief was calculated from the differences in the fitted hyperparameters. The fitted distributions were used to calculate 95% Bayesian credible intervals, which identified the 95% probability interval for difference in cure rates.

Results

Response rates and participant characteristics

Ten (63%) of the 16 people identified as the most influential agreed to participate in the study; two cancelled at short notice due to unexpected events. Participants typically had several roles in the sheep industry (Table 1), and advised several hundred farmers, in a mixture of one-to-one and group settings. They did this through advisory committees, one-to-one consultancy, farm open days, meetings and workshops, press articles, newsletters, and technical publications, and reports for pharmaceutical companies. Some delivered continuing professional development (CPD) to other consultants, two of these organised experts to deliver CPD but did not deliver advice themselves. One participant had affiliations with several breed societies.

Recommendations for treating sheep lame with footrot

The participants listed 13 pieces of advice they gave as 'current' or 'reference standard care' (Table 2). The only advice all eight participants gave was to use parenteral antibiotics and only four participants routinely recommended no foot trimming. Not trimming feet, together with vaccination, segregating sheep with footrot and culling repeatedly lame ewes were considered as reference standard care; not always possible, practical or economical. Lack of farmer motivation was reported as a reason why reference standard treatment may not occur in practice.

Elicited probability distributions and estimates of cure rates

Initially, participants believed treatment A cured 75–95%, and treatment B 10–40%, of sheep within five days (Fig. 1). Values for θ_d ranged from 38-90%, with Bayesian credible intervals ranging from 30-97%, in favour of treatment A. The credible intervals of some participants did not overlap, indicating a wide range of beliefs.

The range of estimates for θ_d narrowed considerably to 60–90% although the mean θ_d change was negligible, 0.70 before to 0.69 after the evidence was presented. However, the mean absolute change in θ_d was 11.2% with all except one participant moving their estimate towards the 'true' value of 0.6. The mean standard deviation of θ_d decreased from 5.9 to 4.3, indicating that reviewing the evidence increased participants confidence in their beliefs (Fig. 1, Table 3), although there were still participants whose credible intervals did not overlap. The estimates of cure rates for each treatment also moved nearer to published evidence but were still overestimates (Table 4).

Participants' discussions on recommended treatment of footrot

Some participants indicated that their opinion on how to treat footrot had not changed as result of the evidence presented, most commonly because they were already aware, at least to some extent, of the evidence-base surrounding treatments A and B. Five participants said they were already giving the evidence in the presentation. Two indicated that the actual cure rates were different from what they had thought, but that this would not change their advice. The eighth participant said that whilst they were already highlighting the negative impact of foot trimming they would stress this more in future.

The group were asked how their beliefs on treatment of footrot had changed since 2003, when the first paper hypothesising that the recommended managements for treatment of footrot at that time were ineffective or incorrect (Wassink, et al., 2003) was published, and then as further papers were published on the benefits of antibiotic treatment and the detrimental effects of foot trimming. The consensus was that whilst it was believed that antibiotics were effective in 2003, when to use them was not clear and the 2003 paper had clarified that immediate treatment of all cases rather than only treatment of chronic cases of footrot was best practice. The new, and most challenging information, was that foot trimming as a routine procedure (Kaler and Green, 2009; Wassink, et al., 2003; Winter, et al., 2015) and as a treatment (Kaler, et al., 2010a; 2010b) and was not beneficial. By 2014 (when the workshop was run and results from all these studies were presented) all key players believed this evidence, although two participants were less convinced that trimming did not have a role in treatment.

Follow up

Seven of the eight participants responded to the follow up questions. All stated that the event had not changed their beliefs; five reiterated that this was because their beliefs were already in line with the evidence presented. Despite this, three participants had changed the advice they gave to their clients as a result of the event; two were placing greater emphasis on rapid individual antibiotic treatment and a third participant stated that they now placed greater emphasis on reducing foot trimming.

Discussion

The key findings were that all the key players believed that treatment A, parenteral and topical antibiotic treatment was superior to treatment B, foot trimming and topical antibiotic treatment. However, despite convergence in estimates of θ_d after reviewing the evidence, participants continued to overestimate the difference in cure rates. The credible intervals of three participants (2, 3, 6) did not contain the actual value for θ_d (Table 3) suggesting strongly held beliefs that did not alter, reflected in that two of these made negligible changes to their distributions (Fig. x) and stated that they were already aware of the evidence. A study on the strength and variation of veterinarians' clinical beliefs regarding dry cow therapy also found that some veterinarians were very confident in their prior beliefs (Higgins, et al., 2012) and that even results from a very large clinical trial would be insufficient to change those veterinarians' opinions.

