

1 **Impact of Research on Contagious Ovine Digital Dermatitis on the Knowledge and**  
2 **Practices of UK Sheep Farmers and Veterinarians.**

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13

14 **Abstract**

15 *Background*

16 Contagious ovine digital dermatitis (CODD) is a common foot disease of sheep which  
17 causes a severe form of lameness and can be difficult to control. Recent research has  
18 provided evidence-based guidance on diagnosis, treatment and farm management control.  
19 The aim of this study was to determine the uptake of this guidance on the knowledge and  
20 practices of UK sheep farmers and veterinarians and identify priorities for future research.

21 *Methods*

22 Data was collected in 2019-20 by electronic surveys of UK sheep veterinarians and farmers  
23 distributed through sheep industry organisations and social media.

24 *Results*

25 284 sheep farmers and 77 veterinarians responded to the surveys. 52% of farmers and 70%  
26 of vets considered that their management of CODD had improved as a direct result of  
27 recent research evidence on the disease. The principle areas improved for both sectors  
28 were biosecurity advice and use of antibiotic treatments.

29 Farmers and veterinarians reported that the priorities for future research should be in  
30 therapeutics, vaccine development and the understanding of disease transmission.

31 *Conclusion*

32 There has been strong uptake of recent evidence based veterinary medicine by farmers and  
33 veterinarians for the management of CODD, particularly in the areas of biosecurity and  
34 responsible antibiotic use.

35 **Introduction**

36 Contagious ovine digital dermatitis (CODD) is recognised as one of the most important  
37 causes of sheep lameness in the UK (1, 2). It was first recognised in 1997 (3) and is now

38 reported to occur widely (1, 4, 5), with recent estimates indicating between 35 and 58% of  
39 UK flocks infected. Until 2011/2012 there was a paucity of research on CODD (5-7).  
40 Treatment of the disease was particularly problematic with no evidence base to support  
41 clinical decision making. Consequently, in the light of the severity of the lameness caused  
42 by CODD, whole flock metaphylactic treatments with antibiotics and antibiotic foot  
43 bathing were common practices to control disease outbreaks. In the context of emerging  
44 global concern regarding antibiotic resistance and responsible use of antibiotics in farming,  
45 there was scepticism over these practices (8).

46 Funding by the British Veterinary Association Animal Welfare Foundation (BVAAWF), the  
47 Agricultural and Horticultural Development Board (AHDB), Hybu Cig Cymru (HCC), Quality  
48 Meat Scotland (QMS) and the Biotechnology and Biological Sciences Research Council  
49 (BBSRC) has enabled researchers at the University of Liverpool to describe some of the  
50 fundamental aspects of this relatively new disease, including its aetiology (9, 10),  
51 epidemiology and risk factors for occurrence (4, 11), clinical presentation (12), animal  
52 welfare impact (13), pathology (14), transmission routes (15, 16), and treatment strategies  
53 (17-20) including the rational selection of antimicrobials based on *in vitro* (20) and *in vivo*  
54 antibiotic efficacies (17). Furthermore, a randomized control trial demonstrated that whole  
55 flock metaphylactic treatments with tilmicosin failed to eradicate CODD from flocks, thus  
56 providing evidence against this practice (19).

57 A key component of the research program was dissemination of the research findings to  
58 veterinarians and sheep farmers via knowledge exchange activities carried out in  
59 conjunction with AHDB and HCC. A broad range of activities were undertaken including  
60 presentations at national and international veterinary conferences, farmer knowledge

61 exchange meetings, on farm demonstrations, articles in the veterinary and farming press,  
62 creation of industry manuals and contributions to policy and webinars.

63 It is essential that veterinary research has a beneficial impact on the communities on whose  
64 behalf the research is being conducted. Therefore, the aim of this study was to 1) identify  
65 the impact of this research activity and subsequent knowledge exchange activities on  
66 improvements to the knowledge and practices of sheep farmers and veterinarians in their  
67 management of CODD and 2) to identify the industry needs for future research on CODD.

