

# Giving calves "the best start": perceptions of colostrum management on dairy farms in England

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1                   **Giving calves "the best start": Perceptions of colostrum**  
2                   **management on dairy farms in England**

3                   Running title: Colostrum management for calves on dairy farms

4  
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13  
14                   **Abstract**

15                   Good colostrum management can confer protective immunity to newborn calves, making calves  
16                   less susceptible to infectious disease, and fundamentally improving both their short- and long-  
17                   term health, welfare and productivity. Industry recommendations commonly refer to 'The Three  
18                   'Q's' of colostrum management: the need for calves to receive sufficient 'Quantity' of high  
19                   'Quality' colostrum 'Quickly' after birth; some also include 'sQueaky clean' and 'Quantification  
20                   of passive transfer'. However, research to date suggests that the failure of passive transfer of  
21                   colostral antibodies is common on commercial dairy farms, contributing to suboptimal calf  
22                   health and mortality. This paper explores why this may be the case by investigating stakeholder  
23                   perceptions of colostrum management and how these perceptions might affect the practice of  
24                   ensuring adequate colostrum administration to newborn calves.

26 Calf rearing and youngstock management practices on English dairy farms were investigated  
27 using 40 in-depth semi-structured interviews: 26 with dairy farmers and 14 with advisors  
28 (including veterinarians, feed and pharmaceutical company representatives). Interviews were  
29 audio recorded, transcribed and thematically coded for analysis. 'The Three 'Q's' were found to  
30 act as useful reminders about the goals of colostrum management, and a case can be made for  
31 further publicising the inclusion of 'sQueaky clean' and 'Quantification of passive transfer' as  
32 there remains a lack of focus on colostrum hygiene and measurement of successful antibody  
33 transfer. Knowledge of the 'Q's did not guarantee implementation, and time and labour  
34 constraints alongside farmer misconceptions must be addressed when offering professional  
35 advice on improving calf health. Further research to encourage on-farm collection and analysis  
36 of monitoring data including rates of passive transfer is particularly needed. Advisors must not  
37 overlook the importance of colostrum management when assessing farm practices and ensure  
38 that they promote evidence-based recommendations if dairy calf morbidity and mortality is to  
39 be reduced.

40

#### 41 **Keywords**

42 Animal welfare; colostrum; dairy calf welfare; dairy calf health; qualitative research;  
43 stakeholder perceptions

44

#### 45 **Introduction**

46 The ingestion of colostrum is of great importance to bovine neonates as it provides nutritive and  
47 non-nutritive components that influence the development of the gastrointestinal tract and the  
48 nutritional, metabolic and immune status of calves (Blum 2003). Of particular importance are  
49 the high levels of immunoglobulin (mainly IgG) in colostrum (Godden 2008). Calves are born  
50 agammaglobulinemic so depend on the absorption of maternal colostral immunoglobulins  
51 through the wall of the small intestine in the first 24 hours of life (Weaver *et al* 2000; Godden  
52 2008). Failure of passive transfer from colostrum is diagnosed when calf serum levels of IgG or

53 total protein are less than 10 g/L or 50 g/L, respectively (Patel *et al* 2014). Failure of passive  
54 transfer increases calves' susceptibility to infectious disease and mortality (Wittum & Perino  
55 1995; Raboisson *et al* 2016), reduces growth rates (Robison *et al* 1988), and has been linked to  
56 lower milk yield during their first lactation (DeNise *et al* 1989). The total cost related to failure  
57 of passive transfer has been estimated as €60 per calf in European dairy systems, including costs  
58 related to mortality, morbidity and reduced average daily weight gain (Raboisson *et al* 2016).

59

60 Current industry recommendations for colostrum management to promote successful passive  
61 transfer are based around principles commonly referred to as 'The Three 'Q's': 'Quantity',  
62 'Quickly' and 'Quality' (Patel *et al* 2014; AHDB Dairy 2018). Calves should consume a volume  
63 of colostrum equating to at least 10% of their bodyweight (3-4 L for a 30-40 kg calf) (Godden  
64 2008). It is a legal requirement in England for calves to receive colostrum within six hours of  
65 birth (The Welfare of Farmed Animals (England) Regulations 2007 (as amended)); after six  
66 hours there is a progressive decline in the efficiency of immunoglobulin transfer across the gut  
67 epithelium until full gut closure at 24 hours of age (Godden 2008; Hart 2016). Calves should be  
68 artificially fed via nipple bottle or oesophageal tube due to concerns about the ability to attain  
69 sufficient immunoglobulin mass when suckling from the dam (McGuirk & Collins 2004; Patel  
70 *et al* 2014). Immunoglobulin content of colostrum can be indirectly assessed using a  
71 colostrometer or Brix refractometer which measure specific gravity and total solids,  
72 respectively. Good quality colostrum contains over 50 g/L of immunoglobulin which equates to  
73 >22% (Brix) (Bartier *et al* 2015). Samples with readings below 20 g/L or 22% (Brix) should be  
74 discarded (AHDB Dairy 2018). Concentrations of immunoglobulin in colostrum have been  
75 shown to decline rapidly over time from calving (Moore 2005) therefore colostrum should be  
76 harvested within six hours of parturition (Godden 2008). Pooling colostrum from multiple dams  
77 is not recommended; immunoglobulin content can be diluted (Weaver *et al* 2000), and disease  
78 risk may be increased (Godden 2008).

79

80 Some extend recommendations from three to five 'Q's by including 'sQueaky clean' and  
81 'Quantifying passive transfer' (Hart 2016). Bacterial contamination of colostrum interferes with  
82 absorption of immunoglobulins (Godden 2008) and total bacterial numbers and faecal coliform  
83 counts should not exceed 1 000 000 and 10 000 cfu/mL, respectively (McGuirk & Collins  
84 2004). Colostrum should be collected hygienically and either fed or refrigerated within one hour  
85 of milking to impede rapid multiplication of microorganisms. Batch-pasteurisation of colostrum  
86 eliminates or at least significantly reduces pathogens, including *Mycobacterium avium*  
87 subspecies *paratuberculosis* which causes Johne's disease (paratuberculosis) in cattle (Godden  
88 2008). Johne's disease can be spread from infected adult cattle to calves through ingestion of  
89 faecal matter or contaminated colostrum, and is a key reason to implement 'snatch calving'  
90 where calves are immediately removed from their dam and fed either colostrum from Johne's  
91 test-negative cows (Windsor & Whittington 2010) or colostrum replacement products (Godden  
92 2008). Herd-based assessment of passive transfer, for example by monitoring serum total  
93 protein in healthy calves or zinc sulphate turbidity testing, can be used to evaluate colostrum  
94 management practices (McGuirk & Collins 2004; Hart 2016). Where high rates of failure of  
95 passive transfer are evident, colostrum protocols are more likely to be reviewed and improved  
96 (Atkinson *et al* 2017; Sumner *et al* 2018).