Overestimates of θ_d came from participants overestimating the value of θ_1, whilst underestimates came from overestimating θ_2 (Table 4). Participants who overestimated θ_d may have been the participants way of demonstrating their strong belief in the superiority of antibiotic injection over foot trimming or they may have misremembered the evidence, possibly because of conscious or unconscious motivational bias (Spetzler and Staelvonholstein, 1975) when influencing others. It is also possible that participants recalled cure rates 10 days after treatment, which were still about 60% difference but an absolute recovery of approximately 90% for treatment A and 30% for treatment B (Kaler, et al., 2010a). Inaccurate estimations might also have occurred if participants did not fully understand / engage with the task. For example, prior to the evidence review, participant 1 was 100% certain that the difference in cure rates was between 80-100% (Table 3, Fig. 2) despite believing the cure rate for treatment A was 95% and the cure rate for treatment B was 40%; which is a difference of only 55% (Table 4). This inconsistency was highlighted to the participant, but they did not change their estimates.

In 2012 there was a similar study to the current study where 11 veterinary practitioners were elicited on their beliefs of treatment for footrot (Higgins, et al,. (2013). Opinions on the difference in cure rates between treatments A and B were narrower for participants in the current study than in Higgins et al., (2013) and in contrast to Higgins et al., (2013), all participants in the current study believed that treatment A was superior to treatment B at the start of the study. These differences may be because the key players in our study were more actively involved in knowledge exchange than the veterinarians in Higgins et al., (2013), and consequently may have been more aware of current research.

Additionally, promotion of the efficacy of treatment A continued from 2012 to 2014 through knowledge exchange and new publications (Winter, et al., 2015), which may have led to wider awareness of its efficacy. Both studies may be limited in their generalisability due to the small number of participants and potential participation bias (e.g. individuals willing to participate in research may be more open to adopting new evidence). However, in the current study we aimed to investigate the beliefs of key players in the industry, and only 16 individuals were identified, a small number of individuals with large influence, and all were invited to participate in the study, 50% finally did.

The group discussion highlighted that the detrimental effect of routine foot trimming was highly novel when first reported in 2003 (Wassink, et al., 2003) because it had been a recommended management for footrot for many years (Morgan 1987; Winter 2004). The 2003 results were challenged initially (Abbott, et al., 2003). Stakeholders in the UK started changing advice and practice as further evidence on the negative effects of routine foot trimming arose (Green, et al., 2007; Kaler and Green, 2009; Kaler, et al., 2010b; Winter, et al., 2015). The participants commented that the beneficial effect of trimming feet with footrot was to expose the wound to air to 'kill' the anaerobic bacteria, some then reflected that this information could encourage severe trimming of feet with the expectation of 'getting in more air'. The one clinical trial where therapeutic foot trimming was tested in controlled conditions indicated that foot trimming diseased feet more than halved the recovery rate, both when sheep were treated with parenteral and topical antibiotic or just topical antibiotic (Kaler, et al., 2010a). Recently, Winter et al., (2015) reported a lower prevalence of lameness in flocks where sheep with footrot were never trimmed. In addition, there is no published evidence that therapeutic foot trimming is beneficial, although many trials include foot trimming as a baseline across all treatment groups (this is described in detail in Kaler et al., 2013). Avoiding trimming has not been adopted across the globe; for example, an article from Switzerland promoted foot trimming in the conclusions without testing this in the study (Locher, et al., 2015).

There were few differences between the participants' current recommendations to farmers and their perceptions of reference standard care (Table 2). This was in contrast to veterinarians in Higgins, et al., (2013) who tailored advice to farmers according to what they believed farmers would realistically act upon. Knowledge exchange providers are often not directly dependent on individual farmers for their livelihood and this independence might help in providing impartial advice. Group advice is also likely to be reference standard advice because it is not possible to vary advice for individual farmer circumstances. One might hypothesise that consultants are similar to first opinion veterinarians and vary advice, however, only a small proportion of sheep farmers use specialist consultants, the majority believing such input is not beneficial or economical (Kaler and Green, 2013). Consequently, farmers who use specialist consultants may be more motivated, proactive and willing to change. In addition, consultants are less reliant on local clients than veterinarians and so might offer more challenging advice; because their reputation is based on making improvements and they might prefer to lose clients not prepared to make changes, rather than compromise their reputation.