## 68 **Materials and Methods**

### 69 *Sheep Farmer Survey*

70 UK sheep farmers were the study population for the farmer electronic survey. They were  
71 contacted through the National Sheep Association, Sheep Veterinary Society email group  
72 and social media networks of Facebook ([www.Facebook.com](http://www.Facebook.com)) and Twitter  
73 ([www.twitter.com](http://www.twitter.com)). A pilot survey was tested on 4 farmers prior to distribution of the final  
74 questionnaire in May to July 2020. The questionnaire consisted of 14 questions. There were  
75 2 questions on demographics, 9 questions on current knowledge and practices on the  
76 diagnosis, prevalence, treatment and prevention of CODD and 2 questions on changes in  
77 farming management practices that were a consequence of recent research information  
78 and advice on CODD. There was one open question asking for farmers views and comments  
79 on future research required for CODD. Farmers were asked to classify CODD lesions based  
80 on a pictorial guide of key diagnostic features of CODD lesions. The electronic survey was  
81 created and distributed through Jisc on-line survey tool ([www.jisc.ac.uk](http://www.jisc.ac.uk)). The project was  
82 approved by University of Liverpool Veterinary Research Ethics Committee (VREC 936).

### 83 *Veterinarian Survey*

84 UK veterinary surgeons who treat sheep as part of their professional practice were the  
85 study population for the electronic survey. They were contacted through the Sheep  
86 Veterinary Society email group and social media networks such as Facebook  
87 ([www.Facebook.com](http://www.Facebook.com)) and Twitter ([www.twitter.com](http://www.twitter.com)). A pilot survey was tested on 4  
88 veterinary surgeons prior to distribution of the final questionnaire in July/August 2019. The  
89 questionnaire consisted of 7 questions. The first five addressed changes in veterinary  
90 surgeon knowledge and practices on the diagnosis, epidemiology and management of  
91 CODD as a direct result of the research conducted at the University of Liverpool. One open  
92 question asked for veterinary surgeon's views on future research required for CODD and  
93 the final question was an open question asking for general comments on CODD research.  
94 The electronic survey was created and distributed through Survey Monkey on-line survey  
95 tool ([www.surveymonkey.co.uk](http://www.surveymonkey.co.uk)). The project was approved by University of Liverpool  
96 Veterinary Research Ethics Committee (VREC819).

#### 97 *Data Analysis*

98 Data was downloaded from the survey into EXCEL (Microsoft, Washington USA) and  
99 analysed in Minitab (Minitab Ltd, Coventry, UK). Results are reported as proportions or  
100 medians plus interquartile ranges as appropriate.

### 101 **Results**

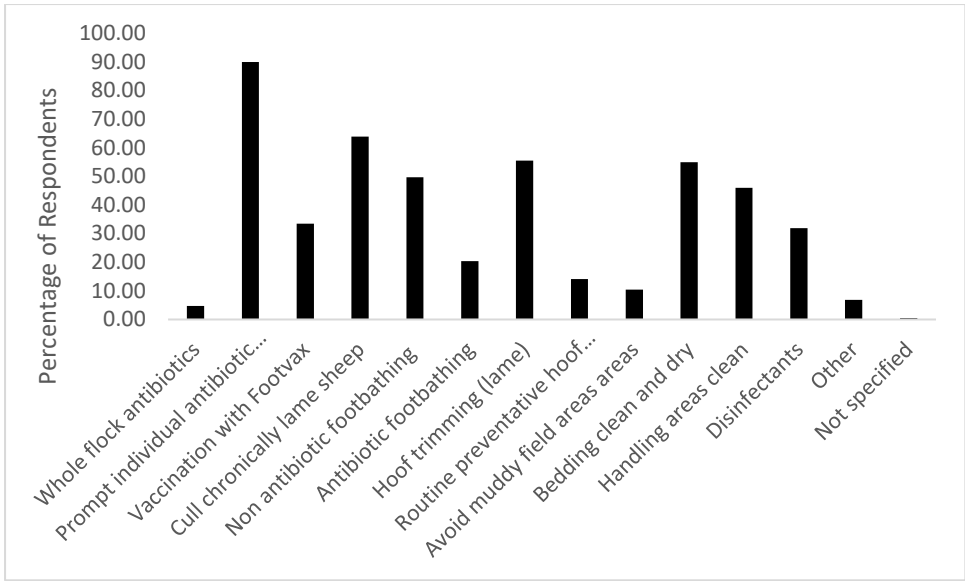
#### 102 *Sheep Farmer Survey*

103 Two hundred and eighty four farmers responded to the survey with representation from  
104 England (65% of respondents), Scotland (10%), Northern Ireland (2%) and Wales (19%).  
105 The median flock size of respondents was 330 (IQR 130-655) breeding ewes. This is  
106 comparable to the UK average of 461 sheep per holding (21).

