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Developing a tool to assess the health-related quality of life in calves with respiratory disease: content validation

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Abstract

Bovine respiratory disease (**BRD**) is a major welfare and productivity issue for calves. Despite the extensive negative impacts on calf welfare and performance, BRD remains challenging to detect and treat effectively. However, the clinical signs of disease are only one aspect of the disease that is experienced by the individual. The assessment of emotional experience in animals is not straightforward, but it is increasingly recognised that the quality of behaviour and demeanour of an individual is a reflection of their internal emotional state. The aim of the present study was to complete the content validation stage of the development process for a health-related quality of life (**HRQOL**) tool. This was based around indicators from an existing conceptual framework containing twenty-three indicators in two domains (clinical signs and behavioural expression). The content validation stage involves engaging with key stakeholders. For this study, this took the form of a survey and discussions with focus

groups, which are standard methods in this field. A survey and stakeholder focus groups were conducted to assess the usefulness of each indicator and its relevance for inclusion within a HRQOL tool. In the survey, participants were asked to rate the usefulness of each of the indicators using a 4-point scale which were then dichotomised into 'useful' and 'less useful'. Based on the 'useful' result, each indicator within the domains was ranked. A similar approach was taken with the responses from the focus groups. Focus group participants were asked to select indicators that they felt were of use and the result of this was used to rank each of the indicators. The ranks of the indicators from both the survey and the focus groups along with the transcripts from the focus groups were used to determine the indicators from each domain to include within the HRQOL tool. Indicators within the clinical signs domain that were included were nasal discharge, cough, respiratory effort, ocular appearance (discharge and vibrancy), body and head posture and ear carriage. For the domain of behavioural expression, the indicators included were movement to feed, responsiveness, spatial proximity, volume of feed intake, motivation at feed and vigour. The next stage will be to validate the construction of the HRQOL tool through its use in practice. Inclusion of indicators that allow the experiential aspects of disease to be recorded in health assessments will likely increase the ability of farmers and others to detect respiratory disease in calves.

Keywords Bovine, Respiratory disease, Clinical signs, Behavioural expression, Qualitative data

Implications

Bovine respiratory disease is a major cause of mortality and morbidity in calves but has proved difficult to control. Using a method that assesses the outward expression of the poor quality of life caused by disease may improve disease detection. This study created a tool that is ready for the next stage of the process which is construct validation. Such tools have the potential to facilitate disease diagnosis but also to evaluate the outcomes of any treatment administered.

Introduction

Bovine respiratory disease (**BRD**) is a major welfare and productivity issue for calves. The welfare of the calf with BRD may be compromised through the effort needed to breathe which may be extenuated through normal exertion, such as raising from lying, moving to feed (Beausoleil and Mellor, 2015). As well as having negative impacts on welfare and causing ill-health and mortality in pre-weaned dairy- (Brickell et al., 2009) and beef-bred calves (Pardon et al. 2012), respiratory disease causes damage to the lungs which contributes to poor growth and fertility later in the animal's life (Virtala et al., 1996; Van Der Fels-Klerx et al., 2002). The number of calves affected by respiratory disease in each herd can be considerable. In a European study on veal calves, it was shown that up to 7% of the calves showed clinical signs of disease. However, post-mortem examination of the calves showed that 13.5% showed signs of mild to moderate disease and 7.7% showed signs of severe respiratory disease (Brscic et al., 2012). A Canadian study showed that 22% of calves were treated for respiratory disease at least once before three months of age (Windeyer et al., 2014). In terms of economic impact, it has been estimated that calf disease costs the UK cattle industry

over £60 M p.a. and a single case of pneumonia costs £43 to treat (National Animal Disease Information Service, 2015).

Despite the extensive negative impacts of respiratory disease in calves on their welfare, performance and subsequently on farm sustainability, respiratory disease remains difficult to detect. This reduces the opportunity for farmers to administer effective treatment promptly. Early treatment will improve the health and welfare outcomes for the treated calf and will also reduce spread of disease to other calves and overall use of antibiotics. A number of methods have been developed to detect respiratory disease in calves. Most commonly used methods score the clinical signs of disease such as the presence of a cough, ear posture, high temperature or discharge from nose or eyes (e.g., the Wisconsin score (McGuirk, 2008) and the California score (Aly et al., 2014)). More recent methods involve the use of ultrasonography to assess lung damage (e.g., Cramer and Ollivett, 2019).

The clinical signs of disease are only one aspect of disease that is experienced by the individual. In humans, it has been recognised that the emotional aspects of the experience of disease (i.e., how being ill with the disease 'feels') is important in terms of disease outcomes (e.g., Hennessy et al., 1994). These experiential aspects are referred to as the 'health-related quality of life' (**HRQOL**) (Rudberg et al., 1992; Guyatt et al., 1993). Psychometric methods have been developed to assess HRQOL and are often used to guide treatment strategies. These typically involve using self-report questionnaires for patients that assess emotional state and activity as well as physical health (CDC, 2000).

The assessment of emotional experience in animals is not straightforward, but it is increasingly recognised that the quality of behaviour, demeanour and facial expressions in animals is a reflection of their internal emotional state (Reefman et al.,

2009; Veissier et al., 2009; Wemelsfelder, 2007) and that emotional well-being is an important aspect of overall health (McMillan, 2002). It is likely that good farmers can also pick up changes in demeanour and behaviour, but this skill is not universal. Accordingly, in recent years, the concept of HRQOL has been extended for use in the assessment and treatment of disease in animals (Bijsmans et al., 2016; Nobel et al., 2019). In this approach, the owner or animal carer is asked to rate the activity and general well-being of their animals. While the majority of the HRQOL tools for animals have been developed for cats and dogs, a tool has also been developed for pigs (Wiseman Orr et al., 2011 a and b). However, there are no tools for cattle, and none for the assessment of BRD. The HRQOL approach has the potential to be useful in detecting this disease, as farmers often anecdotally describe sick calves in terms of their depressed behavioural responses. The HRQOL approach is also observational, and therefore can be used to detect disease from the pen side, which facilitates immediate treatment.