Finally, the follow up telephone questionnaire results suggested that change in beliefs continued after the workshop because more participants were recommending around avoiding foot trimming and rapid treatment than indicated at the event. It might be that the discussion with others at the workshop gave participants more confidence to use the evidence or that they discussed the workshop with others, or tried the treatments on their own sheep. This delayed adoption of evidence has not been evidenced before and it is an intriguing finding.

Conclusions

We demonstrated that key players in the UK sheep industry were aware that prompt parenteral and topical antibiotic treatment was more effective than foot trimming and topical antibiotic to treat footrot. All participants had incorporated parenteral antibiotic in the advice they gave before 2014, but not all recommended avoiding foot trimming. Some participants overestimated the difference in cure rates in favour of treatment with topical and parenteral antibiotic and for some this belief did not change even after they had been presented with the evidence. Participants who were not recommending avoiding foot trimming stated that the evidence had not changed their belief, but three months after the workshop they were recommending avoiding foot trimming.

Conflict of interest statement

None of the authors has any other financial or personal relationships that could inappropriately influence or bias the content of the paper.

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Supplementary materials

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

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Table 1 The roles of each participant in the sheep industry.

Participant	Role	Farmed sheep
1	Knowledge transfer	Yes
2	Consultant	Yes
3	Vet and Consultant	No
4	Consultant	No
5	Knowledge transfer	No
6	Consultant	Yes
7	Vet and Consultant	Yes
8	Consultant and breeder	Yes

Table 2 The number of participants in our study who currently gave each piece of advice to all clients, and the number of participants who would consider each piece of advice to be part of 'reference standard' care.

Advice	Number of participants currently giving this advice to all clients	Number of participants who considered this advice part of 'reference standard' care
Antibiotic injection	8	8
Vaccinate with Footvax	5	6
Treat promptly	4	4
Foot spray	4	4
Do not trim feet	4	5
Segregate sheep with footrot	4	5
Cull repeatedly lame ewes	4	6
Mark ewes	3	3
Record ear tag number	2	2
Check cause of lameness	2	2
Re-treat sheep later if necessary	2	2
Inspect sheep after treating	1	1

Cull sheep with chronically infected or misshapen feet	1	1
Quarantine new sheep	2	4
Footbath new sheep	1	3
Check the feet of all new sheep	1	1
Footbath after gathering	1	2
Avoid gathering sheep	1	3
Inspect the feet of the entire flock	0	1
Avoid buying replacement ewes with poor foot conformation	0	1

Table 3 Hyperparameters for the fitted Gaussian probability distributions.

Participant	Before evidence review			After evidence review			Change in fitted parameters ($\theta_{d(after)} - \theta_{d(before)}$)	
	θ_d cure rate	SD	95% CI	θ_d cure rate	SD	95% CI	Mean	SD
1	90.0	3.8	83 - 97	62.5	4.6	53 - 72	- 27.5	+0.9
2	76.9	3.5	70 - 84	77.5	3.6	70 - 85	+0.6	+0.1
3	90.0	3.8	83 - 97	90.0	3.8	83 - 97	0.0	0.0
4	68.8	9.6	50 - 88	62.5	3.9	55 - 70	-6.3	-5.6
5	58.9	6.2	47 - 71	72.1	6.8	59 - 85	+13.3	+0.6
6	81.7	6.6	69 - 95	67.5	2.4	63 - 72	-14.2	-4.2
7	38.1	4.1	30 - 46	60.0	1.2	58 - 62	+21.9	-2.9
8	57.5	9.8	38 - 77	63.1	7.8	48 - 78	+5.6	-2.0

θ_d, difference in cure rates; SD, standard deviation; CI, credible interval

Table 4 Elicited values for the cure rate by treatment A (inject and spray) and B (trim and spray) and the difference between the two estimated cure rates, before and after the review of the evidence, and the change in estimates after the review of the evidence.

