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

Running title: Colostrum management for calves on dairy farms

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Abstract

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

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

Keywords

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

Introduction

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

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

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

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

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

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

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

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

Materials and methods

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

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

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

Participants

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

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		

192

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

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

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

Data analysis

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

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

Ethical approval

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

Results

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

Colostrum management practices

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

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

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

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

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

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

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

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

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

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

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

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

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

> "I usually draw the teats out just to make sure because we dry them off with [teat sealant], and sometimes it's quite difficult for the calf to get out, so you think it's sucking but it's not" (calf rearer F6 (organic)).
>
> "[The calves are] left with the cow for 24 to 48 hours, but we make sure they've had enough colostrum. If necessary, we will tube them ... Usually it's just a case of getting them to suck the colostrum off the cow and give it a bottle. If they're sucking well and they won't take any colostrum from a bottle then that's fine" (farm manager, F14 (organic)).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

"We've got two piles in the freezer of clean colostrum and Johne's colostrum ... Obviously pasteurisation should kill Johne's, but we don't test that theory. We'll just use the Johne's colostrum for the bulls and beef and save the best colostrum, which is clean, for the heifers" (calf rearer, F1).

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

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

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

Obstacles to good colostrum management

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

> "I don't get the vet to test [calves for passive transfer from colostrum]. May be a thought, I may ask him about it - depends how much he charges" (farm manager, F5).
>
> "We don't [pasteurise], which is something we probably should be thinking about doing. It's just the equipment [cost] ... it's something I'd love to do. It's just something else to add to my wish list" (herd manager, F24).

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

> "We used to put it in the bucket and nearly scorch the outside of the colostrum and the inside would still be frozen whereas now we use the actual pasteuriser which thaws it at the right temperature, all slowly done but within a quick way" (calf rearer, F1).
>
> "As soon as we've put [the pasteuriser] in, we're certainly getting a lot less scour in the calves, so that's been a good investment" (farm manager, F21).

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

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

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

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

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

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

> "To achieve [calves receiving four litres of colostrum within four hours of birth] on a 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.

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

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

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

Farmers' attitudes, motivations and doubts are important considerations when offering guidance and can strengthen tailored advice (Santman-Berends *et al* 2014). Farmers have been shown to perceive targeted advice, including explanations for recommended measures, as useful (Vasseur *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

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

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

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

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

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

The current study indicated that calf mortality and morbidity could be wrongly attributed to disease challenge rather than failure of passive transfer. Advisors could prompt farmers to re-evaluate their assessment of such problems, but our findings suggest some veterinarians do not examine colostrum management when investigating calf issues. One farmer mentioned that his veterinarian did not challenge his tendency to assess colostrum quality by eye. This could be because some recommendations are not considered worthwhile to dispute if farmers are 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

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

Animal welfare implications and conclusion

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

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

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

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