The development of a HRQOL tool involves a number of stages (U.S. Dept. of Health and Humans Services, 2009). The first stage aims to establish content validity, which is the extent to which any new tool measures all important aspects of how the disease affects the sufferer. This stage contains two steps. Firstly, decisions are made on what key concepts (or domains) define the disease outcomes (i.e., can the outcomes be classified as clinical or behavioural?) and then generating ‘items’ or ‘indicators’ within these domains that can be used to assess the disease in question (e.g., presence of eye discharge or reduction in sleep). This step is achieved by reviewing the literature and interviewing key informants such as personnel working in a specific sector or industry to define the items and overall domains. The second step in content validation is to construct a draft tool and to use the opinion of key informants to

determine whether the tool contains all relevant indicators, while avoiding redundancy. This is typically done by using interviews with end-users, and their feedback is used to redraft and refine the tool. Following this, 'construct validity' is assessed in a second stage by determining whether the tool differentiates between known classes of sick and healthy animals.

For BRD in calves, a conceptual framework and a list of items/indicators was established by Bull et al. (2021). This study used a literature review and interviews with key informants (experienced veterinarians and stockworkers dealing with calves on a regular basis) to create a list of twenty-three items in two domains: 'clinical signs' and 'behavioural expression of emotional wellbeing'. The aim of the present study was to complete the content validation stage by assessing the 'usefulness' of each item/indicator and using stakeholder focus groups to construct rating scales for the items identified and to determine whether the tool covered all aspects of disease but did not contain redundant items. From this a draft HRQOL assessment tool for BRD in calves will be created. The construct validity of the tool will be assessed in a further study.

As most HRQOL tools for animals have been designed to assess quality of life in pets, the indicators within the tools assume that that owner has been able to continuously monitor the well-being and activity of their pet. Questions such as 'Did your cat play more/less/the same as last week?' are used to assess quality of life. This continuous, detailed knowledge of individual animal behaviour is not typically available for calves on a farm where 'spot checks' are typically used by the farm staff to assess the animals before them, normally without detailed information on previous appearance or behaviour. Therefore, A HRQOL tool for BRD in calves will likely differ from the 'classical' HRQOL tool and contain indicators and assessment scales that can be used

during these routine checks. This approach was used successfully by Wiseman Orr et al (2011a and b) in their studies on farmed pigs. Crucially, the development of HRQOL indicators that are capable of capturing the depression-like state or lack of vitality that characterises the experience of ill health may improve disease detection rates. As BRD remains a major threat to calf health and well-being, investigation of additional or alternative methods is strongly needed.

Material and methods

This study used the list of indicators generated by Bull et al. (2021). There were two domains created: 'clinical signs' and 'behavioural expression'. The clinical signs domain included rumen fill, hair coat condition, nasal discharge, cough, respiratory rate/effort, eye appearance, drooling saliva, body posture, head carriage and ear carriage. The behavioural expression domain included movement to feed, eye contact, responsiveness, competition at feed, engagement in play, grooming, spatial proximity, volume of feed, motivation at feed, vigour, time standing inactive, lying time and stretching. We aimed to engage the final end-users of the proposed tool; a group which includes farmers (farm managers, stock workers), consultants, veterinarians and researchers. Firstly, a quantitative on-line survey was used to gauge the level of usefulness placed on each indicator using Likert-style scales. Then, a series of qualitative focus group discussions were carried out to further investigate the relevance of each indicator as well as gather opinions on the response option for each indicator. These two methods were selected based on the methodology discussed by Klassen et al. (2012) because the use of a survey could harness a lot of information from a larger number and variety of people and the focus groups could allow for a more

detailed examination of the indicators and thereby obtain much more granular information that the survey was not able to provide.

Survey

Before the survey was opened for responses, it was pilot tested by five farmers who regularly work with cattle and researchers who were not involved with the study. This was carried out to ensure all questions were understandable and that sensible responses could be collected. None of the survey responses from the pilot testing phase of the survey were retained. The survey was opened for responses on 15th December 2020 and closed on 25th January 2021. The survey was created using Google Forms. A copy of the survey can be found in the Supplementary Material S1. Recruitment routes aimed to reach farmers, veterinarians, farm consultants and researchers. The link to the survey was distributed across **SAC** (Scottish Agricultural College) Consulting and **SRUC** (Scotland's Rural College) Veterinary Services as well as with colleagues within the academic division. A press release about the project and survey was released and this was also publicised on various social media channels. In addition, the survey link was sent to people from other research and farming organisations such as **CIEL** (Centre for Innovative Excellence in Livestock, UK), Scottish Dairy Hub and personal networks of farmers, veterinarians and researchers. The survey opened with some demographic questions including participant's gender, location, occupation, and the number of years of experience the respondent had in working with calves. There were additional questions to answer if the 'farmer' option was selected in the occupation question. These questions captured additional information on the number of calves reared per year, the type of farming system the respondent operated and the main rearing systems for their calves. Next, the survey

presented participants with questions that asked them to rate the usefulness of each item/indicator from the conceptual framework of Bull et al. (2021). A brief definition of each item/indicator was included with the question. The respondents were asked to rate usefulness on a four-point Likert-style scale from 'not useful', through 'slightly useful', 'somewhat useful' to 'very useful'. There was also a 'not applicable' option available. At the end of the survey, there was a question to gauge what sort of 'calf' respondents were thinking of when they were answering the previous questions. This question was included as it is evident that there is variation in an individual's definition of a 'calf' with respect to age, stage of maturity and production system (i.e., beef vs dairy). Respondents were also asked if there were any indicators missing from the series of questions and if so, to add detail. Finally, there was another open-ended question for the respondent to make any comments that they deemed relevant to the purpose of the survey based on their own experience of calves with BRD.