	Before evidence review					After evidence review					Change in diff
Part	Treatment A		Treatment B		Diff $(\theta_1 - \theta_2)$	Treatment A		Treatment B		Diff $(\theta_1 - \theta_2)$	in cure rates
	Cure rate θ_1	95% CI	Cure rate θ_2	95% CI		θ_1 Cure rate	95% CI	θ_2 Cure rate	95% CI		$(\theta_1 - \theta_2)_{after} - (\theta_1 - \theta_2)_{before}$
1	95	80 - 100	40	30 - 45	55	70	60 - 75	10	5 - 15	60	+5
2	80	60 - 90	10	5 - 20	70	80	60 - 90	10	5 - 20	70	0
3	75	60 - 90	20	0 - 40	55	75	60 - 90	15	0 - 30	60	+5

4	75	40 - 90	10	0 - 50	65	70	60 - 80	10	0 - 20	60	–5
5	80	60 - 95	30	25 - 45	50	90	70 - 95	25	15 - 30	65	+15
6	90	60 - 100	10	0 - 30	80	75	60 - 100	10	0 - 30	65	–15
7	75	70 - 85	30	15 - 35	45	72	70 - 75	11	10 - 20	61	+16
8	93	85 - 100	35	20 - 40	58	90	70 - 99	35	20 - 50	55	-3

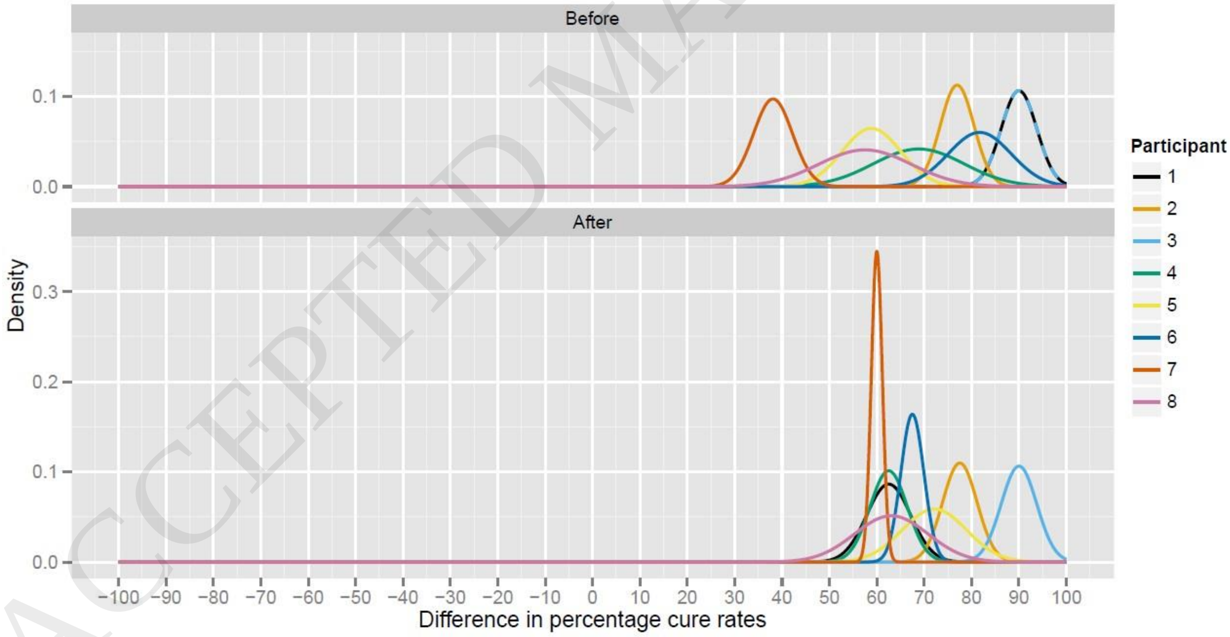
Part, Participant; θ_1, injection and spray; θ_2, trim and spray; Diff, difference; CI, credible interval