107 In total, 97% of respondents were aware of CODD as a disease, whilst 67% of respondents  
108 confirmed that they had identified CODD on their farm. Farmers were asked to estimate  
109 the prevalence of CODD on their farms when disease was at its worst and the reported  
110 median prevalence was 5% (IQR 3-15%). Farmers reported using a range of management  
111 strategies to attempt to control the disease in their flock (Figure 1A). For flock level control  
112 measures, the majority of respondents (90%) used prompt treatment of individual sheep  
113 with antibiotics, followed by culling chronically lame sheep (64%), hoof trimming when  
114 lame (55%), ensuring clean bedding (55%), and non-antibiotic foot bathing (50%). For  
115 treatment of individual sheep affected by CODD (Figure 1B), the most common treatment  
116 used was prompt injection of antibiotics (88%), followed by topical antibiotic application  
117 (77%) and foot trimming (47%). Thirty seven percent of farmers treated sheep with CODD  
118 with analgesics. Oxytetracycline (26%) and amoxicillin (25%) were the most common  
119 antibiotics used. However, when the macrolide drug group usage figures were combined,  
120 35% of antibiotics selected by the farmers to treat CODD cases were from this class of  
121 antibiotic (Figure 1C).

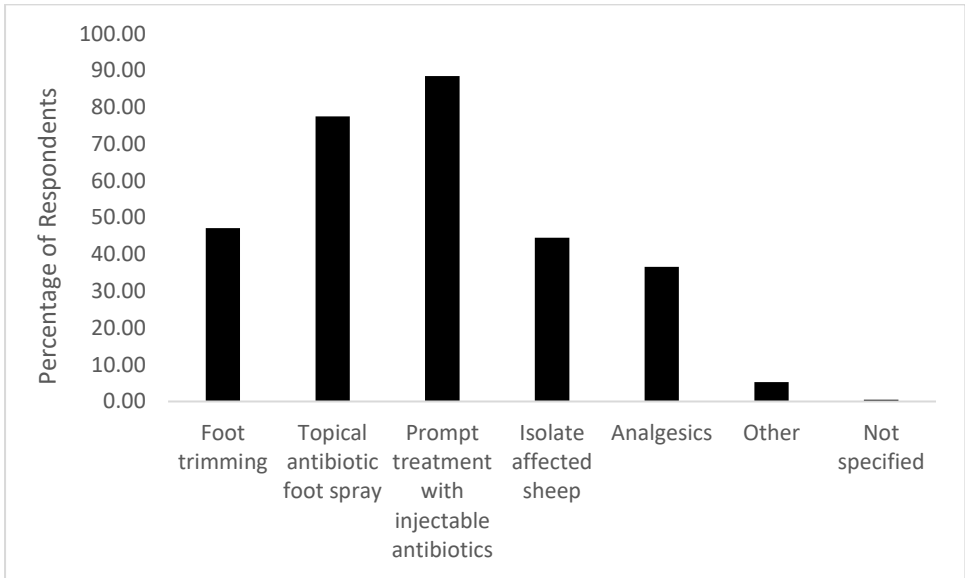
122 Ninety three percent of farmers undertook some form of biosecurity measure to prevent  
123 CODD coming onto their farm, with 43% of farmers following current CODD specific advice  
124 to examine the feet of all bought in sheep on arrival. Seventy five percent of farmers  
125 isolated their bought in sheep on arrival for a median time of 21days (IQR 14-28 days)  
126 (Figure 1D).

127 **A**



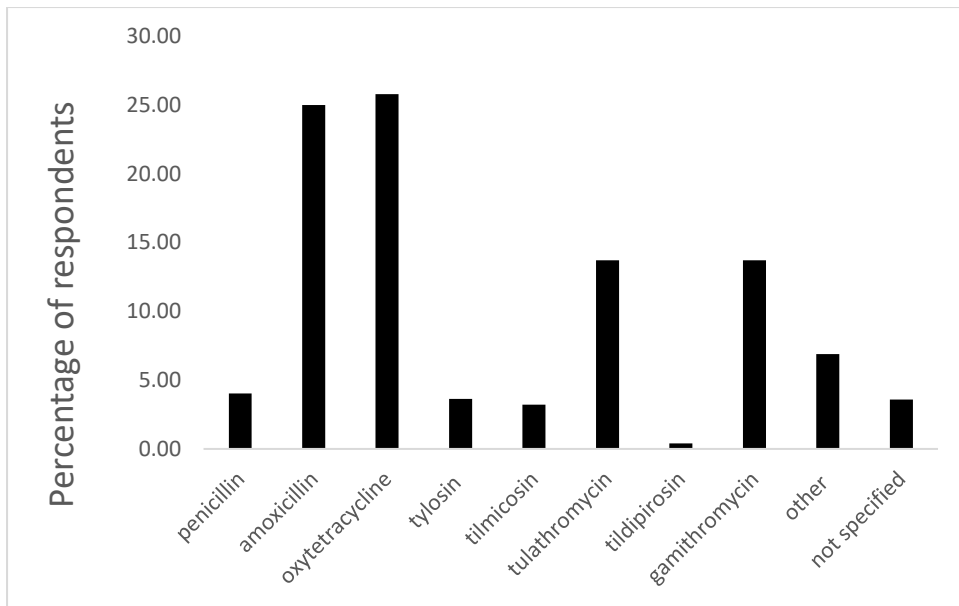
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**B**