Focus groups

A total of four focus groups were established. Meetings were conducted virtually on the 18th and 19th January 2021 via Microsoft Teams due to COVID-19 restrictions at that time. Each focus group was recorded (with participants' permission) which also created a written transcript of the dialog. The virtual format was also favoured as it reduced the time commitment involved in the study for participants, thus encouraging participation by individuals with restrictions on their ability to travel to a meeting (farmers in particular). Each focus group contained four participants along with a facilitator (DJB) and note taker (MH). Participants were drawn from personal and industry contacts and included dairy producers, academics (with animal welfare or dairy production research interests), veterinary representatives and an

advisor/consultant from across the UK. Each group was balanced for participant type where possible. Prior to the focus group, each participant received a document containing a brief outline of the study along with a list of the indicators within each of the two domains. Each focus group discussion followed the same format and lasted for a maximum of two hours. Following participant introductions and an opening/transitional question about their own experience of calves with BRD, the discussion progressed to the key questions. Participants were asked to select which indicators of BRD were of most useful to them for each of the two domains (clinical signs and behavioural expression). With the indicators they selected in mind, participants were then asked how they would measure them using the various response option scales that were available (sourced from a review of the literature). To ensure that no participant was influenced by another's response, a 'text flood' method was used. This method involved each participant typing in their opinion into the chat function within Microsoft Teams and only pressing submit once told to by the facilitator. Participants were asked to select up to five indicators. The note-taker then compiled the responses and presented them to the group in the form of a bar-plot which could then be used for further discussion. The discussions led each group into deciding together which of the indicators they would use in a tool designed to assess HRQOL of BRD in calves. Following the selection of the indicators, there was a discussion of the potential response option scales that could be used to measure the indicators that had been selected. The participants of the focus group were shown examples of the types of response option scales that could be used in practice to score the various indicators. The possible response option scales were A – Visual Analogue Scale, B- numeric scale, C- ordinal scale (e.g., normal, slightly abnormal, severely abnormal) and D- binary scale (e.g., present, absent). Participants were asked to think

about which response option scale would be, in their opinion, the most relevant for each of the indicators they selected for each of the domains. If participants felt that a combination of response option scales were more appropriate, then they were asked to state which combination it was. The 'text-flood' method as previously described was used to capture this information. Again, the note-taker collated all the responses and presented them in the form of a bar-plot to be discussed and allow a group level conclusion to be reached.

Data analysis

Data from the survey and the 'text flood' from the focus groups were collated using Microsoft Excel and all data visualisation was conducted using the ggplot2 package in R Studio (R Core Team, 2016).

Survey

The responses to each question of the survey relating to the indicators were initially collated by response (not useful, slightly useful, somewhat useful, very useful). To determine the degree of usefulness for each indicator within each of the two domains (clinical signs, behavioural expression), the response options of each question were dichotomised by assigning the responses of 'not useful' and 'slightly useful' as 'less useful' and the responses of 'somewhat useful' and 'very useful' as 'useful'. This dichotomisation process was used to simplify the analysis of this data and is a practice that is frequently used within behavioural and social science where the variable of interest is graduated (Cohen, 1983). All the 'not applicable' responses were not included in this process. The total number of responses for 'less useful' and 'useful'

was calculated for each indicator and divided by the number of respondents for each indicator to provide a measure of 'usefulness'. This measure of 'usefulness' was then used to rank each of the indicators from 1 to 13 where 1 was the highest measure and 13 being the lowest.

Focus Groups

A similar approach was taken with the participant responses from the 'text flood' which was collected during the focus groups. The number of times each indicator was selected by participants was calculated and divided by the total number of focus group participants and expressed as a percentage to give a suggestion of the usefulness of each of the indicators. Transcripts from the recording of the focus groups were organised and analysed using MAXQDA Analytics Pro 2020 (release 20.4.1) (VERBI Software GmbH, Berlin, Germany). A thematic analysis was carried out on the transcripts (Braun and Clarke, 2006). The process began with a familiarisation process, which involved listening back to the focus groups and reading though the transcript in full. *A priori* themes were first defined based on each of the indicators for the two domains of the HRQOL framework. Within these themes there were four emergent themes. These were (i) interpretation of the indicator, (ii) positive use of the indicator, (iii) negative use of the indicator and (iv) general comments. The transcript of each focus group was read through, and sections were coded to the appropriate theme or sub-theme. Only one person coded the transcripts in the study which could be a potential limitation of the study in terms of minimising bias. The person coding the transcripts was present within all the focus groups.

Combining data

Each indicator was ranked based on the outcome of examining the data from the survey and the 'text flood' from the focus groups. Indicators that ranked low across both methods (survey and focus group) were removed. Indicators that ranked high across both methods were retained. For the indicators that ranked high in one method but low in the other method, the thematic analysis of the transcripts was referenced to allow a judgement to be made. The indicators that remained after this process were used to create a final list of indicators for the draft HRQOL tool.

Results

Survey

A total of 67 complete responses were collected and analysed.

Demographics

Of the 67 responses, 41.8 % (28 respondents) were female, 56.7% (38) male and 1.5% (1) defined their gender in another way. In terms of location, 34.3% (23) of the respondents were from England, 3.0% (2) from Northern Ireland, 56.7% (38) from Scotland, 1.5 % (1) from Wales and 4.5% (3) from 'other'. The 3 'other' respondents were from the Republic of Ireland (1) and Canada (2).