97  
98 It was first reported over 90 years ago that ingestion of colostrum confers protective immunity  
99 to newborn calves (Smith & Little 1922), yet problems achieving adequate passive transfer from  
100 colostrum remain evident at farm level. Failure of passive transfer was estimated to occur in  
101 19.2% of dairy heifer calves in the US (Beam *et al* 2009), and diagnosed in 26% of calves from  
102 444 calvings across seven UK dairy farms (MacFarlane *et al* 2015) and 33% of dairy calves in a  
103 study of 107 New Zealand dairy farms (Cuttance *et al* 2017). Studies in various countries have  
104 demonstrated that colostrum management remains poor on many farms (Kehoe *et al* 2007;  
105 Vasseur *et al* 2010a; Morrill *et al* 2012) suggesting that the scientific recommendations outlined  
106 above have failed to stimulate uptake of best practice by farmers. This could be because  
107 dissemination efforts have either failed to make farmers aware of recommended best practice or

108 have conveyed the information to farmers but did not motivate them to make improvements to  
109 their colostrum management. In either case, it is very important to understand why  
110 recommendations are not implemented on farms. Farmer attitudes, such as perceived control  
111 and ability to make decisions and take action towards improving calf health, have been shown  
112 to influence husbandry practices related to calf mortality (Vaarst & Sørensen 2009; Santman-  
113 Berends *et al* 2014). Where the alteration of management practices is considered unnecessary,  
114 impractical or unlikely to yield beneficial results, inaction is likely. On the other hand, positive  
115 beliefs about the potential for improvement, and the ease of implementation, are more likely to  
116 result in actions contributing to better calf management (Vaarst & Sørensen 2009; Santman-  
117 Berends *et al* 2014).

118

119 Although farmers have a vital primary role, it is likely that both farmer and advisor perspectives  
120 and their interactions influence colostrum management on farms. For example, in response to  
121 benchmarking reports which included comparative passive transfer rates, many farmers  
122 consulted their veterinarian on how to make specific changes to improve their colostrum  
123 management (Atkinson *et al* 2017). However, in general practice, data relating to calf health are  
124 under-recorded on dairy farms (Bach & Ahedo 2008), and farmers may believe that they have  
125 sufficient knowledge about calf rearing and the causes of problems on their farms, whereas  
126 veterinarians might consider those farmers' knowledge lacking, or inaccurate, in those areas, as  
127 was demonstrated in a Dutch study by Santman-Berends *et al* (2014). In such cases, farmers are  
128 unlikely to consult their veterinarians about calf health or performance issues, but veterinarian-  
129 driven conversations explaining why certain practices could lead to problems and discussing  
130 possible improvements may convince farmers to take action (Santman-Berends *et al* 2014). On  
131 the other hand, it is possible that neither the farmer nor veterinarian is focused on the calf  
132 rearing enterprise (Sumner & von Keyserlingk 2018), meaning colostrum management would  
133 be rarely discussed. Farmers may also receive input from other agricultural advisors with  
134 different areas of expertise and focus compared to veterinarians (Ellingsen *et al* 2012), such as  
135 animal nutritionists and sales representatives from the pharmaceutical industry. Thus, exploring

136 the perceptions of a range of stakeholders with regards to management of colostrum on dairy  
137 farms will yield further useful insights. This paper therefore investigates farmer and farm-  
138 advisor perceptions of colostrum management and administration to calves on dairy farms, to  
139 better understand why uptake of recommendations for best practice may or may not occur.  
140 Accepting the premise that if dairy calf health is generally suboptimal it may not be solely the  
141 fault of farmers, this paper takes a wider perspective on the problem.

## 142 **Materials and methods**

143 Qualitative research methodologies from the social sciences are increasingly used to investigate  
144 animal health and welfare issues from the perspectives of both veterinarians and farmers (eg  
145 Robinson & Epperson 2013; Brennan *et al* 2016; Bourély *et al* 2018; Robinson 2019) and  
146 several authors have advocated such interdisciplinary approaches (eg Whay 2007; Escobar &  
147 Buller 2014). Qualitative methods are particularly useful to gain insight into choices made in  
148 relation to individual contexts, perspectives, emotions and priorities (Escobar & Buller  
149 2014). The current study utilises a critical realist paradigm which combines realist ontology  
150 (there is a real world which exists independently of our interactions with it) with constructivist  
151 epistemology (knowledge of the world is imperfect and subjective, influenced by human  
152 perceptions and concepts, resulting in different yet equally valid experiences and interpretations  
153 of reality). This means that perceptions and physical entities are considered equally important in  
154 understanding phenomena (Maxwell 2012) such as colostrum management on dairy farms.  
155 Whereas quantitative research counts occurrences, (eg which practices occur in a representative  
156 sample of farmers), the aim of this qualitative study is to describe a range of experiences and  
157 beliefs held by farmers and farm advisors which may contribute to choices and actions made  
158 regarding colostrum protocols on farms.

159

160 It is important to note the potential influence of the first author who conducted the face-to-face  
161 interviews, transcriptions and data analyses. Well recognised within the social sciences,  
162 qualitative research requires a reflexivity which considers the potential influence of the

163 researcher, those interviewed, and the context within which the interviews take place (Rose  
164 1997). The researcher embarked on the project from a background in animal health and welfare,  
165 without in-depth knowledge of the dairy industry, and was interested to gain insight into human  
166 influences on animal husbandry. The participants were considered 'experts' in rearing dairy  
167 calves, while the researcher positioned herself as curious to learn about the industry and  
168 individual practices on farms.

169

### 170 ***Participants***

171 Calf rearing and youngstock management practices on English dairy farms were investigated  
172 using 40 in-depth semi-structured interviews - 26 with dairy farmers and 14 with advisors  
173 (veterinarians (n = 11), feed (n = 2) and pharmaceutical company representatives (n = 1)) -  
174 conducted by the first author between May 2016 and June 2017. Advisors were included since  
175 they are often responsible for providing information to farmers, thus it was considered useful to  
176 compare their perceptions with those of farmers. Participants were recruited using purposive  
177 and snowball sampling (Cohen *et al* 2007) which involved approaching relevant individuals at  
178 dairy events and conferences; email and phone call enquiries with existing contacts and  
179 veterinary practices; and asking interviewees to provide details of others who may be interested  
180 in participating in the study. This method provided access to a range of farmers; both males and  
181 females with different roles on farms (farm managers, herd managers, calf rearers and farm  
182 workers) and with various dairy herd sizes and calf rearing systems (Table 1). Advisors willing  
183 to be interviewed tended to be those with a specific interest in dairy youngstock and included  
184 both males and females with a range in years of experience. For logistical reasons, interviews  
185 were conducted in batches according to geographical location. Participants were sourced from  
186 areas of England densely populated with dairy farms (Southwest and Midlands) and from a  
187 north-eastern area where dairy farms were less dense (Yorkshire). This sample diversity  
188 supported the aims of the study to examine how differing experiences affect perspectives and  
189 actions relating to calf management.

190



191 **Table 1.** Interview participant details.