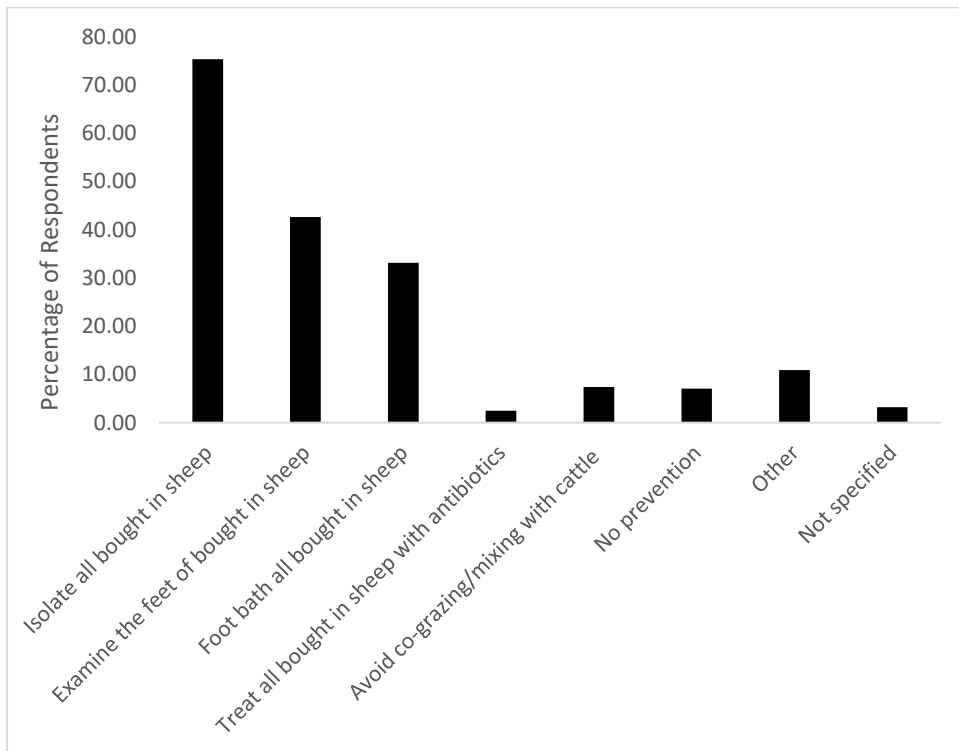
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**C**



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**D**



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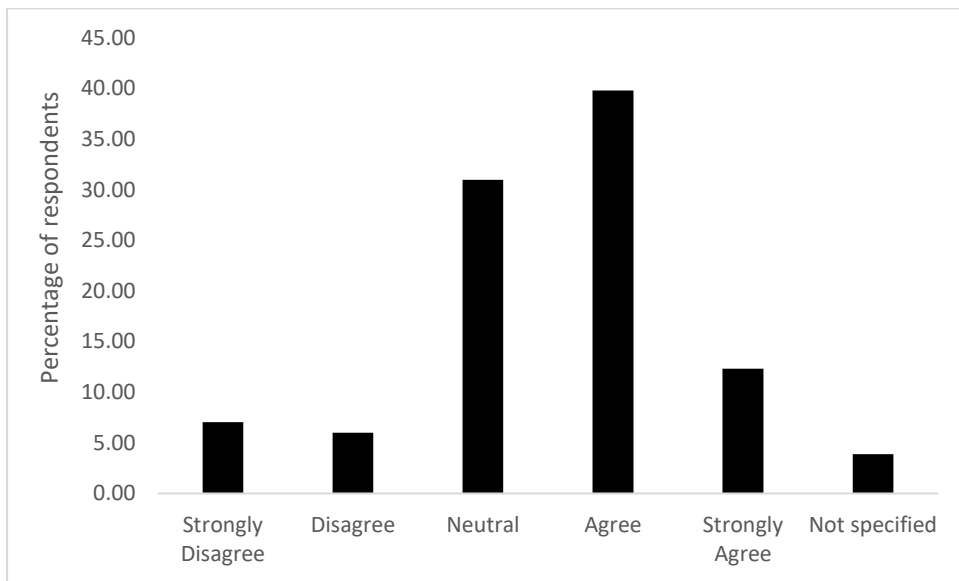
145 **Figure 1: Farmer reported flock level control measures (A). Individual animal level**  
146 **treatments for CODD (B). Antibiotics used by farmers in treatment of CODD (C).**  
147 **Biosecurity measures employed by farmers (D).**  
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149 In response to the question: - "My management of CODD on sheep farms has improved  
150 because of recent guidance on the disease (information may have come through vet advice  
151 or farming press or farmer meetings for example)?", the majority of farmer respondents