With regards to occupation, 50.7% (34) were farmers, 34.4% (23) were veterinarians, 10.5% (7) were consultants/advisors and 4.5% (3) of the respondents were academics. Farmer respondents had an average of 25.6 years of experience with calves (range: 2 - 55 years) and veterinarians had an average of 18.5 years of experience with calves (range: 4 – 40 years). Academic respondents had an average of 10.7 years (range:

10-12 years) of experience with calves and advisor/consultants had on average 15.8 years (range: 5 – 40 years) of experience with calves.

The farmer respondents stated that they reared on average 189 calves per year (range: 12 – 1000 calves). Of the 34 farmer respondents, 22 regarded their enterprise as primarily beef, 9 as primarily dairy, 1 as both beef and dairy, 1 as contract rearing with other enterprises on the farm and 1 as a dedicated calf rearing unit with no other enterprises on the farm. A large portion of the farmer respondents (21) adopted a calf at foot/keeping calf with cow rearing system (so likely to be beef farmers), 4 used individual pens/hutches initially then reared calves in groups fed from a teat/bucket/trough until weaning, 4 reared calves in individual pens/hutches initially but then transferred the calves to a group pen where milk was fed via an automatic/computer-controlled milk feed station until weaning, 1 reared calves in groups from birth via an automatic feeder until weaned, 1 reared calves in groups fed from a teat/bucket/trough from birth until weaning and 3 reared calves in another way. After the indicator questions in the survey, all respondents were asked to describe the type of 'calf' they had been thinking about when answering the previous questions. Of the 67 respondents, 41.8% (28) had been thinking about a calf in the pre-weaning phase (period from birth until completely weaned), 14.9% (10) had been thinking about a calf post weaning (the period after weaning and less than one year of age) and 43.3% (29) of respondents had been thinking about calves in both the pre and post weaning phases.

Indicators – clinical signs domain

The responses for each of the indicators in the clinical signs domain indicating their level of usefulness is shown in Fig. 1. The raw data is shown in Supplementary material

(Figure S1). 'Respiratory rate/effort', 'eye appearance', 'ear carriage' and 'cough' were rated as the most useful indicators. Using this measure of usefulness, there was a noticeable difference across occupations for the indicator drooling saliva. Farmers rated drooling saliva useful more than veterinarians, academics and consultants/advisors.

Indicators – behavioural expression domain

The responses for each of the indicators in the behavioural expression domain indicating their level of usefulness is shown in Fig. 1. The raw data is shown in Supplementary material (Figure S2). 'Vigour', 'volume of feed intake', 'motivation at feed' and 'movement to feed' were rated most highly whereas the indicators, 'eye contact' and 'grooming' secured the lowest level of usefulness. Eye contact secured the lowest level of usefulness across all four occupations surveyed (farmer, veterinarian, academic and consultant/advisor).

Focus Group

Domains and indicators

The responses from each participant for each indicator within both of the domains were collated to give an overall opinion from the focus groups (Fig. 2). Less than 25% of the focus group participants deemed 'drooling saliva', 'rumen fill' and 'hair coat condition' to be useful indicators of BRD in calves. Some participants indicated that the reason that they considered rumen fill and hair coat condition as not useful was that they used calf jackets in their own calf rearing facility. One participant reported that "*Things like rumen fill and hair coat condition at this time of year we've all got*

jackets on our calves.... It wouldn't be a marker that I would necessarily use just purely because they've got the jackets on. It's not something without going in and taking the jackets off all the calves that I can actually monitor if you know what I mean" (dairy farmer). Another participant from a different focus group stated "*I'm really glad nobody chose rumen fill, 'cause I think that's a really bad indicator 'cause sometimes it's really difficult to tell a rumen fill and by the time you get to (them), they're empty, they are probably way over treating or way over rescuing, really" which was echoed by another participant "…I'm thinking about small calves like pre-weaned dairy calves, rumen fill's not really useful unless they're starving and they're totally looking collapsed and empty. It's not a thing I would tend to look at. I see rumen fills much more appropriate for mature adults you know*' (dairy farmer). No focus group participant felt that 'competition at feed', 'eye contact' or the 'time standing inactive' were useful behavioural indicators. For 'competition at feed', two participants highlighted the conditions that would create such competition *"…if you don't create an environment where there is going to be a feed competition, you won't see it. So, on the adlib systems, there's not really a need for competition 'cause it's [feed] always there so you don't pick them out so easily"* (dairy farmer).

Preparation of working version of assessment tool

Domain - Clinical signs

As a result of the ranking process, 'rumen fill', 'drooling saliva' and 'hair coat condition' from the clinical signs domain were excluded from the development of the HRQOL-BRD assessment tool as they were consistently ranked low in terms of importance (Table 1). 'Nasal discharge' and 'head carriage' were retained based on the ranking

from the focus groups, and 'eye appearance' was retained based on the ranking from the survey. Although 'body posture' was mid-ranked by both the survey result and the focus groups it was also retained. This is because during the discussions in the focus groups, some participants stated that when they thought about body posture, they were also thinking about head carriage/positioning and ear carriage and felt that these indicators should be amalgamated into one item. For example, a focus group member stated "*Yeah, I would agree. I suppose that in my mind visually I'm seeing a sick calf at the back of the pen, body posture probably would include to me the head carriage and the ears down, just the whole thing, but whether you can separate them, whether you need to separate them or you are going to say 'poor body posture, sick calf body posture usually means the heads down and the ears are down' doesn't it?"; "That's why I kind of put body posture including the head carriage because it's something that you kind of look at the whole calf how it's holding itself' like we see it looks sad."; "and I think you could actually argue that head carriage, ear carriage and body posture you probably lumping them all in together when you look at the animals. I think they're all the same thing really. So often you take that like when you look at the posture of an animal. You're probably looking at all of them*" (veterinarian).