Location	Interview code	Interviewee (role, gender, age estimate)	Calving pattern	Herd size	
Southwest	F13 (Sit-down)	Farm manager, male, >50	Spring Block	600	
	F14 (Joint)	Farm manager, male, >50 Calf rearer, male, 40-50	Autumn Block	420	
	F15 (Joint)	Farm manager, male, 30-40 Calf rearer and farm worker, male, 30-40	All Year Round	120	
	F16 (Joint)	Calf rearer, female, 30-40 Farm manager, male, 30-40	Spring Block	250	
	F17 (Joint)	Farm manager, male, >50 Farm worker, male, 20-30 Farm worker, female, 20-30	Dairy Bull Calf Rearer (for beef)	N/A	
	F18 (Sit-down)	Calf rearer, female, 20-30	All Year Round	180	
	F19 (Sit-down)	Farm manager, male, 30-40	All Year Round	160	
	F20 (Sit-down)	Farm manager, male, 30-40	Autumn Block	330	
	F23 (Mobile)	Calf rearer and farm worker, male, 30-40	Autumn Block	250	
	F24 (Sit-down)	Herd manager, male, 20-30	All Year Round	200	
	F25 (Joint)	Farm manager, male, >50 Calf rearer, male, 20-30	All Year Round	350	
	F26 (Joint)	Farm manager, male, >50 Calf rearer, female, >50	Autumn Block	500	
	V5	Practice director and youngstock vet, male, 30-40			
	V6	Youngstock vet, male, 30-40			
	V7	Practice partner and farm vet, female, 40-50			
	V8	Practice partner and farm vet, male, >50			
	V11	Youngstock vet, female, 30-40			
	GA1 (V12)	Government advisor vet, female, 40-50			
	Midlands	F1 (Mobile)	Calf rearer, female, 20-30	All Year Round	380
F2 (Sit-down)		Calf rearer, female, 40-50	Autumn Block	350	
F3 (Sit-down)		Calf rearer and farm worker, male, 20-30	All Year Round	350	
F4 (Joint)		Farm manager, male, >50 Farm worker, female, 20-30 Son/trainee vet, male, 20-30	All Year Round	120	
F5 (Sit-down)		Farm manager, male, >50	Autumn and Spring Block	70	
F6 (Sit-down)		Calf rearer, female, 30-40	Spring Block	300	
F7 (Mobile)		Farm manager and calf rearer, male, 30-40	All Year Round	280	
V1		Specialist in cattle health vet, male, 30-40			
V2		Youngstock vet, female, 20-30			
V10		Out of practice vet/feed consultant, male, 40-50			
N1		Feed company salesperson, male, 40-50			
N2		Feed company calf specialist, female, 30-40			
PR1		Pharmaceutical company advisor, female, 30-40			
Yorkshire		F8 (Joint)	Farm manager, male, 40-50 Farm wife, female, 40-50	Dairy Bull Calf Rearer (for beef)	N/A
	F9 (Mobile)	Farm manager, male, 40-50	All Year Round	250	
	F10 (Mobile)	Farm manager, male, >50	Autumn Block	90	
	F11 (Mobile)	Farm administrator, female, 30-40	All Year Round	400	
	F12 (Joint)	Farm manager, male, 40-50 Herd manager, male, 20-30	Autumn Block	370	
	F21 (Mobile)	Farm manager, male, 40-50	All Year Round	1200	
	F22 (Mobile)	Herd manager, female, 20-30	All Year Round	130	
	V3	Newly graduated farm vet starting a youngstock group, male, 20-30			
V4	Farm vet, works on beef calf rearing unit, male, 30-40				

193 **Interviews**

194 The semi-structured interviews followed two separate topic guides, one for farmer interviews  
195 and the other for advisor interviews. These included questions about the background of the  
196 interviewee, their current role and their opinions on the most important aspects of calf rearing.  
197 The farmers were asked about their farm, calf rearing practices and facilities, as well as  
198 problems, desired improvements and useful sources of information. Advisors were asked  
199 questions relating to their input into the calf rearing enterprise of their clients' farms, and how  
200 they thought farmers interacted with information and advice. These guides were designed to  
201 include open-ended questions which ensured conversations remained relevant to calf rearing yet  
202 allowed flexibility to explore issues of most importance to participants (Turner 2010) rather  
203 than being rigidly pre-determined by the interviewer. Advisors (n = 14) and some farmers (n =  
204 9) were interviewed in an individual, sit-down format; other farmers participated in mobile  
205 interviews (n = 8) where questions were posed whilst on a walking tour of the farm (Holton &  
206 Riley 2014), or in joint interviews involving more than one interviewee (n = 20 (9 interviews))  
207 (Riley 2014). These interview formats were decided by the participants according to their  
208 personal preferences.

209  
210 Due to the broad nature of the topic guide, specific questions pertaining to colostrum  
211 management were not included, rather it was mentioned by participants in response to questions  
212 including: 'What are the most important things to get right in calf rearing?'; 'What do you think  
213 might not be done well on farms?' and 'How are calves managed from birth to weaning?'. Data  
214 collection and analysis were conducted concurrently in an iterative process whereby topics  
215 raised by participants could be incorporated into and explored further through ongoing  
216 interviews (Glaser & Strauss 1967) to gain further data richness (Bradley *et al* 2007). The  
217 structure, prompts and areas of focus varied between interviews depending on what participants  
218 were most willing to talk about in detail, and which topics emerged from initial ongoing data  
219 analysis in order to further explore areas of interest, importance or contention. Seven pilot  
220 interviews were conducted (four with farmers, two veterinarians and one feed company

221 representative) to ensure the interview guides were suitable. Since only minor refinements were  
222 made to the guides after these interviews, and responses were relevant and useful to the research  
223 project, the pilot interviews were included in the overall dataset. Data collection ceased when  
224 thematic saturation (the point at which the main ideas and variations relevant to the topic have  
225 been identified) had been achieved (Glaser & Strauss 1967).

226

227 Interviews were audio recorded with consent and subsequently manually transcribed in full  
228 using f4transkript transcription software (Version 6.2.5 Edu, Audiotranskription.de, Marburg,  
229 Germany).

230

### 231 ***Data analysis***

232 NVivo 11 for Windows qualitative data analysis software (Version 11.4.1.1064 Pro, QSR  
233 International Pty Ltd, Victoria, Australia) was used to aid thematic coding of the interview  
234 transcripts which involved re-reading the data and grouping extracts to be interpreted into  
235 themes (Braun & Clarke 2006).

236

237 First and second coding principles (Miles *et al* 2014) were used. Transcripts were initially coded  
238 in NVivo, assigning descriptive codes to arrange extracts into common topics, value codes to  
239 reflect personal factors such as attitudes, beliefs and feelings, and process coding to highlight  
240 actions and consequences (Miles *et al* 2014). These initial codes informed ongoing interviews  
241 and provided a basis for focal topics - such as colostrum management. Second cycle coding was  
242 conducted to further examine specific extracts relating to colostrum management, constructing  
243 patterns, themes and potential explanations. This involved focused coding using NVivo 11  
244 followed by physically arranging individual extracts into common themes and choosing quotes  
245 to include in this paper. Quotes were chosen which clearly represented opinions and experiences  
246 of participants. Some quotes were modified to shorten or improve clarity: ellipses indicate  
247 omitted text and square brackets indicate author's additions or alterations to text.

248

249 ***Ethical approval***

250 Approval was obtained from the Harper Adams University Research Ethics Committee for the  
251 collection and storage of interview data. Participants were provided with researcher contact  
252 details, project information, and made aware that they could withdraw from the study at any  
253 time. Written consent was obtained from participants for interviews to be audio recorded,  
254 transcribed and for these data files to be securely stored. Participants also agreed for  
255 anonymised interview excerpts to be used when reporting findings.

256

257 **Results**

258 Average interview length was 56 minutes (range 26 - 90 minutes). Interview extracts regarding  
259 colostrum were arranged into two main sub-themes: management practices and obstacles to  
260 good colostrum management. These themes include viewpoints and experiences reflective of the  
261 sample diversity in this study.

262

263 ***Colostrum management practices***

264 The way in which colostrum management was conducted on farms varied according to personal  
265 beliefs and knowledge regarding colostrum and recommended management practices. This  
266 theme focuses on the experiences of farmers in the context of their differing farm settings, with  
267 some advisor perspectives on the impact of colostrum management to calf health and farmers'  
268 understanding of the subject.

269

270 All participants, regardless of occupation, recognised the importance of colostrum in calf  
271 rearing. Every farmer interviewed named colostrum as one of the most important factors in  
272 rearing healthy calves:

273 "Colostrum is key, getting that into calves straight away, good quality stuff, and then  
274 you don't have the problems" (calf rearer, F6 (organic)).