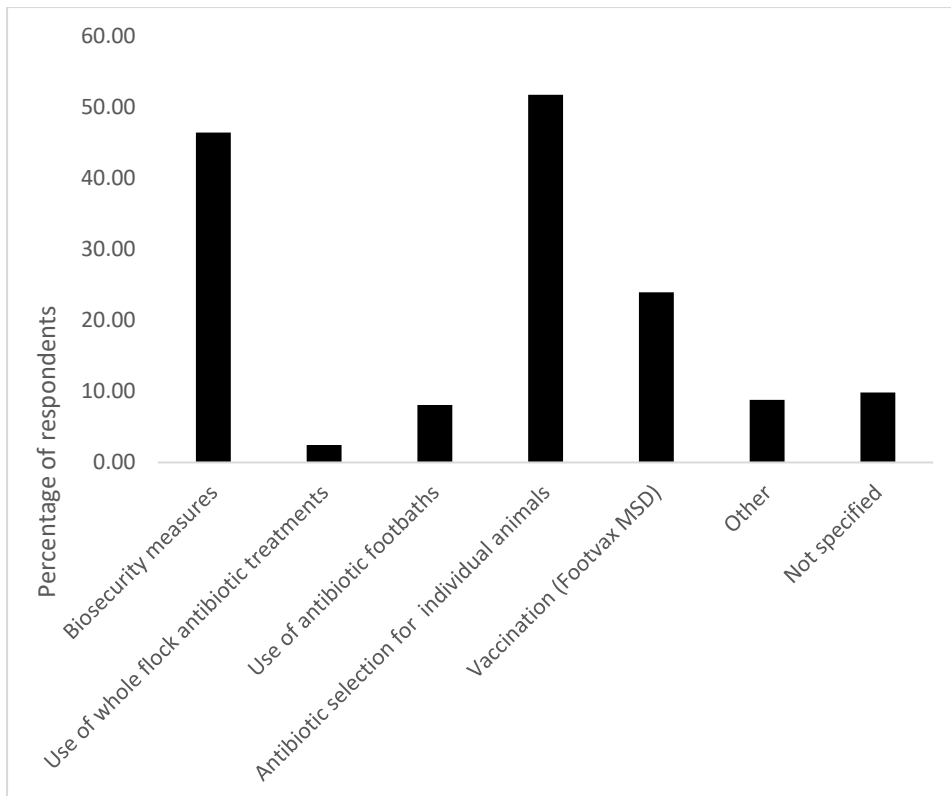


152 (52%) agreed that their management of CODD had been improved (Figure 2A).  
153 Furthermore, when asked "Which aspects of your management of CODD have been  
154 influenced by recent information on CODD (information may have come through vet advice  
155 or farming press or farmer meetings for example)?", they stated that the key management  
156 areas impacted were biosecurity measures (46%), choice of antibiotic (52%) and the use of  
157 the footrot vaccine Footvax (MSD) (24%) (Fig 2B).