Figure legends

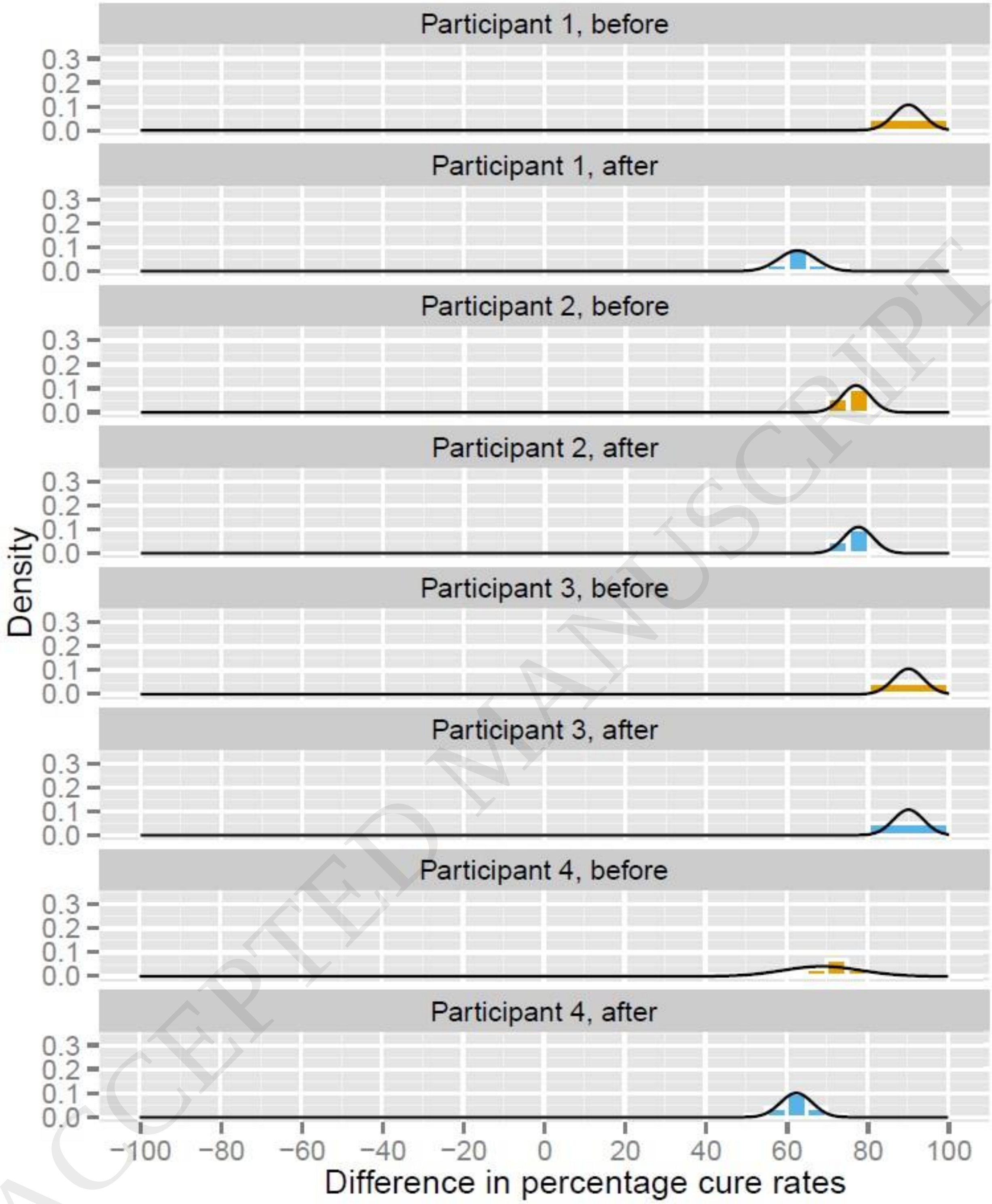
Fig. 1. Fitted Gaussian probability density functions of eight participants, before and after a review of the evidence on treatments for footrot. Positive responses favoured ‘injection and spray’ over ‘trim and spray’. Values for the fitted hyperparameters (mean and standard deviation) are shown in Table 3. The published literature currently supports a difference in cure rates of approximately 60%.