275 Although farmers may not associate colostrum management with mortality, they often  
276 recognised potential impacts on growth and morbidity in calves:

277 "If a calf hasn't had its colostrum it inevitably gets a case of some sort of scour, or a  
278 lack of motivation to drink. That certainly slows them down at the start. I think they can  
279 get through it, but it just doesn't give them the best start" (farm manager, F19).

280

281 Participants were familiar with 'The Three 'Q's' of colostrum management which refer to the  
282 need for high 'Quality colostrum of sufficient 'Quantity' to be fed to calves 'Quickly' after birth.  
283 Advisors used these terms when advising farmers, for example, a pharmaceutical company  
284 advisor (PR1) gave talks to farmer groups which included "*the 'Three 'Q's' of colostrum which I*  
285 *bang on about [mention] all the time*". These recommendations were generally recognised and  
286 acknowledged by farmers, but were implemented to varying degrees, as outlined below.

287

288 Colostrum intake within the first 24 hours of a calf's life was a priority and efforts were made to  
289 provide calves with two to four litres of colostrum within six hours of birth. Many participants  
290 provided additional colostrum feeds, aiming to provide at least six litres of colostrum within six,  
291 12 or 18 hours of birth:

292 "We don't weigh the calves at all during the process, so the amount of colostrum that  
293 they get is always three litres at each feed. Trying to get the first one obviously within  
294 six hours and then the second one as soon after as possible, and then we can sometimes  
295 get a third in within the first 24 hours" (farm manager, F9).

296 Some participants perceived value in feeding colostrum or transition milk for several days after  
297 birth and believed this practice improved calf vigour:

298 "People say to me, "Why do you carry on feeding colostrum for two, three days?"  
299 Alright, it's not being absorbed in the same way, but it is giving local protection, plus I  
300 think giving a smaller amount to those calves and it's higher energy density in that  
301 colostrum. So that's why I like it and they seem to do really well" (calf rearer, F2).

302 Whereas farmers aimed to feed calves quickly after birth, using stored colostrum from Johne's-  
303 free cows which had been refrigerated or frozen, less focus was placed upon milking the dam as  
304 soon after parturition as possible. This appeared largely due to the practicalities of harvesting  
305 colostrum outside of routine milking times:

306 "We try and milk them as soon as they've calved, usually though the parlour at milking  
307 ... but if one calves in the middle of the night, or in the late afternoon-evening, then  
308 we'll just milk her the following morning" (farm manager, F5).

309

310 The method of feeding colostrum to calves largely depended on the time available to staff and  
311 the perceived benefits of available options: leaving calves to suckle the dam, or hand feeding via  
312 artificial teat or oesophageal tube. Organic farmers in particular left the calf with the dam to  
313 suckle colostrum, but admitted calves often required assistance to consume sufficient colostrum:

314 "I usually draw the teats out just to make sure because we dry them off with [teat  
315 sealant], and sometimes it's quite difficult for the calf to get out, so you think it's  
316 sucking but it's not" (calf rearer F6 (organic)).

317 "[The calves are] left with the cow for 24 to 48 hours, but we make sure they've had  
318 enough colostrum. If necessary, we will tube them ... Usually it's just a case of getting  
319 them to suck the colostrum off the cow and give it a bottle. If they're sucking well and  
320 they won't take any colostrum from a bottle then that's fine" (farm manager, F14  
321 (organic)).

322 Veterinarian V8 recalled a farm with high calf mortality where calves were not artificially fed  
323 colostrum, and that may have contributed to severe failure of passive transfer:

324 "I did zinc sulphate turbidity testing on calves ... a result of 20 [ZST Units] or more is  
325 deemed to indicate adequate colostrum, but the highest result I got on that farm was  
326 four. That was the highest one and they calved in individual calving boxes and left the  
327 calf with the cow for two days."

328 Stomach tubing was generally used for efficiency on larger or block calving units dealing with  
329 high numbers of newborn calves:

330 "It's much quicker. You know that the colostrum goes where it wants to go and you  
331 know exactly how much they get" (calf rearer, F26).

332 Although artificial teat feeding (via nipple bottle or bucket) was considered a time-consuming  
333 practice, farmers often preferred to allow calves to suck; tube feeding was used as a last resort  
334 for calves that would not suckle. This seemed due to perceptions of improved calf health and  
335 easier training onto teated milk feeders, which could save time in the future:

336 "We always try them on a bottle first, because obviously it's better for them to suck, but  
337 if they won't drink off the bottle for whatever reason then we will tube them" (calf  
338 rearer, F18).

339 "I don't like tubing anything. [I used to but calves] just seemed to be getting ill. Then I  
340 tried getting them on the teat straight away, and then they transferred to the other teat  
341 feeders easier. So then your job's easier and you don't have to spend as much time with  
342 them" (calf rearer and farm worker, F3).

343 The desire for calf rearing systems to be welfare-friendly and foster a favourable public  
344 perception of farming also affected feeding method:

345 Farm manager: "Some farmers now, it's part of the protocol to stomach tube every calf  
346 with stored or frozen colostrum. [We] don't do it, I don't agree with it. How can you  
347 justify to the general public that you've gotta stick a tube into them?"

348 Calf rearer: "You saw this morning how easy those calves go on that bottle, there's no  
349 need to put a tube down their throat ... They resist it, they don't like it. There's nothing  
350 nice about it" (F16, married couple (organic)).

351

352 Whereas farmers were largely concerned with how calves were fed, advisors were more focused  
353 on the results of the practices used rather than method itself, per se. In accordance with general  
354 recommendations, advisors supported artificial feeding methods, with little preference between  
355 oesophageal tube or teat feeding. Their main focus was that calves were acquiring adequate  
356 passive transfer from colostrum:

357 "I don't mind whether you've chosen to go nipple sucking off buckets ... or [tube] it. As  
358 long as you're getting the results and your calves are doing well then that's fine"  
359 (youngstock veterinarian, V11).

360 Advisors and some farmers appreciated the value of monitoring colostrum quality using a  
361 colostrometer or refractometer before storing or feeding to calves:

362 "I used to just look at colostrum and go "Oh, that looks fine, feed that to the calf" and  
363 now that I've started measuring it ... the amount of colostrum I actually throw away  
364 because it's under [19% on the Brix scale] is amazing! I think we really have seen the  
365 benefits now" (calf rearer, F1).

366 Other farmers were less convinced of the need to quantify colostrum quality and would judge by  
367 eye, or use justifications including parity of the dam, breed or average milk components to  
368 support claims that colostrum quality was satisfactory:

369 "You can just tell from how it looks, how it feels ... I thought the colostrometer  
370 measures the viscosity, how thick it is. So I just thought you would be able to tell that  
371 anyway ... Generally from the older cows you get the kind of frothy, thick colostrum ...  
372 from heifers it's very thin, and I guess it doesn't have all the antibodies" (calf rearer and  
373 farm worker, F3).

374 "Our average butterfat, 12 months, is 4.5 and 3.4 protein - we're not white water. So I  
375 would say our colostrum is probably better than the average" (farm manager, F15).

376 Generally, collecting the colostrum from different cows together was considered beneficial by  
377 farmers to enhance the quality of poorer colostrum:

378 "The good thing with us, all our colostrum from all our cows goes into that [container].  
379 So it's all mixed up, so some of the cows that have got very high colostrum and say a  
380 heifer that hasn't got a lot, it compensates" (calf rearer and farm worker, F23 (organic)).