158 **A**



159 **B**  
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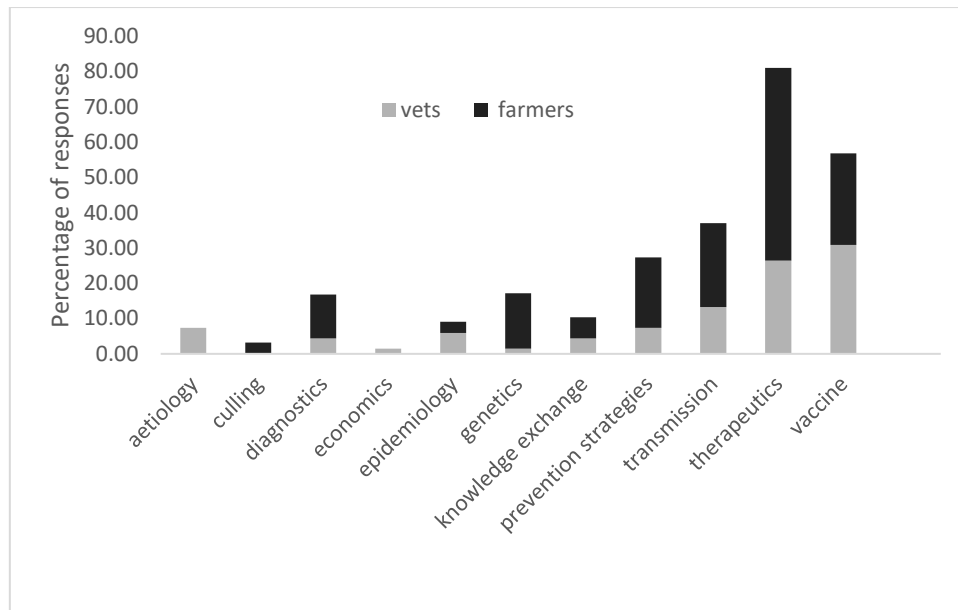


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**Figure 2: Impact of CODD research on farmer knowledge and practices. Percentage agreement of farmers with the statement that their management of CODD on sheep farms has improved because of recent guidance on the disease (A). Aspects of management of CODD that have been influenced by recent information on CODD (B).**

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Analysis of research priorities of both farmers and vets was conducted by grouping the answers into research themes. For the 176 farmers that completed this question, there were 305 responses, with the priority research areas identified as therapeutics (55%), vaccine development (26%), and disease transmission (24%) (figure 3).



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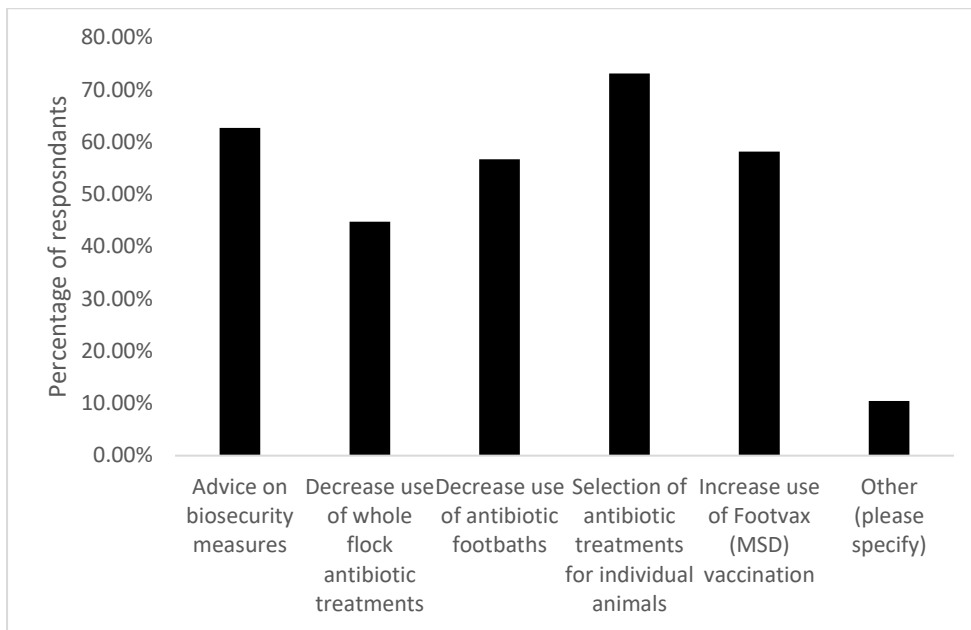
**Figure 3: Farmer (n=176) and veterinary surgeons (n=51) opinions on future research priorities for CODD.**

177 *Veterinary Surgeon Survey*

178 There were 77 responses to the veterinary surgeon’s survey. No demographic data was  
179 collected. Participants were only asked to confirm that they treat sheep as part of their  
180 veterinary practice. In this survey, 73% of respondents considered their awareness of CODD  
181 had increased as a result of recent research, 60% of respondents considered their  
182 knowledge of clinical diagnosis and also the epidemiology of CODD had improved. Overall,  
183 70% of respondents stated that their advice on the management of CODD had improved. In  
184 particular, advice on antibiotic use had changed with 45% of vets decreasing their use of  
185 whole flock antibiotic treatments to control CODD and 57% recommending to reduce the  
186 use of antibiotic footbaths. Research data influenced 73% of vets on their advice of  
187 antibiotic choice. For CODD prevention, 58% of vets had increased their prescribing of  
188 Footvax (MSD) and 63% of vets had changed their advice on biosecurity measures for  
189 CODD based on research findings (Figure 4).