Although a few of the responses also suggested the incorporation of ear carriage as well into this term, there were some participants that felt that it was an indicator in its own right – "*I guess it's just how you interpret your own animals. In some ways it's a bit of a personal thing. For me personally, it's always the eyes and ears I look for first, that's just my general initial response", "I think ear particularly is quite important. I think you see that quite a bit with a sick calf*" (dairy farmer). Therefore, all three of these indicators (body posture, head carriage, ear carriage) were retained but in the creation

of the draft tool, body posture and head carriage were combined into an item referred to as ‘body and head posture’ and ‘ear carriage’ remained as a separate indicator.

‘Eye appearance’ was retained but based on the conceptual framework, it appeared as two indicators – “discharge” and “vibrancy”. It was felt that “eye appearance – sunken” was more related to incidences of scour rather than BRD, so was not included in any further assessment.

Although ‘respiratory rate/effort’ was effectively the most useful indicator as ranked by the result of the survey and the focus groups, it was still an indicator that caused some debate in the focus groups. As one participant put it *“…'cause respiratory rate is something that is countable, …like whereas effort you score*” (veterinarian). That participant went onto say “*Yeah, 'cause I think there's an aspect that where what we've alluded to with body posture and things, but some of it is about is it what do people look for in calves that have got increased respiratorys? I had clients that discard rate and describe that they see the calf pulling (displaying greater physical effort to breathe). It's that kind of right what do they look for- open mouth calves pulling more, extenuated chest movements? But actually, respiratory rate is a rate and if you're looking at scoring, it always fascinated me about why we bundle them in together, because I could ask someone to count something. It's not the easiest to always count it, but you could ask them to count it*.” Based on this response, the indicator was split into ‘respiratory rate’ and ‘respiratory effort’ and only ‘respiratory effort’ was taken forward as it required a score and not a quantification and fitted better with the other indicators.

Domain - Behavioural expression

As ‘competition at feed’, ‘grooming’ and ‘eye contact’ were consistently ranked low in terms of importance, these indicators were excluded from the behavioural expression domain (Table 1). Some further indicators from the behavioural expression domain were excluded based on the results of the discussion in the focus groups. A general re-occurring theme was that ‘stretching’ and ‘engagement in play’ were indicators that, although they may be indicators of a positive emotional state, were either quite time-specific (e.g., stretching after standing up from lying) or could be considered low in frequency of occurrence (e.g., engagement in play). It was also felt that ‘time standing inactive’ and ‘lying time’ should be excluded as they are indicators that would have to be measured across each day and because any HRQOL-BRD assessment tool would be a visual ‘snap-shot’ tool, there was no feasible way to adequately assess these indicators. Despite ‘responsiveness’ being ranked 8th in the results of the survey, it was ranked highly by the focus groups and was retained. ‘Spatial proximity’ was retained despite being mid-ranked by both the survey and focus groups, as it was deemed an indicator that could be easily measured and if it was deemed of little significance after a construct validation study then it could be removed. ‘Spatial proximity’ created a lot of discussion within each of the focus groups with the main topic surrounding the sociability of calves. One participant stated that “*Spatial proximity, I would say, is still viable in housed expression of pneumonia, but that's a fairly kind of classic one, isn't it, really? You know, calves that are just disinterested in the rest of the group for whatever reason, more than just anti-socialness” (*consultant) with another adding *“Your eye goes to the ones that are standing or lying on their own at the back rather than coming to see what's going on, and so I think spatial proximity is useful*” (veterinarian advisor). In contrast, another participant commented that “*we've had a sick calf, but it'll have other calves lying by it, so it doesn't....it wouldn't*

necessarily, you know, if you're looking over the pen, like a group of four calves sat together and the one in the middle was a sick one and I don't think it has a greater bearing on it. You can have a calf that's really happy sat by itself, you go jump in the pen to go into it and it'll shoot off. I just don't think it's an indicator at all of how well an animal actually is" (dairy farmer). These comments illustrate the contrasting views on the use of 'spatial proximity' as an indicator, but it was retained so that its validity could be tested in the final tool. Following the elimination of the aforementioned indicators, seven indicators from the clinical signs domain and six indicators from the behavioural expression domain were taken forward and developed into the draft working version of the assessment tool (Table 2).

Response option scales for indicators

In response to the question of what type of scale is the best to use for each indicator in the clinical signs domain, the focus groups largely agreed that ordinal scales were the most appropriate. However, a combination of response option scales was favoured for use with the indicators from the behavioural expression domain (Fig. 3). One participant's reason for selecting an ordinal scale for the clinical sign indicators was "*I think the reason I chose C [ordinal scale] was 'cause it's got the least decision making to be made. I think with the numeric scale 1 to 10; it's almost like a bigger decision, am I going to go 3, 5, 6 or 7? To be normal, mild, moderate, severe, most people could understand that. I quite like the idea if it was possible for all these different clinical signs to have some sort of a visual for*" (veterinary advisor). Having visuals/pictures of each of the categories for each clinical sign measured using an ordinal scale was a re-occurring theme within all focus groups.

Many participants frequently commented that they found the selection of response option scales for the behavioural expression domain a difficult task. In terms of the combination of response option scales, ordinal scales and binary scales were the most frequently mentioned response option scales.

Discussion

The objective of this study was to create a tool for the assessment of health-related quality of life of calves with respiratory disease based on the conceptual framework constructed by Bull et al. (2021). The aim was to create a tool that could be used by farmers and others for pen-side 'spot checks', primarily for calves managed in pens, but with the potential to be adapted for other management systems. A mixed method approach was taken, analysing data gathered from a survey and from focus groups discussions with potential end-users of such a tool. Using this approach is important as involving end-users from the beginning of the development process means that the resulting tool is more likely to meet their needs and be used in practice. The rather small sample size of the survey may pose slight concern to some. As with any convenience sampling method, other opinions may have been gathered with a wider sample population and a larger sample size. However, there was a good degree of consensus within the sample population.