381 A veterinarian (V7) had a negative view of her clients' knowledge of colostrum quality and  
382 suggested that Johne's management was often conflated with colostrum protocols:



383 "Most of our farmers don't take any notice of quality. Most of them are aware of their  
384 Johne's status, so aren't feeding Johne's colostrum, but that's probably as far as most of  
385 them are going".

386 Hygiene was considered an important factor in calf management overall but was not often  
387 mentioned specifically in relation to colostrum by farmers, but was stressed by advisors. Several  
388 farmers mentioned other farms enacting negative practice where colostrum was left for several  
389 hours at ambient temperature in uncovered buckets. However, a common attitude amongst  
390 farmers was "*we don't have any Johne's problems, so we don't pasteurise [colostrum]*" (farm  
391 manager, F9), with apparent lack of recognition of the role of pasteurisation in reducing  
392 bacterial load in colostrum.

393

394 Many farmer interviewees stored colostrum on-farm, either by freezing or refrigerating;  
395 advisors did not comment on colostrum storage specifically. Farmers considered it important to  
396 ensure colostrum from Johne's-positive dams was not fed to replacement heifer calves, although  
397 some would risk infecting bull and beef calves:

398 "We've got two piles in the freezer of clean colostrum and Johne's colostrum ...

399 Obviously pasteurisation should kill Johne's, but we don't test that theory. We'll just use  
400 the Johne's colostrum for the bulls and beef and save the best colostrum, which is clean,  
401 for the heifers" (calf rearer, F1).

402 Reluctance to use heifer colostrum due to its assumed poorer quality and discarding colostrum  
403 as part of Johne's disease control programmes sometimes led to insufficient colostrum being  
404 available for storage. Some participants lamented that whilst they monitored colostrum quality  
405 they sometimes had to make-do with poorer quality colostrum, or use powdered calf colostrum  
406 replacer as an alternative:

407 "We don't save any colostrum from anything that's got Johne's and a lot of time heifers  
408 don't give sufficient, if any, colostrum. So if I started discarding colostrum that was of a  
409 lower quality in terms of antibodies, I wouldn't have enough to give all the calves" (calf  
410 rearer and farm manager, F7)

411 "We actually use powdered colostrum. We have done a lot of tests on colostrum levels  
412 at a week old on calves that have just been fed the powdered stuff and we have found  
413 that the powdered stuff we use is pretty good. It's not as perfect as the mum's, but we've  
414 kind of proved that it works because there's lots out there that are [useless]" (calf rearer,  
415 F18).

416

#### 417 ***Obstacles to good colostrum management***

418 This theme explores the challenges farmers perceive regarding colostrum management, reasons  
419 behind a failure to follow recommendations, and the perceived role of advisors in supporting  
420 farmers to implement best practice and overcome difficulties.

421

422 Farmer participants appreciated that good colostrum management could improve passive  
423 transfer rates and health status of calves, but these views may not reflect the dairy sector overall.  
424 Advisors and some farmers expressed concern that colostrum management was not done well  
425 on many farms. Maintenance of traditional practices, age profile and educational attainment  
426 were suggested as possible issues:

427 "Colostrum can be [neglected]. Farmers are getting better ... but you still go on farm and  
428 find farmers where they leave the calf with the cow and expect it to find [colostrum]  
429 itself. It worked years ago, and it worked well, but we face a whole different host of  
430 challenges these days than they did 20 or 30 years ago" (calf nutritionist, N2).

431 "I'm surprised by the number of older farmers that don't know the value of colostrum ...  
432 I don't think it's through not being bothered, I think it's through genuine ignorance of  
433 not knowing the importance. I think education must've changed a lot between then and  
434 now because everybody my age [20-30 years] knows that [colostrum is] of extreme  
435 importance" (herd manager, F22).

436 Colostrum provision for bull and beef calves may also be less of a priority on dairy farms, as the  
437 focus is on rearing replacement heifers:

438 "If they calve in the middle of the night, [my boss] tends to go on the theory if it's a  
439 heifer, he will feed it colostrum that night. If it's a bull calf or a beef, he'll leave it for  
440 me and I get in at six [o'clock]" (calf rearer, F18).

441 "Testing colostrum, it's a double edged sword for the likes of us because the best stuff  
442 does go to the heifers" (bull calf rearer, F8).

443

444 Whilst all participating farmers considered colostrum provision to be important, some lacked  
445 the knowledge and confidence to alter their practices, or misinterpreted science-based advice,  
446 leading to uncertainty about the reasons behind recommended colostrum management:

447 "It's just something I know I'm not very good at. I'd like to learn more about it to be  
448 honest with you. Taking a calf away from its mother when she's got colostrum there and  
449 ... giving it colostrum that you've pooled. I'd want to be confident that I was doing it  
450 right" (farm manager, F19).

451 Calf rearer and farm worker: "Why do you ask [how quickly we refrigerate colostrum]?"

452 Interviewer: "Bacteria will grow faster at room temperature than in the fridge" ...

453 Calf rearer and farm worker: "You want some bacteria though, don't you?" (F12).

454 Others were aware of recommendations, but were disinclined to adhere to them. This may be  
455 due to personal preferences, complacency, or negative attitudes towards change and the effort  
456 required to implement advice:

457 "There's always gonna be arguments for everything, isn't there, different ways, but [on  
458 the dam is] how [calves] were meant to be, so it's nice for them" (calf rearer and farm  
459 worker, F23 (organic)).

460 "Any colostrum I have left [from freshly calved cows at morning milking] is in the  
461 bucket now, so anything that calves between now and milking tonight, I will feed that.  
462 Everybody says 'Oh, you shouldn't do that because it's not fresh enough, you should  
463 freeze it and then warm it'. Well yeah, you should do lots of things" (calf rearer, F14  
464 (organic)).

465

466 The effectiveness of colostrum management could be hindered by physical limitations, for  
467 example the shortage of colostrum for storage mentioned previously. Further challenges  
468 included available time, labour and financial considerations. These barriers were commonly  
469 mentioned by advisors as reasons for poor colostrum management. There was general consensus  
470 among all stakeholders that the work required to run a farm demanded time and labour which  
471 were in short supply, and this could impact on the speed of colostrum administration:

472 "I think on dairy farms, one of the big issues is labour. You can't determine when a  
473 cow's gonna calve, and of course you want a calf to get colostrum within six or eight  
474 hours ... everyone's busy on dairy farms. There's just less and less labour, less and less  
475 good stock people on farms" (veterinarian, V10).

476 Farmers agreed that good colostrum management was time consuming. Most designated calf  
477 rearers seemed to cope well with the demands on their time, but those who were also  
478 responsible for additional farm work struggled to balance their tasks:

479 "Colostrum is the hardest thing to do. You've got to be always prepared to take milk out  
480 of the freezer and then defrost it, but that's hard to do if I'm milking or something" (calf  
481 rearer and farm worker F3).

482 Calves born at night often were left unfed for longer, largely due to the lack of available staff,  
483 and this was often considered unfortunate but unavoidable. Often staff responsible for overnight  
484 checks for calvings would not include a designated calf rearer (who was likely to be more  
485 invested in the calves), and feeding colostrum at night was not prioritised as a standard practice:

486 "[A cow] might calve at midnight. I don't get down there until eight o'clock the next  
487 morning ... They say it needs colostrum within six hours ... That's just how it is, you're  
488 not living on the site, it's just one of those things" (calf rearer, F14 (organic)).

489 "If we've got a particularly weak [calf] that we think needs a bit of a perk up, we will  
490 feed it during the night ... If you get here and one's just calved and there's another one  
491 that needs looking at in half an hour's time ... we'll just [tube feed colostrum to] that calf  
492 while we've got five minutes" (farm manager, F13).