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**Figure 4: Changes in veterinary advice on management practices for CODD.**

198 Analysis of research priorities for vets was conducted as described for farmers. For vets  
199 there were 70 responses from 51 vets, with the priority research themes identified as  
200 vaccine development (31%), therapeutics (26%) and disease transmission (13%) (Figure 3).

## 201 Discussion

202 The aim of this study was to measure the impact of recent research on CODD on farmers'  
203 and veterinarians' knowledge and practice around the disease, and to identify where future  
204 research emphasis is needed.

205 Before consideration of the research findings, the limitations of the study should be  
206 considered to inform data interpretation and comparison with other studies. Firstly, the  
207 sampling strategy is a non-random, convenience sample based on UK sheep farmers' and  
208 sheep vets' ability to access, and then be willing to respond to, an electronic questionnaire.  
209 For example, the study population maybe be biased towards younger members of each

210 profession. The inevitable sampling bias means that these findings cannot be generalised  
211 to the entire UK population of sheep farmers and veterinarians. However, the Sheep  
212 Veterinary Society represents members of the veterinary profession from across the UK  
213 with a particular interest in sheep, whose clinical practice involves a significant proportion  
214 of sheep work, and the National Sheep Association is the largest, UK wide association for  
215 sheep farmers. Furthermore, demographic data from the study shows that the farmers who  
216 responded to the survey came from all devolved UK nations, in a similar distribution to the  
217 UK sheep population (21). Finally, it is considered that the impact can be attributed to  
218 recent research at the University of Liverpool. A search of the scientific literature on Web  
219 of Science (22) (15/01/2021) found 17 scientific articles on the study of contagious ovine  
220 digital dermatitis published between 2010 and 2019; 16 out of the 17 articles were  
221 authored by the University of Liverpool researchers. Therefore, it is a fair assumption that  
222 changes in veterinary and farming practice are as a consequence of University of Liverpool  
223 research work. Therefore, the findings of the study can be considered a useful indicator of  
224 the impact of CODD research work on UK veterinary practice and the sheep farming  
225 industry.

226 CODD was reported as a common disease in this population, with 68% of farmers  
227 reporting to have CODD at a median prevalence of 5% (IQR 3-15%) when CODD was at its  
228 worst on the farm. The prevalence estimates reported here are higher than for previous  
229 epidemiological studies. In 2013 in England, the on-farm prevalence of CODD was reported  
230 as 2.3% (1), whilst in 2014 in Wales, it was reported as 2.0% (IQR 1.0–5.0%) (4).

231 Comparisons with this data should be interpreted with caution due to bias caused by non-  
232 random sampling, different study populations, reporting bias by the farmers (the data is a  
233 farmer estimate only and knowledge and awareness of CODD is likely to have increased

234 since this time) and differences in how the question was asked. Since CODD prevalence on  
235 farms fluctuates temporally with some seasonality, in this study, we asked farmers to  
236 estimate prevalence when CODD was at its worst which could account for the apparent  
237 increase in prevalence. However, it is possible that despite improvements and changes in  
238 knowledge and practices around CODD management discussed below, the prevalence of  
239 CODD is increasing in the UK, and further research is urgently needed. The farmers and  
240 veterinarians in the survey have given clear guidance as to where they think research  
241 efforts should be focussed by identifying research on treatment strategies, development of  
242 a vaccine and studies to understand transmission routes as their top three priorities (Figure  
243 3).

244 Nearly all the sheep farmers in the study were aware of CODD, and 52% of farmers and 70%  
245 of vets considered that their management of CODD had improved as a result of recent  
246 research, demonstrating substantial dissemination of the research outputs in a relatively  
247 short period of time since the majority of the work was published in the scientific press  
248 (2014-2018). Importantly, the farmers and veterinary surgeons reported the main  
249 improvements they had made as direct result of the University of Liverpool research was in  
250 biosecurity practices (45% and 63 %, respectively), and antibiotic treatments (52% and 73%,  
251 respectively) (Figures 2 and 4).