The indicators or items from the original conceptual framework from Bull et al. (2021) were presented in both the survey and to the focus group participants. The survey respondents were asked to rate each indicator on a scale from 'not useful' to 'very useful'. All of the indicators presented were deemed to be 'useful' to a certain level suggesting that their inclusion was valid. However, some of the indicators were rated

as being more useful than others in the survey. The outcomes of the survey and the focus groups were different with regards to what indicators were favoured for use. The participants of the focus groups did not consider 'rumen fill', 'hair coat condition' and 'drooling saliva' as viable indicators in the clinical domain. Of interest is that farmers within the survey results generally thought that drooling saliva was of use more than the other groups (veterinarians, academics and consultants/advisors). This group have probably observed this sign more in calves with BRD than the other groups. However, it could also be said that once a calf is drooling saliva, BRD has taken hold and that drooling saliva has the potential to be associated with 'open mouth' breathing of the calf. They also eliminated 'competition at feeding', 'engagement in play', 'time spent standing active', 'lying time' and 'stretching' from the behavioural domain. The inclusion of more indicators by the survey respondents may be due to a number of factors. Most importantly, the focus groups were asked about the use of all indicators in detail such as the positive and negative use of the indicator, whereas the survey only asked respondents to comment on the usefulness. Some of the indicators, such as 'engagement in play', 'stretching', 'lying time' and 'standing active' were viewed by the focus groups as being difficult to assess in a tool that is aimed to be used as a 'snapshot', pen-side test. Indicators are often deleted during the content validation stage in any HRQOL tool (e.g., Randa et al., 2020). The practicality of the measurement of any indicator given the time and resources available is an important consideration in the development of any HRQOL tool (Hennessy et al., 1994). In other studies on animals, the probability of observing the target behaviour during normal observation periods on farms (e.g., Wiseman-Orr et al. (2011a) and of pets (Freeman et al. 2016) influenced what indicators remained in the final tool.

Some of the exclusions recommended by the focus groups also related to the different range of farming systems represented in both groups. The participants of the survey came from a broader range of farming backgrounds (including beef and dairy) and from the United Kingdom and beyond, whereas the focus groups were mainly from a dairy/dairy-beef background and were all based in the United Kingdom. Thus, rumen fill and hair coat condition were excluded because the use of calf jackets may prevent the observation being made. Competition at feeding was also viewed as not informative where farmers use a system that does not require the calves to compete, such as ad libitum feeding or the provision of sufficient space for each calf. Both conditions may be more common in the dairy context than in a suckler beef system. Thus, the final content may be more applicable to a dairy enterprise than a suckler beef system. A different selection of terms may be practical and feasible in more extensively managed calves.

It is interesting that the participants in the focus groups were strongly in favour of using ordinal or binary scales. While we asked these groups for their opinion on the best measurement scales without giving them any background on other current HRQOL tools, their responses are in agreement with the current knowledge that ordinal scales are the most appropriate. The use of categorical rather than numerical scales is almost universal in HRQOL tools for human medicine when a psychological state is being assessed (e.g., Kirshner and Guyatt, 1985; Hennessy et al.,1994). Numerical scales are considered difficult to use when describing a subjective or non-dimensional state (MacKenzie and Charlson, 1986).

While the primary aim in developing this tool was to capture the experiential aspects of disease, by asking end-users that were involved in the day-to-day care of calves for their opinions on indicators of disease it was perhaps inevitable that some indicators

that assess signs of the disease (such as eye and nasal discharge) would be included. However, the nature and valence of the emotional experience (or quality of life) is captured in the indicators. The experience of lethargy, depression and lack of vitality associated with disease is reflected in the behavioural expression domain indicators, particularly 'vigour' and 'responsiveness'. Even some of the indicators in the final 'clinical signs' domain are measures involving physical actions, such as 'respiratory effort' and 'coughing'. The effort required for these actions means that the indicator will capture the negative experiential aspect of the disease (i.e., a coughing calf is likely to feel worse than one that does not cough).

Most other established disease scoring systems for calves quantify the clinical signs of respiratory disease rather than assessing quality of life indicators (e.g., the Wisconsin Scoring System, McGuirk, 2008). Some scoring systems have incorporated the 'attitude' of the calf into their assessment of calf health along with more clinical indicators. Attitude is typically a measure of the activity and responsiveness of the calf (Garcia et al., 2014; Jorgensen et al., 2017; Medrano-Galarza et al., 2018; Cramer et al., 2019; Olson et al., 2019). Cramer et al. (2019) investigated whether they could use a calf attitude score as a primary method for detecting BRD but concluded that although calves with clinical BRD were detected by the score, it did not give very good sensitivity values. Likewise, a disease scoring system based entirely on behaviour measures did not give high sensitivity values and the authors concluded that a behavioural score should be used in conjunction with other indicators (Cramer et al., 2016). These authors concluded that a behaviour score on its own could not reliably detect BRD and that any behavioural score should be used in conjunction with some other method. Some of the behavioural indicators assessed in this study were similar to those suggested by end-users in the present study, including abnormal posture,

isolation (distance from other calves) and response to being approached. Calves with severe BRD were significantly more likely to be socially isolated than other calves and an association was found between approachability and presence of a fever. In a pilot study using the items from their framework, Bull et al. (2021) also found that response to humans was an early indicator of disease. These findings provide further support of the inclusion of spatial proximity, head and body posture and responsiveness in the current tool. As BRD rates remain high across the world and cause significant mortality and morbidity in calves, the development of better disease detection tools is required. Using a HRQOL approach to capture the way the disease affects the demeanour and vitality of the calf may be valuable in this regard.