493 This suggests that 'available labour' is not purely a physical limitation, and personal attitudes  
494 and beliefs also play a role. Veterinarian V11 stressed the importance of motivating all relevant  
495 staff members to work as a team and take ownership of tasks, like colostrum management,  
496 which do not clearly fit into their remit:

497 "A problem with some of these bigger [farms] is that the cows are somebody else's  
498 problem, and the calves are somebody else's, so colostrum falls in-between ... That can  
499 be particularly difficult when you're working with different groups of people and they  
500 quite like the fact that a big job falls between the gap, then it's nobody's fault".

501 Having clearly defined roles for each farm team was considered useful by farm manager F26:

502 "The calf arrives in the calf shed having been through its colostrum policy. That isn't  
503 done by us, that's done by the dairy team."

504

505 Available finance was also partially reliant upon the perceived worth of an investment. Potential  
506 benefits gained must be considered worth the expenditure and be viewed as important compared  
507 to other demands for funds:

508 "I don't get the vet to test [calves for passive transfer from colostrum]. May be a  
509 thought, I may ask him about it - depends how much he charges" (farm manager, F5).

510 "We don't [pasteurise], which is something we probably should be thinking about doing.  
511 It's just the equipment [cost] ... it's something I'd love to do. It's just something else to  
512 add to my wish list" (herd manager, F24).

513 If farmers were able to see positive results of their actions or investments, they seemed pleased  
514 that the decision proved to be cost-effective. Some farmers had invested in a pasteuriser and  
515 considered it beneficial both in terms of making their job easier and improving calf health:

516 "We used to put it in the bucket and nearly scorch the outside of the colostrum and the  
517 inside would still be frozen whereas now we use the actual pasteuriser which thaws it at  
518 the right temperature, all slowly done but within a quick way" (calf rearer, F1).

519 "As soon as we've put [the pasteuriser] in, we're certainly getting a lot less scour in the  
520 calves, so that's been a good investment" (farm manager, F21).

521 This apparent need for changes to have tangible benefits may help to explain why advisors  
522 claimed that farmers would usually wait until a problem presented itself before implementing  
523 colostrum protocols. Some farmer participants confirmed that improvements were made in  
524 response to problems:

525 "Often we put in protocols where they would deliver stomach tube, bottle, teat or bag to  
526 make sure the calf has had [colostrum], but that would usually follow a problem. If it's  
527 all working, why fix it?" (veterinarian, V8).

528 "I've known us to have some real problems, and as soon as we got that colostrum sorted,  
529 that didn't half tick a lot of boxes" (farm manager, F21).

530 However, testing calf serum to monitor rates of passive transfer did not appear to be conducted  
531 by many participant farms. Only two farmers (F18, F24) reported routine testing of calves, and  
532 four (F4, F6, F20, F21) mentioned testing calves in response to problems. This lack of  
533 quantification could make it difficult to identify problems which need addressing, or assess the  
534 benefits of any alterations. Further incentives or checks for good colostrum management may be  
535 beneficial, with one farm manager (F20) suggesting an accreditation scheme for colostrum  
536 management in calves may better encourage best practice:

537 "Guarantee that the calf has had the correct amount of colostrum and it gets a stamp on  
538 the passport. When it goes to market it shows up 'accredited', but it could be checked at  
539 any point, blood tested to see if it's had the right antibodies ... Adding value to the  
540 supply chain, isn't it? Should be part of farm assurance, really".

541  
542 Advisors were frustrated at the lack of objective data to base recommendations on, but were  
543 sympathetic to the difficulties in enacting recommendations on-farm. Recognising that time and  
544 labour were limited, they stressed the need to ensure advice was easy to implement. Youngstock  
545 veterinarian V11 warned against over-simplification of advice and claimed that compromises  
546 could be made when following recommendations while still achieving good results:

547 "To achieve [calves receiving four litres of colostrum within four hours of birth] on a  
548 small herd with limited labour is really tough ... It's not quite as simple as just that,

549           which I think a lot of vets before have gone "Oh, just do this" and walked off ... It's  
550           always a balance, if you've got your timings right, and it's clean, and the other 'Q's are  
551           ticked, then you can get away with giving a bit less volume."

552   However, advisors may not seize opportunities to demonstrate recommended practices to  
553   farmers, as illustrated by this quote from a farm manager:

554           "I fed some colostrum the other day when [the vet] was here and she said "Oh, that's  
555           nice and yellow, and looks nice and thick"" (farm manager, F15).

556   Furthermore, farmers may not recognise the root cause of problems, and rely upon the expertise  
557   of advisors. However, a calf nutritionist (N2) attributed blame to veterinarians overlooking the  
558   role of colostrum management in calf health problems:

559           "It was bad when I started [on the farm] and that was scary because they had all these  
560           vets, and all their input on how to improve things and not one of them had looked at  
561           hygiene in the colostrum management. Not one. And these were vets from a top  
562           university."

563   Such oversights on colostrum management can prove costly and may contribute to high  
564   mortality rates and overuse of antimicrobials:

565           "I took over the work on a 450 cow dairy and the first thing the farmer said is "You  
566           need to be aware that we've got a very difficult bug to treat on this farm, it really  
567           hammers our calves" ... He spent all his money on vaccines and everything that got sick  
568           had to be treated with antibiotics, and still a load of them died ... In the year after we  
569           [improved colostrum management], having lost 96 calves the year before, he lost six  
570           calves" (farm veterinarian, V8).

571

## 572   **Discussion**

573   As has been demonstrated in studies such as Robinson (2017) and Adam *et al* (2017), it is  
574   important to understand the context within which farmers operate, and the various intrinsic and  
575   extrinsic influences that may affect their attitudes and behaviours in relation to livestock health.

576 The themes explored in the current study demonstrate a heterogeneous group of both farmers  
577 and farm advisors whose individual perspectives, experiences and contexts impact their actions  
578 and recommendations relating to colostrum management. Appreciating this diversity is  
579 important for achieving a holistic understanding of calf health and welfare at farm level. Indeed,  
580 the opinions of farm advisors such as livestock nutritionists rarely feature in the animal health  
581 and welfare literature, and these important perspectives need to be included in future research  
582 studies.

583

584 Farmer and advisor interviewees agreed that colostrum intake is of great importance for calf  
585 rearing, and key to giving calves "the best start". Participants appreciated that good colostrum  
586 management could prevent problems in calves, but focused on the importance of antibodies in  
587 colostrum rather than other beneficial factors (eg hormones and growth factors (Blum &  
588 Hammon 2000)). Although all participants recognised the importance of colostrum and its role  
589 in calf health, it does not necessarily follow that farmers follow best practice or that advisors  
590 focus on or suggest improvements to colostrum management. Efforts to administer colostrum to  
591 bull and beef calves were likely to be lax; these animals are not destined to become dairy herd  
592 replacements (although beef heifer calves may join suckler herds) and may have low market  
593 value (Weigel & Barlass 2003). Even regarding potential replacement heifers, the general  
594 consensus between participants was that colostrum management in the overall dairy industry  
595 was better than it had been historically, but standards could be further improved. Recent  
596 recommendations include the five 'Q's' of colostrum management (Hart 2016), but the majority  
597 of advice and scientific literature focuses on 'The Three 'Q's' ' (Patel *et al* 2014; AHDB Dairy  
598 2018). No participants in the current study, including advisors, referred to five 'Q's, but  
599 knowledge of 'The Three 'Q's' was commonplace among farmers and advisors. However, some  
600 interviewees mentioned less-informed farmers and several participants appeared to require  
601 clarity about the reasoning behind recommendations.