252 The findings on the farmer biosecurity practice improvements to prevent disease incursion  
253 are particularly encouraging, as it is arguably the most important disease control measure  
254 at the flock level. Nearly all the farmers (93%) had biosecurity measures in place to prevent  
255 CODD introduction, the majority (75%) following best practice general industry advice to  
256 isolate animals for 3-4 weeks (23, 24) and 43% following CODD specific advice to examine  
257 the feet of all bought in sheep on arrival (1, 13) (Figure 1D).

258 As already indicated, concerns existed around the treatment of CODD in the early 2010's  
259 (25) when whole flock treatments with antibiotics, deemed critically important for human  
260 health, were being advocated, as well as antibiotic foot bathing. However, at that time little  
261 was known about the aetiology and treatment of CODD, and the severity of the disease  
262 and impact on sheep welfare was of concern. Research on CODD treatment has come a  
263 considerable way since then. We have investigated *in vitro* antibiotic efficacy (20), and  
264 undertaken two large scale randomized controlled field trials (17, 19). This data has been  
265 shared widely with sheep farmers and veterinarians such that 90% of farmers are treating  
266 sheep with the recommended prompt antibiotic treatment (Figure 1B), whilst 45% of  
267 veterinarians have decreased their use of whole flock antibiotic treatments and 57% have  
268 ceased or reduced recommendations to use antibiotic footbaths. Research data influenced  
269 73% of vets on their advice of antibiotic choice (Figure 4). On farms, the farmers are using a  
270 range of antibiotic treatments (Figure 3), most of which (apart from oxytetracycline 34%)  
271 would be expected to be effective based on current evidence (20). Finally, both vets and  
272 farmers have taken up a number of CODD disease control measures that have emerged  
273 from the study of epidemiology and associated risk factors (11). For example, footrot has  
274 been identified as the major risk factor for CODD, with a vaccine efficacy of 32%  
275 protection against clinical disease (17). Encouragingly, 58% of vets increased their  
276 prescribing of the footrot vaccine, Footvax (MSD), to aid control of CODD (Figure 4). Whilst  
277 34% of the farmers reported using Footvax (MSD) as a control measure for CODD in their  
278 flocks (figure 1A).

279 Although there were many positive findings in the study in the uptake of evidence based  
280 veterinary practice, there are some areas of concern. In particular, the common practice of  
281 foot trimming lame (55%) and non-lame sheep (14%) by farmers in this study (figure 1A).

282 Research evidence has identified that foot trimming is contraindicated in the treatment of  
283 footrot (26), increases the risk of lameness in flocks (27) and has the potential to spread  
284 disease (28) and is now not advised in the treatment of lame sheep (29). So, it is concerning  
285 that the practices are still relatively common amongst farmers.

## 286 **Conclusion**

287 The survey has shown that there has been strong uptake of recent evidence based  
288 veterinary medicine by farmers and veterinarians for the management of CODD,  
289 particularly in the areas of biosecurity and responsible antibiotic use. However, despite  
290 these positive efforts by the industry, there is evidence to suggest that CODD prevalence  
291 could be increasing in the UK and further research and knowledge exchange is required to  
292 tackle this. Farmers and veterinarians have identified their research priorities as treatment  
293 strategies, vaccine design and disease transmission.

## 294 **Funding**

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## 296 ***Authors' contributions***

297 JD undertook the original research and knowledge exchange activities on CODD, co-  
298 designed the current study and wrote the first draft of the manuscript. TW co-designed the  
299 current study, undertook data analysis and critically evaluated the manuscript, NFRS  
300 undertook data analysis. JWA, DGW, NJE and SC undertook the original research and  
301 knowledge exchange activities on CODD and critically evaluated the manuscript.

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## 392 **Figure Legends**

393 **Figure 1: Farmer reported flock level CODD control measures (A). Individual animal**  
394 **level treatments for CODD (B). Antibiotics used by farmers in treatment of CODD (C).**  
395 **Biosecurity measures employed by farmers (D).**

396 **Figure 2: Impact of CODD research on farmer knowledge and practices. Percentage of**  
397 **farmers agreeing with the statement that their management of CODD on sheep farms**  
398 **has improved because of recent guidance on the disease (A). Aspects of management**  
399 **of CODD that have been influenced by recent information on CODD (B).**

400 **Figure 3: Farmer (n=176) and veterinary surgeons (n=51) opinions on future research**  
401 **priorities for CODD.**

402 **Figure 4: Changes in veterinary advice on management practices for CODD.**

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