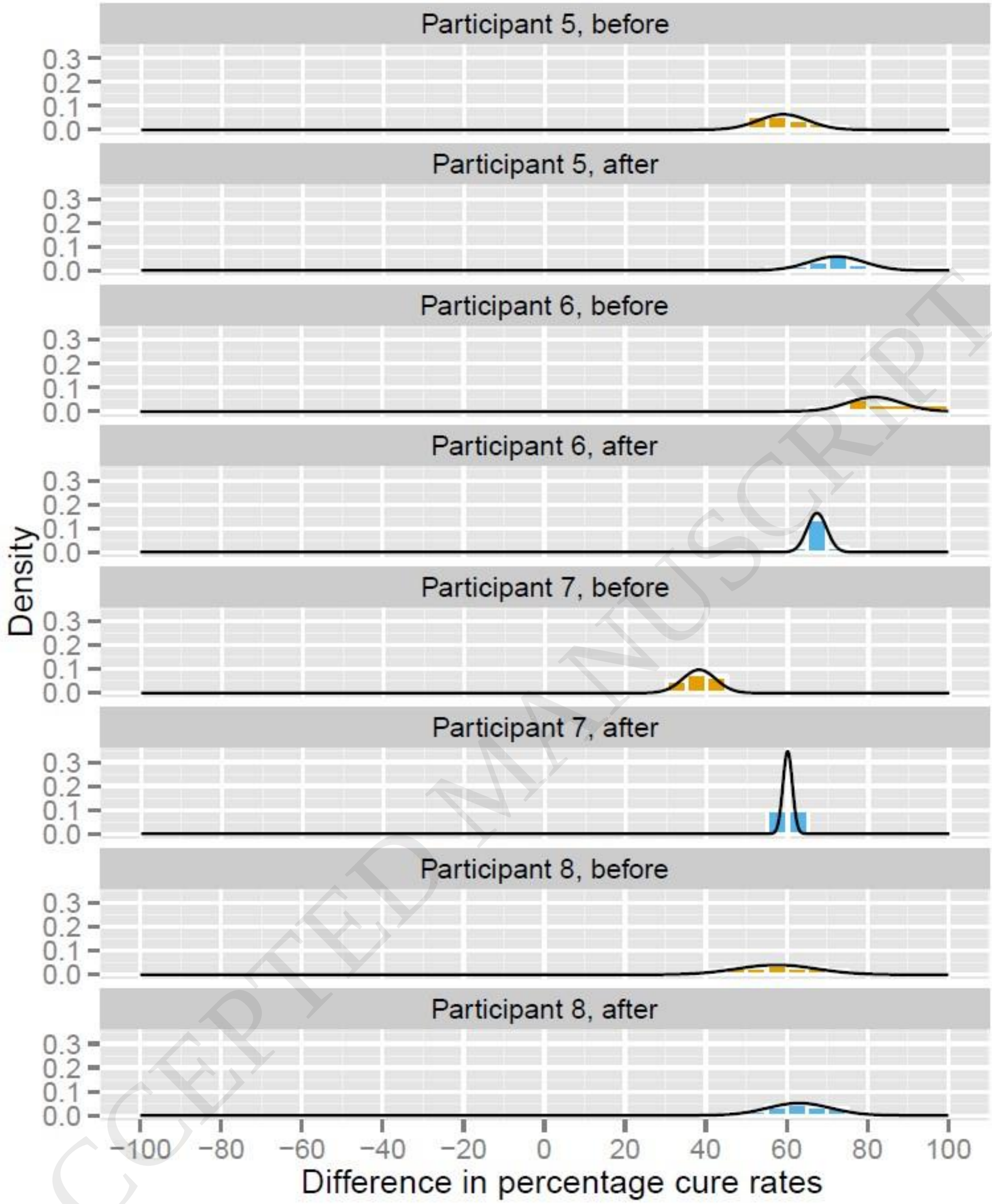
Fig. 2. (a and b) Eight participants probability density functions fitted to the raw elicited data from each participant. Positive responses favoured ‘injection and spray’ over ‘trim and spray’. Values for the fitted hyperparameters (mean and standard deviation) are shown in Table 3.

Figr-1



Figr-2


Participant 1, before
Participant 1, after
Participant 2, before
Participant 2, after
Participant 3, before
Participant 3, after
Participant 4, before
Participant 4, after
0.3
0.2
0.1
0.0
Density
−100
−80
−60
−40
−20
0
20
40
60
80
100
Difference in percentage cure rates



Participant 5, before
Participant 5, after
Participant 6, before
Participant 6, after
Participant 7, before
Participant 7, after
Participant 8, before
Participant 8, after
Density
0.0
0.1
0.2
0.3
−100
−80
−60
−40
−20
0
20
40
60
80
100
Difference in percentage cure rates