602



603 Even where recommendations were understood, achieving each 'Q' could be challenging. The  
604 recommendation to feed equivalent to 10% of a calf's bodyweight in colostrum is of limited use;  
605 calves are rarely weighed (Hart 2016) and farmers in this study more often quoted  
606 recommended values of 3-4 L. Farmers were aware that calves required at least one colostrum  
607 feed within six hours of birth, but achieving this could be difficult: some farms only harvested  
608 colostrum at routine milking times, which delayed its collection following calving, and time and  
609 labour limitations were apparent. This is consistent with previous findings where time pressures  
610 and prioritisation of the milking herd negatively impacted the speed of colostrum administration  
611 to newborn calves (Santman-Berends *et al* 2014). In the present study, calf rearers with clearly  
612 defined roles, mainly pertaining to calf care, had more time designated to calves; they could  
613 focus on calf requirements and consider the benefits of good colostrum management. Staff  
614 having the time to carry out their tasks and respond to unforeseen problems is fundamental to  
615 good animal husbandry: time management, control and perceived self-efficacy have been found  
616 to influence the severity of calf mortality on farms (Vaarst & Sørensen 2009). However, staff  
617 structure, labour costs, calving pattern and calf numbers can make a designated calf rearer an  
618 unrealistic solution on many farms. In particular, night-time calvings often resulted in delayed  
619 colostrum administration; either night checks were conducted by staff who were not involved in  
620 calf rearing and focused on assisting calving, or not conducted at all. This highlights the  
621 importance of ensuring the entire farm team is motivated to engage with calves, and consider  
622 their management worth investing time and money into, as stressed by youngstock veterinarian  
623 V11. Indeed, Vasseur *et al* (2010b) found that encouraging active participation in training and  
624 learning new methods was a good way to stimulate farmers to improve their colostrum  
625 management practices.

626

627 Farmers' attitudes, motivations and doubts are important considerations when offering guidance  
628 and can strengthen tailored advice (Santman-Berends *et al* 2014). Farmers have been shown to  
629 perceive targeted advice, including explanations for recommended measures, as useful (Vasseur  
630 *et al* 2010b) and whilst tailored approaches are more likely to prompt implementation (Vasseur

631 *et al* 2010b; Santman-Berends *et al* 2014), they did not guarantee improvements to colostrum  
632 practices within six months (Vasseur *et al* 2010b). This could suggest that some farmers are  
633 slow or reluctant to adapt existing practices (Santman-Berends *et al* 2014), or that improved  
634 understanding alone is insufficient motivation to make or maintain changes. In the current  
635 study, feeding method was chosen according to perceived benefits or drawbacks rather than  
636 basing decisions on evidence-based recommendations. Decisions were based on ease, time,  
637 suitability for the farm system, and sometimes veterinary advice. A herd's Johne's status often  
638 influenced feeding practices due to controls against infecting calves (Windsor & Whittington  
639 2010). One farmer was concerned that he might enact snatch calving incorrectly, so continued to  
640 leave calves to suckle their dam. This reluctance to replace one suboptimal protocol with  
641 another is understandable. Doubts could be eased with improved encouragement, guidance in  
642 amending established systems or practices, and reassurance that alterations would have positive  
643 effects.

644

645 Several organic farmers in the current study believed leaving calves to suckle colostrum from  
646 their mother was natural and therefore beneficial. The concept of 'naturalness' is a key aspect of  
647 organic farming (Vetouli *et al* 2010), and research indicates that cow-calf contact can encourage  
648 appropriate social behaviours of calves (Buchli *et al* 2017). However, this practice increases the  
649 risk of failure of passive transfer (McGuirk & Collins 2004), so farm staff should feed  
650 colostrum to calves (Patel *et al* 2014). There were also negative perceptions of recommended  
651 practices; for example, one farming couple had ethical objections over oesophageal tube-feeding  
652 of colostrum as standard practice, believing that public perception would be negative. When  
653 done correctly, stomach-tubing is generally considered a safe method (Besser *et al* 1991; Kaske  
654 *et al* 2005), and immunoglobulin transfer is comparable to teat feeding (Besser *et al* 1991;  
655 Chigerwe *et al* 2012). However, calves sometimes resist swallowing the tube and incorrect  
656 procedure could result in aspiration (Chigerwe *et al* 2012), injuries to the pharynx and  
657 potentially fatal drenching pneumonia (Kaske *et al* 2005). These findings indicate tube-feeding

658 may be an unpleasant experience for calves, and warrant further investigation into its effects on  
659 calf welfare.

660

661 Advisors indicated most clients knew very little about their colostrum quality and claimed  
662 withholding colostrum from Johne's-positive dams was considered sufficient by some farmers.  
663 All farmer participants appreciated that colostrum quality related to its immunoglobulin content,  
664 but bacterial contamination was less of a concern. There was some evidence of misinterpretation  
665 or incomplete knowledge or understanding of scientific findings. For example, one farmer  
666 participant conflated the role of bacteria in acquired immunity with the cleanliness of colostrum,  
667 similar to farmers believing disease exposure to be a protective biosecurity measure (Brennan *et*  
668 *al* 2016; Frössling & Nöremark 2016). Other farmer participants considered the benefits of  
669 pasteurisation to be limited to the prevention of Johne's disease. However, pasteurising  
670 colostrum has been shown to reduce its bacterial load and can reduce pathogen exposure to  
671 newborn calves (Elizondo-Salazar *et al* 2010). This emphasises the importance of extending  
672 'The Three 'Q's' to include hygiene as a specific recommendation.

673

674 Whilst participants who assessed colostrum quality using a colostrometer or Brix refractometer  
675 considered it a useful practice, one farmer used 19% (Brix) as a cut-off point which given that  
676 the recommendation is that colostrum should have a Brix reading of 22% or higher, could mean  
677 less than one third of poor quality samples are correctly identified (Bartier *et al* 2015). Some  
678 farmers used poorer quality colostrum to alleviate colostrum shortages. Other farmers assumed  
679 it was an unnecessary bother; they believed immunoglobulin content of colostrum could be  
680 adequately judged according to its viscosity and colour. Safeguards were implemented eg  
681 withholding colostrum from primiparous dams, though this practice may be unnecessary and  
682 wasteful as heifer colostrum can be of high quality (Godden 2008) and seemed to contribute to  
683 colostrum shortages on some farms. Pooling colostrum from multiple dams was often  
684 considered beneficial but high-quality colostrum is actually diluted by larger volumes of low  
685 immunoglobulin content colostrum (Weaver *et al* 2000). Colour measurement via

686 spectrophotometry has indicated that colostrum with a more yellow and darker colour is likely  
687 to contain higher levels of immunoglobulin and constituents which contribute to the nutritive  
688 value of colostrum (Gross *et al* 2014). However, it is unlikely that judging colostrum by eye  
689 provides reliable and accurate indication of quality compared to recommended implements.  
690 Though colostrometers have been criticised for their fragility and temperature dependency, Brix  
691 refractometers function independently of temperature and are user-friendly, requiring a very  
692 small amount of colostrum to sample (Bartier *et al* 2015), but still add another step to the  
693 colostrum management routine. A lack of enthusiasm to quantify measures has been reported in  
694 other areas concerning cattle health and welfare, eg farmers in one study did not believe  
695 mobility scoring would improve their ability to identify cases of lameness (Horseman *et al*  
696 2014). This suggests farmers will monitor and implement recording practices only when *they*  
697 perceive some benefit or reward for doing so, regardless of best practice advice. This is  
698 somewhat paradoxical, as limited data can hinder the assessment of the risk or reward  
699 associated with management practices.