Both the conceptual framework and the survey have incorporated indicators that are appropriate for a range of calf-rearing systems. However, the focus groups were more representative of the dairy/dairy-beef rearing industry in the UK. This may mean that if the tool were to be used in a specialised pasture-based beef system or an intensive feedlot, the indicators included in the final tool may need to be adjusted. However, a number of indicators are included in our final version that cover the experience of disease for any calf. The next step in the development of a working HRQOL tool for BRD in calves will be to test the construct validity in a study in which the scores from this tool are compared with a gold standard test. The focus of the working HRQOL tool will be on pre-weaned dairy bred calves. The current intention would be to sum the response option for each of the indicators to give an overall measure of HRQOL. If the construct validation stage proves successful, then the process to create an overall measure of HRQOL could potentially be explored.

Ethics approval

The SRUC Social Science Ethics committee reviewed the survey and the use of the focus groups and approved the proposal (SRUC SSEC/12/2020/Haskell).

Data and model availability statement

None of the data were deposited in an official repository. The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Declaration of interest

None.

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Table 1

Ranking of each indicator by domain (clinical signs, behavioural expression in calves) based on percentage (%) useful responses from survey and focus group participants after being dichotomised.

	Survey		Focus Group	
Indicators (by domain)	% useful	Rank	% participants	Rank
Domain: Clinical signs				
Respiratory rate/effort	98.5	1	100	1
Cough (spontaneous)	95.5	2=	73.3	2
Ear carriage	95.5	2=	60	4=
Eye appearance	95.5	2=	33.3	7
Body posture	92.4	5	53.3	6
Head carriage	91	6=	66.7	3
Nasal discharge	91	6=	60	4=
Rumen fill	85.1	8	13.3	9
Drooling saliva	80.3	9	20	8
Hair coat condition	67.2	10	6.7	10
Domain: Behavioural expression				
Vigour	98.5	1	46.7	6
Motivation at feed	95.5	2=	66.7	4
Volume of feed intake	95.5	2=	86.7	1
Movement to feed	94	4	73.3	2=
Engagement in play	88.1	5=	26.7	8=
Lying time	88.1	5=	53.3	5
Spatial proximity	86.6	7	26.7	8=
Responsiveness	86.4	8	73.3	2=
Time standing inactive	84.8	9	0	11=
Stretching	84.6	10	40	7
Competition at feed	83.3	11	0	11=
Grooming	71.2	12	6.7	10
Eye contact	53.7	13	0	11=

'=' means of equal ranking

Table 2

Indicators within each of the two domains (clinical signs, behavioural expression in calves) selected for inclusion in the draft working version of the HRQOL (health-related quality of life) assessment tool

Domain	
Clinical signs	Behavioural expression
Respiratory effort	Vigour
Cough	Motivation at feed
Ear carriage	Volume of feed intake
Eye appearance - discharge	Movement to feed
Eye appearance - vibrancy	Spatial proximity
Nasal discharge	Responsiveness
Body & head posture	

Figure captions

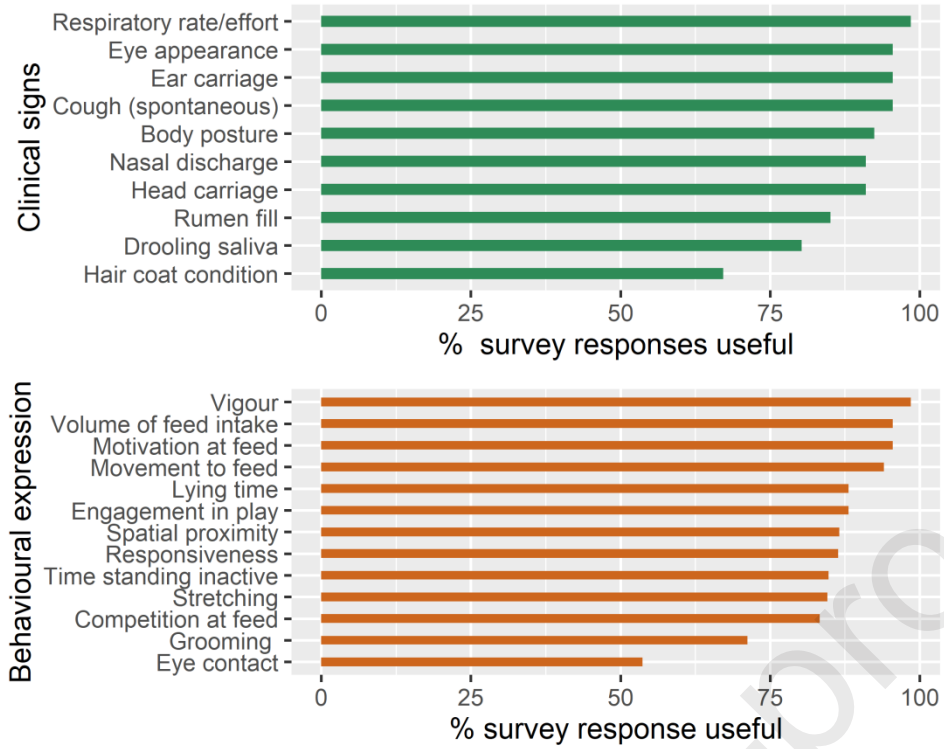
Fig. 1. Usefulness of indicators by domains (Clinical signs, Behavioural expression in calves) from survey participants after being dichotomised.