700

701 Some advisor interviewees claimed that farmers would usually improve their colostrum  
702 management only in response to a recognised health problem. Similar attitudes have been found  
703 in research concerning biosecurity and vaccination - farmers will often react to a problem rather  
704 than taking preventive action (Richens *et al* 2015; Brennan *et al* 2016). This tendency for  
705 reactivity as opposed to proactivity could relate to limited time and labour - why put effort into  
706 changing practices that are apparently functional? Sub-standard record keeping by farmers  
707 (Escobar 2015), particularly concerning calves (Bach & Ahedo 2008), prevents evidence-based,  
708 objective assessment of calf health and welfare issues before they present themselves as  
709 noticeable and concerning problems. Producers who participated in a benchmarking program for  
710 failure of passive transfer and average daily gain in milk-fed calves were motivated to alter  
711 management practices to improve calf performance (Atkinson *et al* 2017). However, very few  
712 of the participants interviewed in our study tested calves to monitor passive transfer and  
713 subsequent performance. For optimal evaluation of serum total protein or IgG concentrations,

714 blood samples must be taken within the first week of a calf's life, and timing should be  
715 consistent to allow comparison (Villarroel *et al* 2013). This may be difficult to achieve, and cost  
716 of testing can deter farmers, but Brix refractometers, in addition to testing colostrum quality,  
717 can be used as an inexpensive estimate of calf serum immunoglobulin (Deelen *et al* 2014).  
718 Achieving adequate transfer of immunity is the ultimate goal, regardless of which practices are  
719 used, so convincing farmers to adhere to the fifth 'Q' of colostrum management - quantification  
720 of passive transfer - is of great importance.

721

722 Lack of calf monitoring data may also partly explain why few participant farmers mentioned the  
723 economic significance of colostrum management, and why most downplayed the importance of  
724 colostrum administration in preventing calf mortality. One farmer suggested testing calves for  
725 adequate passive transfer as part of an accreditation scheme or farm assurance, but such  
726 approaches may not be highly motivating to farmers (Leach *et al* 2010). Farm advisors could  
727 potentially better highlight the avoidable cost of failure of passive transfer and aid decision-  
728 making using the method described by Raboisson *et al* (2016). The ongoing benefits of good  
729 colostrum management could also be better promoted. For example, calves with adequate  
730 passive transfer require fewer antimicrobial treatments (Berge *et al* 2009). In this vein, the  
731 Responsible Use of Medicines in Agriculture (RUMA) Alliance recently launched the  
732 '#ColostrumIsGold' campaign which promotes the role of colostrum management in reducing  
733 antibiotic usage on-farm ([www.colostrumisgold.org](http://www.colostrumisgold.org)).

734

735 The current study indicated that calf mortality and morbidity could be wrongly attributed to  
736 disease challenge rather than failure of passive transfer. Advisors could prompt farmers to re-  
737 evaluate their assessment of such problems, but our findings suggest some veterinarians do not  
738 examine colostrum management when investigating calf issues. One farmer mentioned that his  
739 veterinarian did not challenge his tendency to assess colostrum quality by eye. This could be  
740 because some recommendations are not considered worthwhile to dispute if farmers are  
741 perceived as likely to continue using methods despite advice to the contrary. In such cases,

742 providing visual assessment criteria to guide farmers' judgement might be beneficial, but this  
743 should be done alongside recommending best practice, possibly by demonstrating use of a  
744 colostrometer or Brix refractometer. Veterinarians are key advisors to farmers (Elliott *et al*  
745 2011; Garforth *et al* 2013) so it is important that they provide a comprehensive and competent  
746 service which promotes science-based recommendations. It cannot be assumed that limited  
747 uptake of evidence-based advice is solely due to lack of engagement by farmers.

748

749 Interviews were a useful method to gain insight into participants' perspectives on colostrum  
750 management. Findings are indicative of what the wider dairy farmer population in England may  
751 believe or practice, but further research is needed to establish statistical representation. The first  
752 author was responsible for all interviews, transcription and coding which could introduce  
753 researcher bias and a tendency for invalid interpretations of participants' perspectives (Miles *et*  
754 *al* 2014). To protect descriptive validity, verbatim transcriptions were made from audio  
755 recordings of the interviews and the selection and editing of presented quotes did not distort  
756 what was actually said. However, it was necessary to infer meaning from the words of  
757 participants who may distort or conceal their views or recall experiences inaccurately (Maxwell  
758 2012). To encourage honest, open discussion of calf rearing issues, interviews were conducted  
759 in a non-judgemental manner and participants chose their preferred interview format (seated,  
760 mobile or joint).

761

762 A range of participants were recruited. Farm managers, herd managers and calf rearers working  
763 on farms of varying sizes provided insight into the perspectives and priorities of those with  
764 different responsibilities and schedules. Advisors were knowledgeable about dairy youngstock  
765 and able to provide informative accounts of calf rearing based on their experiences. That fewer  
766 advisors participated in the project than farmers is not a concern since no statistical comparisons  
767 were made, but these interviews were valuable in triangulating the data obtained from the  
768 farmers, and also in exploring the wider context to colostrum management that we aimed for in  
769 the study. Due to farm-specific variations eg in calving pattern, herd size, staff structure and

770 finances, the point of thematic saturation required a greater number of interviews for farmers  
771 than for advisors. All interview formats yielded useful insights into calf rearing but mobile and  
772 joint interviews were particularly informative. Mobile interviews enhanced farm-specific  
773 discussion since the researcher could view buildings, equipment and animals whilst participants  
774 reflected on their day-to-day practices (Holton & Riley 2014). Joint interviews allowed for co-  
775 narration which provided details and reflection on shared experiences which would have been  
776 unattainable by the interviewer alone (Riley 2014). Interviews specifically designed to  
777 investigate one particular aspect of calf rearing eg colostrum management would have allowed  
778 for more probing questions to generate more detailed data on that topic (Weller *et al* 2018).  
779 However, the goal of the present research was to explore the broad topic of dairy calf rearing so  
780 the emergent theme of colostrum management could not have been pre-empted.

781

## 782 **Animal welfare implications and conclusion**

783 Our study demonstrates that 'The Three 'Q's' acted as useful reminders about the goals of  
784 colostrum management. It is possible that greater dissemination of 'The Five 'Q's', which include  
785 hygiene and monitoring of passive transfer as specific criteria, could further increase awareness  
786 of those important aspects. Knowledge of the 'Q's' of colostrum management did not guarantee  
787 implementation of recommended protocols. To motivate action to reduce failure of passive  
788 transfer rates in calves, advice should consider: physical challenges including John's  
789 management and time constraints; misconceptions, eg about the role of pathogens in acquired  
790 immunity; and farmers' perceptions, priorities and preferences. The welfare implications of  
791 oesophageal tube feeding may need further investigation if it is to be recommended as standard  
792 practice.

793

794 Quantification of passive transfer, when considered alongside health, growth and performance  
795 data, could help convince farmers that improved colostrum management merits the investment  
796 of more time, labour and finance. However, most farmers were reluctant to record and analyse

797 data, so different motivational tactics to encourage long-term monitoring should be trialled.  
798 Advisors must not overlook the critical importance of colostrum management when  
799 investigating calf health issues and should promote the use of evidence-based recommendations  
800 in the farm context when advising farmers on dairy calf health and welfare.

801

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808

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