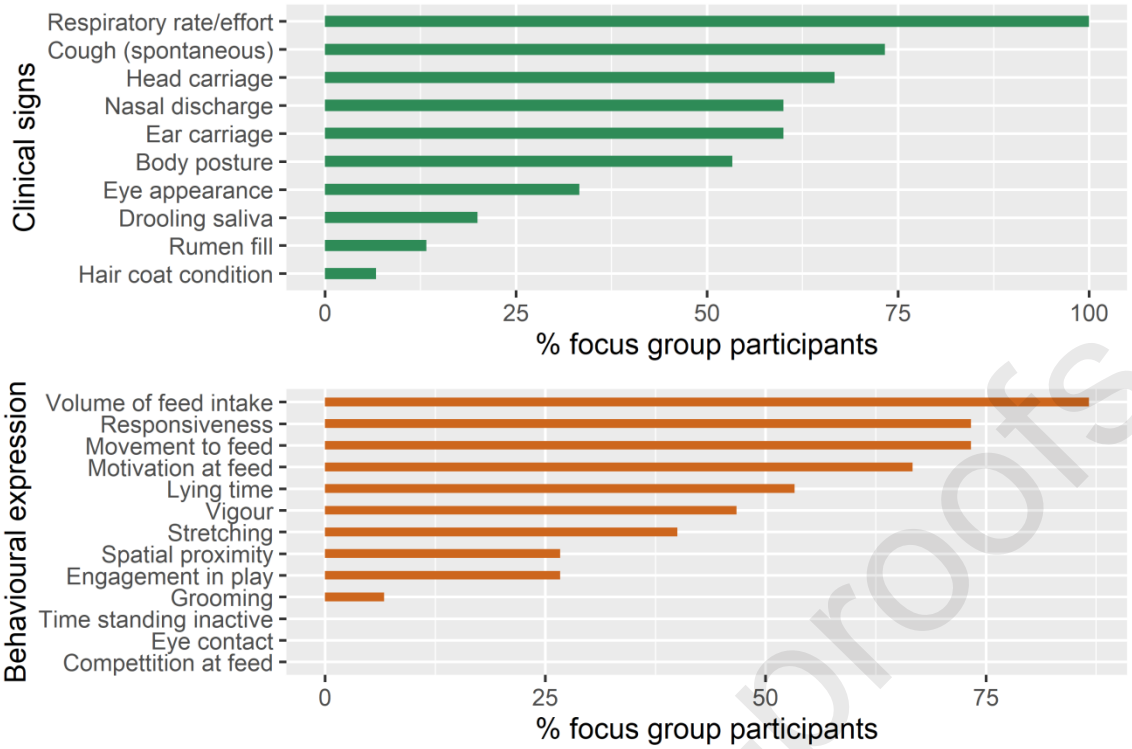
Fig. 2. Collated focus group participant responses per indicator by domain (clinical signs, behavioural expression in calves). The percentage (%) of participants who deemed the indicator to be important in determining the health-related quality of life of calves with BRD (Bovine Respiratory Disease).

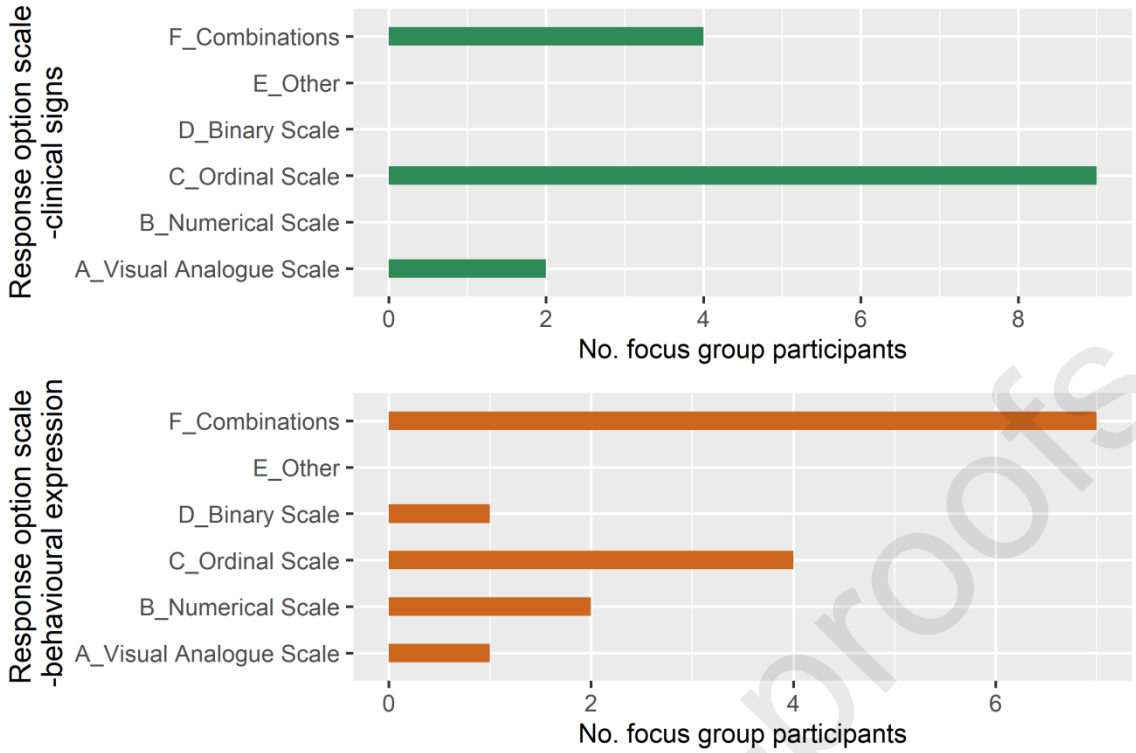
Fig. 3. Selection of response option scales by domain (clinical signs, behavioural expression in calves) by focus group participants.

Highlights

- Study aimed to validate quality of life indicators of calf respiratory disease
- Key end-user opinion sought using a combination of survey and focus groups
- Mix of clinical and behavioural indicators selected for use in a tool
- Next step will be a study to validate the construct of the tool in practice
- Such tools have potential to aid disease diagnosis and evaluate treatment outcomes







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